7th Edition (2020)



ELECTRICAL TAC
WITH COMMENTS

This document created by the Florida Department of Business and Professional Regulation -
850-487-1824

Total Mods for report: 13

TAC: Electrical

Total Mods for **Electrical** in **Approved as Modified: 1**

Total Mods for report: 13

Sub Code: Building

E7209

1

Date Submitted	11/7/2018	**Section**	449.3.15	**Proponent**	Bryan Holland
Chapter	4	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation Approved as Modified

Commission Action Pending Review

Comments

General Comments **Yes**

Alternate Language **No**

Related Modifications

7210, 7211, and 7212

Summary of Modification

This proposed modification revises the requirements for lightning and surge protection for added clarity and effective enforcement.

Rationale

This proposed modification simply revises the language to clarify the rules. The change to .1 corrects the proper name for the NFPA 780 Standard. The changes to .2, .4, and .5 are minor editorial revisions for clarity. The change to .6 corrects the product name from "suppressors" to "protectors" as indicated by the UL 497 and UL 497A Standards.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification does not add any new criteria so impacts to the local entity are minimal.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will not change the cost of compliance to building or property owners.

Impact to industry relative to the cost of compliance with code

This proposed modification will not change the cost of compliance to industry.

Impact to small business relative to the cost of compliance with code

This proposed modification will not change the cost of compliance to small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed change clarifies the rules for lightning and surge protection which directly impacts the health, safety, and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves the code by adding clarity and correcting used terms.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

Text of Mod 7209-A2

449.3.15 Lightning protection.

449.3.15.1

A lightning protection system shall be provided for all new buildings and additions in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

449.3.15.2

Where additions are constructed to existing buildings, the existing building's lightning protection system, if present, shall be interconnected to the new lightning protection system.~~connected to the new lightning protection system, shall be inspected and brought into compliance with current standards.~~

449.3.15.3

A lightning protection system shall be installed on all buildings in which outpatient surgical procedures, cardiac catherization procedures, or pain management procedures that utilize I.V. drip sedation are provided.

449.3.15.4

~~There shall be surge protection~~ Surge protective devices (SPDs) shall be installed in accordance with NFPA 70, National Electrical Code, as required by NFPA 780, Standard for the Installation of Lightning Protection Systems for all normal and emergency electrical services.

449.3.15.5

Additional surge protection shall be provided for all low voltage and power connections to all electronic equipment in critical care areas and life safety systems and equipment such as fire alarm, nurse call and other critical systems. Protection shall be in accordance with NFPA 70, National Electrical Code and the appropriate IEEE Standards for the type of equipment protected.

449.3.15.6

All ~~low-voltage system main or branch circuits~~ communication systems entering or exiting the structure shall have surge ~~suppressors~~protectors installed for each pair of conductors and shall have visual indication for protector failure to the maximum extent feasible.

Text of Mod 7209-A2

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Alternate Language

1st Comment Period History

7209-A2

Proponent Bryan Holland **Submitted** 1/8/2019 **Attachments** Yes

Rationale

The only alternative language being proposed is under Section 449.3.15.6 where "low voltage system main or branch circuits" is being replaced with "communication systems". No other changes being recommended for this proposed modification. This will match the language in SP7255, SP7218, and a SP7211 comment.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This comment does not add any new criteria, just clarification, so impacts to the local entity are minimal.

Impact to building and property owners relative to cost of compliance with code

This comment will not change the cost of compliance to building and property owners.

Impact to industry relative to the cost of compliance with code

This comment will not change the cost of compliance to industry.

Impact to Small Business relative to the cost of compliance with code

This proposed modification will not change the cost of compliance to small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This comment adds clarification which directly impacts health, safety, and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This comment improves the code by correcting the terminology of the revised section.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This comment does not discriminate against materials, products, or systems of construction.

Does not degrade the effectiveness of the code

This comment enhances the effectiveness of the code.

2nd Comment Period

E7209-G2

Proponent Michael Riley **Submitted** 5/23/2019 **Attachments** Yes

Comment:

Proposed code modification 7209 does not meet the statutory standards of Chapter 553. See attached comments.

2nd Comment Period

E7209-G3

Proponent Bryan Holland **Submitted** 5/26/2019 **Attachments** No

Comment:

Please disregard general comment SP7209-G2. The comment is not valid as it attempts to address the existing requirements of the code and not the proposed modification that is currently open for comment. The editorial revisions made to this section by the modification did not add to or take away from any of the current requirements. Therefore, none of the statements made in the general comment are relevant.

1st Comment Period History

E7209-G1

Proponent Vincent Della Croce **Submitted** 1/8/2019 **Attachments** No

Comment:

I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

449.3.15 Lightning protection.

449.3.15.1

A lightning protection system shall be provided for all new buildings and additions in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

449.3.15.2

Where additions are constructed to existing buildings, the existing building's lightning protection system, if present, shall be interconnected to the new lightning protection system.~~connected to the new lightning protection system, shall be inspected and brought into compliance with current standards.~~

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A lightning protection system shall be installed on all buildings in which outpatient surgical procedures, cardiac catherization procedures, or pain management procedures that utilize I.V. drip sedation are provided.

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449.3.15.5

Additional surge protection shall be provided for all low voltage and power connections to all electronic equipment in critical care areas and life safety systems and equipment such as fire alarm, nurse call and other critical systems. Protection shall be in accordance with NFPA 70, National Electrical Code and the appropriate IEEE Standards for the type of equipment protected.

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The controlling statutory standards for approving an amendment or modification to the Florida Building Code are as follows. Proposed code modification 7209 does not meet the statutory standards:

1. *Is needed in order to accommodate the specific needs of this state.*
2. *Has a reasonable and substantial connection with the health, safety, and welfare of the general public.*

It is undisputed that structural fire incidents are declining – not increasing – in the United States from 1977 to 2015 so there is no reason for FBC to impose this new tax for LPS and SPD on Florida's economy. Haynes, *Fire Loss in the United States 2015*, NFPA, September 2016, Figure 1 at p. 11. Haynes concludes that "[t]he total number of fires continues to be on a downward trend, as does the number of outside fires, structure fires and vehicle fires." P. 35. Direct property damage from lightning fires has declined as well from 1977 to 2015 in 2015 dollars. More specifically, the amount of direct property damage to non-home structures caused by lightning fires dropped over 70% annually from 1980 to 2014 ($249 million to $65 million). Ahrens, *Structure Fires Started by Lightning*, NFPA, April 2017, at Table 2, p. 4. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/fire-causes/lightning-fires-and-lightning-strikes

In 2011 Fire Departments reported 27,100 total lightning fires in the United States. Of these reported fires 20,400, or 75% of the total, were outside fires or non-structure fires. Only 7% of lightning fires from 2007-2011 were "non-home structure fires." Ahrens, *Lightning Fires and Lightning Strikes*, NFPA, Fire Analysis and Research Div., June 2013, p. 1. Exhibit C. There were only 1,800 "non-home structure" fires. *Lightning Fires and Lightning Strikes* at Table 4, p. 14. By 2014, the number of "non-home structure fires" was even lower (1,400). *Structure Fires Started by Lightning*, at Table 2, p. 4.

Therefore, the Proposed Code Modification is not needed and does not have a reasonable and substantial connection with the health, safety and welfare of Floridians. The Proposed Code Modification overstates the risk and costs of lightning damage to structures in Florida and given the overstated threat of damage caused by lightning strikes, the costs of complying with the proposed LPS and SPD requirements exceed the benefits of their installation in Florida.

3. *Strengthens or improves the Florida Building Code, or in the case of innovation or new technology, will provide equivalent or better products or methods or systems of construction.*
4. *Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities.*

The restriction of approved LPS to only NFPA 780-compliant systems provides no equivalent products, methods, or systems of construction and is entirely discriminatory as to all other products, methods and systems. The Proposed Code Modification would wholly exclude from Florida construction projects UL Certified Lightning Protection Systems and specific Components and Systems such as UL96A Master Labeled LPSs and UL Letter of Findings LPS.

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Further the modification excludes LPS such as IEC 62305, DOD DDESB 6055.9, DOE M440.1-1, FAA Std – 019e, FAA 6950.19A, NASA E-0012F, API – 2003, and any new LPS technology that may be developed and otherwise certified.

5. *Does not degrade the effectiveness of the Florida Building Code.*

An inherent conflict exists in the Proposed Code Modification. While LPS must be NFPA 780-compliant, SPD must be installed in accordance with NFPA 70, National Electric Code. These codes conflict as to installation of SPDs and where they are required to be installed in a structure.

§553.73 (9) (a)

Further, a proposed amendment must include a fiscal impact statement that documents the costs and benefits of the proposed amendment:

The proposed modification would needlessly – but substantially – unfairly tax the Florida economy. The narrative for Proposed Code Modification 6460 in 2017 providing for new LPS building requirements admitted that "[t]he average cost of a complete LPS is approximately 1% to 5% of total construction cost of the building." Dr. Issa's draft report presented to the Technical Advisory Committee at that time directly acknowledges these additional costs:

> "[t]he largest cost impact for the 2015 Florida specific changes came from proposed code change E6460, the installation of Lightning Protection Systems (LPS). The anticipated cost of the LPS was estimated to add 5% to the buildings total cost. Up to 80% of that cost reportedly could be offset through insurance reductions, **however such insurance reductions are not guaranteed and were therefore omitted from this cost estimate.**" (emphasis supplied) Issa, *Evaluation of the Cost Impact of Florida's specific changes to 2015 I-Codes "Prescriptive Code Changes"*, Draft Final Report, April 17, 2017, at Executive Summary p. 1.

§553.73 (9) (b)

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TAC: Electrical

Total Mods for **Electrical** in **Approved as Submitted: 3**

Total Mods for report: 13

Sub Code: Building

E7218

2

Date Submitted	11/8/2018	**Section**	453.17.7	**Proponent**	Bryan Holland
Chapter	4	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation Approved as Submitted

Commission Action Pending Review

Comments

General Comments **Yes**

Alternate Language **No**

Related Modifications

7209, 7210, 7211, and 7212

Summary of Modification

This proposed modification revises the section to match the language for lightning and surge protection for hospitals (449.3.15), nursing homes (450.3.19), and as proposed for assisted living facilities (464.4.7).

Rationale

The current language of the section is vague and nondescript. The proposed language aligns the section with lightning and surge protection requirements found in 449.3.15 for hospitals, 450.3.19 for nursing homes, and as proposed in 464.4.7 for assisted living facilities. These prescriptive details will assist design professionals, installers, and AHJs when applying and enforcing this rule.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will not impact the local entity.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will not change the cost of construction for building and property owners of SREF structures.

Impact to industry relative to the cost of compliance with code

This proposed modification will have no fiscal impact on industry.

Impact to small business relative to the cost of compliance with code

This proposed modification will have no impact on small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected to the health, safety, and welfare of the general public by harmonizing all lightning and surge protection requirements of the FBC-B.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves the code by adding prescriptive and clear rules for compliance.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

2nd Comment Period

E7218-G2

Proponent	Michael Riley	**Submitted**	5/24/2019	**Attachments**	Yes

Comment:

Proposed code modification 7218 does not meet the statutory standards of Chapter 553. See attached comments.

2nd Comment Period

E7218-G3

Proponent	Bryan Holland	Submitted	5/26/2019	Attachments	No

Comment:

Please disregard general comment SP7218-G2. The comment is not valid as it attempts to address the existing requirements of the code and not the proposed modification that is currently open for comment. The editorial revisions made to this section by the modification did not add to or take away from any of the current requirements. Therefore, none of the statements made in the general comment are relevant.

2nd Comment Period

E7218-G4

Proponent	Joe Bigelow	Submitted	5/28/2019	Attachments	Yes

Comment:

Submitted by Shroder Joseph & Associates via FedEX

1st Comment Period History

E7218-G1

Proponent	Vincent Della Croce	Submitted	1/8/2019	Attachments	No

Comment:

I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

453.17.7 Lightning protection.

~~All facilities in high lightning risk areas shall be evaluated using the Risk Assessment Guide in NFPA 780 and other standards which address lightning protection, and shall be protected accordingly.~~

453.17.7.1

A lightning protection system shall be provided for all new buildings and additions in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

453.17.7.2

Where additions are constructed to existing buildings, the existing building's lightning protection system, if present, shall be interconnected to the new lightning protection system.

453.17.7.3

Surge protective devices (SPDs) shall be installed in accordance with NFPA 70, National Electrical Code, as required by NFPA 780, Standard for the Installation of Lightning Protection Systems for all normal and emergency electrical services.

453.17.7.4

All communication systems entering or exiting the structure shall have surge protectors installed for each pair of conductors and shall have visual indication for protector failure to the maximum extent feasible.

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The controlling statutory standards for approving an amendment or modification to the Florida Building Code are as follows. Proposed code modification 7218 does not meet the statutory standards:

1. *Is needed in order to accommodate the specific needs of this state.*
2. *Has a reasonable and substantial connection with the health, safety, and welfare of the general public.*

It is undisputed that structural fire incidents are declining – not increasing – in the United States from 1977 to 2015 so there is no reason for FBC to impose this new tax for LPS and SPD on Florida's economy. Haynes, *Fire Loss in the United States 2015*, NFPA, September 2016, Figure 1 at p. 11. Haynes concludes that "[t]he total number of fires continues to be on a downward trend, as does the number of outside fires, structure fires and vehicle fires." P. 35. Direct property damage from lightning fires has declined as well from 1977 to 2015 in 2015 dollars. More specifically, the amount of direct property damage to non-home structures caused by lightning fires dropped over 70% annually from 1980 to 2014 ($249 million to $65 million). Ahrens, *Structure Fires Started by Lightning*, NFPA, April 2017, at Table 2, p. 4. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/fire-causes/lightning-fires-and-lightning-strikes

In 2011 Fire Departments reported 27,100 total lightning fires in the United States. Of these reported fires 20,400, or 75% of the total, were outside fires or non-structure fires. Only 7% of lightning fires from 2007-2011 were "non-home structure fires." Ahrens, *Lightning Fires and Lightning Strikes*, NFPA, Fire Analysis and Research Div., June 2013, p. 1. Exhibit C. There were only 1,800 "non-home structure" fires. *Lightning Fires and Lightning Strikes* at Table 4, p. 14. By 2014, the number of "non-home structure fires" was even lower (1,400). *Structure Fires Started by Lightning*, at Table 2, p. 4.

Therefore, the Proposed Code Modification is not needed and does not have a reasonable and substantial connection with the health, safety and welfare of Floridians. The Proposed Code Modification overstates the risk and costs of lightning damage to structures in Florida and given the overstated threat of damage caused by lightning strikes, the costs of complying with the proposed LPS and SPD requirements exceed the benefits of their installation in Florida.

3. *Strengthens or improves the Florida Building Code, or in the case of innovation or new technology, will provide equivalent or better products or methods or systems of construction.*
4. *Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities.*

The restriction of approved LPS to only NFPA 780-compliant systems provides no equivalent products, methods, or systems of construction and is entirely discriminatory as to all other products, methods and systems. The Proposed Code Modification would wholly exclude from Florida construction projects UL Certified Lightning Protection Systems and specific Components and Systems such as UL96A Master Labeled LPSs and UL Letter of Findings LPS. Further the modification excludes LPS such as IEC 62305, DOD DDESB 6055.9, DOE M440.1-

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1, FAA Std – 019e, FAA 6950.19A, NASA E-0012F, API – 2003, and any new LPS technology that may be developed and otherwise certified.

5. *Does not degrade the effectiveness of the Florida Building Code.*

An inherent conflict exists in the Proposed Code Modification. While LPS must be NFPA 780-compliant, SPD must be installed in accordance with NFPA 70, National Electric Code. These codes conflict as to installation of SPDs and where they are required to be installed in a structure.

§553.73 (9) (a)

Further, a proposed amendment must include a fiscal impact statement that documents the costs and benefits of the proposed amendment:

The proposed modification would needlessly – but substantially – unfairly tax the Florida economy. The narrative for Proposed Code Modification 6460 in 2017 providing for new LPS building requirements admitted that "[t]he average cost of a complete LPS is approximately 1% to 5% of total construction cost of the building." Dr. Issa's draft report presented to the Technical Advisory Committee at that time directly acknowledges these additional costs:

> "[t]he largest cost impact for the 2015 Florida specific changes came from proposed code change E6460, the installation of Lightning Protection Systems (LPS). The anticipated cost of the LPS was estimated to add 5% to the buildings total cost. Up to 80% of that cost reportedly could be offset through insurance reductions, **however such insurance reductions are not guaranteed and were therefore omitted from this cost estimate.**" (emphasis supplied) Issa, *Evaluation of the Cost Impact of Florida's specific changes to 2015 I-Codes "Prescriptive Code Changes"*, Draft Final Report, April 17, 2017, at Executive Summary p. 1.

§553.73 (9) (b)

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Schröder Joseph & Associates LLP
ATTORNEYS AT LAW

Linda H. Joseph, Esq.
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May 23, 2019

Via Federal Express

Florida Building Commission
Special Occupancy Technical Advisory Committee
2601 Blair Stone Road
Tallahassee, Florida 32399

Via Email (rsbrowdy@aol.com)

Richard S. Browdy
Chairman, Florida Building Commission
2601 Blair Stone Road
Tallahassee, Florida 32399

Re: Comments on Proposed Code Modification 7218, Florida Building Code

Gentlemen:

Our law firm represents Heary Bros. Lightning Protection Co., Inc. ("Heary Bros.") and its division, Lightning Preventor of America®. Heary Bros. offers both NFPA 780 compliant systems as well as its Preventor® system which is an early streamer emission system ("ESE system") that is installed in compliance with its manufacturer's standard, HBP 21. This letter is submitted to comment on proposed Modification 7218 to require that all Florida Education Facilities install lightning protection systems in accordance with National Fire Protection Association ("NFPA") 780. The modification should not be accepted and instead there should continue to be the ability for the owner, architect and engineer on such projects for ALFs to select the type of lightning protection system that best fits the needs of the project.

Under the rules governing modification of the Florida Building Code, a prerequisite to accepting a proposed modification such as E6460 is that it "DOES NOT DISCRIMINATE AGAINST MATERIALS, PRODUCTS, METHODS, OR SYSTEMS OF CONSTRUCTION OF DEMONSTRATED CAPABILITIES." (553.73 (9) (a) 3 F.S.). It is respectfully submitted, for the reasons discussed in detail below, that Modification 7218 cannot be accepted because it will violate this fundamental prerequisite under Florida State law (553.73 (9) (a) 3 F.S.) by discriminating against manufacturers and installers of Early Streamer Emission ("ESE") lightning protection systems which constitute a competing alternative of "demonstrated

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capabilities." Indeed, there is no reasonable justification for favoring Faraday lightning protection systems installed under NFPA 780 over ESE lightning protection systems installed under HBP 21 or other equivalent standards which have been approved, specified by architects and engineers and successfully used for many decades throughout the United States and the world.

THE NEED TO REJECT THE PROPOSED MODIFICATION

While most if not all companies in the lightning protection industry either exclusively provide either Faraday Systems or ESE Systems, Heary Bros. manufactures both types of lightning protection systems available in the marketplace today: (1) the traditional Faraday lightning protection systems governed by NFPA 780; and (2) its ESE lightning protection systems which have been successfully installed under HBP 21 for over 30 years under its $11 Million Guaranty backed by Travelers Insurance Company without a single documented lost. Proposed Code Modification 7218—as proposed--would eliminate for Florida Building owners the ESE option.

Importantly, Heary Bros. does not seek to exclude other ESE manufacturers or installers by offering its proven standard known as HBP 21, a copy of which is attached as Exhibit A, as one proven alternative standard. **Instead, the Florida Building Commission should accept other alternative equivalent standards and not limit the standard to NFPA 780.** The point is that architects, engineers and owners should be free to make a choice and should not be limited to one option, particularly since modification 7218 was propounded by a representative of the Faraday Industry which stands to obtain an exclusive monopoly under the proposal. Notably, these types of restrictive changes to the Florida Building Code to require that lightning protection systems comply with NFPA 780 have been proposed by the Florida Industry previously and rejected by the Florida Building Commission for sound reasons in 2017. *See, e.g.*, Modification E6460 rejected by the Florida Building Commission in 2017.

There is no reason to adopt Proposed Modification 7218 and limit the lightning protection systems for Florida Education Facilities to compliance with NFPA 780. Not only does Heary Bros.' HBP 21 have a proven track record, but it also has the support of Traveler's insurance which provides $11 million in coverage to support Heary Bros.' guaranty of its ESE system. This support is documented by Exhibit B. The reason that Heary Bros. offers both options to its customers is because its ESE system offers a much less expensive option while its NFPA 780 Faraday alternative is more expensive with no technical or scientific basis of superior performance to justify the added cost. Heary Bros. believes the consumer should have the option to decide. Modification 7218—which Heary Bros. learned about for the first time in this week—should be rejected or modified so as not to eliminate that choice for Florida owners, architects and engineers.

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As explained below, not only has it been established in the lightning protection industry that there is no scientific basis for preferring the method of installation of the Faraday system whose installations are governed by NFPA 780 over ESE lightning protection systems, but also the installation approach of the Faraday systems (which uses more cable and more terminals) renders the Faraday System more costly with no added benefit to owners and consumers.

Heary Bros. readily concedes that its profit margins with respect to the sale of the components of Faraday systems exceeds the profit margins on ESE systems because the installation design for Faraday systems requires more cables, more down runs and more terminals and connections despite the lack of any scientific basis for claiming a difference in performance of the two systems. It should come as no surprise that the proponent of this change in the Florida Code is the Faraday Industry and those companies that exclusively install only Faraday Systems under the NFPA 780 standards. These entities consistently promote codes based on NFPA 780 and dominate the NFPA 780 committee.

There is no difference between the quality of the components of ESE systems and Faraday systems. Notably, the components of both the Faraday System and the ESE systems have been listed by Underwriters' Laboratories, Inc. pursuant to UL 96 which provides the "quality control" for component parts of lightning protection systems. In contrast, NFPA 780 ONLY governs the method of installation and requires more cabling, terminals, connectors and more grounding because of differences in the terminals used by each of these two competing systems.

Other factors to consider are that NFPA itself discloses that NFPA 780 has no scientific basis and has never recommended that this standard be adopted as "code." Further, the author of this letter made presentations to New York State when it considered adopting a similar code change more than two decades ago and New York State ultimately rejected the very code change now being considered— a change virtually identical to that being proposed here—and ruled that there was "no technical justification" for its adoption. Again, the proposed change in law simply imposes more costs on building owners with no scientific or practical justification.

If there is an argument being made regarding "insurance savings" by the proponents of this change in law, their evidence merely confirms that lightning protection—may in some few instances—results in insurance rebates, but the documentation does not show that only NFPA 780 systems are eligible for such rebates or whether these rebates are applicable solely to surge protection which is a separate and distinct product.. Moreover, what is indisputable is that the Faraday systems governed by NFPA 780 systems are NOT eligible for Heary Bros. $11 million guaranty backed by Travelers Insurance Company which Travelers offers only for ESE systems installed in compliance with Heary Bros.' manufacturer's standard—coverage which is provided based on Heary Bros.' decades of field experience with this type of system that exceeds thirty

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years. Copies of documentation demonstrating this insurance coverage are attached hereto as Exhibit B.

Perhaps the best illustration of burden that Proposed Modification 7218 would impose on building owners is the fact that so many building owners have in the past chosen the ESE system in preference to the Faraday system governed by NFPA 780. I have attached as Exhibit C a list of just a small sampling of Florida projects now enjoying the benefits of Heary Bros.' ESE system and $11 Million Guaranty which include numerous government and municipal buildings, resort and recreational centers, churches and corporate buildings. This constitutes a small sampling of Heary Bros.' ESE installations throughout the State of Florida—all of which have been installed in compliance with Heary Bros.' manufacturer's standard and have NOT been the subject of a single documented failure. Similarly, Federal and State governments have preferred the option of Heary Bros. ESE system with its $11 million guaranty over Faraday systems governed by NFPA 780. A list of a sampling of these projects is attached as Exhibit D which included, by way of illustration, such buildings as the Huntsville Alabama Public Safety Complex, the Los Angeles Federal Building, San Diego V. A. Medical Center, the Cape Canaveral Air Force Station, the Council Building for City of Coconut Creek, Florida, the Tampa Gateway Post Office Building, the Holmes Beach Florida Baseball Field and the U.S. Naval Air Station in Milton Florida. Again, these are just a very few examples of government installations in various States from all over the United States.

NFPA ITSELF MAKES CLEAR THAT NFPA 780 IS NOT SCIENTIFICALLY BASED

The proponents of the Faraday systems governed by NFPA 780 often argue that the existence of "national standards" for Faraday Systems (such as NFPA 780 and its parallel standard UL96A) somehow demonstrates that Faraday Systems are "scientific" and "proven." These types of statements are inconsistent with the very nature of national standards in the United States. NFPA 780 itself makes it very clear in its disclosures that NFPA 780 is NOT based on science, research, records of testing or even field experience. Instead, the NFPA specifically includes in the preamble to NFPA 780 (and in all NFPA consensus standards) the following disclaimers as to the efficacy of such standards:

> "While **the NFPA** administers the process and establishes rules to promote fairness in the development of consensus, it **does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards. The NFPA disclaims liability for any personal injury, property or other damages** of any nature whatsoever….directly or indirectly resulting from the …use of, or reliance on this document. **The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein**."

This excerpt from the preface to NFPA 780 is enclosed as Exhibit E. (Emphasis added.)

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THE LEADING INDUSTRY LITERATURE REJECTS ANY SUPERIORTY OF FARADAY SYSTEMS OVER ESE LIGHTNING PROTECTION SYSTEMS

We have attached the most recognized studies comparing ESE systems to Faraday Systems governed by NFPA 780, including a report generated by the NFPA itself in 1999. Specifically, attached as Exhibits F and G, respectively, are pertinent excerpts from the Report of the National Institute of Standards and Technology, entitled "Literature Review and Technical Analysis of Early Streamer Emission Systems of Lightning Protection" (1995) (hereinafter "NIST Report") and the Report of the NFPA's Third-Party Independent Evaluation Panel entitled "Early Streamer Emission Lightning Protection Technology" (1999) (hereafter "Bryan Report").

Both the NIST and the Bryan Report concluded that ESE systems have both an adequate theoretical basis and laboratory testing. NIST Report at page 25; Bryan Report at page 26. However, the authors of both reports found that there is insufficient field testing of either ESE systems or traditional (also known as "Faraday") systems of lightning protection under natural thunderstorm conditions. NIST Report at page. 16. Bryan Report at page 26. These findings of inadequate field testing of both traditional Faraday systems and ESE systems of lightning protection were based in part on the fact that there have been reported failures of both types of systems, and there was virtually no documentation to determine the cause of the failure.[1] As a result, both reports concluded that no meaningful conclusions regarding the performance of either type of system could be drawn based on either reported failures or lack of failures of either type of system under natural thunderstorm conditions. NIST Report at page 25; Bryan Report pages.23-24.

Based on this lack of field testing---or even laboratory testing—for traditional (Faraday) systems of lightning protection, the NIST Report concluded that "insufficient quantitative data see to exist about the performance of traditional rods…." NIST at page 24. Dr. Bryan, a former member of the NFPA Standards Council, went so far as to conclude that because of a lack of field or laboratory testing, NFPA 780 systems had insufficient scientific validation to warrant an NFPA standard and recommended that NFPA 780 be "downgraded" to a recommended practice. Bryan Report at pages 27-28.

It also is worth noting that both the NIST and Bryan Reports were highly critical of studies, funded by the Faraday industry, conducted by Professor Moore and Dr. Rison of the

[1] Both Faraday and ESE Systems—like other products—sometimes experience failures due to failure to maintain the systems properly or due to installation errors. Faraday Systems rely on their "track record" in field to support their efficacy. ESE Systems, like Faraday System, also have similar field experience. For example, in over twenty years and with thousands of systems installed in the United States, Heary Bros. have had no documented failures and their insurance carriers have paid no claims. Of course, Heary Bros.' ESE systems are installed in compliance with its manufacturer's standard to ensure adequate installation.

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New Mexico Institute of Mining and Technology. The NIST Report questioned whether any meaningful conclusions could be drawn based on tests conducted at elevations of 3000 m, and that the testing at this altitude "raise questions about the interpretation of such observations" NIST Report at 21.

Similarly, the Bryan Report identified several significant problems with the methodology employed by Professor Moore and Dr. Rison. The Bryan Report noted that despite reporting a "failure" of an ESE system, the ESE terminal had been damaged and--as a result--the study failed to document that the ESE terminal was even working at the time of the alleged strike within the zone of protection. Bryan Report at 17. The Bryan Report also noted that Dr. Rison's and Professor Moore's research questioned the efficacy of terminals used in NFPA 780 systems (Faraday Systems), noting that in four years not a single sharp pointed Franklin rod was struck. *Id.* at 18.

The lack of a scientific basis for NFPA 780 and UL 96A also has been confirmed in an article by written by Professor Martin Uman (a leading lightning protection expert who is often quoted by Faraday manufacturers) and published in the December 2002 issue of *American Meteorological Society*. The article states "[t]he theoretical justification of the traditional [Faraday] approach is fairly crude, in part due to our incomplete understanding of lightning's attachment to ground-based objects. Hence, the fact that traditional [Faraday lightning protection] systems have a history of success in preventing or minimizing damage to structures is the primary justification for their use." December 2002 Edition of *American Meteorological Society* at page 1809. Of course, as noted above, Heary Bros.' ESE systems have the same history of success based on field experience now exceeding thirty years—success which has been acknowledged by Heary Bros.' insurance carriers who provide insurance coverage for its ESE systems through Travelers Insurance Company.

CONCLUSION

For all the foregoing reasons, we respectfully request that you reject Proposed Code Modification 7218. Importantly, as explained above, Proposed Code Modification 7218 clearly cannot be adopted under Florida law because it discriminates against manufacturers and installers of ESE lightning protection systems which constitute a competing alternative of "demonstrated capabilities." Florida State law (553.73 (9) (a) 3 F.S.). Moreover, the Proposed Code Modification 7218 should be accepted since it simply is the right thing to do to preserve an option that architects, engineers and owners have chosen for decades with success and—to do otherwise—would provide the Faraday industry with an unfair and unlawful monopoly. Thus, the action proposed by this letter is in the interests of retaining the owners' ability to choose and will avoid the creation of state law that conflicts with federal antitrust laws and imposes

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anticompetitive restraints on the marketplace.

Sincerely,

SCHRODER, JOSEPH & ASSOCIATES, LLP

Linda H. Joseph

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EXHIBIT A

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Manufacturer's Installation Standard
For
Lightning Protection Systems Using
Early Streamer Emission Air Terminals

HBP-21

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INTRODUCTION

1. Scope

1.1 The requirements of this standard cover the design of systems using Early Streamer Emission ("ESE") air terminals for strikes. The Standard is divided into Three Levels of Protection. Electrical transmission lines and equipment are not within the scope of this standard.

1.2 These requirements apply to lightning protection systems that are complete and cover all parts of a structure. Partial systems are not covered by this standard.

1.3 Where fittings, devices or other components required by this standard are available as listed or labeled, such components shall be used. Otherwise the components shall be approved by the authority having jurisdiction (i.e. Engineer of Record, Architect, Owner, Applied Research Laboratories or Underwriter's Laboratories).

1.4 This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's Standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards."

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2. Glossary

2.1 For the purpose of this standard the following definitions apply:

Lightning Protection System is complete system of air terminals(s), conductors, ground terminals, bonding conductors, transient voltage surge suppression devices and other components required to complete a system.

2.2 AIR TERMINAL:

Is the component of the system that is intended to intercept the lightning strokes.

2.3 APPROVED:

Acceptable to the "authority having jurisdiction".

2.4 AUTHORITY HAVING JURISTICTION:

Is the organization, office or individual responsible for "approving" the equipment, and installation or a procedure.

2.5 BONDING:

An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents.

2.6 CABLE: A conductor formed of a number of wires stranded together.

2.7 CHIMNEY:

A smoke or vent stack having a flue with cross sectional area less than 500 sq in (.3 sq m) and a total height of less than 75 feet (23m).

2.8 CONDUCTOR:

The portion of a lightning protection system that is intended to carry the lightning discharge to the ground.

2.8.1 MAIN CONDUCTOR:

A conductor that interconnects air terminals and serves as a down lead to ground.

2.8.2 BONDING CONDUCTOR:

A conductor intended to be used for potential equalization between metal bodies and the lightning protection system. Bonding conductors are not designed or intended to carry main lightning current.

2.9 FASTENER:

An attachment to secure the conductor to the structure.

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2.10 GROUNDED:

Connected to earth or to some conducting body that is connected to earth.

2.10.1 GROUND GRID:

A system of grounding electrodes consisting of interconnected bare cables buried in the earth.

2.10.2 GROUND TERMINAL (ELECTRODE):

The portion of a lightning protection system that is installed for the purpose of providing electrical contact with earth.

2.11 LIGHTNING STRIKE:

The entire lightning event that can consist of one or more lightning strokes.

2.12 LOOP CONDUCTOR:

A conductor that encircles a structure that is used to interconnect ground terminals, main conductors or other grounded bodies.

2.13 METAL FRAME STRUCTURE:

A structure with electrically continuous structure members of sufficient size to provide electrical path equivalent to that of the lightning conductors in this standard.

2.14 SHALL:

Indicates a mandatory requirement of this Standard.

2.15 SHOULD:

Indicates a recommendation or that which is advised but not required.

2.16 SURGE ARRESTORS:

Are devices designed to limit damaging surge voltages by discharging or bypassing the current while maintaining the ability of repeating these functions. Heary Brothers Lightning Protection Co., Inc. and its Division Lightning Preventor of America do not manufacture Surge Arrestors nor do they warranty the equipment.

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3. GENERAL REQUIREMENTS

3.1 GENERAL DESIGN REQUIREMENTS:
A lightning protection system using an Early Streamer Emission Air Terminal (s) shall be designed with provisions for inspection and maintenance.

3.2 Every installation shall be reviewed by a prior study to determine the level of protection required (See Figure 3.5.1).

3.3 The position of the E.S.E. air terminal, including height of above structure shall be determined in accordance with the level of protection required. (See Figure 3.5.1)

3.4 The number of terminals will depend on the system design under the Manufacturer's Standard based upon the dimensions of the area to be protected. (See Figure 3.5.1)

3.5 There are multiple styles of E.S.E. air terminals and systems available. For purposes of this standard they have been divided into separate levels of protection, with each level having its own installation requirements. A chart is provided (See Figure 3.5.1) as a general guideline in determining which level of protection best fits the requirements of the project.

3.6 All bolts on bolt pressure connectors require to be torqued at 150 pound-inches (17N-m).

3.7 This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's Standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards."

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Figure 3.5.1 Levels of Protection for ESE Lightning Protection Systems

FEATURES	LEVEL 1	LEVEL 2	LEVEL 3
Number of ESE Terminals Required Pursuant to System Design	1 Air Terminal (See Note: A)	1 Air Terminal (See Note: A)	1 Air Terminal (See Note: B)
Grounding Resistance Requirements	10Ω (ohms) or less	10 Ω (ohms) or less	25Ω (ohms) or less
Warranty	15 year material workmanship	15 year material workmanship	5 year material workmanship
Air Terminal height above all roof top projections	20' (6.1m)	20' (6.1 m)	7' (2 m)
Transient Voltage Surge Suppression	Shall be installed on all service entrances of electric, telephone, cable, and antenna lead-in.	Shall be installed on all service entrances of electric, telephone, cable, antenna lead-in.	Shall be installed on all service entrances of electric, telephone, cable, antenna lead-in.
ARL Listing and UL Listing mark on applicable components	Required	Required	Required
Building Height	Unlimited	Unlimited	Under 75' (23m)
Building Types	All	All	Residential, Farm, Agricultural, Small commercial.

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(Note: A)

Manufacturer's Installation Standard HBP-21Level 1 and Level 2 require one (1) ESE Air Terminal to be installed on the roof for every circular area of 337,810 feet. Structures may be on any height and the ESE lightning protection system must comply with all other requirements within this Manufacturer's Installation Standard HBP-21. This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

(Note: B)

Manufacturer's Installation Standard HBP-21 Level 3 requires one (1) ESE Air Terminal to be installed on the roof for every circular area of 70,650 feet. Structures may be of any height and the ESE lightning protection system must comply with all other requirements within this Manufacturer's Installation Standard HBP-21. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lighting protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

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LEVEL 1

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

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4. Level 1 General Installation and Component Requirements

4.1 An ESE lightning protection system installation consists of the following interconnected parts

(a) One or more ESE air terminals
(b) Mast and mounting systems - as required based on level of protection desired.
(c) Bonding conductors - as required based on level of protection.
(d) Ground system – Single grid to loop conductor system.
(e) Equipotential Bonding.
(f) Transient Voltage Surge Suppression.

4.1.1 The number of ESE air terminals will depend on the system design under the Manufacturer's Standard based upon the area indicated in Figure 3.5.1 for Level 1 type systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

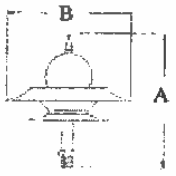
4.1.2 Components Tables 4.1.1.1 and Figure 4.1.1.2 provides minimum sizes and weights for use in ESE lightning protection system installation.

Figure 4.1.1.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	½" /12.7mm	½"/ 12.7 mm	½"/ 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	14AWG 375lbs /1000/ or 558 g/m 115,000 CM / 58 mm ^{2}	13AWG 190lbs/1000/ 283 g/m 192000 CM/ 97 mm ^{2}
Ground Terminals	Ground Rod / Ground Plate	¾" x 10' (20mm x 3000mm)/ 24" x 24"x 20 gauge (600mm x 600mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 4.1.1.2 Early Streamer Emission Air Terminal

A= 12"
B= 9"



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4.2 ESE Air terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of copper, copper alloy, aluminum or stainless steel. The main conductive parts of the ESE air terminal shall have the minimum dimensions in accordance with table 4.1.1.1 and Figure 4.1.1.2 for minimum dimensions of ESE Air Terminal.

4.2.1 Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind.
NOTE: Wind design requirements should be consistent with local building code requirements.

4.2.2 Where an air terminal or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

4.2.3 The tip of any ESE air terminal or mast shall not be less than 20' (6.1m) above the protected structures, including antennas, cooling towers, tanks, roofs and masts.

4.2.4 The ESE air terminal shall be mounted on structures such as flagpoles, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as, sports facilities and stadiums, golf courses, public parks, camping sites and racetracks. The ESE unit shall be mounted at an elevation indicated in Section 4.2.3.

4.3 Storage areas for Flammable and Combustible Liquids or Flammable Gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

4.4 Surge Suppression devices shall be installed on electric and telephone service entrances, antenna lead-ins, and electrical and electronic cables/ conductors entering or exiting the building.

4.4.1 Electrical Surge Suppression device shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty. Units shall be mounted as to minimize inductance installation. (i.e. As close to equipment to be protected or by use of documented low inductance cabling).

4.5 General, In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounded medium.

B. The influence of a non-grounded metal body, such as metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium (Air or solid materials).

D. Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

E. Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall maintain the minimum protection above these objects as specified in Section 4.2.3
NOTE: For additional bonding requirements see Section 5.2 and 5.3.

4.6 Components

4.6.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

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4.6.2 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gasses or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

4.6.3 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding or other aluminum surfaces.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum conductors and components shall not be:

a. Embedded in concrete or masonry.

b. In direct contact with a surface coated with alkaline base paint, or

c. Installed in wet locations, for example eave troughs or downspouts.

d. Installed in direct contact with earth.

D. Components used for connection of aluminum down conductors to copper or copper-clad grounding equipment shall provide separation between aluminum and copper materials. These fittings may be a Stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper components.

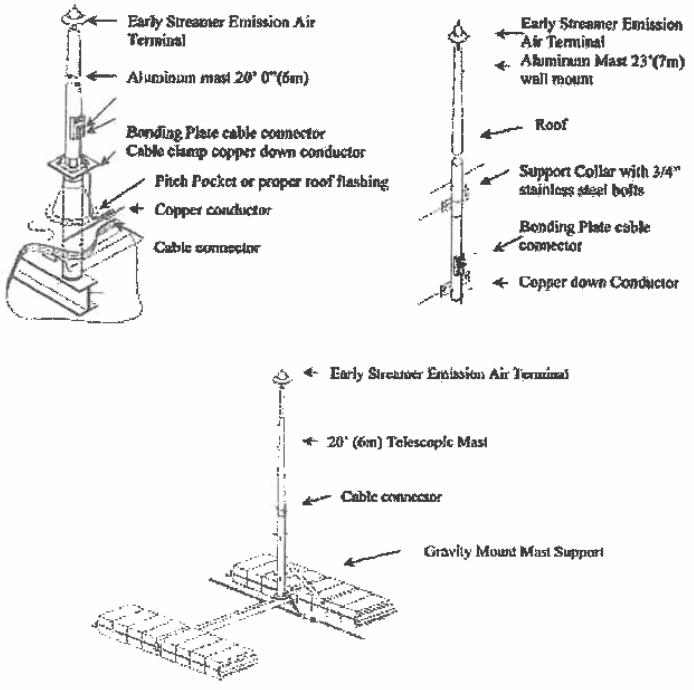
4.6.4 Unless otherwise indicated in this standard, an air terminal shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

5. Level 1 Air Terminal Installation Requirements

5.1 Early Streamer Emission Air Terminals

A. ESE Air Terminals shall be mounted at a height consistent with the requirements of Section 4.2.3 or a minimum of 20' above all projections on the roof.
See Figure 5.1.1 for sample mast mounting details.

Figure 5.1.1

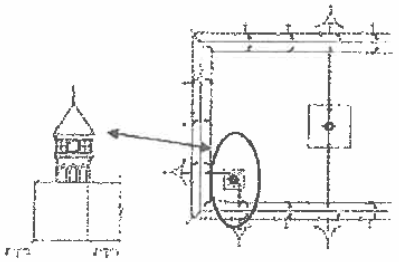


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B. ESE Air Terminals shall be provided in proper quantity and location based on the system design under Manufacturer's Standard. See Figure 3.5.1 Level 1 requirements. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

C. Additional ESE air terminals shall be provided in situations where steeples, cupolas, crosses, stacks, chimneys, etc. project above the protected roof area. This requirement applies to all projections which could provide a potential upward streamer release. The addition air terminals shall be provided regardless of whether or not the projection is within or outside the area covered by the system design under the Manufacturer's Standard. See Figure 5.1.2. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

Figure 5.1.2



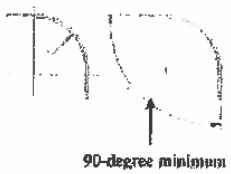
D. Conductors shall be securely fastened to roof or structure at intervals not exceeding 3'0" on center.

E. ESE Air Terminals shall be provided with a minimum of two paths to ground. Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets. See Figure 5.1.4

F. No Bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However conductors may raise a rate of 3" per 12" of run. See Figure 5.1.3 and Figure 5.1.4

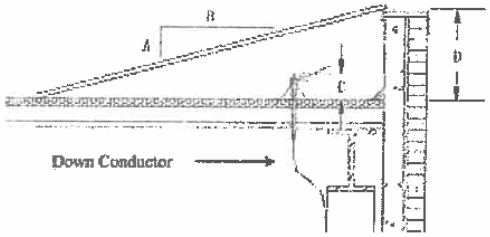
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Figure 5.1.3



NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement

Figure 5.1.4



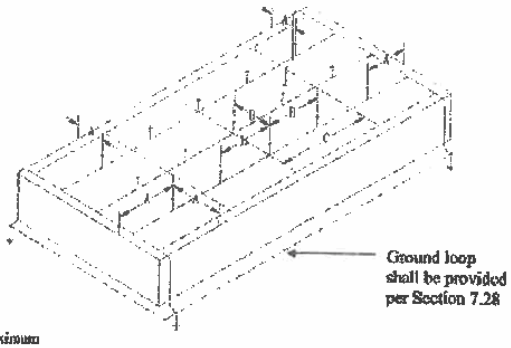
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in Section 5.1.D

5.1.1 In situations where multiple air terminals are required, the perimeter air terminals shall be positioned so that they are not more than 230' (70m) for the outside edge of the building nor shall the ESE Air Terminals be spaced more than 460' (140m) apart at any time. A cross run cable shall be provided at intervals of 1000' (305m) when building exceeds 2000' (610m) in length in any direction. See Fig 5.1.1.1. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed ho have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

5.1.2 Down Conductors in situations where multiple ESE Air Terminals are required shall be spaced at intervals no more than 500' (152m) apart around the perimeter of the structure. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

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Figure 5.1.1.1



A= 230' (70m) maximum
B= 460' (140 m) maximum
C= 1000' (305m)

6. Level 1 Bonding Requirements

6.1 Roof top Interconnection loop

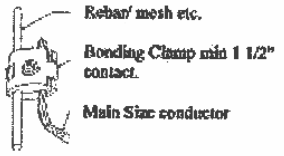
A. An interconnection loop around the perimeter of the roof structure shall be provided to which ESE Ground Conductors shall be bonded.

B. Loops shall be provided at all intermediate and lower roof levels and connected at a minimum of two (2) locations to the down conductors.

a. Bonding connections shall be made with main size conductor to all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, etc. whether exposed or not at all inside and outside corners of structure as a minimum. Additional bonding connections shall be made at intervals not exceeding 60' (18m) around the perimeter of the structure. Care shall be taken to assure that all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, et. Whether exposed or not is electrically continuous or made so. (See Fig. 6.2.4 and Fig 6.25).

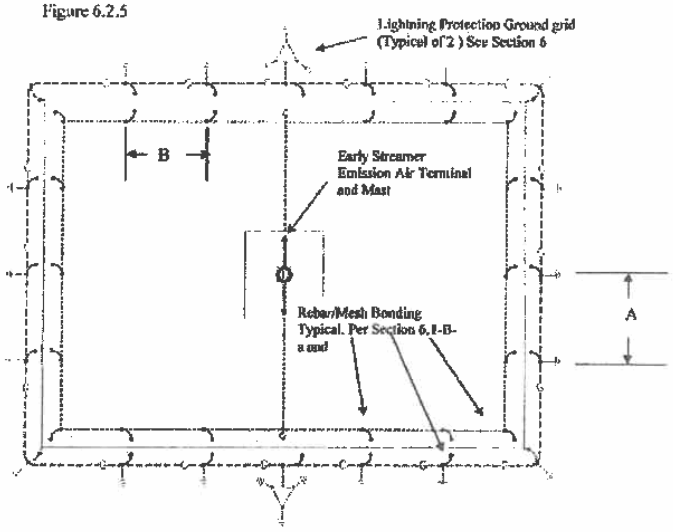
b. Down Conductors shall be bonded to the structural steel, reinforcing rod or other structural support at the top and bottom of conductor run.

Figure 6.2.4



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Figure 6.2.5



A= 60' (18m) Maximum Spacing
B= 60' (18m) Maximum Spacing

Note: For Base Grounding requirements see Section 7

6.2 Bonding Requirements

A. Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless;

B. Inherently bonded to the lightning protection system.

C. Sanitary vents, roof drains, flashings, copings, etc. located within 6' (1.8m) of a lightning protection conductor, shall be bonded via secondary sized conductor to the lightning protection system.

7. Level 1 Grounding System Requirements

7.1 Down Conductors"

7.1.1 A minimum of Two (2) Down Conductors Shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 5.1.2

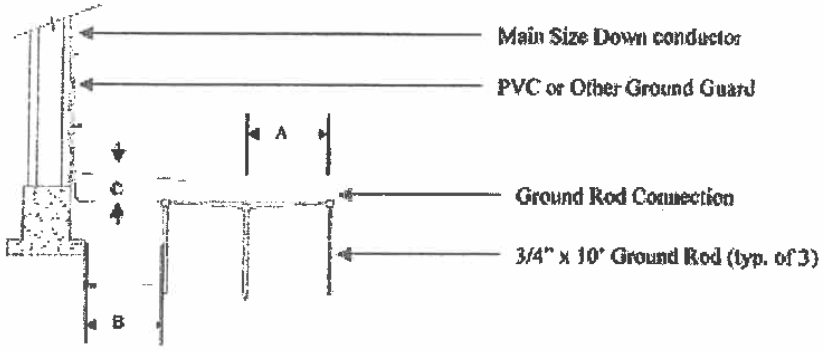
7.1.2 Down Conductors shall be spaced at least 10' (3m) apart.

7.1.3 Down conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, Fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See figure 7.2.1.1

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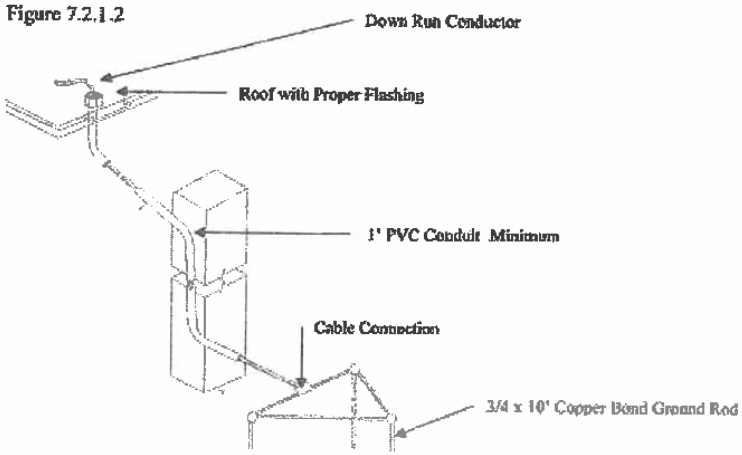
7.1.4 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 7.2.1.2

Figure 7.2.1.1



A= 10' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 3' (0.3m) Minimum

Figure 7.2.1.2



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7.1.5 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

A. If electrically continuous, structural steel shall be permitted to be used as the down conductor.

B. Test joints shall be provided for each down conductor. They shall be accessible and located as near as practicable to the ground termination.

7.1.6 Masonry Anchors used to secure the lightning protection materials shall have a minimum outside diameter of ¼ in. (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed, the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

7.1.7 Connector Fittings shall be used at all "end to end, "tee" or "Y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lbs. Fittings used for required connections shall be of bolted, welded or high compression type and bear the ARL Listing and UL Listing.

7.1.8 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of materials shall be used that forms an electrolytic couple of such nature that, in the presence of moisture, corrosion is accelerated.

7.2 Grounding

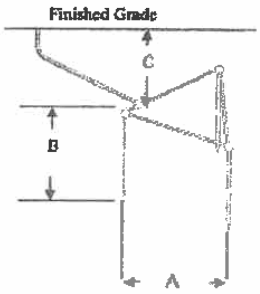
7.2.1 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 10 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

7.2.2 Ground electrodes shall be of copper-bond steel in sufficient number as to achieve a 10-ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 3' (1m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 7.2.1.1

7.2.3 Ground rod terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

7.2.4 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configured either in a straight line or in delta formation. Where the ground terminals are spaced a minimum of 10' (3m) apart. See Figures 7.2.3.1 and 7.2.3.2

Figure 7.2.3.1



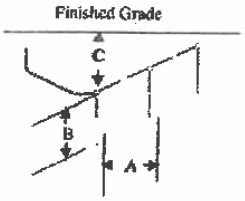
A= 10' (3m) Minimum

B= 10' (3m) Minimum (Typical)

C= 3' (1m) Minimum

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Figure 7.2.3.2



A= 10' (3m) Minimum

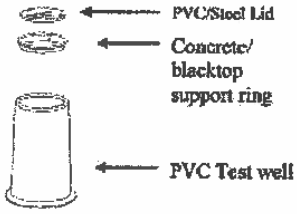
B= 10' (3m) Minimum (Typical)

C= 3' (1m) Minimum

7.2.5 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

7.2.6 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems.
NOTE 1: For Further information, see NFPA 70 National Electric Code, which contains detailed information on the grounding of electrical systems.
NOTE 2: Ground rod or ground ring/loop electrodes should be installed below the frost line where practicable and in accordance with Section 7.2.8

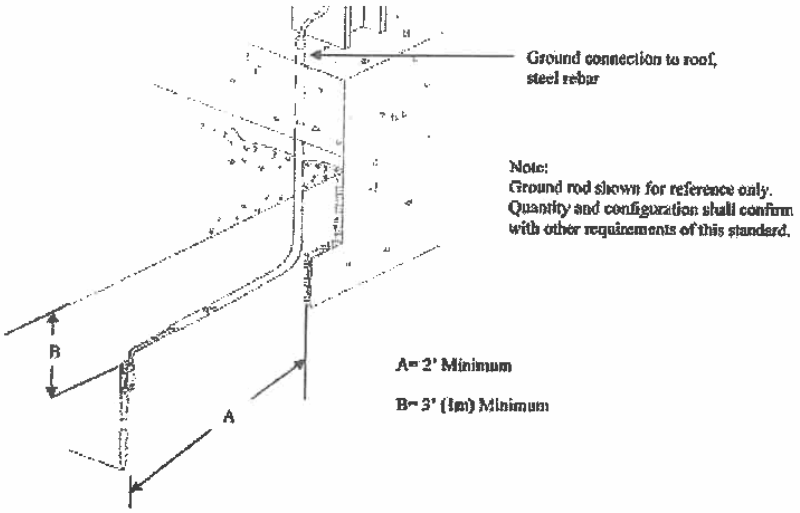
Figure 7.2.6.1



7.2.7 Grounding ring/loop Electrode encircling the structure shall be provided and in direct contact with the earth at a depth of not less than 2ft. The ground ring conductor shall be sized at a minimum of that of the main sized conductor. See Figure 7.2.8.1

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Figure 7.2.8.1



7.2.8 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include, but not be limited to lightning protection, electrical services, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

7.2.9 Common Ground Bonding. If electric telephone or other systems are bonded to metallic water pipe, only one connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

8. Level 1 Structural Steel Systems

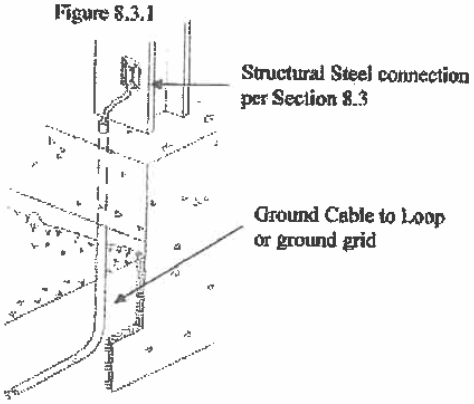
8.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

8.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60ft (18m). Ground terminals shall be connected together via a main size conductor as indicated in sec 7.2. Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

8.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq in (5200mm²). The area of attachment shall be free of paint, grease oil and debris. (See Figure 8.3.1)

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Figure 8.3.1



8.4 Early Streamer Emission Air terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 8.3

8.5 Metal Bodies. Certain Metal bodies located outside or inside the structure contribute to lightning hazards because they are grounded or assist in providing a path to ground for lightning currents. Such metal bodies shall be bonded to the lightning protection system in accordance with Section 4.5.

8.6 Concealment in Steel Reinforced Concrete. Conductors or other components of the lightning protection system concealed in steel reinforced concrete units shall be connected to the reinforcing steel. Concealed down conductors shall be connected to vertical reinforcing steel. Roof conductors or other concealed horizontal conductors runs shall be connected to reinforcing steel/structural steel at intervals not exceeding 60ft (18m) and at all corners. See Section 6.

8.7 Down Conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel and/or structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 200ft (60m). Such connections shall be made using listed clamps or listed bonding plates or by exothermic welding. The use of PVC conduit or other non-metallic chase does not negate the need for these interconnections.

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LEVEL 2

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

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9. Level 2 General Installations and Component Requirements

9.1 An ESE lightning protection system installation consists of the following interconnected parts
- (a) One or more ESE air terminals
- (b) Mast and mounting systems – as required based on level of protection desired
- (c) Bonding conductors – as required based on level of protection.
- (d) Ground system – Single grid to loop conductor system
- (e) Equipotential Bonding
- (f) Transient Voltage Surge Suppression

9.2 The number of ESE air terminals will depend on the system design under the manufacturer's Standard based on the area as indicated in Figure 3.5.1 for Level 2 Systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumer should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

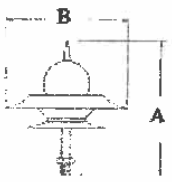
9.3 Components Tables Figure 9.3.1 and Figure 9.3.2 provide minimum sizes and weights for use in ESE lightning protection system installation.

Figure 9.3.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	1/2 "/ 12.7mm	1/2" / 12.7 mm	1/2" / 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	14AWG 375lbs /1000/ or 558 g/m 115,000 CM / 58 mm ^{2}	13AWG 190lbs/1000/ 283 g/m 192000 CM/ 97 mm ^{2}
Ground Terminals	Ground Rod / Ground Plate	¾" x 10' (20mm x 3000mm)/ 24" x 24"x 20 gauge (600mm x 600mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 9.3.2 Early Streamer Emission Air Terminal

A= 12"
B= 9"



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9.4 ESE Air Terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of copper, copper alloy, aluminum or stainless steel. The main conductive parts of the ESE air terminals shall have the minimum dimensions in accordance with Figures 9.3.1 and Figure 9.3.2 for minimum dimensions of ESE Air Terminals Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind

NOTE: Wind design requirements should be consistent with local building code requirements.

9.4.1 Where an air terminal or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

9.4.2 The tip of any ESE air terminal shall not be less than 20' (6.1m) above the protected structures, including antennas, cooling towers, tanks, roof and masts.

9.4.3 The ESE air terminals shall be mounted on structures such as flagpole, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as, sports facilities and stadiums, golf courses, public parks, camping sites and racetracks. The ESE unit shall be mounted at an elevation as indicated in Section 9.4.2.

9.5 Storage Areas for flammable and combustible liquids or flammable gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

9.5.1 Electrical Surge Suppression device shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty. Units shall be mounted as to minimize inductance installation. (I.e. As close to equipment to be protected or by use of documented low inductance cabling.)

Note 1: Electrical systems and utilization equipment within the structure may require further surge suppression. Such protection is not part of this standard. NFPA 70, National Electric Code and ANSI/IEEE C62.41-1991 2nd Edition, shall be consulted for further information and installation requirements.

Note 2: Illustrations shown in this are those of Heary Brothers Lightning Protection Co., Inc. (HBLP) and its division Lightning Preventor of America (LPA). HBLP and LPA do not manufacture or warranty surge protection devices. Warranties required of this standard shall be the responsibility or the surge protection device manufacturer.

9.6 General. In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounded medium.

B. The influence of a non-grounded metal body, such as a metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium (air or solid materials).

(a) Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

(b) Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall still maintain the minimum protection above these objects as specified in Section 9.4.2.

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9.7 Components

9.7.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

9.7.2 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gases or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

9.7.3 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding, or other aluminum surfaces.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum Conductors and components shall not be:

a) Embedded in concrete or masonry;

b) In direct contact with a surface coated with alkaline base paint; or

c) Installed in wet locations, for example eave troughs or downspouts.

d) Installed in direct contact with earth

D. Components used for connection of aluminum down conductors to copper or copper-clad grounding equipment shall provide separation between aluminum and copper materials. These fittings may be a stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper materials.

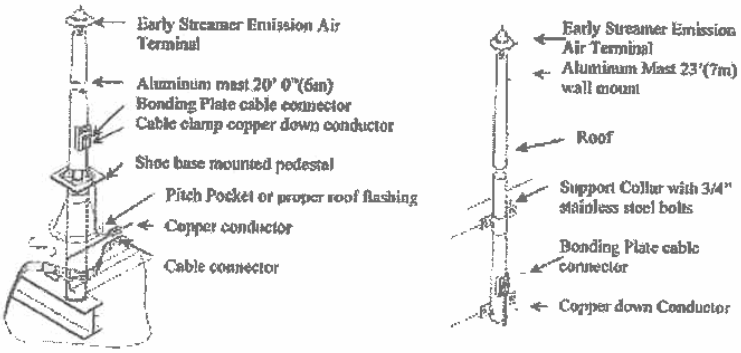
9.7.4 Unless otherwise indicated in this standard, an air terminal shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

10. Level 2 Air Terminals Installation Requirements

10.1 Early Streamer Emission Air Terminals

A. ESE Air Terminals shall be mounted at a height consist with the requirements of Section 9.4.2 or a minimum of 20' above all projections on the roof. See Figure 10.1.1 for sample mast mounting details.

Figure 10.1.1



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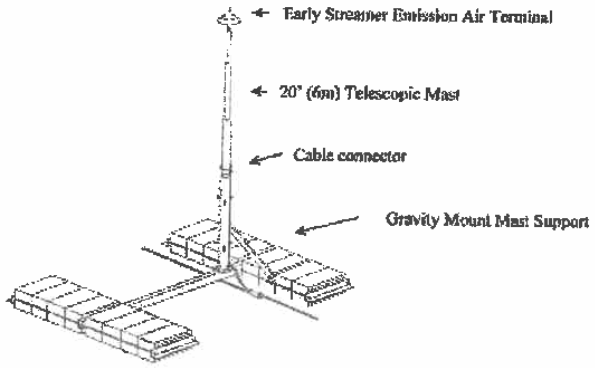
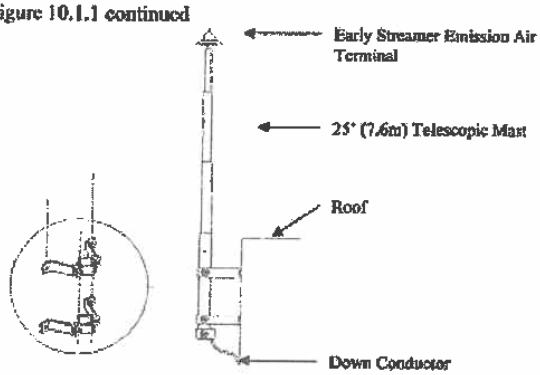


Figure 10.1.1 continued



10.2 ESE Air Terminals shall be provided in proper quantity and location based on the system design under the Manufacturer's Standard. See Figure 3.5.1 for Level 2. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

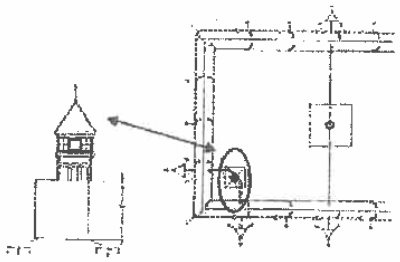
10.3 Conductors shall be securely fastened to roof or structure at intervals not exceeding 3'0" on center.

10.4 Additional ESE air terminals shall be provided in situations where steeples, cupolas, crosses, stacks, chimneys, etc project above a protected roof area. This requirement applies to all projections which could provide a potential upward streamer release. The addition air terminals shall be provided regardless of whether or not the projection is within or outside the area covered by the system design under the Manufacturer's Standard. See Figure 10.2.1. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those

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terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

Figure 10.2.1



10.5 ESE Air Terminals shall be provided with a minimum of two paths to ground. Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets.

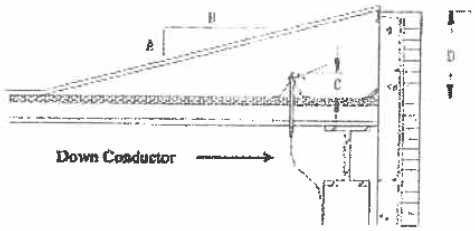
10.6 No Bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However Conductors may rise at a rate of 3" per 12" of run. See Figure 10.5.1 and Figure 10.6.1

Figure 10.5.1



NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement.

Figure 10.6.1



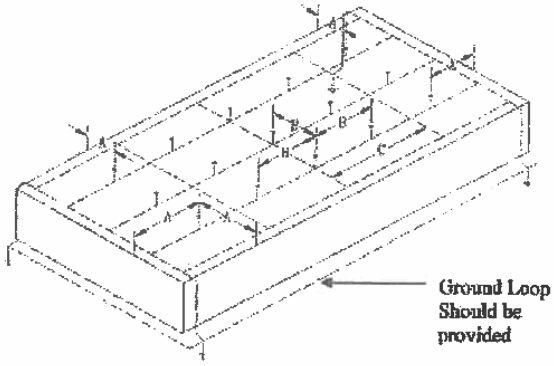
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in

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10.7 In situations where multiple air terminals are required, the perimeter air terminals shall be positioned so that they are no more than 230' (70m) from the outside edge of the building nor shall be ESE Air Terminals be spaced more than 460' (140m) apart at any time. A cross run cable shall be provided at intervals of 1000' (305m) When building exceed 200' (610m) in length in any direction. See Figure 10.8.1. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

10.8 Down Conductors in situations where multiple ESE Air Terminals are required shall be spaced at intervals no more than 500' (152m) apart around the perimeter of the structure.

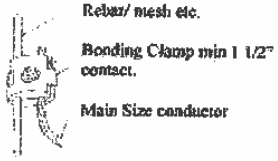
Figure 10.8.1



A= 230' (70m) maximum
B= 460' (140 m) maximum
C= 1000' (305m)

10.9 Bonding connections shall be made with main size conductor to all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, etc., whether exposed or not, at the upper and lower extremities of each down conductor. Care shall be taken to assure that all rebar, reinforcing rod, structural steel, interior wall mesh, nylon mesh in stucco walls etc, whether exposed or not is electrically continuous or made so. (See Fig. 10.9.1 and Fig 10.9.2).

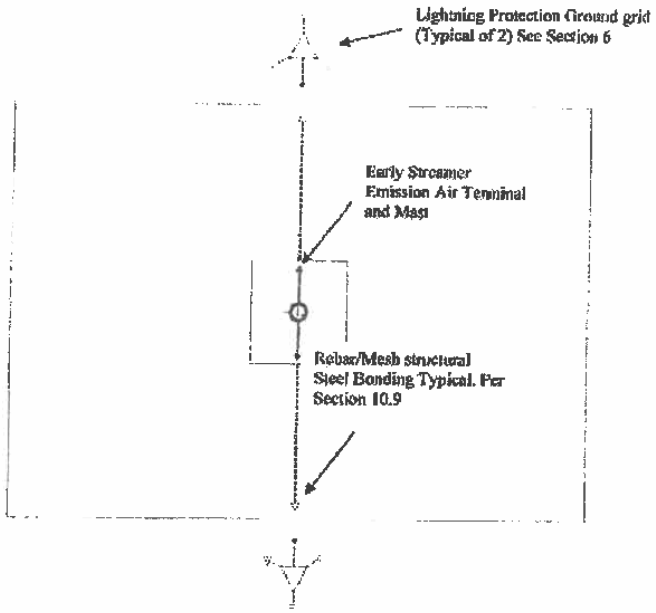
Figure 10.9.1



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Figure 10.9.2



11. Level 2 Bonding Requirements

11.1 Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless.

A. Inherently bonded to the lightning protection system.

11.2 Sanitary vents, roof drains, flashings, copings, etc located within 6' (1.8m) of a lightning protection conductor, shall be bonded via secondary sized conductor to the lightning protection system.

12. Level 2 Grounding System Requirements

12.1 Down Conductors and Grounding

12.2 A minimum of two (1) down conductors shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 10.8.

12.3 A single down conductor shall be permitted to be used where the length of run does not exceed 65ft (19m).

12.4 If the horizontal length is greater than the vertical length, two (2) down conductors shall be required and separated a minimum of 10' (3m).

12.4.1 For lengths greater than 65' (19m) two conductors shall be required.

12.4.2 For masts, a single down conductor only shall be required.

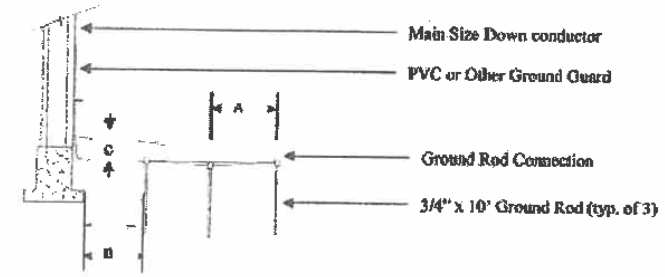
12.4.3 If electrically conductive, the mast shall be permitted to be used as the down conductor.

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12.5 Down Conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, Fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See figure 12.4.1.

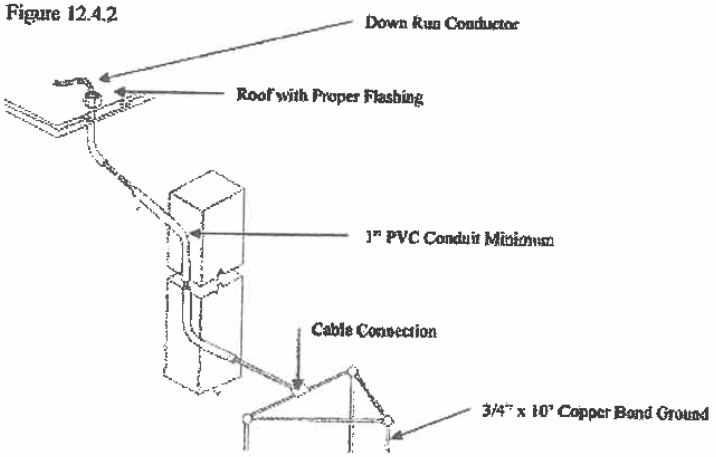
12.6 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 12.4.2.

Figure 12.4.1



A= 10' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 1' (0.3m) Minimum

Figure 12.4.2



12.7 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

12.7.1 If electrically continuous, structural steel shall be permitted to be used as the down conductor.

12.8 Masonry Anchors used to secure the lightning protection components shall have a minimum outside diameter of ¼" (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

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12.9 Connector Fittings shall be used at all "end to end", "tee" or "y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lbs. Fittings used for required connections shall be of bolted, welded, or high compression type and bear the ARL Listing and UL Listing.

12.10 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of materials shall be used that forms an electrolytic couple of such nature that, in the presence of moisture, corrosion is accelerated.

12.11 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 10 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants*, method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

12.12 Ground electrodes shall be of copper-bond steel in sufficient number as to achieve a 10-ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 1' (0.3m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 12.4.1

12.13 Ground Rod terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

12.14 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configured either in a straight line or in delta formation. Where the ground terminals are spaced a minimum of 10' (3m) apart. See Figures 12.4.1 and 12.4.2.

12.15 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

12.16 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems.

NOTE 1: For further information, see NFPA 70 National Electric Code, which contains detailed information on the grounding of electrical systems.

12.17 Ground ring/loop electrode encircling the structure should be provided and in direct contact with the earth at a depth of not less than 2 ft. The ground ring conductor shall be sized at a minimum of that of the main sized conductor.

12.18 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include lightning protection, electric service, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

12.19 Common Ground Bonding. If electric, telephone or other systems are bonded to metallic water pipe; only on connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

12.20 If the horizontal length is greater than the vertical length, two down conductors shall be required and separated a minimum of 10' (3m).

(a) For lengths greater than 65' (19m) two conductors shall be required.

(b) For masts, a single down conductor only shall be required.

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(c) If electrically conductive, the mast shall be permitted to be used as the down conductor.

13. Level 2 Structural Steel Systems

13.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

13.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60 ft (18m). Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

13.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq inches (5200mm²). The area of attachment shall be free of paint, grease oil and debris.

13.4 Early Streamer Emission Air Terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 13.3.

13.5 Metal Bodies. Certain metal bodies located outside or inside the structure contribute to lightning hazards because they are grounded or assist in providing a path to ground for lightning currents. Such metal bodies shall be bonded to the lightning protection system in accordance with Section 11.

13.6 Concealment in Steel Reinforced Concrete. Conductors or other components of the lightning protection system concealed in steel reinforced concrete units shall be connected to the reinforcing steel. Concealed down conductors shall be connected to vertical reinforcing steel. Roof conductors or other concealed horizontal conductor runs shall be connected to reinforcing steel and structural steel at intervals not exceeding 60ft (18m) and at all corners. See Section 10.9.

13.7 Down Conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel and/or structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 200 ft (60m). Such connections shall be made using listed clamps or listed bonding plates or by exothermic welding. The use of PVC conduit or other non-metallic chase does not negate the need for the interconnections.

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LEVEL 3

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

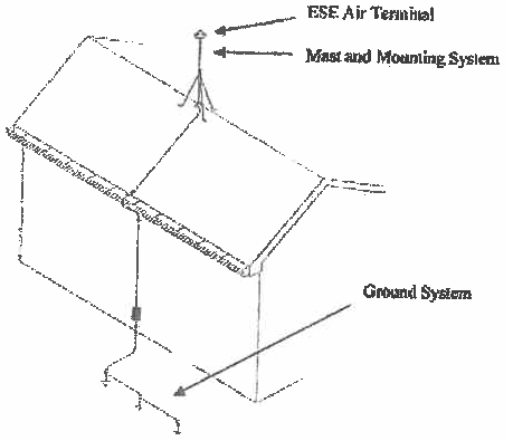
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14. Level 3 General Installation Requirements

14.1 An ESE lightning protection system installation consists of the following interconnected parts see figure 14.1.1.

a. One or more ESE air terminals.
b. Mast and mounting systems – as required based on level of protection.
c. Ground system – Single grid to loop conductor system.
d. Equipotential Bonding.
e. Transient Voltage Surge Suppression.

Figure 14.1.1



14.2 The number of ESE air terminals will depend on the system design under the Manufacturer's Standard based on the area as indicated in Figure 3.5.1 for Level 3 Systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

14.3 Components Tables Figure 14.3.1 and Figure 14.3.2 provide minimum sizes and weights for use in ESE lightning protection system installation.

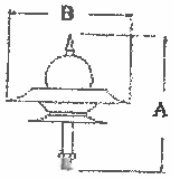
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Figure 14.3.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	1/2 "/ 12.7mm	1/2" / 12.7 mm	1/2" / 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	16AWG 190lbs /1000/ or 278 g/m 61900 CM / 35 mm^2	14AWG 110lbs/1000/ 164 g/m 98600 CM/ 50 mm^2
Ground Terminals	Ground Rod / Ground Plate	5/8" x 8' (16 mm x 2400mm)/ 18" x 18"x 20 gauge (460mm x 460mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 14.3.2 Early Streamer Emission Air Terminal

A= 12" (300mm)
B= 9" (230mm)



14.4 ESE Air Terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of aluminum, copper, copper alloy, or stainless steel. The main conductive parts of the ESE air terminal shall have the minimum dimensions in accordance with Figures 14.3.1 and Figure 14.3.2.

14.5 ESE Air Terminals Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind.

14.5.1 Where an air terminals or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

14.5.2 The tip of any ESE air terminal shall not be less than 7' (2.1m) above the protected structures, including antennas, cooling towers, tanks, roof and masts.

14.5.3 The ESE air terminals shall be mounted on structures such as flagpole, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as sports facilities and stadium, golf courses, public parks, camping sites and racetracks. The ESE unit shall still be mounted at an elevation as indicated in Section 14.5.2

14.5.4 Storage areas for flammable and combustible liquids or flammable gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

14.5.5 Electrical Surge Suppression devices shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty.

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Units shall be mounted as to minimize inductance installation. (I.e. As close to equipment to be protected or by use of documented low inductance cabling).

NOTE 1: Electrical systems and utilization equipment within the structure may require further surge suppression. Such protection is not part of this standard. NFPA 70, National Electric Code and ANSI/IEEE C62.41-1991 2nd Edition, shall consulted for further information and installation requirements.

NOTE 2: Illustrations shown in this standard are those of Heary Brothers Lightning Protection Co., Inc. (HBLP) and its division Lightning Preventor of America (LPA). HBLP and LPA do not manufacture or warranty surge protection devices. Warranties required of this standard shall be the responsibility of the surge protection device manufacturer.

14.6 General. In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounding medium.

B. The influence of a non-grounded metal body, such as metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium, (Air or solid materials).

D. Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

E. Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall still maintain the minimum projection above these objects as specified in section 14.5.2 and the object shall be bonded to the lightning protection system by means of main sized conductor.

15. Level 3 Components

15.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

15.1.1 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gases or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

15.2 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding, or other aluminum.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum conductors and components shall not be embedded in concrete or masonry;

a) In direct contact with a surface coated with alkaline base paint; or installed in wet locations, for example eave troughs or downspouts.

b) Installed in direct contact with earth.

c) Components used for connection of aluminum down conductors to copper or copper-bond grounding equipment shall provide separation between aluminum and copper materials. These fitting may be a stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper materials.

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15.2.1 Unless otherwise indicated in this standard, an air terminals shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

16. Level 3 Air Terminal Installation Requirements

16.1 Early Streamer Emission Air Terminals

16.1.1 ESE Air Terminals shall be mounted at a height consistent with the requirements of Section 14.5.2 or a minimum of 7' (2.1m) above all projections on the roof. See Figure 16.1.1 for sample mast mounting details and figure 16.1.2 for installation diagram.

Figure 16.1.1

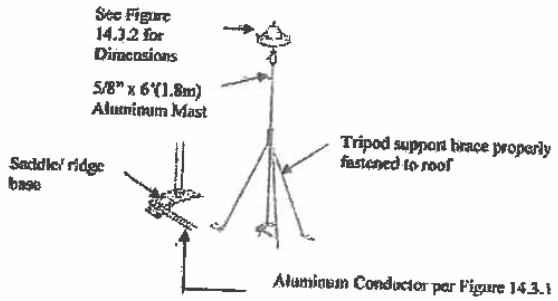
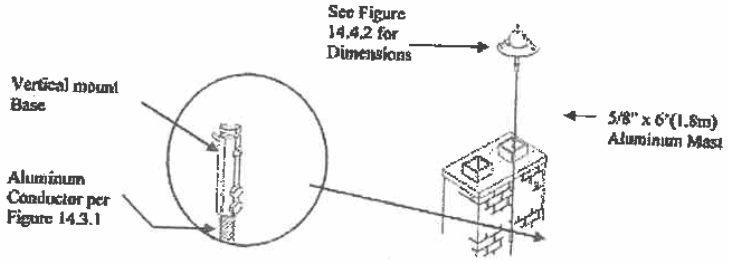
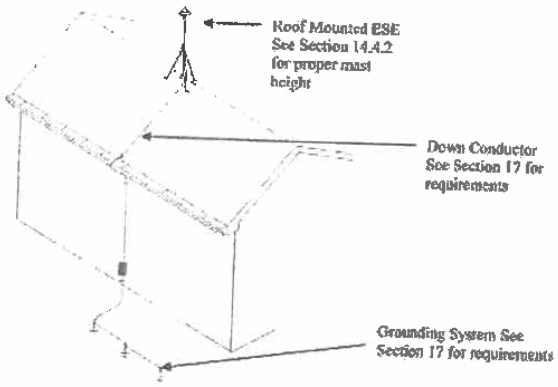


Figure 16.1.1 (Continued)



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Figure 16.1.2



16.1.2 ESE Air Terminals shall be provided in proper quantity and location based on the system design under the Manufacturer's Standard. See Figure 3.5.1 and for Level 3 Systems. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

16.1.3 Conductors shall be securely fastened to roof or structure at intervals not exceeding 3' (1m) on center.

16.1.4 The ESE Air Terminals shall be provided with a minimum of one path to ground. (See Section 17 for additional requirements) Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets. See Figure 16.1.4

16.1.5 No bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However Conductors may raise a rate of 3" per 12" of run. See Figure 16.1.3 and Figure 16.1.4

Figure 16.1.3



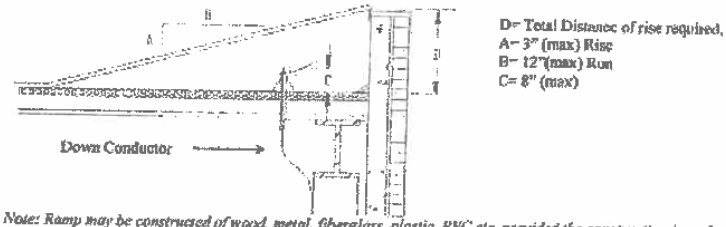
R= Radius bend, 8 inches (203 mm) minimum

90-degree minimum

NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement.

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Figure 16.1.4



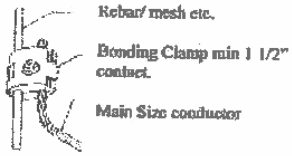
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in Section 16.1.3.

16.1.6 In situations where multiple air terminals are required, air terminals shall be positioned so that they are no more than 150' (45m) from the outside edge of the building nor shall they be more than 300' (90m) apart. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

16.1.7 Down Conductors in situations where multiple ESE Air Terminals are required shall be installed in accordance with Section 17.

16.1.8 Bonding connections shall be made to all rebar, reinforcing rod, structural steel etc. at the upper on lower extremities of the down conductor. See Figure 16.18.

Figure 16.18



16.2 Roof Top Bonding Requirements;

16.2.1 Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless the equipment is inherently connected to the ground system through direct bond or common bond.

16.2.2 Sanitary vents, roof drains, flashings, gutters, copings etc. Located within 6' (1.8m) of the lightning protection system, shall be bonded via a secondary sized conductor to the system unless the equipment is inherently bonded to the lightning protection system.

17. Level 3 Grounding System Requirements

17.1 A minimum of two (2) down conductors shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 16.1.7.

17.2 A single down conductor shall be permitted to be used where the length of run does not exceed 65ft (19m).

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17.3 If the horizontal length is greater than the vertical length, two down conductors shall be required and separated a minimum of 10' (3m).

17.4 For lengths greater than 65' (19m) two conductors shall be required.

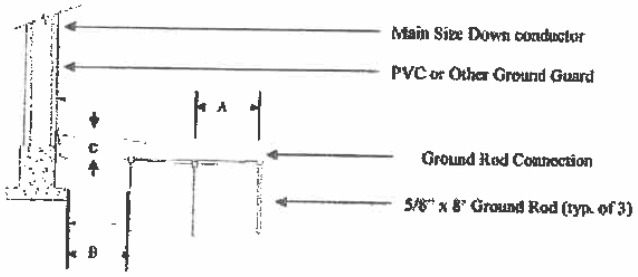
17.5 For masts, a single down conductor only shall be required.

17.6 If electrically conductive, the mast shall be permitted to be used as the down conductor.

17.7 Down Conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See Figure 17.8.1

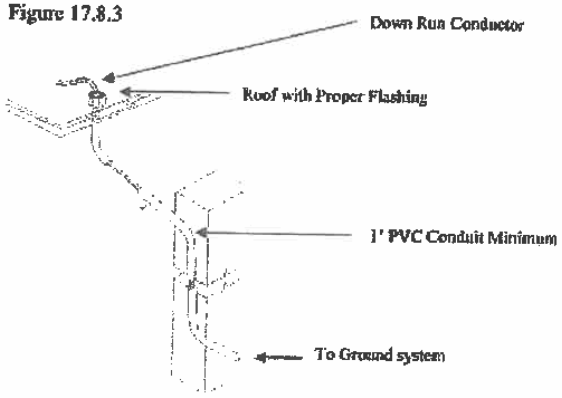
17.8 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 17.8.3.

Figure 17.8.1



A= 8' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 1' (0.3m) Minimum

Figure 17.8.3



17.9 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

17.10 If electrically continuous, structural steel shall be permitted to be used as the down conductor.

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17.11 Masonry Anchors used to secure the lightning protection components shall have a minimum outside diameter of ¼ in. (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed, the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

17.12 Connector Fittings shall be used at all "end to end", "tee", or "y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lb. Fittings used for required connections shall be of bolted, welded or high compression type and bear the ARL Listing and UL Listing.

17.13 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of components shall be used that forms an electrolytic couple of such nature that in the presence of moisture, corrosion is accelerated.

17.14 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 25 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

17.15 Ground electrodes shall be of copper-bond steel or copper plate in sufficient number as to achieve a 25 ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 1' (0.3m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 17.8.1.

17.16 Ground Rod Terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

17.17 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configures in a straight line. Where the ground terminals are spaced a minimum of 8' (3m) apart. See Figure 17.8.1.

17.18 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

17.19 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems. *NOTE 1: For further information, see NFPA 70National Electric Code, which contains detailed information on the grounding of electrical systems.*

17.20 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include lightning protection, electric service, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25 ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

17.21 Common Ground Bonding. If electric, telephone or other systems are bonded to metallic water pipe; only one connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

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18. Level 3 Structural Steel Systems

18.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

18.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60ft (18m). Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

18.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq inches (5200mm²). The area of attachment shall be free of paint, grease, oil, and debris.

18.4 Early Streamer Emission Air Terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 18.3.

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EXHIBIT B

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USI

April 29th, 2019

Heary Bros Lightning Protection Co Inc
11291 Moore Rd
Springville, NY 14141

To Whom It May Concern:

During the many years we have done business with Heary Brothers Lightning Protection Co. Inc., we have found your commitment to developing quality products for your customers as paramount. Included in that commitment would be the successful line of the Early Streamer Lightning Protection Equipment.

Your dedication has allowed us to establish a comprehensive and cost-effective insurance program for your companies. Because of your dedication, we have been able to secure 11 million dollars of Liability limits. This includes coverage for damage from direct lightning strikes to the structure of any buildings. Please see enclosed America Certificate of Guarantee as additional evidence.

In addition, claims activity has been negligible and we, as your broker, the The Travelers Insurance Company, as your carrier, appreciate your attention to workplace safety and products liability quality control efforts. In today's highly competitive world, this is critical.

Without a doubt, your company was built around a commitment to give customers the products they need and confidence in our ability to meet or exceed expectations. We encourage your efforts and with you continued success.

Sincerely,

Timothy M. Wroblewski
Vice President

TW/lam

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FIRST NIAGARA

April 24, 2015

Heary Bros Lightning Protection Co Inc
11291 Moore Rd
Springville, NY 14141

To Whom It May Concern:

During the many years we have done business with Heary Brothers Lightning Protection Co. Inc., we have found your commitment to developing quality products for your customers as paramount. Included in that commitment would be the successful line of the Early Streamer Lightning Protection Equipment.

Your dedication has allowed us to establish a comprehensive and cost-effective insurance program for your companies. Because of your dedication, we have been able to secure 11 million dollars of Liability limits. This includes coverage for damage from direct lightning strikes to the structure of any buildings. Please see enclosed America Certificate of Guarantee as additional evidence.

In addition, claims activity has been negligible and we, as your broker, the The Travelers Insurance Company, as your carrier, appreciate your attention to workplace safety and products liability quality control efforts. In today's highly competitive world, this is critical.

Without a doubt, your company was built around a commitment to give customers the products they need and confidence in our ability to meet or exceed expectations. We encourage your efforts and with you continued success.

Sincerely,

Timothy M. Wroblewski
Vice President

TW/lam

First Niagara Risk Management, Inc.
726 Exchange Street, Suite 900 • Buffalo, NY 14210
Phone: 716-819-5500 • Toll Free: 800-854-9121 • Fax: 716-819-5140

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EXHIBIT C

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Preventor System Installations In Florida

ProjectName	Address	City	State
7000 Williams Island Building		Adventura	FL
Florida Hospital Altamonte Office		Altamonte Springs	FL
Turner Agriculture Center and Extension Office		Arcadia	FL
Marriott - Aventura Hotel		Aventura	FL
Alliant Food Service		Boca Raton	FL
Boca Museum		Boca Raton	FL
Boca Raton Condos		Boca Raton	FL
Caterpillar C-2 Expansion		Boca Raton	FL
Sears Store	Glades Road	Boca Raton	FL
TAG (The Answer Group) Main Building		Boca Raton	FL
TAG Main Building East Emissions Building		Boca Raton	FL
The Polo Club of Boca Raton		Boca Raton	FL
Bealls Corp Headquarters		Bradenton	FL
Paul Azinger Residence		Bradenton	FL
St. Stephens School		Bradenton	FL
Tara Preserve Golf Clubhouse		Bradenton	FL

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ProjectName	Address	City	State
Suntree Elementary and Chiller Building		Brevard Co	FL
Florida Welcome Center		Campbelton	FL
Advanced Elastomers		Cantonement	FL
Cape Canaveral AF Station Patrick AFB Cape Arrays		Cape Canaveral	FL
Cape Canaveral Station	Patrick Air Force Ba	Cape Canaveral	FL
Satellite Assembly Bldg Cape Canaveral		Cape Canaveral	FL
Kreiseder Residence		Casey Key	FL
Silverstein Residence		Casey Key	FL
Florida Hospital		Celebration	FL
Clyde Dyal Water Treatment Plant		Christmas	FL
Citrus Springs Utilities	1360 N. Citrus Spri	Citrus Springs	FL
Baystreet Plaza @ International Mall		Clearwater	FL
Capitol One Phase IV		Clearwater	FL
Catile Tower		Clearwater	FL
Church of Scientology Sandcastle Addition		Clearwater	FL
Crescent Beach Club		Clearwater	FL
Crescent Beach Club		Clearwater	FL
General Services Bldg		Clearwater	FL

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ProjectName	Address	City	State
Pinellas County Utilities		Clearwater	FL
Ruth Eckerd Hall		Clearwater	FL
Ruth Eckerd Hall - CEP Addition		Clearwater	FL
St. Cecelia Intraparochial School		Clearwater	FL
The Sirata Beach Resort		Clearwater	FL
The Tides@ Feather Sound		Clearwater	FL
Worthington Square Apartments		Clearwater	FL
City of Coconut Creek - Council Building		Coconut Creek	FL
City of Coconut Creek - Motor Pool Building		Coconut Creek	FL
Coconut Creek Public Safety		Coconut Creek	FL
Sabal Pines - Ball Field #2		Coconut Creek	FL
Sabal Pines - Elementary School		Coconut Creek	FL
Sabal Pines - Hockey Rink		Coconut Creek	FL
Sabal Pines - Maintenance Facility		Coconut Creek	FL
Sabal Pines - Pines Pavilion		Coconut Creek	FL
Sabal Pines - Soccer Field #1		Coconut Creek	FL
Body of Christ Family Life Center		College	FL
Stone/Bag Paper Container Facility	Hwy 29 & Becks La	Contonement	FL

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ProjectName	Address	City	State
Alahamra Tower		Coral Gables	FL
The Alhambra Hotel/Office	50 Alhambra Circle	Coral Gables	FL
University of Miami Intra Mural Fields		Coral Gables	FL
Sheik Island Horse Farm		Dade City	FL
BCC Building 27/ New Child Develop. CTR		Davie	FL
BCC Student Services Building		Davie	FL
Nova Southeastern College Parking Garage		Davie	FL
Phil Smith Toyota		Davie	FL
Rolling Hills Golf and Country Club		Davie	FL
Daytona Auto Dealers Exchange		Daytona Beach	FL
Daytona Marriott Hotel	100 N Atlantic Ave	Daytona Beach	FL
Deerfield Beach Grand Hilton	100 Fairway Drive	Deerfield Beach	FL
Granada Royale Hotel	902 S. E. 20th Ave.	Deerfield Beach	FL
Deltona Lake Track "A"	Diamond Street	Deltona	FL
Deltona WWTP	Saxton & Agatha	Deltona	FL
Deltona WWTP	Lombardy Ctr	Deltona	FL
Deltona WWTP	Cortland Blvd	Deltona	FL
Deltona WWTP	Fisher Drive	Deltona	FL

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ProjectName	Address	City	State
Well # 2 & High Service Pump	Unit 21 Sagmore Dr	Deltona	FL
Silver Beach Condominium		Destin Beach	FL
Guardian Angel School		Dunedin	FL
Our Lady of Lourdes		Dunedin	FL
Burdines Dept. Store		Fort Lauderdale	FL
Marriott - Ft Pierce Travel Plaza	Florida Turnpike Mi	Ft Pierce	FL
Granada Royale Hotel	1101 S.E. 17th Stree	Ft. Lauderdale	FL
Riverside Hotel		Ft. Lauderdale	FL
McGregor Point Hotel		Ft. Myers	FL
Raymond Building Products		Ft. Myers	FL
Raymond Building Supply Rack Storage		FT. Myers	FL
Raymond Building Supply Warehouse Building		FT. Myers	FL
Palm Court Yacht Club		Ft. Walton Beach	FL
Holy Faith Church	700 N.W. 39th Roa	Gainesville	FL
Main Library	on SR-26 Across fro	Gainesville	FL
Nordstrom Distribution Center		Gainesville	FL
UF Hotel and Conference Center		Gainesville	FL
Union Street Station		Gainesville	FL

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ProjectName	Address	City	State
Jack Sawyer	608 Fairpoint Drive	Gulf Breeze	FL
Palmento General Hospital	W. 20th & W. 68th	Hialeah	FL
Aqua Penn Water Co.		High Springs	FL
City of Holmes Beach Baseball Field	5901 Marina Drive	Holmes Beach	FL
North Lake Elementary		Indian River	FL
Sebastian Highlands WTP	1001 Prineville Roa	Indian River City	FL
Richard Herrmann II Residence	405 15th Ave	Indian Rocks Beach	FL
Florida Power/Light Co Martin Combined Cycle # 3,4	State Road 710	Indiantown	FL
Martin Plant Combined Cycle 3 & 4		Indiantown	FL
Allbritton Communications	7025 AC Skinner Pk	Jacksonville	FL
Berkman Plaza		Jacksonville	FL
Cathedral Terrace		Jacksonville	FL
Cathedral Towers		Jacksonville	FL
Cathedral Townhouses		Jacksonville	FL
Cypress Village Apartments	4600 Middleton Par	Jacksonville	FL
Sears Logistics Center		Jacksonville	FL
The Pointe		Jupiter	FL
The Phoenix @ Peachtree		Kennesaw	FL

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ProjectName	Address	City	State
Dolphin Hotel - Epcot Center	1500 Epcot Resort	Lake Buena Vista	FL
Dolphin/Swan Hotel Causeway & Grotto	1500 Epcot Resort	Lake Buena Vista	FL
Royal Plaza Hotel	1905 Preview Blvd	Lake Buena Vista	FL
Swan Hotel - Epcot Center	1500 Epcot Resort	Lake Buena Vista	FL
Westgate Lakes Sales Center		Lake Buena Vista	FL
Columbia Correctional Institution		Lake City	FL
Marriott - Lake Worth Travel Plaza	Florida Turnpike Mi	Lake Worth	FL
Publix Deli Plant	PO Box 407	Lakeland	FL
RMC Ewell Corp		Lakeland	FL
FCCI Insurance Group		Lakewood Ranch	FL
US Post Office - Land O Lakes		Land O Lakes	FL
Central Catholic High School		Lecanto	FL
Citrus Co. Landfill		Lecanto	FL
St. Stalastic Church		Lecanto	FL
FDOT District 5		Leesburg	FL
Lehigh Post Office		Lehigh	FL
Ben Price Residence	Gulf of Mexico Driv	Longboat Key	FL
James Gradner Residence		Longboat Key	FL

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ProjectName	Address	City	State
Sea Place Condominium Complex M1 & M2	1945 Gulf of Mexic	Longboat Key	FL
Wagner Residence	5940 Gulf of Mexic	Longboat Key	FL
Albert Whitted Expansion		Longwood	FL
Lowell Correctional Institution		Lowells	FL
St. Timothy's Catholic Church		Lutz	FL
Marco Island Pump Station	RTE 951	Marco Island	FL
South Fork High School		Martin Co.,	FL
Brevard Educational Facility		Melborne	FL
Eau Gallie High School Gymnasium & Auditorium		Melborne	FL
Brickell Station Towers	30 S.W. 8th Street	Miami	FL
Doral Concourse		Miami	FL
La Tour Condo		Miami	FL
Lincoln Financial Center	701 Brickell Ave.	Miami	FL
Marriott - Snapper Creek Travel Plaza	Florida Turnpike Mi	Miami	FL
Metropolitan Sun Bank	777 Brickell Ave	Miami	FL
Porta Vita		Miami	FL
Pro-Player Stadium		Miami	FL
Sienna		Miami	FL

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ProjectName	Address	City	State
Softel Hotel	5800 Blue Lagoon	Miami	Fl
Telemundo Networf		Miami	FL
Tequesta Condominium	808 Bricknell Key D	Miami	FL
Three Tequesta Point		Miami	FL
University of Miami Hecht Athletic Center		Miami	FL
University of Miami Knight Baseball Stadium & Foot		Miami	FL
University of Miami Schiff Tennis Ctr & Hecht Ath		Miami	FL
Loews Hotel & Convention Center		Miami Beach	FL
Portofino Tower		Miami Beach	FL
Sandy Park Health Care Center		Miami Beach	FL
US Naval Air Station Bldg 1406 & 1424	Whiting Field South	Milton	FL
Mulberry Post Office		Mulberry	FL
North Port St. Lucie WTP	Gulf Port Terrace	N. Port St. Lucie	FL
Collier Residence		Naples	FL
Gerry Residence	3400 Gordon Drive	Naples	FL
HorseCreek Properties Collier Equestrian Facility		Naples	FL
Horsecreek Properties Collier Equestrian Facility	Daniels Road	Naples	FL
Naples Cay Seapointe Condo	10 Seagate Drive	Naples	FL

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ProjectName	Address	City	State
Royal Poinciana Country Club	Goodlette Rd	Naples	FL
The Savoy Condo	4041 Gulf Shore Blv	Naples	FL
Blazer Residence		Navarre	FL
Caribbean Resort Condo		Navarre Beach	FL
The Fountaians Condominium		New Smyrna Beach	FL
Implant Innovations Inc.		North Palm Beach	FL
King Plastics Inc.		North Port	FL
Bishop Larkin Pastoral Center	9th Avenue	North St. Petersburg	FL
Lowell Correctional Facility Water Tower		Ocala	FL
Marion Oaks Water TRT Plant	14170 S.W. 39th Av	Ocala	FL
Marriott - Turkey Travel Plaza	Florida Turnpike Mi	Ocee	FL
Marriott - Ft Drum Travel Plaza	Florida Turnpike Mi	Okeechobee	FL
BIC Manufacturing Plant(III) Myerlake		Oldsmar	FL
Florida Hospital East Orlando		Orlando	FL
Florida Hospital Orlando		Orlando	FL
Martin Marietta Conflow Area Site	Kirtland Road	Orlando	FL
Orlando Utilities Commission Power Plant		Orlando	FL
St. Johns Rive Water Management		Palatka	FL

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ProjectName	Address	City	State
St. Johns River Waste Management District Office		Palatka	FL
SWA Tipping Floor Building		Palm Beach	FL
The Diplomat Hotel - Main Building		Palm Beach	FL
SWA West Central Tipping Floor		Palm Beach Co	FL
George Young United Methodist Church		Palm Harbor	FL
St. Mark Village	Rte 19	Palm Harbor	FL
William E. Dunn Water Reclamation Facility		Palm Harbor	FL
Riviera Dunes Marina		Palmetto	FL
St. Andrews Condo		Panama City	FL
Hidden Dunes Condominium		Panama City Beach	FL
Landmark Holiday Beach Resort		Panama City Beach	FL
The Summit Resort	Thomas Drive	Panama City Beach	FL
Camp-O-Pines Pensacola Christian College		Pensacola	FL
Ellyson Industrial Park	Ellyson Field Proj	Pensacola	FL
Gelman Sciences	8780 Fly Road	Pensacola	FL
George Estes Residence		Pensacola	FL
Girls Parking Garage -Pensacola Christian College		Pensacola	FL
H-6 Academic Building		Pensacola	FL

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ProjectName	Address	City	State
McKenzie Building- Pensacola Christian College		Pensacola	FL
Phoenix 10 Condominium		Pensacola	FL
University of West FL Admin. Building		Pensacola	FL
University of West FL Classroom Building		Pensacola	FL
Sabine Yacht & Racquet Club	330 Fort Pickens Rd	Pensacola Beach	FL
Eden Condominium		Peridido Key	FL
St. Clements Catholic Church		Plant City	FL
American Heritage Fine Arts Building		Plantation	FL
Crossroads 4		Plantation	FL
Motorola		Plantation	FL
Motorola Inc.		Plantation	FL
Spa Atlantis		Pompano	FL
Ligi Tool		Pompano Beach	FL
Marriott - Pompano Travel Plaza	Florida Turnpike Mi	Pompano Beach	FL
Charlotte County Public Works		Port Charlotte	FL
Dr. Eugene Gregosh Residence		Port Charlotte	FL
East Port Environmental Services		Port Charlotte	FL
Peace River WTP	Kings Hwy	Port Charlotte	FL

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ProjectName	Address	City	State
Peace River WTP	Intake Structure	Port Charlotte	FL
Port Malabar WTP		Port Malbar	FL
Bishop Larkin School		Port Richey	FL
Charlotte County Sheriff's Administration	Metro Pkwy	Punta Gorda	FL
Chateau Towers	Gulfport Blvd	S. Pasadena	FL
Espirtu Santo Catholic School		Safety Harbor	FL
The Shipley Residence		Sannibel Island	FL
Baker Electronics		Sarasota	FL
C'A' D' Zan John't Mable Rigling Home		Sarasota	FL
Davis Residence		Sarasota	FL
Ed Windemuller Residence	Saddle Oaks Estates	Sarasota	FL
Ken Miller Barn		Sarasota	FL
Lincoln Properties/ NBD Bank Building	240 N Washington	Sarasota	FL
Marina Towers Condominium		Sarasota	FL
Meridian @ The Oaks Building III		Sarasota	FL
Sarasota Herald Tribune		Sarasota	FL
Scott Sign Systems		Sarasota	FL
Scott Signs Phase II		Sarasota	FL

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ProjectName	Address	City	State
Sun Hydraulics Inc.		Sarasota	FL
The Phoenix Condo	Golden Gate Point	Sarasota	FL
The Radisson Hotel Lido Beach	Ben Franklin Drive	Sarasota	FL
The Renaissance		Sarasota	FL
Sebastian WTP	Filbert Street	Sebastian	FL
Lake Jackson Post Office		Sebring	FL
St. Cloud High School		St Cloud	FL
Casa Monica Hotel		St. Augustine	FL
St. Augustine Shores	771 Alahambra	St. Augustine	FL
Marriott - Canoe Creek Travel Plaza	Florida Turnpike Mi	St. Cloud	FL
School "C" Osceola Co. School District		St. Cloud	FL
Incarnation Church		St. Petersburg	FL
Jabil Circuit Inc.	10800 Roosevelt Blv	St. Petersburg	FL
Midcore Parking Garage		St. Petersburg	FL
San Seair Condominiums		St. Petersburg	FL
St. Marks Family Life Center	PO Box 43022	St. Petersburg	FL
Wheelbrator Corp		St. Petersburg	FL
SECO Office Building		Sumterville	FL

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ProjectName	Address	City	State
Capital One Building One	8745 Henderson Ro	Tampa	FL
Capital One Phase II Building 2 Renaissance	8745 Henderson Ro	Tampa	FL
Capital One Phase II Parking Garage	8745 Henderson Ro	Tampa	FL
Capital One Phase III Parking Garage	8745 Henderson Ro	Tampa	FL
Capital One Phase IV Flagpole	8745 Henderson Ro	Tampa	FL
Capital One Softball Field	8745 Henderson Ro	Tampa	FL
Capital One Tai Chi Building	8745 Henderson Ro	Tampa	FL
Florida Aquarium		Tampa	FL
Gateway Post Office		Tampa	FL
Group Tech		Tampa	FL
Lee Moffit Cancer Center Parking Garage		Tampa	FL
Marriott -Tampa		Tampa	FL
Muvico	18002 Richmond Pa	Tampa	FL
Myrtle Oaks		Tampa	FL
Notre Dame High School		Tampa	FL
Seaboard Waste Water TRT Plant	8234 Causeway Blv	Tampa	FL
St. Mary's Episcopal Day School		Tampa	FL
St. Pete Catholic High School		Tampa	FL

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ProjectName	Address	City	State
Tampa Bay Water Groundwater Clear Well Tank		Tampa	FL
Tampa Bay Water Surface		Tampa	FL
Tampa Juvenile Detention Center		Tampa	FL
The Garrison Condo		Tampa	FL
The Sorelle Residence		Tampa	FL
Westshore Plaza Phase III Expansion		Tampa	FL
City of Titusville Blue Heron WRF		Titusville	FL
City of Titusville Blue Heron WRF		Titusville	FL
Reliant Energy Corp. Maintenance Instrumentation B		Titusville	FL
Reliant Energy Corporation Intake Structure	Highway US 1	Titusville	FL
Sipprelle Residence		Ussepa Island	FL
Meridian @ The Oaks		Venice	FL
Woodmere Clubhouse		Venice	FL
Our Lady of the Rosary-Ballfield	21010 S.R. 54	West Land O'Lakes	FL
Our Lady of the Rosary-Flagpole	21010 S.R. 54	West Land O'Lakes	FL
SWA (CMRF)		West Palm Beach	FL
Marriott - Okahumpka Travel Plaza	Florida Turnpike Mi	Wildwood	FL
Florida Hospital		Winter Park	FL

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ProjectName	Address	City	State
Florida Brewing Company		Ybor City	FL

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Preventor 2005 Installations (Government)

Project Name	Address	City	State
Kodiak Building (SCAT) Mobile Structure on Rails		Kodiak	AK
Huntsville Public Safety Complex		Huntsville	AL
New Phoenix City Hall	Package Street	Phoenix	AZ
Phoenix Central Library		Phoenix	AZ
Los Angeles Federal Bldg. GSA	255 E. Temple Street	Los Angeles	CA
GSA Oakland Federal Building		Oakland	CA
California Federal Service Center	1515 Walnut Grove Avenue	Rosemead	CA
V.A. Medical Center		San Diego	CA
FBI Center New 9 Story Office Bldg		Washington	DC
Florida Welcome Center		Campbelton	FL
Cape Canaveral AF Station Patrick AFB Cape Arrays		Cape Canaveral	FL
Cape Canaveral Station	Patrick Air Force Base	Cape Canaveral	FL
Satellite Assembly Bldg Cape Canaveral		Cape Canaveral	FL
General Services Bldg		Clearwater	FL
City of Coconut Creek - Council Building		Coconut Creek	FL
City of Coconut Creek - Motor Pool Building		Coconut Creek	FL

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Project Name	Address	City	State
Coconut Creek Public Safety		Coconut Creek	FL
Marriott - Ft Pierce Travel Plaza	Florida Turnpike Mile Mkr 144	Ft Pierce	FL
City of Holmes Beach Baseball Field	5901 Marina Drive	Holmes Beach	FL
Marriott - Lake Worth Travel Plaza	Florida Turnpike Mile Mrk. 94	Lake Worth	FL
US Post Office - Land O Lakes		Land O Lakes	FL
FDOT District 5		Leesburg	FL
Marriott - Snapper Creek Travel Plaza	Florida Turnpike Mile Mkr 19	Miami	FL
US Naval Air Station Bldg 1406 & 1424	Whiting Field South & North Tower	Milton	FL
Mulberry Post Office		Mulberry	FL
Marriott - Turkey Travel Plaza	Florida Turnpike Mile Mkr 263	Ocee	FL
Marriott - Ft Drum Travel Plaza	Florida Turnpike Mile Mkr 184	Okeechobee	FL
St. Johns Rive Water Management		Palatka	FL
Marriott - Pompano Travel Plaza	Florida Turnpike Mile Mrk 65	Pompano Beach	FL
East Port Environmental Services		Port Charlotte	FL
Charlotte County Sheriff's Administration	Metro Pkwy	Punta Gorda	FL
Marriott - Canoe Creek Travel Plaza	Florida Turnpike Mile Mrk 229	St. Cloud	FL
Gateway Post Office		Tampa	FL
Marriott - Okahumpka Travel Plaza	Florida Turnpike Mile Mrk 299	Wildwood	FL

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Project Name	Address	City	State
Cherokee County Public Safety Complex		Canton	GA
Montgomery County Courthouse		Chula	GA
Paulding County Courthouse	Courthouse Square	Dallas	GA
Handcock Co. Courthouse		Greenfield	IN
Courthouse		Tipton	IN
Campbell County Courthouse	4th Street	Newport	KY
Westover AFB Hangar		Chicopee	MA
Westover AFB Upgrade Hangar B-700		Chicopee Falls	MA
Melrose City Hall	Essex& Main St	Melrose	MA
Natick Municipal Complex		Natick	MA
Mt. Holyoke Summit Lodge	Holyoke State Park	S. Hadley	MA
Wellesley Town Hall	525 Washington St	Wellesley	MA
Bethesda Metro Center	7450 Wisconsin Ave	Bethesda	MD
National Park		Landover	MD
Van Buren County Courthouse		Paw Paw	MI
Public Service of New Hampshire Corporate Hdqrts.		Mancester	NH
Veterans Memorial Home	132 Evergreen Rd	Edison	NJ
Oyster Creek Emergency Bldg	Route 9	Forked River	NJ

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Project Name	Address	City	State
Municipal Complex		Hanover Twp.	NJ
Manchester Town Hall	1 Colonial Drive @ Rte 37	Lakehurst	NJ
Morris County Hall of Records	Ann Street	Morristown	NJ
NJIT Library Bldg	Central Ave	Newark	NJ
South Brunswick Maintenance. Storage Complex		S. Brunswick	NJ
City Hall and Police Dept	Morris & Springfield Aves	Summit	NJ
GTE Government Systems White Sands Missile Range		WSMR	NM
State Legislature Building			NV
Yuca Mountain Test Site			NV
Regional Justice Center		Las Vegas	NV
New Reno Federal Building		Reno	NV
Galena Maintenance Station		Washoe	NV
Broadway Office Complex	625 Broadway	Albany	NY
Transitional Housing	Jackson & Cypress	Bronx	NY
Transitional Housing	141st	Bronx	NY
Transitional Housing for the Homeless	50 W. Mt Eden & Inwood	Bronx	NY
Transitional Housing	Linden Blvd	Brooklyn	NY
Transitional Housing for the Homeless	St. Johns Place & E. NY Ave.	Brooklyn	NY

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Project Name	Address	City	State
Family Court Building		Buffalo	NY
The Rath County Office Building		Buffalo	NY
Tompkins County DOT Admin Facility. Bus Garage	Willow Ave	Ithaca	NY
Police & Hwy Dept Bldg	525 Pavement Road	Lancaster	NY
Niagara Falls Housing Authority-Wrobel Towers	Main Street	Niagara Falls	NY
Orchard Park Municipal Center	S-4295 South Buffalo Street	Orchard Park	NY
Criminal Courts Building		Riverhead	NY
Roosevelt Island Phase II	Building I	Roosevelt	NY
Manhasset Fire House	Prospect Rd	Thomaston	NY
West Valley Nuclear Services		West Valley	NY
Logan County Court House		Bellefontaine	OH
Wood County Court House		Bowling Green	OH
Gurnet County Courthouse		Cambridge	OH
Pickway County Courthouse		Circleville	OH
Fayette County Courthouse		Fayette	OH
Trumbull County Courthouse		Trumbull	OH
Owasso City Hall		Owasso	OK
Coudersport Court House		Coudersport	PA

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Project Name	Address	City	State
Potter County Courthouse	1 East Second Street	Coudersport	PA
Cameron County Courthouse	20 East Fifth St	Emporium	PA
Emporium Court House		Emporium	PA
Valley Forge Plaza	First & Moore rd	King of Prussia	PA
Berks County Courthouse	6th & Court St,	Reading	PA
Berks County Services Center	Reed & Court Sts	Reading	PA
Elk County Court House		Ridgeway	PA
Warren County Courthouse		Warren	PA
City Hall Ave Parking Facility		Norfolk	VA
FBI Firearms Range Renov. [26m Range & Stress Obst		Quantico	VA
National Parks Service bldg	North Cascades Visitor Ctr	New Halem	WA

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Preface from NFPA 780

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REPORT OF THE THIRD-PARTY INDEPENDENT EVALUATION PANEL ON THE EARLY STREAMER EMISSION LIGHTNING PROTECTION TECHNOLOGY

BY

John L. Bryan

Richard G. Biermann

Glenn A. Erickson

Submitted to the National Fire Protection Association Standards Council on September 1, 1999

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Rison (336) reported in 1991 on studies conducted at the Langmuir Laboratory from July 15 to August 23, 1991 to evaluate whether a radioactive ESE air terminal provided protection within a 100 meter radius as reported by the Manufacturer. The ESE device was installed on a twenty foot mast 4 meters below South Baldy Peak. Video cameras were used to record the occurrence of lightning strikes. There were two recorded lightning strikes within the 100 meter radius area during the approximate five week study, one 85 meters from the ESE device and one approximately 78 meters from the device. However, the following statement should be noted from the report:

> Near the end of the test period, it was noticed that the radioactive Preventor had been damaged --the weld had broken between the spherical ball on the Preventor and the nut to which it attached. It is not certain when or how this happened. There was no evidence of tampering or vandalism. Examination of the tip of the Preventor under a microscope showed evidence of melting, such as would occur if lightning were to have struck it. Most likely, the Preventor was struck by lightning at a time when the camcorders were not turned on (when the peak was in a cloud, or a storm occurred in the early morning hours), and the lightning broke the weld.[13]

Thus, it might appear that the ESE device was active in a lightning strike not recorded by the video cameras utilized during the study, since there were periods during the study when the cameras were inactive.

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[13]Rison, William, A Study of Lightning Strikes in The Vicinity of a Radioactive Preventor, Langmuir Laboratory, New Mexico Tech., Socorro, NM, 11-8-91, p. 4.

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Moore *et al.* (248) reported in 1998 a summary of all the field tests of the radioactive "Preventor" ESE device during the summers of 1990, 1991, 1993, 1994, 1995, 1996, and 1997. Moore's analysis is as follows:

> In the six summers during which the "preventor" was exposed to thunderstorms overhead, lightning struck six different sites within 100 meters of the device yet the "preventor" itself was never struck.
>
> Digitized measurements with quarter-microsecond time resolution, of the currents that flowed from the "Preventor" during two nearby lightning strikes in September 1997 showed no indication that the "Preventor" emitted any effective "early streamers". In fact, during one of these discharges, lightning struck a blunt rod located 20 meters distant yet no streamers were emitted from the "Preventor" to connect with this close strike.[14]

It should be noted these seven-year tests involved a single ESE device of a radioactive type. It should also be noted that Moore's (243) field studies under natural lightning conditions have questioned the validity of the effectiveness of the sharp-pointed Franklin air terminal as follows:

> The failure of radioactive-ionizing and of sharply pointed air terminals to participate in lightning discharges by being pre-eminent connectors of lightning to earth is no surprise to solentists studying thunderstorms and lightning. For the past 40 years, I have been measuring the electric currents flowing into the air from both radioactive electrodes and from sharply pointed ones under the influence of the strong electric fields beneath thunderstorms but not one of my well-exposed electrodes has ever been struck by lightning.[15]

[14] Moore, C. B., William Rison, and G. D. Aulich, An Assessment of The Radioactive "Preventor" as an Early Streamer Emitting Lightning Protector, New Mexico Tech., Langmuir Laboratory for Atmospheric Research, Socorro,NM, 12-29-98, pp. 24-25.

[15] 243. Moore, Charles B., New Mexico Tech., "Personal Communication to Subcommittee of NFPA Board of Directors", 9-4-95, p. 1.

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2. Consideration of System Performance

It would appear the ultimate evaluation of any complete lightning protection system would be the performance of the systems as installed on buildings. The submitted materials included one reference to the failure of a conventional system with Franklin rods (328) and there was one newspaper account of a Franklin rod system failure resulting in personnel injuries. (252) There were several studies of failures of ESE lightning protection systems. (146) (220).

The failure of the Franklin rod system resulting in the eleven personnel injuries occurred at the Robert F. Kennedy stadium in Washington, D.C. on June 13, 1998. (252) Richardson reported on the failure of a Franklin rod air terminal located approximately four feet from an externally mounted camera on the building which was damaged by a lightning strike. (328)

Makerras *et al.*, (220) have reported on four cases of lightning striking buildings in Singapore from the late 1960's until the 1980's. Hartono and Robiah (146) have reported on ten cases of failures on buildings protected with ESE lightning protection systems. This study utilized photographs of the building conditions both before and after the reported lightning strikes on the damaged areas of the buildings. It was found from this photographic study the damage appeared to be dependent on the number of strokes received, the strength of the lightning stroke and

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the shape of the structure at the point of the stroke. Although not specified in the study Hartono and Robiah have indicated lightning strike damage was found on buildings protected with Franklin air terminals as indicated in the following statement:

> Studies conducted on the buildings equipped with the standard lightning air terminals (Franklin rod type) also exhibited similar lightning damage locations on or near the rooftop. Based on this comparison, we conclude that no advantage can be obtained by using the ESE device in protecting the building against direct lightning strikes.[21]

It should be noted that all of the incidents of system failure submitted to the panel lacked the necessary detailed documentation to enable a valid analysis as to the effectiveness of the system. Even the most detailed photo study lacked the necessary documentation consisting of the following: The manufacture and model of the air terminal. The date the installation was completed, thus establishing the age of the system when the lightning strike occurred. The maintenance and condition of the system when the strike occurred, including the condition of the down conductors and the grounding system. It would appear that detailed documentation of lightning protection system operations or failures is a needed component for the evaluation of the effectiveness of lightning protection systems of all types on various buildings of differing heights and configurations.

[21]Hartono, Zainal Abidin and Ibrahim Robiah, A Long Term Study on The Performance of Early Streamer Emission Air Terminals in a highly Isokeraunic Region. 2-19-99, p. 2.

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Van Brunt *et al.*, (369) has referenced this problem of adequate data on lightning protection system performance in the following manner:

> There are reports of incidents where ESE devices failed to provide the protection specified by the manufacturer [156,158,165,215]. Statistics on the failure of conventional systems have also been documented [109]. When examining reports of "failures", one can always raise questions about their cause, e.g., whether they are primarily a consequence of exaggerated claims made by the manufacturer or a consequence of misuse (faulty installation) of the device. Reports of isolated failures raise legitimate concerns, but are seldom accompanied by enough supporting data about the event to enable a determination of why the failure occurred. Generally it is difficult to draw significant conclusions from single events that can be used to improve system design or evaluate system performance.[22]

Thus, given the present situation of lightning protection system performance not being a priority of the proponents of the systems, the manufacturers, the insurance companies or public officials it would appear little valid information or data relative to a validation of the theoretical basis of the systems will be obtained.

III. RECOMMENDATIONS TO STANDARDS COUNCIL

Based on a thorough and complete evaluation of the 377 items submitted to the third-party independent panel the members of the panel have agreed in a complete consensus on the following recommendations to the National Fire Protection Association Standards Council. It should be

[22]Van Brunt, Richard J., Thomas L. Nelson, Samar L. Firebaugh, Early Streamer Emission Air Terminals Lightning Protection Systems: Literature Review and Technical Analysis. Quincy, MA. National Fire protection Research Foundation,1-31-95, p, 25.

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recognized the Standards Council is the official designated authority on any action to be taken relative to the NFPA lightning protection documents.

A. Scientific and Technical Basis of ESE

The initial question posed to the third-party independent evaluation panel was stated as: "whether the ESE lightning protection technology is scientifically and technically sound." The panel's review of the submitted materials resulted in the following determinations:

1. The ESE air terminals appear to be technically sound since they are generally equivalent to the conventional Franklin air terminal in laboratory experiments.

2. However, neither the ESE air terminals nor the conventional Franklin rod appear to be scientifically or technically sound when evaluated in field tests under natural lightning conditions.

3. The ESE lightning protection technology as currently developed in the installation of complete systems does not appear to be scientifically and technically sound in relation to the claimed areas of protection or the essentials of the grounding system.

B. Adequacy of Theoretical Basis and Lab Tests

The second specific question posed to the third-party independent review panel was stated as: "whether the ESE lightning protection technology is supported by adequate scientific-theoretical basis and

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laboratory testing." The panel's review of the submitted materials resulted in the following determinations:

1. There does appear to be an adequate theoretical basis for the early streamer emission lightning protection air terminal concept and design from a physical viewpoint.

2. There does not appear to be an adequate theoretical basis for the claimed enhanced areas of protection with limited down conductors and grounding system.

3. The high voltage laboratory tests of the ESE air terminals appear to be adequate in scope and quantity, but they are limited in that they are not equivalent to an evaluation of the complete ESE lightning protection system under natural thunderstorm conditions.

C. NFPA Lightning Protection Documents

The third-party independent evaluation panel was also directed in the Settlement Agreement as follows: "This panel, in issuing its report, shall address the following issues, and any other issues it deems relevant:" The panel considered the issues of the existing NFPA 780 document titled: Standard for The Installation of Lightning Protection Systems 1997 edition, (294) and the proposed NFPA 781 document titled: Standard for Lightning Protection Systems Using Early Streamer Emission Air Terminals. (277) The panel considered the need for each document and each committee's membership and balance in accordance with NFPA

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procedures. The panel's review of the submitted materials resulted in the following determinations:

1. The current NFPA 780 Committee should be discharged and the Committee should be completely restructured. The committee needs new and additional memberships in the membership categories of enforcer, consumer, user, insurance, labor, special expert and research/testing..

2. The Council should solicit memberships from prominent users such as: FAA, DOE, DOD, NASA, IBM, Reedy Creek Improvement District, phone, radio, television organizations and electric power utilities.

3. The NFPA 780 document should be reformulated as a Guide or Recommended Practice. It appears to the panel the NFPA 780 document does not meet the NFPA criteria for a standard since the recommended lightning protection system has never been scientifically or technically validated and the Franklin rod air terminals have not been validated in field tests under thunderstorm conditions. The NFPA criteria for a standard as stated in the NFPA 99 Directory (298) is as follows:

> Standard --A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fineprintnote and are not to be consider as part of the requirements of a standard.[21]

[21]NFPA, National Fire Protection Association 1999 Directory, Quincy, MA, 11-98, p. 52.

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EARLY STREAMER EMISSION AIR TERMINALS LIGHTNING PROTECTION SYSTEMS

LITERATURE REVIEW AND TECHNICAL ANALYSIS

Prepared by

Dr. Richard J. Van Brunt
Thomas L. Nelson
Samara L. Firebaugh



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BATTERYMARCH PARK
QUINCY, MASSACHUSETTS, U.S.A. 02269

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January 1995

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development has been established from laboratory investigations [113], considerably less is known about the dynamics and interactions of these species in a discharge compared to what is known about ions. In particular, very little is known about how they contribute to lightning discharge initiation or propagation under relevant atmospheric conditions. As with negative ions, the metastable content of the air around a lightning terminal will be affected by relative humidity and general air contamination. The influence of metastable species should not extend significantly beyond the end of a lightning rod. Their role, if anything, will be to enhance initial development of a streamer at the rod tip.

In summary, it would appear that enhancement of upward streamer initiation from an ESE terminal (compared to a conventional terminal) has a plausible physical basis. However, it would also appear that a complete and universally accepted understanding of how all ESE devices work has not yet been achieved, and it can be argued that a better understanding is needed to make meaningful quantitative comparisons between the performances of ESE and conventional devices. To reach such an understanding it will undoubtedly be necessary to address numerous basic questions such as:

1. What are the predominant streamer initiation mechanisms under different conditions of polarity, atmospheric humidity, air contamination, and terminal geometry?

2. What are the relative roles of ions, electrons, and metastable species on the development and propagation of a streamer discharge from a terminal for different conditions?

3. What is the likelihood of corona formation around a terminal and how will the presence of corona affect the ability of the terminal to launch a streamer upon approach of a lightning stroke?

4. In the case of radioactive terminals, what is the dependence of the streamer initiation probability on the intensity and type of radiation source?

5. In the case of electrically triggered devices, how does the streamer initiation probability depend on the timing and magnitude of the electrically triggered spark?

6. Also for electrically triggered devices, how reliable is the field sensor that controls the triggering, and can its performance be affected by local space charge?

Attempts to find answers to questions like these are the focus of much ongoing experimental and theoretical research, not only on lightning, but on electrical discharge phenomena in general.

D. Validation of ESE System Performance

Three general methods have been used to evaluate and test the performance of lightning protection systems, namely: 1) small-scale laboratory or outdoor tests in which lightning, or the effects of lightning are simulated by applying high-voltage impulses

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lightning seldom hits a terminal regardless of whether or not it is equipped with an ESE device [182,183,215]. Although a few isolated strikes to the mountain were reported to have occurred within the supposed zones of protection of ESE terminals [183,215], it would appear that the overwelming majority of strikes to the mountain were at considerable distance from any terminal. In any case, the failure of air terminals to attract lightning on mountain tops at elevations of 3000 m (9843 feet) or more is obviously disturbing and raises questions about the interpretation of such observations. Before any serious conclusions are drawn about the performance of lightning attractors from tests performed on mountain tops, it may be necessary to consider the perturbing effect of the mountain itself on such parameters as the surface charge distribution and electric-field profile under a thundercloud, as well as the extent that lightning strokes at such high elevations differ from those that normally occur in lower, flatter locations. It would appear that the answers to some of these questions might already be found in the literature.

It is noted in some papers that lightning that occurs at high elevations generally differs on average from that which occurs at sea level, if in no other respect than that it has less distance to cover in going from the cloud to ground [36]. At an elevation of 3000 m, the ground can be quite close to or even engulfed by the base of a storm cloud. Certainly the results from high mountain tests cannot be dismissed, and such tests should continue, as should similar tests underway at other locations [107]. The problem is how to interpret the results of these tests and infer what they might imply about air terminal performance at lower elevations, and what they indicate about the influence of mountainous or rocky terrain on the effective zone of protection of an air terminal.

The unfavorable statistical odds associated with natural lightning can be partially overcome by using artificially triggered lightning. Tests have shown that lightning can be triggered with reasonably high probability by a rocket launched into a thundercloud [124,160,190,193]. A long trailing wire is usually attached to the rocket which provides a low resistance path to guide the initial discharge and define its direction of propagation [45,120,193]. Transportable facilities have been developed for rocket triggering of lightning that can be used for testing at nearly any location [231]. Although tests of air terminals are being made using triggered lightning, there are questions that can be raised about the meaning of such tests. There is evidence that triggered lightning is unlike natural lightning both in its intensity and propagation characteristics. In particular, it has been noted that triggered lightning is of lower current than natural lightning and exhibits characteristics more like those of return strokes observed in natural lightning [78,161]. It has also been argued that triggered lightning does not satisfactorily mimic the primary stroke and is therefore unsuited for investigation of the attachment to a grounded lightning conductors, i.e. its use in evaluating air terminals would appear to be questionable [78]. The extent to which rocket-triggered lightning behaves like natural lightning seems to depend on the length of the trailing wire and the distance of the bottom end of the wire above

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9. Radiation hazards

In the case of ESE devices that employ radioactive materials, issues have been raised in the literature about the possible radiation hazards to humans that the use of these devices present [24,25,39,81,180,196,278]. As noted above, radioactive air terminals are banned in some countries, presumably because of perceived health hazards. It has been noted that ^{241}Am sources used in lightning protection devices are not any more hazardous than similar sources approved for use in smoke detectors or static eliminators [109,167,180]. Nevertheless, there are those who argue that the public may be placed at risk from a proliferation of radioactive materials in devices that can enter the environment without adequate controls [25,81,180]. An evaluation of the health and safety aspects of radioactive sources used in air terminals lies outside the scope of this report. However, we have identified this as a serious issue that the manufacturers and users of radioactive terminals must be prepared to address.

4. Damage and maintenance

Given that ESE devices likely have a structure and associated instrumentation that are more complex than conventional air terminals, questions can be raised about their susceptibility to damage during a lightning strike. The electric current and energy deposited by a lightning stroke can be sufficiently high to actually melt metallic structures and destroy electronic components. There are numerous reports of damage inflicted by the primary lightning stroke to metal parts on aircraft, etc. [70,79,138,209,237,269]. The possibility of damage means that a lightning protection device may require periodic inspection and/or maintenance that is generally not required for conventional terminals. Although this problem is pointed out [155], there seems to be very little discussion about it in the open literature.

IV. CONCLUSIONS

The possible conclusions that can be drawn from an examination of the literature included in the bibliography are discussed in this section. The main conclusions of this report are briefly summarized in Section VI.

Because of the sparsity of information that can be found in the peer-reviewed literature from tests of early streamer emission air terminals, either in the laboratory or in the natural environment, it is nearly impossible to make quantitatively meaningful statements or judgements about the performance of ESE devices in comparison to conventional Franklin rods. In fact, insufficient reliable quantitative data seem to exist about the performance of conventional rods, and there seems to be an ongoing debate about the best geometrical design for conventional terminals required to achieve optimum lightning attraction efficiency.

Nearly all of the information or data that could found on ESE device performance resulted either from tests performed by manufacturers of lightning protection sys-

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tems or by those directly or indirectly employed by such manufacturers. Although abundant criticism is published by non-manufacturers about the performance of ESE devices, especially radioactive air terminals, it is seldom based on actual test data. Those on both sides of the issue invoke lack of evidence in making their case about the performance of ESE terminals. Proponents of these devices claim that a lack of credible statistical data on failure of ESE terminals proves their effectiveness; while critics of these terminals argue that a lack of evidence about the improved performance of ESE terminals over conventional terminals proves their ineffectiveness. In either case, one must beware of faulty logic, in as much as a lack of evidence never proves the lack of something.

There are reports of incidents where ESE devices failed to provide the protection specified by the manufacturer [156,158,165,215]. Statistics on the failure of conventional systems have also been documented [109]. When examining reports of "failures", one can always raise questions about their cause, e.g., whether they are primarily a consequence of exaggerated claims made by the manufacturer or a consequence of misuse (faulty installation) of the device. Reports of isolated failures raise legitimate concerns, but are seldom accompanied by enough supporting data about the event to enable a determination of why the failure occurred. Generally it is difficult to draw significant conclusions from single events that can be used to improve system design or evaluate system performance. There is no reason to believe that an air terminal is 100% efficient in attracting lightning, regardless of what kind of ESE device it uses, if any. Considering the wide range of possible atmospheric conditions and types of lightning behavior that have been recorded, it is not surprising that air terminals of all types will sometimes fail [37,201,271]. Tall structures are reported to be struck occasionally by lightning at points far below the top, i.e., outside of the "protection zone" [173,185,186]. Any claims of 100% efficiency in the performance of a lightning attractor should be viewed with skepticism. In any case, the meaning of the term "efficiency", when specified for an air terminal, should be clearly defined and understood.

A reasonable physical basis for the operation of an ESE device appears to exist in the sense that there is good evidence from laboratory investigations that the probability of initiating a streamer discharge from an electrode can be increased significantly by irradiation or electrical triggering. However, the precise amount by which this enhancement in streamer initiation improves the lightning attraction efficiency of an air terminal remains questionable. There is reason to doubt that it significantly extends the maximum range of protection. A lightning stroke that would not hit a conventional terminal because of the fact that it does not enhance the field at the terminal tip enough to allow streamer formation will also not likely hit a terminal equipped with an ESE device. (The exception would be an ESE device that significantly increases the terminal potential during the approach of a lightning stroke.) In our view, the possible advantage offered by an ESE device, if operated properly, is that it helps to insure that a streamer will be initiated if the field produced by the

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E7255

Date Submitted	12/20/2018	**Section**	450.3.19	**Proponent**	Bryan Holland
Chapter	4	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation Approved as Submitted
Commission Action Pending Review

Comments

General Comments Yes

Alternate Language No

Related Modifications

7209, 7211, and 7212

Summary of Modification

This proposed modification revises the requirements for lightning and surge protection for added clarity and effective enforcement.

Rationale

This proposed modification simply revises the language to clarify the rules. The change to .1 corrects the proper name for the NFPA 780 Standard. The changes to .2, .3, and .4 are minor editorial revisions for clarity. The change to .5 corrects the product name from "suppressors" to "protectors" as indicated by the UL 497 and UL 497A Standards.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification does not add any new criteria so impacts to the local entity are minimal.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will not change the cost of compliance to building or property owners.

Impact to industry relative to the cost of compliance with code

This proposed modification will not impact the industry relative to the cost of compliance with code.

Impact to small business relative to the cost of compliance with code

This proposed modification will not impact businesses relative to the cost of compliance with code.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed change clarifies the rules for lightning and surge protection which directly impacts the health, safety, and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves the code by adding clarity and correcting used terms.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

2nd Comment Period

E7255-G2

Proponent Michael Riley **Submitted** 5/23/2019 **Attachments** Yes

Comment:

Proposed code modification 7255 does not meet the statutory standards of Chapter 553. See attached comments.

2nd Comment Period

E7255-G3

Proponent Bryan Holland **Submitted** 5/26/2019 **Attachments** No

Comment:

Please disregard general comment SP7255-G2. The comment is not valid as it attempts to address the existing requirements of the code and not the proposed modification that is currently open for comment. The editorial revisions made to this section by the modification did not add to or take away from any of the current requirements. Therefore, none of the statements made in the general comment are relevant.

2nd Comment Period

E7255-G4

Proponent Joe Bigelow **Submitted** 5/28/2019 **Attachments** Yes

Comment:

Submitted by Shroder Joseph & Associates via FedEX

1st Comment Period History

E7255-G1

Proponent Vincent Della Croce **Submitted** 1/8/2019 **Attachments** No

Comment:

I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

450.3.19 Lightning protection.

450.3.19.1

A lightning protection system shall be provided for all new buildings and additions in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

450.3.19.2

Where additions are constructed to existing buildings, the existing building's lightning protection system, if present, shall be interconnected to the new lightning protection system. ~~connected to the new lightning protection system, shall be inspected and brought into compliance with current standards.~~

450.3.19.3

~~There shall be sure protection~~ Surge protective devices (SPDs) shall be installed in accordance with NFPA 70, National Electrical Code, as required by NFPA 780, Standard for the Installation of Lightning Protection Systems for all normal and emergency electrical services.

450.3.19.4

Additional surge protection shall be required for all low voltage and power connections to all electronic equipment in critical care areas and life safety systems and equipment such as fire alarm, nurse call and other critical systems. Protection shall be in accordance with NFPA 70, National Electrical Code and the appropriate IEEE Standards for the type of equipment protected.

450.3.19.5

All ~~low-voltage~~ communication systems ~~main or branch circuits~~ entering or exiting the structure shall have surge ~~suppressors~~ protectors installed for each pair of conductors and shall have visual indication for protector failure to the maximum extent feasible.

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The controlling statutory standards for approving an amendment or modification to the Florida Building Code are as follows. Proposed code modification 7255 does not meet the statutory standards:

1. *Is needed in order to accommodate the specific needs of this state.*
2. *Has a reasonable and substantial connection with the health, safety, and welfare of the general public.*

It is undisputed that structural fire incidents are declining – not increasing – in the United States from 1977 to 2015 so there is no reason for FBC to impose this new tax for LPS and SPD on Florida's economy. Haynes, *Fire Loss in the United States 2015*, NFPA, September 2016, Figure 1 at p. 11. Haynes concludes that "[t]he total number of fires continues to be on a downward trend, as does the number of outside fires, structure fires and vehicle fires." P. 35. Direct property damage from lightning fires has declined as well from 1977 to 2015 in 2015 dollars. More specifically, the amount of direct property damage to non-home structures caused by lightning fires dropped over 70% annually from 1980 to 2014 ($249 million to $65 million). Ahrens, *Structure Fires Started by Lightning*, NFPA, April 2017, at Table 2, p. 4. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/fire-causes/lightning-fires-and-lightning-strikes

In 2011 Fire Departments reported 27,100 total lightning fires in the United States. Of these reported fires 20,400, or 75% of the total, were outside fires or non-structure fires. Only 7% of lightning fires from 2007-2011 were "non-home structure fires." Ahrens, *Lightning Fires and Lightning Strikes*, NFPA, Fire Analysis and Research Div., June 2013, p. 1. Exhibit C. There were only 1,800 "non-home structure" fires. *Lightning Fires and Lightning Strikes* at Table 4, p. 14. By 2014, the number of "non-home structure fires" was even lower (1,400). *Structure Fires Started by Lightning*, at Table 2, p. 4.

Therefore, the Proposed Code Modification is not needed and does not have a reasonable and substantial connection with the health, safety and welfare of Floridians. The Proposed Code Modification overstates the risk and costs of lightning damage to structures in Florida and given the overstated threat of damage caused by lightning strikes, the costs of complying with the proposed LPS and SPD requirements exceed the benefits of their installation in Florida.

3. *Strengthens or improves the Florida Building Code, or in the case of innovation or new technology, will provide equivalent or better products or methods or systems of construction.*
4. *Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities.*

The restriction of approved LPS to only NFPA 780-compliant systems provides no equivalent products, methods, or systems of construction and is entirely discriminatory as to all other products, methods and systems. The Proposed Code Modification would wholly exclude from Florida construction projects UL Certified Lightning Protection Systems and specific Components and Systems such as UL96A Master Labeled LPSs and UL Letter of Findings LPS.

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Further the modification excludes LPS such as IEC 62305, DOD DDESB 6055.9, DOE M440.1-1, FAA Std – 019e, FAA 6950.19A, NASA E-0012F, API – 2003, and any new LPS technology that may be developed and otherwise certified.

5. *Does not degrade the effectiveness of the Florida Building Code.*

An inherent conflict exists in the Proposed Code Modification. While LPS must be NFPA 780-compliant, SPD must be installed in accordance with NFPA 70, National Electric Code. These codes conflict as to installation of SPDs and where they are required to be installed in a structure.

§553.73 (9) (a)

Further, a proposed amendment must include a fiscal impact statement that documents the costs and benefits of the proposed amendment:

The proposed modification would needlessly – but substantially – unfairly tax the Florida economy. The narrative for Proposed Code Modification 6460 in 2017 providing for new LPS building requirements admitted that "[t]he average cost of a complete LPS is approximately 1% to 5% of total construction cost of the building." Dr. Issa's draft report presented to the Technical Advisory Committee at that time directly acknowledges these additional costs:

> "[t]he largest cost impact for the 2015 Florida specific changes came from proposed code change E6460, the installation of Lightning Protection Systems (LPS). The anticipated cost of the LPS was estimated to add 5% to the buildings total cost. Up to 80% of that cost reportedly could be offset through insurance reductions, **however such insurance reductions are not guaranteed and were therefore omitted from this cost estimate.**" (emphasis supplied) Issa, *Evaluation of the Cost Impact of Florida's specific changes to 2015 I-Codes "Prescriptive Code Changes"*, Draft Final Report, April 17, 2017, at Executive Summary p. 1.

§553.73 (9) (b)

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May 23, 2019

Via Federal Express

Florida Building Commission
Special Occupancy Technical Advisory Committee
2601 Blair Stone Road
Tallahassee, Florida 32399

Via Email (rsbrowdy@aol.com)

Richard S. Browdy
Chairman, Florida Building Commission
2601 Blair Stone Road
Tallahassee, Florida 32399

Re: Comments on Proposed Code Modification 7255, Florida Building Code

Gentlemen:

Our law firm represents Heary Bros. Lightning Protection Co., Inc. ("Heary Bros.") and its division, Lightning Preventor of America®. Heary Bros. offers both NFPA 780 compliant systems as well as its Preventor® system which is an early streamer emission system ("ESE system") that is installed in compliance with its manufacturer's standard, HBP 21. This letter is submitted to comment on proposed Modification 7255 to require that all Florida nursing homes install lightning protection systems in accordance with National Fire Protection Association ("NFPA") 780. The modification should not be accepted and instead there should continue to be the ability for the owner, architect and engineer on such projects for ALFs to select the type of lightning protection system that best fits the needs of the project.

Under the rules governing modification of the Florida Building Code, a prerequisite to accepting a proposed modification such as E6460 is that it "DOES NOT DISCRIMINATE AGAINST MATERIALS, PRODUCTS, METHODS, OR SYSTEMS OF CONSTRUCTION OF DEMONSTRATED CAPABILITIES." (553.73 (9) (a) 3 F.S.). It is respectfully submitted, for the reasons discussed in detail below, that Modification 7255 cannot be accepted because it will violate this fundamental prerequisite under Florida State law (553.73 (9) (a) 3 F.S.) by discriminating against manufacturers and installers of Early Streamer Emission ("ESE") lightning protection systems which constitute a competing alternative of "demonstrated

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capabilities." Indeed, there is no reasonable justification for favoring Faraday lightning protection systems installed under NFPA 780 over ESE lightning protection systems installed under HBP 21 or other equivalent standards which have been approved, specified by architects and engineers and successfully used for many decades throughout the United States and the world.

THE NEED TO REJECT THE PROPOSED MODIFICATION

While most if not all companies in the lightning protection industry either exclusively provide either Faraday Systems or ESE Systems, Heary Bros. manufactures both types of lightning protection systems available in the marketplace today: (1) the traditional Faraday lightning protection systems governed by NFPA 780; and (2) its ESE lightning protection systems which have been successfully installed under HBP 21 for over 30 years under its $11 Million Guaranty backed by Travelers Insurance Company without a single documented lost. Proposed Code Modification 7255—as proposed--would eliminate for Florida Building owners the ESE option.

Importantly, Heary Bros. does not seek to exclude other ESE manufacturers or installers by offering its proven standard known as HBP 21, a copy of which is attached as Exhibit A, as one proven alternative standard. **Instead, the Florida Building Commission should accept other alternative equivalent standards and not limit the standard to NFPA 780.** The point is that architects, engineers and owners should be free to make a choice and should not be limited to one option, particularly since modification 7255 was propounded by a representative of the Faraday Industry which stands to obtain an exclusive monopoly under the proposal. Notably, these types of restrictive changes to the Florida Building Code to require that lightning protection systems comply with NFPA 780 have been proposed by the Florida Industry previously and rejected by the Florida Building Commission for sound reasons in 2017. *See, e.g.*, Modification E6460 rejected by the Florida Building Commission in 2017.

There is no reason to adopt Proposed Modification 7255 and limit the lightning protection systems for Florida nursing homes to compliance with NFPA 780. Not only does Heary Bros.' HBP 21 have a proven track record, but it also has the support of Traveler's insurance which provides $11 million in coverage to support Heary Bros.' guaranty of its ESE system. This support is documented by Exhibit B. The reason that Heary Bros. offers both options to its customers is because its ESE system offers a much less expensive option while its NFPA 780 Faraday alternative is more expensive with no technical or scientific basis of superior performance to justify the added cost. Heary Bros. believes the consumer should have the option to decide. Modification 7255—which Heary Bros. learned about for the first time in this week—should be rejected or modified so as not to eliminate that choice for Florida owners, architects and engineers.

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As explained below, not only has it been established in the lightning protection industry that there is no scientific basis for preferring the method of installation of the Faraday system whose installations are governed by NFPA 780 over ESE lightning protection systems, but also the installation approach of the Faraday systems (which uses more cable and more terminals) renders the Faraday System more costly with no added benefit to owners and consumers.

Heary Bros. readily concedes that its profit margins with respect to the sale of the components of Faraday systems exceeds the profit margins on ESE systems because the installation design for Faraday systems requires more cables, more down runs and more terminals and connections despite the lack of any scientific basis for claiming a difference in performance of the two systems. It should come as no surprise that the proponent of this change in the Florida Code is the Faraday Industry and those companies that exclusively install only Faraday Systems under the NFPA 780 standards. These entities consistently promote codes based on NFPA 780 and dominate the NFPA 780 committee.

There is no difference between the quality of the components of ESE systems and Faraday systems. Notably, the components of both the Faraday System and the ESE systems have been listed by Underwriters' Laboratories, Inc. pursuant to UL 96 which provides the "quality control" for component parts of lightning protection systems. In contrast, NFPA 780 ONLY governs the method of installation and requires more cabling, terminals, connectors and more grounding because of differences in the terminals used by each of these two competing systems.

Other factors to consider are that NFPA itself discloses that NFPA 780 has no scientific basis and has never recommended that this standard be adopted as "code." Further, the author of this letter made presentations to New York State when it considered adopting a similar code change more than two decades ago and New York State ultimately rejected the very code change now being considered— a change virtually identical to that being proposed here—and ruled that there was "no technical justification" for its adoption. Again, the proposed change in law simply imposes more costs on building owners with no scientific or practical justification.

If there is an argument being made regarding "insurance savings" by the proponents of this change in law, their evidence merely confirms that lightning protection—may in some few instances—results in insurance rebates, but the documentation does not show that only NFPA 780 systems are eligible for such rebates or whether these rebates are applicable solely to surge protection which is a separate and distinct product.. Moreover, what is indisputable is that the Faraday systems governed by NFPA 780 systems are NOT eligible for Heary Bros. $11 million guaranty backed by Travelers Insurance Company which Travelers offers only for ESE systems installed in compliance with Heary Bros.' manufacturer's standard—coverage which is provided based on Heary Bros.' decades of field experience with this type of system that exceeds thirty

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years. Copies of documentation demonstrating this insurance coverage are attached hereto as Exhibit B.

Perhaps the best illustration of burden that Proposed Modification 7255 would impose on building owners is the fact that so many building owners have in the past chosen the ESE system in preference to the Faraday system governed by NFPA 780. I have attached as Exhibit C a list of just a small sampling of Florida projects now enjoying the benefits of Heary Bros.' ESE system and $11 Million Guaranty which include numerous government and municipal buildings, resort and recreational centers, churches and corporate buildings. This constitutes a small sampling of Heary Bros.' ESE installations throughout the State of Florida—all of which have been installed in compliance with Heary Bros.' manufacturer's standard and have NOT been the subject of a single documented failure. Similarly, Federal and State governments have preferred the option of Heary Bros. ESE system with its $11 million guaranty over Faraday systems governed by NFPA 780. A list of a sampling of these projects is attached as Exhibit D which included, by way of illustration, such buildings as the Huntsville Alabama Public Safety Complex, the Los Angeles Federal Building, San Diego V. A. Medical Center, the Cape Canaveral Air Force Station, the Council Building for City of Coconut Creek, Florida, the Tampa Gateway Post Office Building, the Holmes Beach Florida Baseball Field and the U.S. Naval Air Station in Milton Florida. Again, these are just a very few examples of government installations in various States from all over the United States.

NFPA ITSELF MAKES CLEAR THAT NFPA 780 IS NOT SCIENTIFICALLY BASED

The proponents of the Faraday systems governed by NFPA 780 often argue that the existence of "national standards" for Faraday Systems (such as NFPA 780 and its parallel standard UL96A) somehow demonstrates that Faraday Systems are "scientific" and "proven." These types of statements are inconsistent with the very nature of national standards in the United States. NFPA 780 itself makes it very clear in its disclosures that NFPA 780 is NOT based on science, research, records of testing or even field experience. Instead, the NFPA specifically includes in the preamble to NFPA 780 (and in all NFPA consensus standards) the following disclaimers as to the efficacy of such standards:

> "While **the NFPA** administers the process and establishes rules to promote fairness in the development of consensus, it **does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards. The NFPA disclaims liability for any personal injury, property or other damages** of any nature whatsoever….directly or indirectly resulting from the …use of, or reliance on this document. **The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.**"

This excerpt from the preface to NFPA 780 is enclosed as Exhibit E. (Emphasis added.)

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THE LEADING INDUSTRY LITERATURE REJECTS ANY SUPERIORTY OF FARADAY SYSTEMS OVER ESE LIGHTNING PROTECTION SYSTEMS

We have attached the most recognized studies comparing ESE systems to Faraday Systems governed by NFPA 780, including a report generated by the NFPA itself in 1999. Specifically, attached as Exhibits F and G, respectively, are pertinent excerpts from the Report of the National Institute of Standards and Technology, entitled "Literature Review and Technical Analysis of Early Streamer Emission Systems of Lightning Protection" (1995) (hereinafter "NIST Report") and the Report of the NFPA's Third-Party Independent Evaluation Panel entitled "Early Streamer Emission Lightning Protection Technology" (1999) (hereafter "Bryan Report").

Both the NIST and the Bryan Report concluded that ESE systems have both an adequate theoretical basis and laboratory testing. NIST Report at page 25; Bryan Report at page 26. However, the authors of both reports found that there is insufficient field testing of either ESE systems or traditional (also known as "Faraday") systems of lightning protection under natural thunderstorm conditions. NIST Report at page. 16. Bryan Report at page 26. These findings of inadequate field testing of both traditional Faraday systems and ESE systems of lightning protection were based in part on the fact that there have been reported failures of both types of systems, and there was virtually no documentation to determine the cause of the failure.[1] As a result, both reports concluded that no meaningful conclusions regarding the performance of either type of system could be drawn based on either reported failures or lack of failures of either type of system under natural thunderstorm conditions. NIST Report at page 25; Bryan Report pages.23-24.

Based on this lack of field testing---or even laboratory testing—for traditional (Faraday) systems of lightning protection, the NIST Report concluded that "insufficient quantitative data see to exist about the performance of traditional rods…." NIST at page 24. Dr. Bryan, a former member of the NFPA Standards Council, went so far as to conclude that because of a lack of field or laboratory testing, NFPA 780 systems had insufficient scientific validation to warrant an NFPA standard and recommended that NFPA 780 be "downgraded" to a recommended practice. Bryan Report at pages 27-28.

It also is worth noting that both the NIST and Bryan Reports were highly critical of studies, funded by the Faraday industry, conducted by Professor Moore and Dr. Rison of the

[1] Both Faraday and ESE Systems—like other products—sometimes experience failures due to failure to maintain the systems properly or due to installation errors. Faraday Systems rely on their "track record" in field to support their efficacy. ESE Systems, like Faraday System, also have similar field experience. For example, in over twenty years and with thousands of systems installed in the United States, Heary Bros. have had no documented failures and their insurance carriers have paid no claims. Of course, Heary Bros.' ESE systems are installed in compliance with its manufacturer's standard to ensure adequate installation.

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New Mexico Institute of Mining and Technology. The NIST Report questioned whether any meaningful conclusions could be drawn based on tests conducted at elevations of 3000 m, and that the testing at this altitude "raise questions about the interpretation of such observations" NIST Report at 21.

Similarly, the Bryan Report identified several significant problems with the methodology employed by Professor Moore and Dr. Rison. The Bryan Report noted that despite reporting a "failure" of an ESE system, the ESE terminal had been damaged and--as a result--the study failed to document that the ESE terminal was even working at the time of the alleged strike within the zone of protection. Bryan Report at 17. The Bryan Report also noted that Dr. Rison's and Professor Moore's research questioned the efficacy of terminals used in NFPA 780 systems (Faraday Systems), noting that in four years not a single sharp pointed Franklin rod was struck. *Id.* at 18.

The lack of a scientific basis for NFPA 780 and UL 96A also has been confirmed in an article by written by Professor Martin Uman (a leading lightning protection expert who is often quoted by Faraday manufacturers) and published in the December 2002 issue of *American Meteorological Society*. The article states "[t]he theoretical justification of the traditional [Faraday] approach is fairly crude, in part due to our incomplete understanding of lightning's attachment to ground-based objects. Hence, the fact that traditional [Faraday lightning protection] systems have a history of success in preventing or minimizing damage to structures is the primary justification for their use." December 2002 Edition of *American Meteorological Society* at page 1809. Of course, as noted above, Heary Bros.' ESE systems have the same history of success based on field experience now exceeding thirty years—success which has been acknowledged by Heary Bros.' insurance carriers who provide insurance coverage for its ESE systems through Travelers Insurance Company.

CONCLUSION

For all the foregoing reasons, we respectfully request that you reject Proposed Code Modification 7255. Importantly, as explained above, Proposed Code Modification 7255 clearly cannot be adopted under Florida law because it discriminates against manufacturers and installers of ESE lightning protection systems which constitute a competing alternative of "demonstrated capabilities." Florida State law (553.73 (9) (a) 3 F.S.). Moreover, the Proposed Code Modification 7255 should be accepted since it simply is the right thing to do to preserve an option that architects, engineers and owners have chosen for decades with success and—to do otherwise—would provide the Faraday industry with an unfair and unlawful monopoly. Thus, the action proposed by this letter is in the interests of retaining the owners' ability to choose and will avoid the creation of state law that conflicts with federal antitrust laws and imposes

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anticompetitive restraints on the marketplace.

Sincerely,

SCHRODER, JOSEPH & ASSOCIATES, LLP

Linda H. Joseph

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EXHIBIT A

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Manufacturer's Installation Standard
For
Lightning Protection Systems Using
Early Streamer Emission Air Terminals

HBP-21

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INTRODUCTION

1. Scope

1.1 The requirements of this standard cover the design of systems using Early Streamer Emission ("ESE") air terminals for strikes. The Standard is divided into Three Levels of Protection. Electrical transmission lines and equipment are not within the scope of this standard.

1.2 These requirements apply to lightning protection systems that are complete and cover all parts of a structure. Partial systems are not covered by this standard.

1.3 Where fittings, devices or other components required by this standard are available as listed or labeled, such components shall be used. Otherwise the components shall be approved by the authority having jurisdiction (i.e. Engineer of Record, Architect, Owner, Applied Research Laboratories or Underwriter's Laboratories).

1.4 This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's Standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards."

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2. Glossary

2.1 For the purpose of this standard the following definitions apply:

Lightning Protection System is complete system of air terminals(s), conductors, ground terminals, bonding conductors, transient voltage surge suppression devices and other components required to complete a system.

2.2 AIR TERMINAL:

Is the component of the system that is intended to intercept the lightning strokes.

2.3 APPROVED:

Acceptable to the "authority having jurisdiction".

2.4 AUTHORITY HAVING JURISTICTION:

Is the organization, office or individual responsible for "approving" the equipment, and installation or a procedure.

2.5 BONDING:

An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents.

2.6 CABLE: A conductor formed of a number of wires stranded together.

2.7 CHIMNEY:

A smoke or vent stack having a flue with cross sectional area less than 500 sq in (.3 sq m) and a total height of less than 75 feet (23m).

2.8 CONDUCTOR:

The portion of a lightning protection system that is intended to carry the lightning discharge to the ground.

2.8.1 MAIN CONDUCTOR:

A conductor that interconnects air terminals and serves as a down lead to ground.

2.8.2 BONDING CONDUCTOR:

A conductor intended to be used for potential equalization between metal bodies and the lightning protection system. Bonding conductors are not designed or intended to carry main lightning current.

2.9 FASTENER:

An attachment to secure the conductor to the structure.

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2.10 GROUNDED:

Connected to earth or to some conducting body that is connected to earth.

2.10.1 GROUND GRID:

A system of grounding electrodes consisting of interconnected bare cables buried in the earth.

2.10.2 GROUND TERMINAL (ELECTRODE):

The portion of a lightning protection system that is installed for the purpose of providing electrical contact with earth.

2.11 LIGHTNING STRIKE:

The entire lightning event that can consist of one or more lightning strokes.

2.12 LOOP CONDUCTOR:

A conductor that encircles a structure that is used to interconnect ground terminals, main conductors or other grounded bodies.

2.13 METAL FRAME STRUCTURE:

A structure with electrically continuous structure members of sufficient size to provide electrical path equivalent to that of the lightning conductors in this standard.

2.14 SHALL:

Indicates a mandatory requirement of this Standard.

2.15 SHOULD:

Indicates a recommendation or that which is advised but not required.

2.16 SURGE ARRESTORS:

Are devices designed to limit damaging surge voltages by discharging or bypassing the current while maintaining the ability of repeating these functions. Heary Brothers Lightning Protection Co., Inc. and its Division Lightning Preventor of America do not manufacture Surge Arrestors nor do they warranty the equipment.

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3. GENERAL REQUIREMENTS

3.1 GENERAL DESIGN REQUIREMENTS:

A lightning protection system using an Early Streamer Emission Air Terminal (s) shall be designed with provisions for inspection and maintenance.

3.2 Every installation shall be reviewed by a prior study to determine the level of protection required (See Figure 3.5.1).

3.3 The position of the E.S.E. air terminal, including height of above structure shall be determined in accordance with the level of protection required. (See Figure 3.5.1)

3.4 The number of terminals will depend on the system design under the Manufacturer's Standard based upon the dimensions of the area to be protected. (See Figure 3.5.I)

3.5 There are multiple styles of E.S.E. air terminals and systems available. For purposes of this standard they have been divided into separate levels of protection, with each level having its own installation requirements. A chart is provided (See Figure 3.5.1) as a general guideline in determining which level of protection best fits the requirements of the project.

3.6 All bolts on bolt pressure connectors require to be torqued at 150 pound-inches (17N-m).

3.7 This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's Standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards."

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Figure 3.5.1 Levels of Protection for ESE Lightning Protection Systems

FEATURES	LEVEL 1	LEVEL 2	LEVEL 3
Number of ESE Terminals Required Pursuant to System Design	1 Air Terminal (See Note: A)	1 Air Terminal (See Note: A)	1 Air Terminal (See Note: B)
Grounding Resistance Requirements	10Ω (ohms) or less	10 Ω (ohms) or less	25Ω (ohms) or less
Warranty	15 year material workmanship	15 year material workmanship	5 year material workmanship
Air Terminal height above all roof top projections	20' (6.1m)	20' (6.1 m)	7' (2 m)
Transient Voltage Surge Suppression	Shall be installed on all service entrances of electric, telephone, cable, and antenna lead-in.	Shall be installed on all service entrances of electric, telephone, cable, antenna lead-in.	Shall be installed on all service entrances of electric, telephone, cable, antenna lead-in.
ARL Listing and UL Listing mark on applicable components	Required	Required	Required
Building Height	Unlimited	Unlimited	Under 75' (23m)
Building Types	All	All	Residential, Farm, Agricultural, Small commercial.

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(Note: A)

Manufacturer's Installation Standard HBP-21Level 1 and Level 2 require one (1) ESE Air Terminal to be installed on the roof for every circular area of 337,810 feet. Structures may be on any height and the ESE lightning protection system must comply with all other requirements within this Manufacturer's Installation Standard HBP-21. This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

(Note: B)

Manufacturer's Installation Standard HBP-21 Level 3 requires one (1) ESE Air Terminal to be installed on the roof for every circular area of 70,650 feet. Structures may be of any height and the ESE lightning protection system must comply with all other requirements within this Manufacturer's Installation Standard HBP-21. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lighting protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

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LEVEL 1

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

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4. Level 1 General Installation and Component Requirements

4.1 An ESE lightning protection system installation consists of the following interconnected parts

(a) One or more ESE air terminals
(b) Mast and mounting systems - as required based on level of protection desired.
(c) Bonding conductors - as required based on level of protection.
(d) Ground system – Single grid to loop conductor system.
(e) Equipotential Bonding.
(f) Transient Voltage Surge Suppression.

4.1.1 The number of ESE air terminals will depend on the system design under the Manufacturer's Standard based upon the area indicated in Figure 3.5.1 for Level 1 type systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

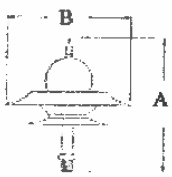
4.1.2 Components Tables 4.1.1.1 and Figure 4.1.1.2 provides minimum sizes and weights for use in ESE lightning protection system installation.

Figure 4.1.1.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	½" /12.7mm	½"/ 12.7 mm	½"/ 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	14AWG 375lbs /1000/ or 558 g/m 115,000 CM / 58 mm^2	13AWG 190lbs/1000/ 283 g/m 192000 CM/ 97 mm^2
Ground Terminals	Ground Rod / Ground Plate	¾" x 10' (20mm x 3000mm)/ 24" x 24"x 20 gauge (600mm x 600mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 4.1.1.2 Early Streamer Emission Air Terminal

A= 12"
B= 9"



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4.2 ESE Air terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of copper, copper alloy, aluminum or stainless steel. The main conductive parts of the ESE air terminal shall have the minimum dimensions in accordance with table 4.1.1.1 and Figure 4.1.1.2 for minimum dimensions of ESE Air Terminal.

4.2.1 Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind.

NOTE: Wind design requirements should be consistent with local building code requirements.

4.2.2 Where an air terminal or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

4.2.3 The tip of any ESE air terminal or mast shall not be less than 20' (6.1m) above the protected structures, including antennas, cooling towers, tanks, roofs and masts.

4.2.4 The ESE air terminal shall be mounted on structures such as flagpoles, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as, sports facilities and stadiums, golf courses, public parks, camping sites and racetracks. The ESE unit shall be mounted at an elevation indicated in Section 4.2.3.

4.3 Storage areas for Flammable and Combustible Liquids or Flammable Gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

4.4 Surge Suppression devices shall be installed on electric and telephone service entrances, antenna lead-ins, and electrical and electronic cables/ conductors entering or exiting the building.

4.4.1 Electrical Surge Suppression device shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty. Units shall be mounted as to minimize inductance installation. (i.e. As close to equipment to be protected or by use of documented low inductance cabling).

4.5 General, In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounded medium.

B. The influence of a non-grounded metal body, such as metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium (Air or solid materials).

D. Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

E. Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall maintain the minimum protection above these objects as specified in Section 4.2.3

NOTE: For additional bonding requirements see Section 5.2 and 5.3.

4.6 Components

4.6.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

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4.6.2 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gasses or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

4.6.3 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding or other aluminum surfaces.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum conductors and components shall not be:
   a. Embedded in concrete or masonry.
   b. In direct contact with a surface coated with alkaline base paint, or
   c. Installed in wet locations, for example eave troughs or downspouts.
   d. Installed in direct contact with earth.

D. Components used for connection of aluminum down conductors to copper or copper-clad grounding equipment shall provide separation between aluminum and copper materials. These fittings may be a Stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper components.

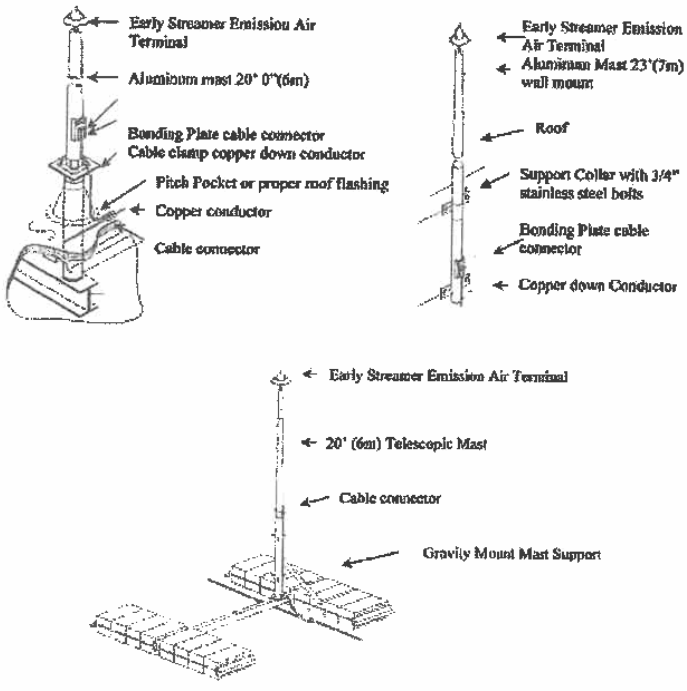
4.6.4 Unless otherwise indicated in this standard, an air terminal shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

5. Level 1 Air Terminal Installation Requirements

5.1 Early Streamer Emission Air Terminals

A. ESE Air Terminals shall be mounted at a height consistent with the requirements of Section 4.2.3 or a minimum of 20' above all projections on the roof.
See Figure 5.1.1 for sample mast mounting details.

Figure 5.1.1

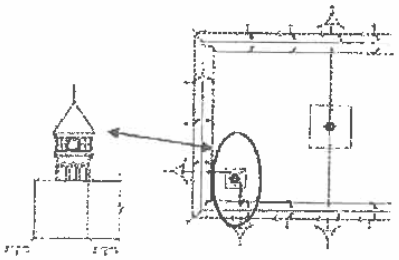


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B. ESE Air Terminals shall be provided in proper quantity and location based on the system design under Manufacturer's Standard. See Figure 3.5.1 Level 1 requirements. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

C. Additional ESE air terminals shall be provided in situations where steeples, cupolas, crosses, stacks, chimneys, etc. project above the protected roof area. This requirement applies to all projections which could provide a potential upward streamer release. The addition air terminals shall be provided regardless of whether or not the projection is within or outside the area covered by the system design under the Manufacturer's Standard. See Figure 5.1.2. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

Figure 5.1.2



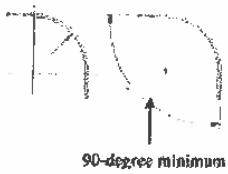
D. Conductors shall be securely fastened to roof or structure at intervals not exceeding 3'0" on center.

E. ESE Air Terminals shall be provided with a minimum of two paths to ground. Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets. See Figure 5.1.4

F. No Bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However conductors may raise a rate of 3" per 12" of run. See Figure 5.1.3 and Figure 5.1.4

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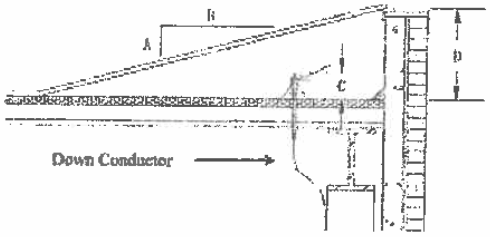
Figure 5.1.3



R= Radius bend, 8 inches (203 mm) minimum

NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement

Figure 5.1.4



D= Total Distance of rise required.
A= 3" (max) Rise
B= 12"(max) Run
C= 8" (max)

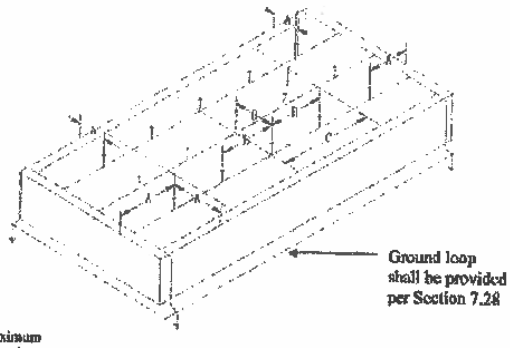
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in Section 5.1.D

5.1.1 In situations where multiple air terminals are required, the perimeter air terminals shall be positioned so that they are not more than 230' (70m) for the outside edge of the building nor shall the ESE Air Terminals be spaced more than 460' (140m) apart at any time. A cross run cable shall be provided at intervals of 1000' (305m) when building exceeds 2000' (610m) in length in any direction. See Fig 5.1.1.1. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed ho have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

5.1.2 Down Conductors in situations where multiple ESE Air Terminals are required shall be spaced at intervals no more than 500' (152m) apart around the perimeter of the structure. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

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Figure 5.1.1.1



6. Level 1 Bonding Requirements

6.1 Roof top Interconnection loop

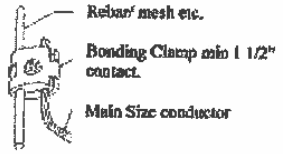
A. An interconnection loop around the perimeter of the roof structure shall be provided to which ESE Ground Conductors shall be bonded.

B. Loops shall be provided at all intermediate and lower roof levels and connected at a minimum of two (2) locations to the down conductors.

a. Bonding connections shall be made with main size conductor to all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, etc. whether exposed or not at all inside and outside corners of structure as a minimum. Additional bonding connections shall be made at intervals not exceeding 60' (18m) around the perimeter of the structure. Care shall be taken to assure that all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, et. Whether exposed or not is electrically continuous or made so. (See Fig. 6.2.4 and Fig 6.25).

b. Down Conductors shall be bonded to the structural steel, reinforcing rod or other structural support at the top and bottom of conductor run.

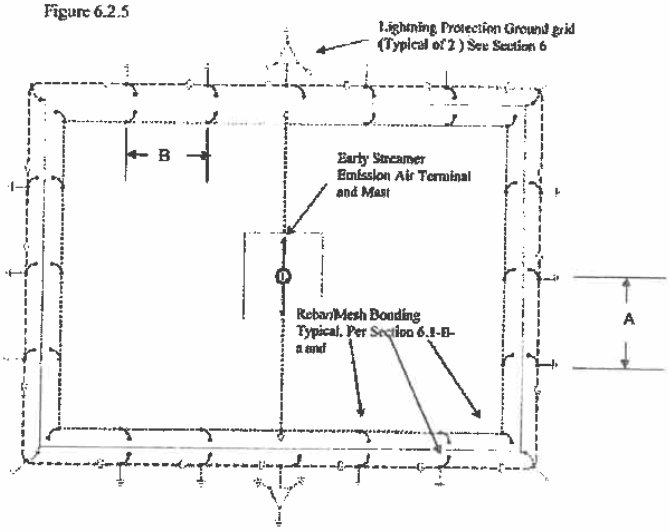
Figure 6.2.4



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Figure 6.2.5



A= 60' (18m) Maximum Spacing
B= 60' (18m) Maximum Spacing

Note: For Base Grounding requirements see Section 7

6.2 Bonding Requirements

A. Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless;

B. Inherently bonded to the lightning protection system.

C. Sanitary vents, roof drains, flashings, copings, etc. located within 6' (1.8m) of a lightning protection conductor, shall be bonded via secondary sized conductor to the lightning protection system.

7. Level 1 Grounding System Requirements

7.1 Down Conductors"

7.1.1 A minimum of Two (2) Down Conductors Shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 5.1.2

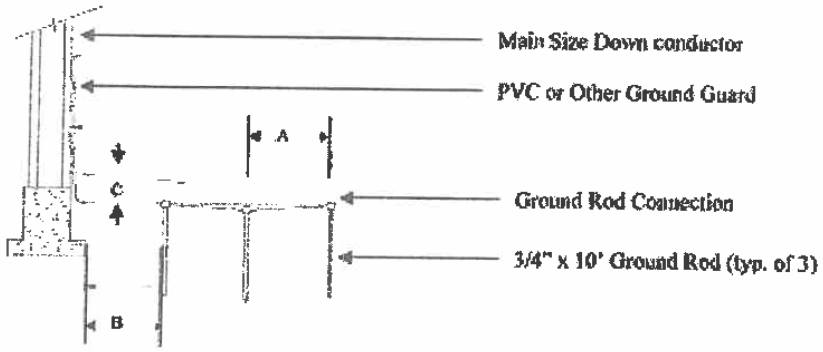
7.1.2 Down Conductors shall be spaced at least 10' (3m) apart.

7.1.3 Down conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, Fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See figure 7.2.1.1

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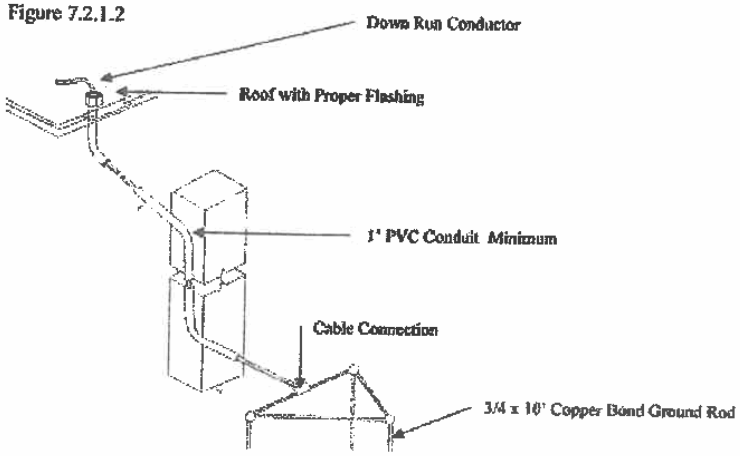
7.1.4 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 7.2.1.2

Figure 7.2.1.1



A= 10' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 3' (0.3m) Minimum

Figure 7.2.1.2



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7.1.5 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

A. If electrically continuous, structural steel shall be permitted to be used as the down conductor.

B. Test joints shall be provided for each down conductor. They shall be accessible and located as near as practicable to the ground termination.

7.1.6 Masonry Anchors used to secure the lightning protection materials shall have a minimum outside diameter of ¼ in. (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed, the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

7.1.7 Connector Fittings shall be used at all "end to end, "tee" or "Y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lbs. Fittings used for required connections shall be of bolted, welded or high compression type and bear the ARL Listing and UL Listing.

7.1.8 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of materials shall be used that forms an electrolytic couple of such nature that, in the presence of moisture, corrosion is accelerated.

7.2 Grounding

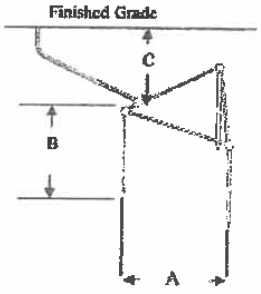
7.2.1 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 10 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

7.2.2 Ground electrodes shall be of copper-bond steel in sufficient number as to achieve a 10-ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 3' (1m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 7.2.1.1

7.2.3 Ground rod terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

7.2.4 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configured either in a straight line or in delta formation. Where the ground terminals are spaced a minimum of 10' (3m) apart. See Figures 7.2.3.1 and 7.2.3.2

Figure 7.2.3.1



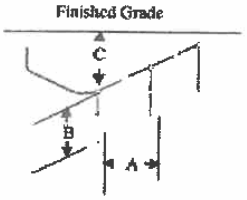
A= 10' (3m) Minimum

B= 10' (3m) Minimum (Typical)

C= 3' (1m) Minimum

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Figure 7.2.3.2



A= 10' (3m) Minimum

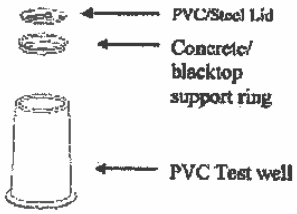
B= 10' (3m) Minimum (Typical)

C= 3' (1m) Minimum

7.2.5 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

7.2.6 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems.
NOTE 1: For Further information, see NFPA 70 National Electric Code, which contains detailed information on the grounding of electrical systems.
NOTE 2: Ground rod or ground ring/loop electrodes should be installed below the frost line where practicable and in accordance with Section 7.2.8

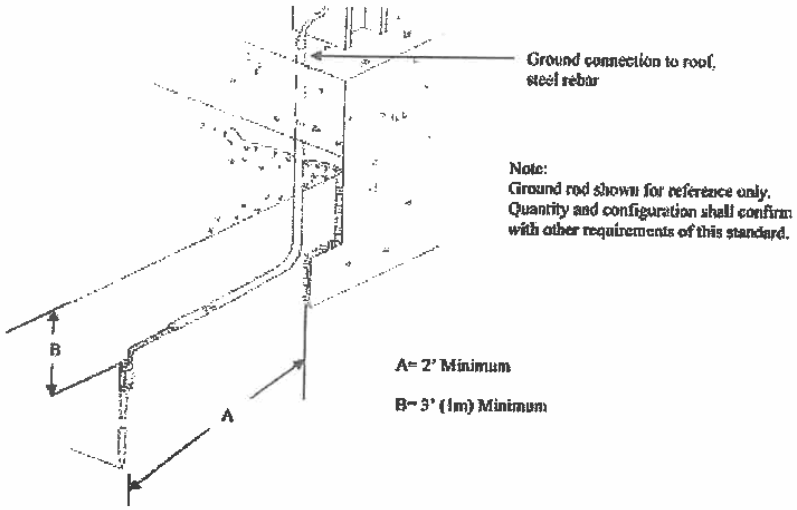
Figure 7.2.6.1



7.2.7 Grounding ring/loop Electrode encircling the structure shall be provided and in direct contact with the earth at a depth of not less than 2ft. The ground ring conductor shall be sized at a minimum of that of the main sized conductor. See Figure 7.2.8.1

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Figure 7.2.8.1



7.2.8 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include, but not be limited to lightning protection, electrical services, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

7.2.9 Common Ground Bonding. If electric telephone or other systems are bonded to metallic water pipe, only one connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

8. Level 1 Structural Steel Systems

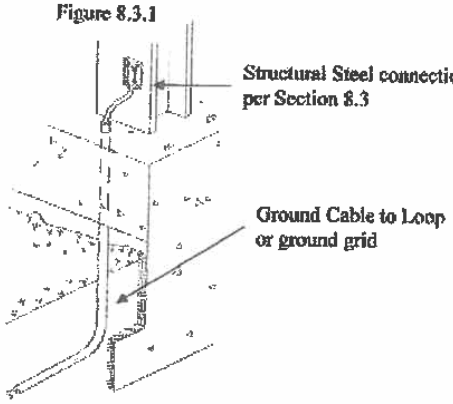
8.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

8.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60ft (18m). Ground terminals shall be connected together via a main size conductor as indicated in sec 7.2. Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

8.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq in (5200mm²). The area of attachment shall be free of paint, grease oil and debris. (See Figure 8.3.1)

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Figure 8.3.1



8.4 Early Streamer Emission Air terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 8.3

8.5 Metal Bodies. Certain Metal bodies located outside or inside the structure contribute to lightning hazards because they are grounded or assist in providing a path to ground for lightning currents. Such metal bodies shall be bonded to the lightning protection system in accordance with Section 4.5.

8.6 Concealment in Steel Reinforced Concrete. Conductors or other components of the lightning protection system concealed in steel reinforced concrete units shall be connected to the reinforcing steel. Concealed down conductors shall be connected to vertical reinforcing steel. Roof conductors or other concealed horizontal conductors runs shall be connected to reinforcing steel/structural steel at intervals not exceeding 60ft (18m) and at all corners. See Section 6.

8.7 Down Conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel and/or structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 200ft (60m). Such connections shall be made using listed clamps or listed bonding plates or by exothermic welding. The use of PVC conduit or other non-metallic chase does not negate the need for these interconnections.

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LEVEL 2

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

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9. Level 2 General Installations and Component Requirements

9.1 An ESE lightning protection system installation consists of the following interconnected parts
- (a) One or more ESE air terminals
- (b) Mast and mounting systems – as required based on level of protection desired
- (c) Bonding conductors – as required based on level of protection.
- (d) Ground system – Single grid to loop conductor system
- (e) Equipotential Bonding
- (f) Transient Voltage Surge Suppression

9.2 The number of ESE air terminals will depend on the system design under the manufacturer's Standard based on the area as indicated in Figure 3.5.1 for Level 2 Systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumer should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

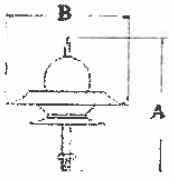
9.3 Components Tables Figure 9.3.1 and Figure 9.3.2 provide minimum sizes and weights for use in ESE lightning protection system installation.

Figure 9.3.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	1/2 "/ 12.7mm	1/2" / 12.7 mm	1/2" / 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	14AWG 375lbs /1000/ or 558 g/m 115,000 CM / 58 mm ^{2}	13AWG 190lbs/1000/ 283 g/m 192000 CM/ 97 mm ^{2}
Ground Terminals	Ground Rod / Ground Plate	¾" x 10' (20mm x 3000mm)/ 24" x 24"x 20 gauge (600mm x 600mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 9.3.2 Early Streamer Emission Air Terminal

A= 12"
B= 9"



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9.4 ESE Air Terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of copper, copper alloy, aluminum or stainless steel. The main conductive parts of the ESE air terminals shall have the minimum dimensions in accordance with Figures 9.3.1 and Figure 9.3.2 for minimum dimensions of ESE Air Terminals Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind

NOTE: Wind design requirements should be consistent with local building code requirements.

9.4.1 Where an air terminal or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

9.4.2 The tip of any ESE air terminal shall not be less than 20' (6.1m) above the protected structures, including antennas, cooling towers, tanks, roof and masts.

9.4.3 The ESE air terminals shall be mounted on structures such as flagpole, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as, sports facilities and stadiums, golf courses, public parks, camping sites and racetracks. The ESE unit shall be mounted at an elevation as indicated in Section 9.4.2.

9.5 Storage Areas for flammable and combustible liquids or flammable gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

9.5.1 Electrical Surge Suppression device shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty. Units shall be mounted as to minimize inductance installation. (I.e. As close to equipment to be protected or by use of documented low inductance cabling.)

Note 1: Electrical systems and utilization equipment within the structure may require further surge suppression. Such protection is not part of this standard. NFPA 70, National Electric Code and ANSI/IEEE C62.41-1991 2nd Edition, shall be consulted for further information and installation requirements.

Note 2: Illustrations shown in this are those of Heary Brothers Lightning Protection Co., Inc. (HBLP) and its division Lightning Preventor of America (LPA). HBLP and LPA do not manufacture or warranty surge protection devices. Warranties required of this standard shall be the responsibility or the surge protection device manufacturer.

9.6 General. In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounded medium.

B. The influence of a non-grounded metal body, such as a metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium (air or solid materials).

(a) Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

(b) Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall still maintain the minimum protection above these objects as specified in Section 9.4.2.

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9.7 Components

9.7.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

9.7.2 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gases or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

9.7.3 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding, or other aluminum surfaces.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum Conductors and components shall not be:

a) Embedded in concrete or masonry;

b) In direct contact with a surface coated with alkaline base paint; or

c) Installed in wet locations, for example eave troughs or downspouts.

d) Installed in direct contact with earth

D. Components used for connection of aluminum down conductors to copper or copper-clad grounding equipment shall provide separation between aluminum and copper materials. These fittings may be a stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper materials.

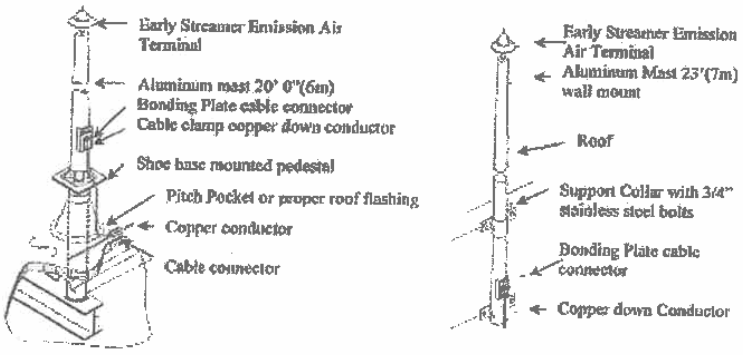
9.7.4 Unless otherwise indicated in this standard, an air terminal shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

10. Level 2 Air Terminals Installation Requirements

10.1 Early Streamer Emission Air Terminals

A. ESE Air Terminals shall be mounted at a height consist with the requirements of Section 9.4.2 or a minimum of 20' above all projections on the roof. See Figure 10.1.1 for sample mast mounting details.

Figure 10.1.1



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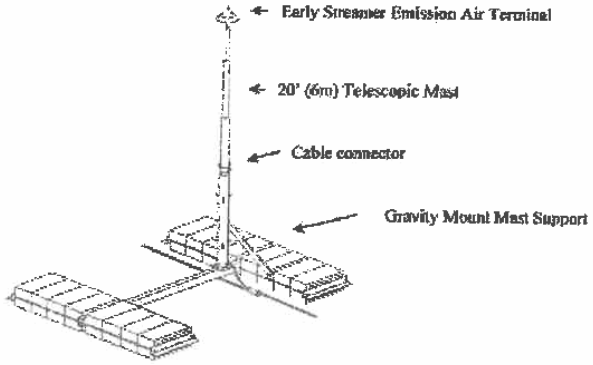
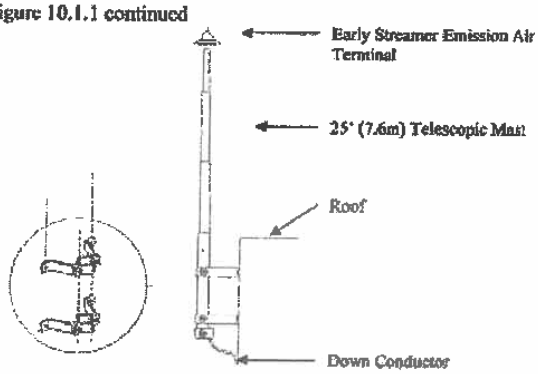


Figure 10.1.1 continued



10.2 ESE Air Terminals shall be provided in proper quantity and location based on the system design under the Manufacturer's Standard. See Figure 3.5.1 for Level 2. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

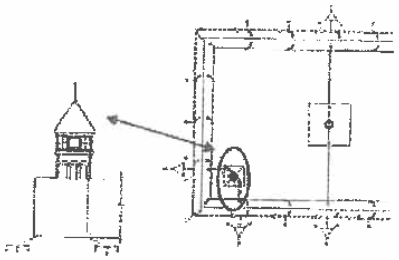
10.3 Conductors shall be securely fastened to roof or structure at intervals not exceeding 3'0" on center.

10.4 Additional ESE air terminals shall be provided in situations where steeples, cupolas, crosses, stacks, chimneys, etc project above a protected roof area. This requirement applies to all projections which could provide a potential upward streamer release. The addition air terminals shall be provided regardless of whether or not the projection is within or outside the area covered by the system design under the Manufacturer's Standard. See Figure 10.2.1. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those

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terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

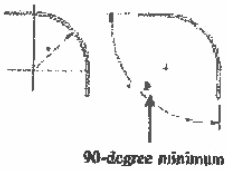
Figure 10.2.1



10.5 ESE Air Terminals shall be provided with a minimum of two paths to ground. Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets.

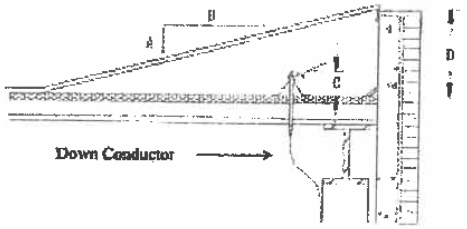
10.6 No Bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However Conductors may rise at a rate of 3" per 12" of run. See Figure 10.5.1 and Figure 10.6.1

Figure 10.5.1



NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement.

Figure 10.6.1



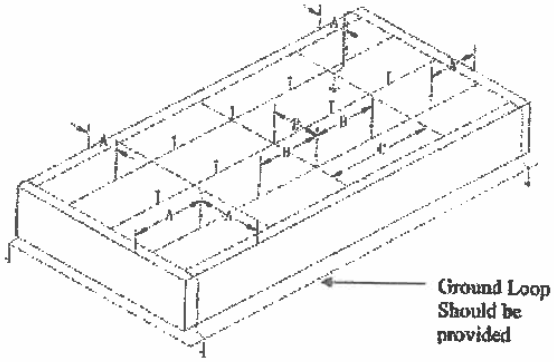
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in

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10.7 In situations where multiple air terminals are required, the perimeter air terminals shall be positioned so that they are no more than 230' (70m) from the outside edge of the building nor shall be ESE Air Terminals be spaced more than 460' (140m) apart at any time. A cross run cable shall be provided at intervals of 1000' (305m) When building exceed 200' (610m) in length in any direction. See Figure 10.8.1. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

10.8 Down Conductors in situations where multiple ESE Air Terminals are required shall be spaced at intervals no more than 500' (152m) apart around the perimeter of the structure.

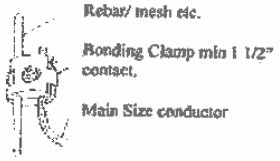
Figure 10.8.1



A= 230' (70m) maximum
B= 460' (140 m) maximum
C= 1000' (305m)

10.9 Bonding connections shall be made with main size conductor to all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, etc., whether exposed or not, at the upper and lower extremities of each down conductor. Care shall be taken to assure that all rebar, reinforcing rod, structural steel, interior wall mesh, nylon mesh in stucco walls etc, whether exposed or not is electrically continuous or made so. (See Fig. 10.9.1 and Fig 10.9.2).

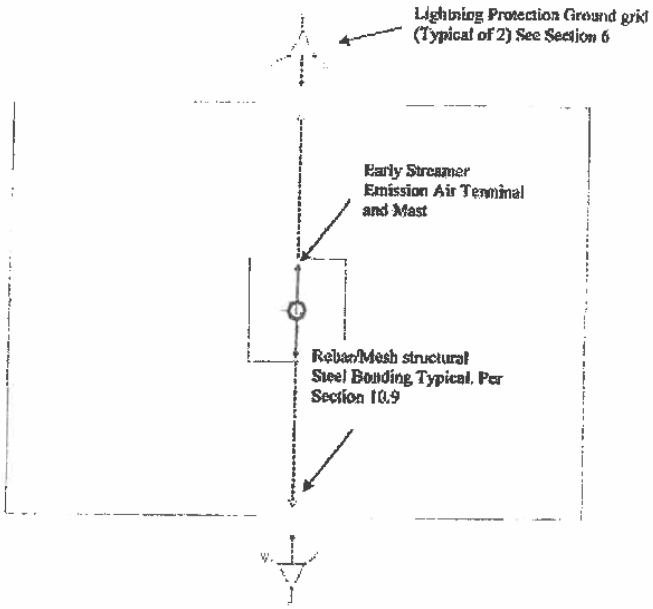
Figure 10.9.1



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Figure 10.9.2



11. Level 2 Bonding Requirements

11.1 Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless.

A. Inherently bonded to the lightning protection system.

11.2 Sanitary vents, roof drains, flashings, copings, etc located within 6' (1.8m) of a lightning protection conductor, shall be bonded via secondary sized conductor to the lightning protection system.

12. Level 2 Grounding System Requirements

12.1 Down Conductors and Grounding

12.2 A minimum of two (1) down conductors shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 10.8.

12.3 A single down conductor shall be permitted to be used where the length of run does not exceed 65ft (19m).

12.4 If the horizontal length is greater than the vertical length, two (2) down conductors shall be required and separated a minimum of 10' (3m).

12.4.1 For lengths greater than 65' (19m) two conductors shall be required.

12.4.2 For masts, a single down conductor only shall be required.

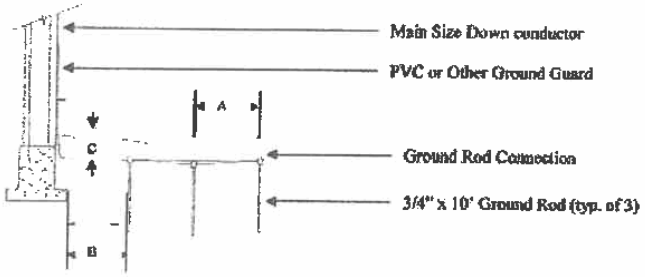
12.4.3 If electrically conductive, the mast shall be permitted to be used as the down conductor.

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12.5 Down Conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, Fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See figure 12.4.1.

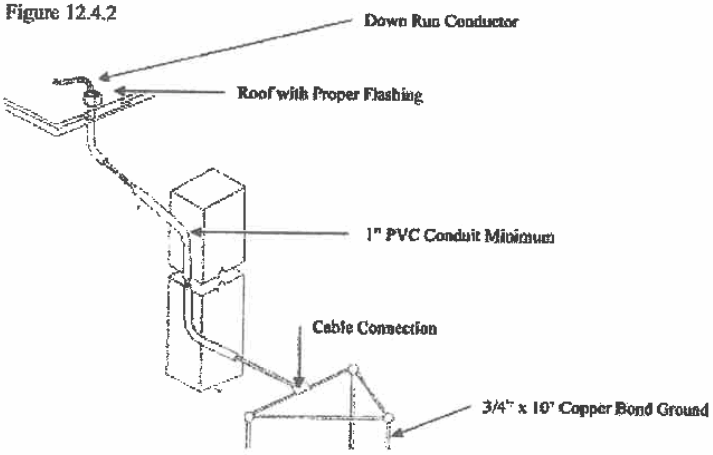
12.6 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 12.4.2.

Figure 12.4.1



A= 10' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 1' (0.3m) Minimum

Figure 12.4.2



12.7 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

12.7.1 If electrically continuous, structural steel shall be permitted to be used as the down conductor.

12.8 Masonry Anchors used to secure the lightning protection components shall have a minimum outside diameter of ¼" (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

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12.9 Connector Fittings shall be used at all "end to end", "tee" or "y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lbs. Fittings used for required connections shall be of bolted, welded, or high compression type and bear the ARL Listing and UL Listing.

12.10 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of materials shall be used that forms an electrolytic couple of such nature that, in the presence of moisture, corrosion is accelerated.

12.11 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 10 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

12.12 Ground electrodes shall be of copper-bond steel in sufficient number as to achieve a 10-ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 1' (0.3m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 12.4.1

12.13 Ground Rod terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

12.14 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configured either in a straight line or in delta formation. Where the ground terminals are spaced a minimum of 10' (3m) apart. See Figures 12.4.1 and 12.4.2.

12.15 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

12.16 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems.

NOTE 1: For further information, see NFPA 70 National Electric Code, which contains detailed information on the grounding of electrical systems.

12.17 Ground ring/loop electrode encircling the structure should be provided and in direct contact with the earth at a depth of not less than 2 ft. The ground ring conductor shall be sized at a minimum of that of the main sized conductor.

12.18 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include lightning protection, electric service, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

12.19 Common Ground Bonding. If electric, telephone or other systems are bonded to metallic water pipe; only on connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

12.20 If the horizontal length is greater than the vertical length, two down conductors shall be required and separated a minimum of 10' (3m).

(a) For lengths greater than 65' (19m) two conductors shall be required.

(b) For masts, a single down conductor only shall be required.

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(c) If electrically conductive, the mast shall be permitted to be used as the down conductor.

13. Level 2 Structural Steel Systems

13.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

13.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60 ft (18m). Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

13.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq inches (5200mm²). The area of attachment shall be free of paint, grease oil and debris.

13.4 Early Streamer Emission Air Terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 13.3.

13.5 Metal Bodies. Certain metal bodies located outside or inside the structure contribute to lightning hazards because they are grounded or assist in providing a path to ground for lightning currents. Such metal bodies shall be bonded to the lightning protection system in accordance with Section 11.

13.6 Concealment in Steel Reinforced Concrete. Conductors or other components of the lightning protection system concealed in steel reinforced concrete units shall be connected to the reinforcing steel. Concealed down conductors shall be connected to vertical reinforcing steel. Roof conductors or other concealed horizontal conductor runs shall be connected to reinforcing steel and structural steel at intervals not exceeding 60ft (18m) and at all corners. See Section 10.9.

13.7 Down Conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel and/or structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 200 ft (60m). Such connections shall be made using listed clamps or listed bonding plates or by exothermic welding. The use of PVC conduit or other non-metallic chase does not negate the need for the interconnections.

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LEVEL 3

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

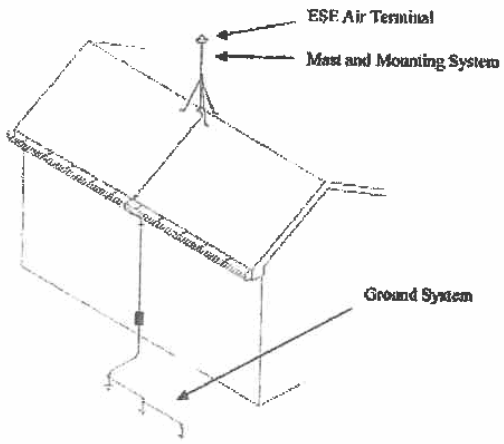
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14. Level 3 General Installation Requirements

14.1 An ESE lightning protection system installation consists of the following interconnected parts see figure 14.1.1.

a. One or more ESE air terminals.
b. Mast and mounting systems – as required based on level of protection.
c. Ground system – Single grid to loop conductor system.
d. Equipotential Bonding.
e. Transient Voltage Surge Suppression.

Figure 14.1.1



14.2 The number of ESE air terminals will depend on the system design under the Manufacturer's Standard based on the area as indicated in Figure 3.5.1 for Level 3 Systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

14.3 Components Tables Figure 14.3.1 and Figure 14.3.2 provide minimum sizes and weights for use in ESE lightning protection system installation.

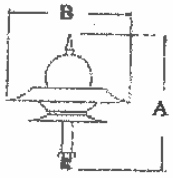
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Figure 14.3.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	1/2 "/ 12.7mm	1/2" / 12.7 mm	1/2" / 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	16AWG 190lbs /1000/ or 278 g/m 61900 CM / 35 mm ^{2}	14AWG 110lbs/1000/ 164 g/m 98600 CM/ 50 mm ^{2}
Ground Terminals	Ground Rod / Ground Plate	5/8" x 8' (16 mm x 2400mm)/ 18" x 18"x 20 gauge (460mm x 460mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 14.3.2 Early Streamer Emission Air Terminal

A= 12" (300mm)
B= 9" (230mm)



14.4 ESE Air Terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of aluminum, copper, copper alloy, or stainless steel. The main conductive parts of the ESE air terminal shall have the minimum dimensions in accordance with Figures 14.3.1 and Figure 14.3.2.

14.5 ESE Air Terminals Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind.

14.5.1 Where an air terminals or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

14.5.2 The tip of any ESE air terminal shall not be less than 7' (2.1m) above the protected structures, including antennas, cooling towers, tanks, roof and masts.

14.5.3 The ESE air terminals shall be mounted on structures such as flagpole, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as sports facilities and stadium, golf courses, public parks, camping sites and racetracks. The ESE unit shall still be mounted at an elevation as indicated in Section 14.5.2

14.5.4 Storage areas for flammable and combustible liquids or flammable gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

14.5.5 Electrical Surge Suppression devices shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty.

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Units shall be mounted as to minimize inductance installation. (I.e. As close to equipment to be protected or by use of documented low inductance cabling).

NOTE 1: Electrical systems and utilization equipment within the structure may require further surge suppression. Such protection is not part of this standard. NFPA 70, National Electric Code and ANSI/IEEE C62.41-1991 2nd Edition, shall consulted for further information and installation requirements.

NOTE 2: Illustrations shown in this standard are those of Heary Brothers Lightning Protection Co., Inc. (HBLP) and its division Lightning Preventor of America (LPA). HBLP and LPA do not manufacture or warranty surge protection devices. Warranties required of this standard shall be the responsibility of the surge protection device manufacturer.

14.6 General. In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounding medium.

B. The influence of a non-grounded metal body, such as metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium, (Air or solid materials).

D. Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

E. Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall still maintain the minimum projection above these objects as specified in section 14.5.2 and the object shall be bonded to the lightning protection system by means of main sized conductor.

15. Level 3 Components

15.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

15.1.1 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gases or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

15.2 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding, or other aluminum.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum conductors and components shall not be embedded in concrete or masonry;

a) In direct contact with a surface coated with alkaline base paint; or installed in wet locations, for example eave troughs or downspouts.

b) Installed in direct contact with earth.

c) Components used for connection of aluminum down conductors to copper or copper-bond grounding equipment shall provide separation between aluminum and copper materials. These fitting may be a stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper materials.

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15.2.1 Unless otherwise indicated in this standard, an air terminals shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

16. Level 3 Air Terminal Installation Requirements

16.1 Early Streamer Emission Air Terminals

16.1.1 ESE Air Terminals shall be mounted at a height consistent with the requirements of Section 14.5.2 or a minimum of 7' (2.1m) above all projections on the roof. See Figure 16.1.1 for sample mast mounting details and figure 16.1.2 for installation diagram.

Figure 16.1.1

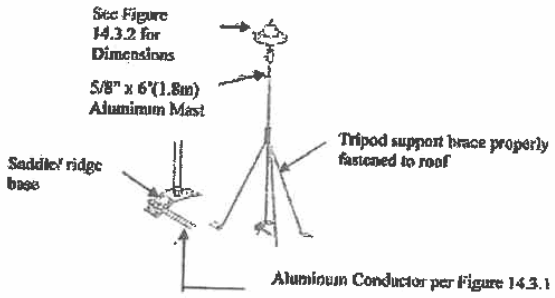
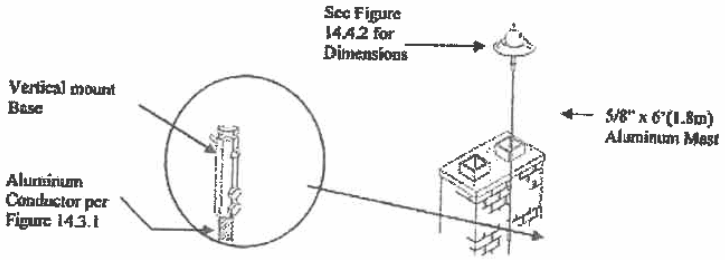
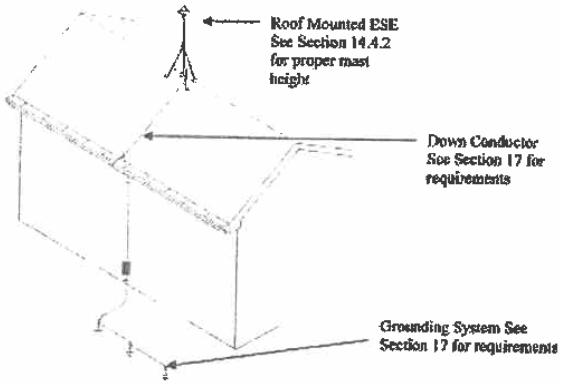


Figure 16.1.1 (Continued)



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Figure 16.1.2



16.1.2 ESE Air Terminals shall be provided in proper quantity and location based on the system design under the Manufacturer's Standard. See Figure 3.5.1 and for Level 3 Systems. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

16.1.3 Conductors shall be securely fastened to roof or structure at intervals not exceeding 3' (1m) on center.

16.1.4 The ESE Air Terminals shall be provided with a minimum of one path to ground. (See Section 17 for additional requirements) Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets. See Figure 16.1.4

16.1.5 No bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However Conductors may raise a rate of 3" per 12" of run. See Figure 16.1.3 and Figure 16.1.4

Figure 16.1.3



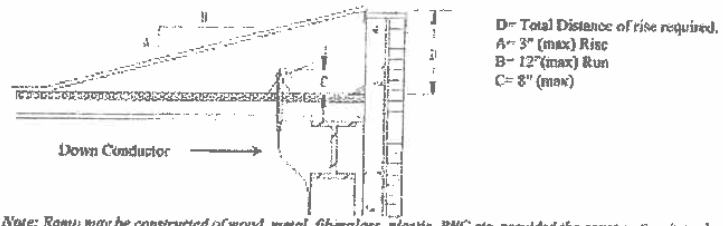
R= Radius bend, 8 inches (203 mm) minimum

90-degree minimum

NOTE: *Through roof, through wall and tee type connectors do not need to comply with this requirement.*

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Figure 16.1.4



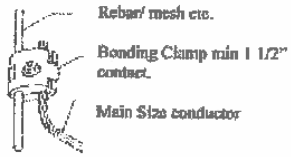
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in Section 16.1.3.

16.1.6 In situations where multiple air terminals are required, air terminals shall be positioned so that they are no more than 150' (45m) from the outside edge of the building nor shall they be more than 300' (90m) apart. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

16.1.7 Down Conductors in situations where multiple ESE Air Terminals are required shall be installed in accordance with Section 17.

16.1.8 Bonding connections shall be made to all rebar, reinforcing rod, structural steel etc. at the upper on lower extremities of the down conductor. See Figure 16.18.

Figure 16.18



16.2 Roof Top Bonding Requirements;

16.2.1 Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless the equipment is inherently connected to the ground system through direct bond or common bond.

16.2.2 Sanitary vents, roof drains, flashings, gutters, copings etc. Located within 6' (1.8m) of the lightning protection system, shall be bonded via a secondary sized conductor to the system unless the equipment is inherently bonded to the lightning protection system.

17. Level 3 Grounding System Requirements

17.1 A minimum of two (2) down conductors shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 16.1.7.

17.2 A single down conductor shall be permitted to be used where the length of run does not exceed 65ft (19m).

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17.3 If the horizontal length is greater than the vertical length, two down conductors shall be required and separated a minimum of 10' (3m).

17.4 For lengths greater than 65' (19m) two conductors shall be required.

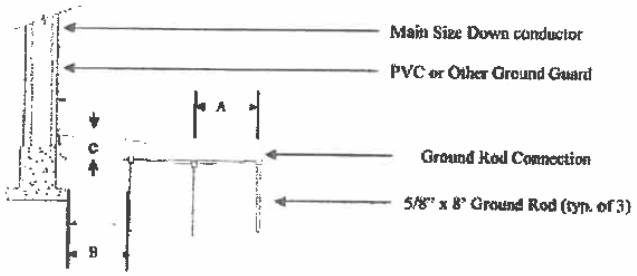
17.5 For masts, a single down conductor only shall be required.

17.6 If electrically conductive, the mast shall be permitted to be used as the down conductor.

17.7 Down Conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See Figure 17.8.1

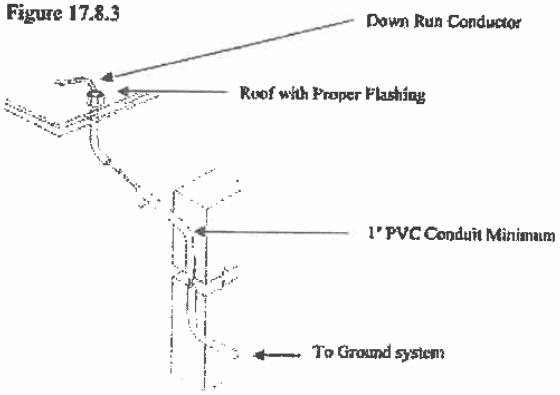
17.8 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 17.8.3.

Figure 17.8.1



A= 8' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 1' (0.3m) Minimum

Figure 17.8.3



17.9 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

17.10 If electrically continuous, structural steel shall be permitted to be used as the down conductor.

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17.11 Masonry Anchors used to secure the lightning protection components shall have a minimum outside diameter of ¼ in. (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed, the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

17.12 Connector Fittings shall be used at all "end to end", "tee", or "y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lb. Fittings used for required connections shall be of bolted, welded or high compression type and bear the ARL Listing and UL Listing.

17.13 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of components shall be used that forms an electrolytic couple of such nature that in the presence of moisture, corrosion is accelerated.

17.14 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 25 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

17.15 Ground electrodes shall be of copper-bond steel or copper plate in sufficient number as to achieve a 25 ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 1' (0.3m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 17.8.1.

17.16 Ground Rod Terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

17.17 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configures in a straight line. Where the ground terminals are spaced a minimum of 8' (3m) apart. See Figure 17.8.1.

17.18 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

17.19 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems. *NOTE 1: For further information, see NFPA 70National Electric Code, which contains detailed information on the grounding of electrical systems.*

17.20 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include lightning protection, electric service, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25 ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

17.21 Common Ground Bonding. If electric, telephone or other systems are bonded to metallic water pipe; only one connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

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18. Level 3 Structural Steel Systems

18.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

18.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60ft (18m). Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

18.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq inches (5200mm²). The area of attachment shall be free of paint, grease, oil, and debris.

18.4 Early Streamer Emission Air Terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 18.3.

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EXHIBIT B

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USI

April 29th, 2019

Heary Bros Lightning Protection Co Inc
11291 Moore Rd
Springville, NY 14141

To Whom It May Concern:

During the many years we have done business with Heary Brothers Lightning Protection Co. Inc., we have found your commitment to developing quality products for your customers as paramount. Included in that commitment would be the successful line of the Early Streamer Lightning Protection Equipment.

Your dedication has allowed us to establish a comprehensive and cost-effective insurance program for your companies. Because of your dedication, we have been able to secure 11 million dollars of Liability limits. This includes coverage for damage from direct lightning strikes to the structure of any buildings. Please see enclosed America Certificate of Guarantee as additional evidence.

In addition, claims activity has been negligible and we, as your broker, the The Travelers Insurance Company, as your carrier, appreciate your attention to workplace safety and products liability quality control efforts. In today's highly competitive world, this is critical.

Without a doubt, your company was built around a commitment to give customers the products they need and confidence in our ability to meet or exceed expectations. We encourage your efforts and with you continued success.

Sincerely,

Timothy M. Wroblewski
Vice President

TW/lam

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FIRST NIAGARA

April 24, 2015

Heary Bros Lightning Protection Co Inc
11291 Moore Rd
Springville, NY 14141

To Whom It May Concern:

During the many years we have done business with Heary Brothers Lightning Protection Co. Inc., we have found your commitment to developing quality products for your customers as paramount. Included in that commitment would be the successful line of the Early Streamer Lightning Protection Equipment.

Your dedication has allowed us to establish a comprehensive and cost-effective insurance program for your companies. Because of your dedication, we have been able to secure 11 million dollars of Liability limits. This includes coverage for damage from direct lightning strikes to the structure of any buildings. Please see enclosed America Certificate of Guarantee as additional evidence.

In addition, claims activity has been negligible and we, as your broker, the The Travelers Insurance Company, as your carrier, appreciate your attention to workplace safety and products liability quality control efforts. In today's highly competitive world, this is critical.

Without a doubt, your company was built around a commitment to give customers the products they need and confidence in our ability to meet or exceed expectations. We encourage your efforts and with you continued success.

Sincerely,

Timothy M. Wroblewski
Vice President

TW/lam

First Niagara Risk Management, Inc.
726 Exchange Street, Suite 900 • Buffalo, NY 14210
Phone: 716-819-5500 • Toll Free: 800-854-9121 • Fax: 716 819-5140

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EXHIBIT C

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Preventor System Installations In Florida

ProjectName	Address	City	State
7000 Williams Island Building		Adventura	FL
Florida Hospital Altamonte Office		Altamonte Springs	FL
Turner Agriculture Center and Extension Office		Arcadia	FL
Marriott - Aventura Hotel		Aventura	FL
Alliant Food Service		Boca Raton	FL
Boca Museum		Boca Raton	FL
Boca Raton Condos		Boca Raton	FL
Caterpillar C-2 Expansion		Boca Raton	FL
Sears Store	Glades Road	Boca Raton	FL
TAG (The Answer Group) Main Building		Boca Raton	FL
TAG Main Building East Emissions Building		Boca Raton	FL
The Polo Club of Boca Raton		Boca Raton	FL
Bealls Corp Headquarters		Bradenton	FL
Paul Azinger Residence		Bradenton	FL
St. Stephens School		Bradenton	FL
Tara Preserve Golf Clubhouse		Bradenton	FL

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ProjectName	Address	City	State
Suntree Elementary and Chiller Building		Brevard Co	FL
Florida Welcome Center		Campbelton	FL
Advanced Elastomers		Cantonement	FL
Cape Canaveral AF Station Patrick AFB Cape Arrays		Cape Canaveral	FL
Cape Canaveral Station	Patrick Air Force Ba	Cape Canaveral	FL
Satellite Assembly Bldg Cape Canaveral		Cape Canaveral	FL
Kreiseder Residence		Casey Key	FL
Silverstein Residence		Casey Key	FL
Florida Hospital		Celebration	FL
Clyde Dyal Water Treatment Plant		Christmas	FL
Citrus Springs Utilities	1360 N. Citrus Spri	Citrus Springs	FL
Baystreet Plaza @ International Mall		Clearwater	FL
Capitol One Phase IV		Clearwater	FL
Catile Tower		Clearwater	FL
Church of Scientology Sandcastle Addition		Clearwater	FL
Crescent Beach Club		Clearwater	FL
Crescent Beach Club		Clearwater	FL
General Services Bldg		Clearwater	FL

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ProjectName	Address	City	State
Pinellas County Utilities		Clearwater	FL
Ruth Eckerd Hall		Clearwater	FL
Ruth Eckerd Hall - CEP Addition		Clearwater	FL
St. Cecelia Intraparochial School		Clearwater	FL
The Sirata Beach Resort		Clearwater	FL
The Tides@ Feather Sound		Clearwater	FL
Worthington Square Apartments		Clearwater	FL
City of Coconut Creek - Council Building		Coconut Creek	FL
City of Coconut Creek - Motor Pool Building		Coconut Creek	FL
Coconut Creek Public Safety		Coconut Creek	FL
Sabal Pines - Ball Field #2		Coconut Creek	FL
Sabal Pines - Elementary School		Coconut Creek	FL
Sabal Pines - Hockey Rink		Coconut Creek	FL
Sabal Pines - Maintenance Facility		Coconut Creek	FL
Sabal Pines - Pines Pavilion		Coconut Creek	FL
Sabal Pines - Soccer Field #1		Coconut Creek	FL
Body of Christ Family Life Center		College	FL
Stone/Bag Paper Container Facility	Hwy 29 & Becks La	Contonement	FL

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ProjectName	Address	City	State
Alahamra Tower		Coral Gables	FL
The Alhambra Hotel/Office	50 Alhambra Circle	Coral Gables	FL
University of Miami Intra Mural Fields		Coral Gables	FL
Sheik Island Horse Farm		Dade City	FL
BCC Building 27/ New Child Develop. CTR		Davie	FL
BCC Student Services Building		Davie	FL
Nova Southeastern College Parking Garage		Davie	FL
Phil Smith Toyota		Davie	FL
Rolling Hills Golf and Country Club		Davie	FL
Daytona Auto Dealers Exchange		Daytona Beach	FL
Daytona Marriott Hotel	100 N Atlantic Ave	Daytona Beach	FL
Deerfield Beach Grand Hilton	100 Fairway Drive	Deerfield Beach	FL
Granada Royale Hotel	902 S. E. 20th Ave.	Deerfield Beach	FL
Deltona Lake Track "A"	Diamond Street	Deltona	FL
Deltona WWTP	Saxton & Agatha	Deltona	FL
Deltona WWTP	Lombardy Ctr	Deltona	FL
Deltona WWTP	Cortland Blvd	Deltona	FL
Deltona WWTP	Fisher Drive	Deltona	FL

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ProjectName	Address	City	State
Well # 2 & High Service Pump	Unit 21 Sagmore Dr	Deltona	FL
Silver Beach Condominium		Destin Beach	FL
Guardian Angel School		Dunedin	FL
Our Lady of Lourdes		Dunedin	FL
Burdines Dept. Store		Fort Lauderdale	FL
Marriott - Ft Pierce Travel Plaza	Florida Turnpike Mi	Ft Pierce	FL
Granada Royale Hotel	1101 S.E. 17th Stree	Ft. Lauderdale	FL
Riverside Hotel		Ft. Lauderdale	FL
McGregor Point Hotel		Ft. Myers	FL
Raymond Building Products		Ft. Myers	FL
Raymond Building Supply Rack Storage		FT. Myers	FL
Raymond Building Supply Warehouse Building		FT. Myers	FL
Palm Court Yacht Club		Ft. Walton Beach	FL
Holy Faith Church	700 N.W. 39th Roa	Gainesville	FL
Main Library	on SR-26 Across fro	Gainesville	FL
Nordstrom Distribution Center		Gainesville	FL
UF Hotel and Conference Center		Gainesville	FL
Union Street Station		Gainesville	FL

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ProjectName	Address	City	State
Jack Sawyer	608 Fairpoint Drive	Gulf Breeze	FL
Palmento General Hospital	W. 20th & W. 68th	Hialeah	FL
Aqua Penn Water Co.		High Springs	FL
City of Holmes Beach Baseball Field	5901 Marina Drive	Holmes Beach	FL
North Lake Elementary		Indian River	FL
Sebastian Highlands WTP	1001 Prineville Roa	Indian River City	FL
Richard Herrmann II Residence	405 15th Ave	Indian Rocks Beach	FL
Florida Power/Light Co Martin Combined Cycle # 3,4	State Road 710	Indiantown	FL
Martin Plant Combined Cycle 3 & 4		Indiantown	FL
Allbritton Communications	7025 AC Skinner Pk	Jacksonville	FL
Berkman Plaza		Jacksonville	FL
Cathedral Terrace		Jacksonville	FL
Cathedral Towers		Jacksonville	FL
Cathedral Townhouses		Jacksonville	FL
Cypress Village Apartments	4600 Middleton Par	Jacksonville	FL
Sears Logistics Center		Jacksonville	FL
The Pointe		Jupiter	FL
The Phoenix @ Peachtree		Kennesaw	FL

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ProjectName	Address	City	State
Dolphin Hotel - Epcot Center	1500 Epcot Resort	Lake Buena Vista	FL
Dolphin/Swan Hotel Causeway & Grotto	1500 Epcot Resort	Lake Buena Vista	FL
Royal Plaza Hotel	1905 Preview Blvd	Lake Buena Vista	FL
Swan Hotel - Epcot Center	1500 Epcot Resort	Lake Buena Vista	FL
Westgate Lakes Sales Center		Lake Buena Vista	FL
Columbia Correctional Institution		Lake City	FL
Marriott - Lake Worth Travel Plaza	Florida Turnpike Mi	Lake Worth	FL
Publix Deli Plant	PO Box 407	Lakeland	FL
RMC Ewell Corp		Lakeland	FL
FCCI Insurance Group		Lakewood Ranch	FL
US Post Office - Land O Lakes		Land O Lakes	FL
Central Catholic High School		Lecanto	FL
Citrus Co. Landfill		Lecanto	FL
St. Stalastic Church		Lecanto	FL
FDOT District 5		Leesburg	FL
Lehigh Post Office		Lehigh	FL
Ben Price Residence	Gulf of Mexico Driv	Longboat Key	FL
James Gradner Residence		Longboat Key	FL

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ProjectName	Address	City	State
Sea Place Condominium Complex M1 & M2	1945 Gulf of Mexic	Longboat Key	FL
Wagner Residence	5940 Gulf of Mexic	Longboat Key	FL
Albert Whitted Expansion		Longwood	FL
Lowell Correctional Institution		Lowells	FL
St. Timothy's Catholic Church		Lutz	FL
Marco Island Pump Station	RTE 951	Marco Island	FL
South Fork High School		Martin Co.,	FL
Brevard Educational Facility		Melborne	FL
Eau Gallie High School Gymnasium & Auditorium		Melborne	FL
Brickell Station Towers	30 S.W. 8th Street	Miami	FL
Doral Concourse		Miami	FL
La Tour Condo		Miami	FL
Lincoln Financial Center	701 Brickell Ave.	Miami	FL
Marriott - Snapper Creek Travel Plaza	Florida Turnpike Mi	Miami	FL
Metropolitan Sun Bank	777 Brickell Ave	Miami	FL
Porta Vita		Miami	FL
Pro-Player Stadium		Miami	FL
Sienna		Miami	FL

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ProjectName	Address	City	State
Softel Hotel	5800 Blue Lagoon	Miami	Fl
Telemundo Networf		Miami	FL
Tequesta Condominium	808 Bricknell Key D	Miami	FL
Three Tequesta Point		Miami	FL
University of Miami Hecht Athletic Center		Miami	FL
University of Miami Knight Baseball Stadium & Foot		Miami	FL
University of Miami Schiff Tennis Ctr & Hecht Ath		Miami	FL
Loews Hotel & Convention Center		Miami Beach	FL
Portofino Tower		Miami Beach	FL
Sandy Park Health Care Center		Miami Beach	FL
US Naval Air Station Bldg 1406 & 1424	Whiting Field South	Milton	FL
Mulberry Post Office		Mulberry	FL
North Port St. Lucie WTP	Gulf Port Terrace	N. Port St. Lucie	FL
Collier Residence		Naples	FL
Gerry Residence	3400 Gordon Drive	Naples	FL
HorseCreek Properties Collier Equestrian Facility		Naples	FL
Horsecreek Properties Collier Equestrian Facility	Daniels Road	Naples	FL
Naples Cay Seapointe Condo	10 Seagate Drive	Naples	FL

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ProjectName	Address	City	State
Royal Poinciana Country Club	Goodlette Rd	Naples	FL
The Savoy Condo	4041 Gulf Shore Blv	Naples	FL
Blazer Residence		Navarre	FL
Caribbean Resort Condo		Navarre Beach	FL
The Fountaians Condominium		New Smyrna Beach	FL
Implant Innovations Inc.		North Palm Beach	FL
King Plastics Inc.		North Port	FL
Bishop Larkin Pastoral Center	9th Avenue	North St. Petersburg	FL
Lowell Correctional Facility Water Tower		Ocala	FL
Marion Oaks Water TRT Plant	14170 S.W. 39th Av	Ocala	FL
Marriott - Turkey Travel Plaza	Florida Turnpike Mi	Ocee	FL
Marriott - Ft Drum Travel Plaza	Florida Turnpike Mi	Okeechobee	FL
BIC Manufacturing Plant(III) Myerlake		Oldsmar	FL
Florida Hospital East Orlando		Orlando	FL
Florida Hospital Orlando		Orlando	FL
Martin Marietta Conflow Area Site	Kirtland Road	Orlando	FL
Orlando Utilities Commission Power Plant		Orlando	FL
St. Johns Rive Water Management		Palatka	FL

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ProjectName	Address	City	State
St. Johns River Waste Management District Office		Palatka	FL
SWA Tipping Floor Building		Palm Beach	FL
The Diplomat Hotel - Main Building		Palm Beach	FL
SWA West Central Tipping Floor		Palm Beach Co	FL
George Young United Methodist Church		Palm Harbor	FL
St. Mark Village	Rte 19	Palm Harbor	FL
William E. Dunn Water Reclamation Facility		Palm Harbor	FL
Riviera Dunes Marina		Palmetto	FL
St. Andrews Condo		Panama City	FL
Hidden Dunes Condominium		Panama City Beach	FL
Landmark Holiday Beach Resort		Panama City Beach	FL
The Summit Resort	Thomas Drive	Panama City Beach	FL
Camp-O-Pines Pensacola Christian College		Pensacola	FL
Ellyson Industrial Park	Ellyson Field Proj	Pensacola	FL
Gelman Sciences	8780 Fly Road	Pensacola	FL
George Estes Residence		Pensacola	FL
Girls Parking Garage -Pensacola Christian College		Pensacola	FL
H-6 Academic Building		Pensacola	FL

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ProjectName	Address	City	State
McKenzie Building- Pensacola Christian College		Pensacola	FL
Phoenix 10 Condominium		Pensacola	FL
University of West FL Admin. Building		Pensacola	FL
University of West FL Classroom Building		Pensacola	FL
Sabine Yacht & Racquet Club	330 Fort Pickens Rd	Pensacola Beach	FL
Eden Condominium		Peridido Key	FL
St. Clements Catholic Church		Plant City	FL
American Heritage Fine Arts Building		Plantation	FL
Crossroads 4		Plantation	FL
Motorola		Plantation	FL
Motorola Inc.		Plantation	FL
Spa Atlantis		Pompano	FL
Ligi Tool		Pompano Beach	FL
Marriott - Pompano Travel Plaza	Florida Turnpike Mi	Pompano Beach	FL
Charlotte County Public Works		Port Charlotte	FL
Dr. Eugene Gregosh Residence		Port Charlotte	FL
East Port Environmental Services		Port Charlotte	FL
Peace River WTP	Kings Hwy	Port Charlotte	FL

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ProjectName	Address	City	State
Peace River WTP	Intake Structure	Port Charlotte	FL
Port Malabar WTP		Port Malbar	FL
Bishop Larkin School		Port Richey	FL
Charlotte County Sheriff's Administration	Metro Pkwy	Punta Gorda	FL
Chateau Towers	Gulfport Blvd	S. Pasadena	FL
Espirtu Santo Catholic School		Safety Harbor	FL
The Shipley Residence		Sannibel Island	FL
Baker Electronics		Sarasota	FL
C'A' D' Zan John't Mable Rigling Home		Sarasota	FL
Davis Residence		Sarasota	FL
Ed Windemuller Residence	Saddle Oaks Estates	Sarasota	FL
Ken Miller Barn		Sarasota	FL
Lincoln Properties/ NBD Bank Building	240 N Washington	Sarasota	FL
Marina Towers Condominium		Sarasota	FL
Meridian @ The Oaks Building III		Sarasota	FL
Sarasota Herald Tribune		Sarasota	FL
Scott Sign Systems		Sarasota	FL
Scott Signs Phase II		Sarasota	FL

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ProjectName	Address	City	State
Sun Hydraulics Inc.		Sarasota	FL
The Phoenix Condo	Golden Gate Point	Sarasota	FL
The Radisson Hotel Lido Beach	Ben Franklin Drive	Sarasota	FL
The Renaissance		Sarasota	FL
Sebastian WTP	Filbert Street	Sebastian	FL
Lake Jackson Post Office		Sebring	FL
St. Cloud High School		St Cloud	FL
Casa Monica Hotel		St. Augustine	FL
St. Augustine Shores	771 Alahambra	St. Augustine	FL
Marriott - Canoe Creek Travel Plaza	Florida Turnpike Mi	St. Cloud	FL
School "C" Osceola Co. School District		St. Cloud	FL
Incarnation Church		St. Petersburg	FL
Jabil Circuit Inc.	10800 Roosevelt Blv	St. Petersburg	FL
Midcore Parking Garage		St. Petersburg	FL
San Seair Condominiums		St. Petersburg	FL
St. Marks Family Life Center	PO Box 43022	St. Petersburg	FL
Wheelbrator Corp		St. Petersburg	FL
SECO Office Building		Sumterville	FL

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ProjectName	Address	City	State
Capital One Building One	8745 Henderson Ro	Tampa	FL
Capital One Phase II Building 2 Renaissance	8745 Henderson Ro	Tampa	FL
Capital One Phase II Parking Garage	8745 Henderson Ro	Tampa	FL
Capital One Phase III Parking Garage	8745 Henderson Ro	Tampa	FL
Capital One Phase IV Flagpole	8745 Henderson Ro	Tampa	FL
Capital One Softball Field	8745 Henderson Ro	Tampa	FL
Capital One Tai Chi Building	8745 Henderson Ro	Tampa	FL
Florida Aquarium		Tampa	FL
Gateway Post Office		Tampa	FL
Group Tech		Tampa	FL
Lee Moffit Cancer Center Parking Garage		Tampa	FL
Marriott -Tampa		Tampa	FL
Muvico	18002 Richmond Pa	Tampa	FL
Myrtle Oaks		Tampa	FL
Notre Dame High School		Tampa	FL
Seaboard Waste Water TRT Plant	8234 Causeway Blv	Tampa	FL
St. Mary's Episcopal Day School		Tampa	FL
St. Pete Catholic High School		Tampa	FL

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ProjectName	Address	City	State
Tampa Bay Water Groundwater Clear Well Tank		Tampa	FL
Tampa Bay Water Surface		Tampa	FL
Tampa Juvenile Detention Center		Tampa	FL
The Garrison Condo		Tampa	FL
The Sorelle Residence		Tampa	FL
Westshore Plaza Phase III Expansion		Tampa	FL
City of Titusville Blue Heron WRF		Titusville	FL
City of Titusville Blue Heron WRF		Titusville	FL
Reliant Energy Corp. Maintenance Instrumentation B		Titusville	FL
Reliant Energy Corporation Intake Structure	Highway US 1	Titusville	FL
Sipprelle Residence		Ussepa Island	FL
Meridian @ The Oaks		Venice	FL
Woodmere Clubhouse		Venice	FL
Our Lady of the Rosary-Ballfield	21010 S.R. 54	West Land O'Lakes	FL
Our Lady of the Rosary-Flagpole	21010 S.R. 54	West Land O'Lakes	FL
SWA (CMRF)		West Palm Beach	FL
Marriott - Okahumpka Travel Plaza	Florida Turnpike Mi	Wildwood	FL
Florida Hospital		Winter Park	FL

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ProjectName	Address	City	State
Florida Brewing Company		Ybor City	FL

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Preventor 2005 Installations (Government)

Project Name	Address	City	State
Kodiak Building (SCAT) Mobile Structure on Rails		Kodiak	AK
Huntsville Public Safety Complex		Huntsville	AL
New Phoenix City Hall	Package Street	Phoenix	AZ
Phoenix Central Library		Phoenix	AZ
Los Angeles Federal Bldg. GSA	255 E. Temple Street	Los Angeles	CA
GSA Oakland Federal Building		Oakland	CA
California Federal Service Center	1515 Walnut Grove Avenue	Rosemead	CA
V.A. Medical Center		San Diego	CA
FBI Center New 9 Story Office Bldg		Washington	DC
Florida Welcome Center		Campbelton	FL
Cape Canaveral AF Station Patrick AFB Cape Arrays		Cape Canaveral	FL
Cape Canaveral Station	Patrick Air Force Base	Cape Canaveral	FL
Satellite Assembly Bldg Cape Canaveral		Cape Canaveral	FL
General Services Bldg		Clearwater	FL
City of Coconut Creek - Council Building		Coconut Creek	FL
City of Coconut Creek - Motor Pool Building		Coconut Creek	FL

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Project Name	Address	City	State
Coconut Creek Public Safety		Coconut Creek	FL
Marriott - Ft Pierce Travel Plaza	Florida Turnpike Mile Mkr 144	Ft Pierce	FL
City of Holmes Beach Baseball Field	5901 Marina Drive	Holmes Beach	FL
Marriott - Lake Worth Travel Plaza	Florida Turnpike Mile Mrk. 94	Lake Worth	FL
US Post Office - Land O Lakes		Land O Lakes	FL
FDOT District 5		Leesburg	FL
Marriott - Snapper Creek Travel Plaza	Florida Turnpike Mile Mkr 19	Miami	FL
US Naval Air Station Bldg 1406 & 1424	Whiting Field South & North Tower	Milton	FL
Mulberry Post Office		Mulberry	FL
Marriott - Turkey Travel Plaza	Florida Turnpike Mile Mkr 263	Ocee	FL
Marriott - Ft Drum Travel Plaza	Florida Turnpike Mile Mkr 184	Okeechobee	FL
St. Johns Rive Water Management		Palatka	FL
Marriott - Pompano Travel Plaza	Florida Turnpike Mile Mrk 65	Pompano Beach	FL
East Port Environmental Services		Port Charlotte	FL
Charlotte County Sheriff's Administration	Metro Pkwy	Punta Gorda	FL
Marriott - Canoe Creek Travel Plaza	Florida Turnpike Mile Mrk 229	St. Cloud	FL
Gateway Post Office		Tampa	FL
Marriott - Okahumpka Travel Plaza	Florida Turnpike Mile Mrk 299	Wildwood	FL

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Project Name	Address	City	State
Cherokee County Public Safety Complex		Canton	GA
Montgomery County Courthouse		Chula	GA
Paulding County Courthouse	Courthouse Square	Dallas	GA
Handcock Co. Courthouse		Greenfield	IN
Courthouse		Tipton	IN
Campbell County Courthouse	4th Street	Newport	KY
Westover AFB Hangar		Chicopee	MA
Westover AFB Upgrade Hangar B-700		Chicopee Falls	MA
Melrose City Hall	Essex& Main St	Melrose	MA
Natick Municipal Complex		Natick	MA
Mt. Holyoke Summit Lodge	Holyoke State Park	S. Hadley	MA
Wellesley Town Hall	525 Washington St	Wellesley	MA
Bethesda Metro Center	7450 Wisconsin Ave	Bethesda	MD
National Park		Landover	MD
Van Buren County Courthouse		Paw Paw	MI
Public Service of New Hampshire Corporate Hdqrts.		Mancester	NH
Veterans Memorial Home	132 Evergreen Rd	Edison	NJ
Oyster Creek Emergency Bldg	Route 9	Forked River	NJ

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Project Name	Address	City	State
Municipal Complex		Hanover Twp.	NJ
Manchester Town Hall	1 Colonial Drive @ Rte 37	Lakehurst	NJ
Morris County Hall of Records	Ann Street	Morristown	NJ
NJIT Library Bldg	Central Ave	Newark	NJ
South Brunswick Maintenance. Storage Complex		S. Brunswick	NJ
City Hall and Police Dept	Morris & Springfield Aves	Summit	NJ
GTE Government Systems White Sands Missile Range		WSMR	NM
State Legislature Building			NV
Yuca Mountain Test Site			NV
Regional Justice Center		Las Vegas	NV
New Reno Federal Building		Reno	NV
Galena Maintenance Station		Washoe	NV
Broadway Office Complex	625 Broadway	Albany	NY
Transitional Housing	Jackson & Cypress	Bronx	NY
Transitional Housing	141st	Bronx	NY
Transitional Housing for the Homeless	50 W. Mt Eden & Inwood	Bronx	NY
Transitional Housing	Linden Blvd	Brooklyn	NY
Transitional Housing for the Homeless	St. Johns Place & E. NY Ave.	Brooklyn	NY

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Project Name	Address	City	State
Family Court Building		Buffalo	NY
The Rath County Office Building		Buffalo	NY
Tompkins County DOT Admin Facility. Bus Garage	Willow Ave	Ithaca	NY
Police & Hwy Dept Bldg	525 Pavement Road	Lancaster	NY
Niagara Falls Housing Authority-Wrobel Towers	Main Street	Niagara Falls	NY
Orchard Park Municipal Center	S-4295 South Buffalo Street	Orchard Park	NY
Criminal Courts Building		Riverhead	NY
Roosevelt Island Phase II	Building I	Roosevelt	NY
Manhasset Fire House	Prospect Rd	Thomaston	NY
West Valley Nuclear Services		West Valley	NY
Logan County Court House		Bellefontaine	OH
Wood County Court House		Bowling Green	OH
Gurnet County Courthouse		Cambridge	OH
Pickway County Courthouse		Circleville	OH
Fayette County Courthouse		Fayette	OH
Trumbull County Courthouse		Trumbull	OH
Owasso City Hall		Owasso	OK
Coudersport Court House		Coudersport	PA

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Project Name	Address	City	State
Potter County Courthouse	1 East Second Street	Coudersport	PA
Cameron County Courthouse	20 East Fifth St	Emporium	PA
Emporium Court House		Emporium	PA
Valley Forge Plaza	First & Moore rd	King of Prussia	PA
Berks County Courthouse	6th & Court St,	Reading	PA
Berks County Services Center	Reed & Court Sts	Reading	PA
Elk County Court House		Ridgeway	PA
Warren County Courthouse		Warren	PA
City Hall Ave Parking Facility		Norfolk	VA
FBI Firearms Range Renov. [26m Range & Stress Obst		Quantico	VA
National Parks Service bldg	North Cascades Visitor Ctr	New Halem	WA

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Preface from NFPA 780

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REPORT OF THE THIRD-PARTY INDEPENDENT EVALUATION PANEL ON THE EARLY STREAMER EMISSION LIGHTNING PROTECTION TECHNOLOGY

BY

John L. Bryan

Richard G. Biermann

Glenn A. Erickson

Submitted to the National Fire Protection Association Standards Council on September 1, 1999

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Rison (336) reported in 1991 on studies conducted at the Langmuir Laboratory from July 15 to August 23, 1991 to evaluate whether a radioactive ESE air terminal provided protection within a 100 meter radius as reported by the Manufacturer. The ESE device was installed on a twenty foot mast 4 meters below South Baldy Peak. Video cameras were used to record the occurrence of lightning strikes. There were two recorded lightning strikes within the 100 meter radius area during the approximate five week study, one 85 meters from the ESE device and one approximately 78 meters from the device. However, the following statement should be noted from the report:

> Near the end of the test period, it was noticed that the radioactive Preventor had been damaged --the weld had broken between the spherical ball on the Preventor and the nut to which it attached. It is not certain when or how this happened. There was no evidence of tampering or vandalism. Examination of the tip of the Preventor under a microscope showed evidence of melting, such as would occur if lightning were to have struck it. Most likely, the Preventor was struck by lightning at a time when the camcorders were not turned on (when the peak was in a cloud, or a storm occurred in the early morning hours), and the lightning broke the weld.[13]

Thus, it might appear that the ESE device was active in a lightning strike not recorded by the video cameras utilized during the study, since there were periods during the study when the cameras were inactive.

---

[13] Rison, William, A Study of Lightning Strikes in The Vicinity of a Radioactive Preventor, Langmuir Laboratory, New Mexico Tech., Socorro, NM, 11-8-91, p. 4.

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Moore *et al.* (248) reported in 1998 a summary of all the field tests of the radioactive "Preventor" ESE device during the summers of 1990, 1991, 1993, 1994, 1995, 1996, and 1997. Moore's analysis is as follows:

> In the six summers during which the "preventor" was exposed to thunderstorms overhead, lightning struck six different sites within 100 meters of the device yet the "preventor" itself was never struck.
>
> Digitized measurements with quarter-microsecond time resolution, of the currents that flowed from the "Preventor" during two nearby lightning strikes in September 1997 showed no indication that the "Preventor" emitted any effective "early streamers". In fact, during one of these discharges, lightning struck a blunt rod located 20 meters distant yet no streamers were emitted from the "Preventor" to connect with this close strike.[14]

It should be noted these seven-year tests involved a single ESE device of a radioactive type. It should also be noted that Moore's (243) field studies under natural lightning conditions have questioned the validity of the effectiveness of the sharp-pointed Franklin air terminal as follows:

> The failure of radioactive-ionizing and of sharply pointed air terminals to participate in lightning discharges by being pre-eminent connectors of lightning to earth is no surprise to scientists studying thunderstorms and lightning. For the past 40 years, I have been measuring the electric currents flowing into the air from both radioactive electrodes and from sharply pointed ones under the influence of the strong electric fields beneath thunderstorms but not one of my well-exposed electrodes has ever been struck by lightning.[15]

[14] Moore, C. B., William Rison, and G. D. Aulich, An Assessment of The Radioactive "Preventor" as an Early Streamer Emitting Lightning Protector, New Mexico Tech., Langmuir Laboratory for Atmospheric Research, Socorro,NM, 12-29-98, pp. 24-25.

[15] 243. Moore, Charles B., New Mexico Tech., "Personal Communication to Subcommittee of NFPA Board of Directors", 9-4-95, p. 1.

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2. Consideration of System Performance

It would appear the ultimate evaluation of any complete lightning protection system would be the performance of the systems as installed on buildings. The submitted materials included one reference to the failure of a conventional system with Franklin rods (328) and there was one newspaper account of a Franklin rod system failure resulting in personnel injuries. (252) There were several studies of failures of ESE lightning protection systems. (146) (220).

The failure of the Franklin rod system resulting in the eleven personnel injuries occurred at the Robert F. Kennedy stadium in Washington, D.C. on June 13, 1998. (252) Richardson reported on the failure of a Franklin rod air terminal located approximately four feet from an externally mounted camera on the building which was damaged by a lightning strike. (328)

Makerras *et al.*, (220) have reported on four cases of lightning striking buildings in Singapore from the late 1960's until the 1980's. Hartono and Robiah (146) have reported on ten cases of failures on buildings protected with ESE lightning protection systems. This study utilized photographs of the building conditions both before and after the reported lightning strikes on the damaged areas of the buildings. It was found from this photographic study the damage appeared to be dependent on the number of strokes received, the strength of the lightning stroke and

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the shape of the structure at the point of the stroke. Although not specified in the study Hartono and Robiah have indicated lightning strike damage was found on buildings protected with Franklin air terminals as indicated in the following statement:

> Studies conducted on the buildings equipped with the standard lightning air terminals (Franklin rod type) also exhibited similar lightning damage locations on or near the rooftop. Based on this comparison, we conclude that no advantage can be obtained by using the ESE device in protecting the building against direct lightning strikes.[21]

It should be noted that all of the incidents of system failure submitted to the panel lacked the necessary detailed documentation to enable a valid analysis as to the effectiveness of the system. Even the most detailed photo study lacked the necessary documentation consisting of the following: The manufacture and model of the air terminal. The date the installation was completed, thus establishing the age of the system when the lightning strike occurred. The maintenance and condition of the system when the strike occurred, including the condition of the down conductors and the grounding system. It would appear that detailed documentation of lightning protection system operations or failures is a needed component for the evaluation of the effectiveness of lightning protection systems of all types on various buildings of differing heights and configurations.

[21]Hartono, Zainal Abidin and Ibrahim Robiah, A Long Term Study on The Performance of Early Streamer Emission Air Terminals in a highly Isokeraunic Region. 2-19-99, p. 2.

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Van Brunt *et al.*, (369) has referenced this problem of adequate data on lightning protection system performance in the following manner:

> There are reports of incidents where ESE devices failed to provide the protection specified by the manufacturer [156,158,165,215]. Statistics on the failure of conventional systems have also been documented [109]. When examining reports of "failures", one can always raise questions about their cause, e.g., whether they are primarily a consequence of exaggerated claims made by the manufacturer or a consequence of misuse (faulty installation) of the device. Reports of isolated failures raise legitimate concerns, but are seldom accompanied by enough supporting data about the event to enable a determination of why the failure occurred. Generally it is difficult to draw significant conclusions from single events that can be used to improve system design or evaluate system performance.[22]

Thus, given the present situation of lightning protection system performance not being a priority of the proponents of the systems, the manufacturers, the insurance companies or public officials it would appear little valid information or data relative to a validation of the theoretical basis of the systems will be obtained.

III. RECOMMENDATIONS TO STANDARDS COUNCIL

Based on a thorough and complete evaluation of the 377 items submitted to the third-party independent panel the members of the panel have agreed in a complete consensus on the following recommendations to the National Fire Protection Association Standards Council. It should be

[22]Van Brunt, Richard J., Thomas L. Nelson, Samar L. Firebaugh, Early Streamer Emission Air Terminals Lightning Protection Systems: Literature Review and Technical Analysis, Quincy, MA, National Fire protection Research Foundation,1-31-95, p, 25.

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recognized the Standards Council is the official designated authority on any action to be taken relative to the NFPA lightning protection documents.

A. Scientific and Technical Basis of ESE

The initial question posed to the third-party independent evaluation panel was stated as: "whether the ESE lightning protection technology is scientifically and technically sound." The panel's review of the submitted materials resulted in the following determinations:

1. The ESE air terminals appear to be technically sound since they are generally equivalent to the conventional Franklin air terminal in laboratory experiments.

2. However, neither the ESE air terminals nor the conventional Franklin rod appear to be scientifically or technically sound when evaluated in field tests under natural lightning conditions.

3. The ESE lightning protection technology as currently developed in the installation of complete systems does not appear to be scientifically and technically sound in relation to the claimed areas of protection or the essentials of the grounding system.

B. Adequacy of Theoretical Basis and Lab Tests

The second specific question posed to the third-party independent review panel was stated as: "whether the ESE lightning protection technology is supported by adequate scientific theoretical basis and

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laboratory testing." The panel's review of the submitted materials resulted in the following determinations:

1. There does appear to be an adequate theoretical basis for the early streamer emission lightning protection air terminal concept and design from a physical viewpoint.

2. There does not appear to be an adequate theoretical basis for the claimed enhanced areas of protection with limited down conductors and grounding system.

3. The high voltage laboratory tests of the ESE air terminals appear to be adequate in scope and quantity, but they are limited in that they are not equivalent to an evaluation of the complete ESE lightning protection system under natural thunderstorm conditions.

C. NFPA Lightning Protection Documents

The third-party independent evaluation panel was also directed in the Settlement Agreement as follows: "This panel, in issuing its report, shall address the following issues, and any other issues it deems relevant:" The panel considered the issues of the existing NFPA 780 document titled: Standard for The Installation of Lightning Protection Systems 1997 edition, (294) and the proposed NFPA 781 document titled: Standard for Lightning Protection Systems Using Early Streamer Emission Air Terminals. (277) The panel considered the need for each document and each committee's membership and balance in accordance with NFPA

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procedures. The panel's review of the submitted materials resulted in the following determinations:

1. The current NFPA 780 Committee should be discharged and the Committee should be completely restructured. The committee needs new and additional memberships in the membership categories of enforcer, consumer, user, insurance, labor, special expert and research/testing..

2. The Council should solicit memberships from prominent users such as: FAA, DOE, DOD, NASA, IBM, Reedy Creek Improvement District, phone, radio, television organizations and electric power utilities.

3. The NFPA 780 document should be reformulated as a Guide or Recommended Practice. It appears to the panel the NFPA 780 document does not meet the NFPA criteria for a standard since the recommended lightning protection system has never been scientifically or technically validated and the Franklin rod air terminals have not been validated in field tests under thunderstorm conditions. The NFPA criteria for a standard as stated in the NFPA 99 Directory (298) is as follows:

> Standard --A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fineprintnote and are not to be consider as part of the requirements of a standard.[23]

[23]NFPA, National Fire Protection Association 1999 Directory, Quincy, MA, 11-98, p. 52.

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EARLY STREAMER EMISSION AIR TERMINALS LIGHTNING PROTECTION SYSTEMS

LITERATURE REVIEW AND TECHNICAL ANALYSIS

Prepared by

Dr. Richard J. Van Brunt
Thomas L. Nelson
Samara L. Firebaugh



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January 1995

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development has been established from laboratory investigations [113], considerably less is known about the dynamics and interactions of these species in a discharge compared to what is known about ions. In particular, very little is known about how they contribute to lightning discharge initiation or propagation under relevant atmospheric conditions. As with negative ions, the metastable content of the air around a lightning terminal will be affected by relative humidity and general air contamination. The influence of metastable species should not extend significantly beyond the end of a lightning rod. Their role, if anything, will be to enhance initial development of a streamer at the rod tip.

In summary, it would appear that enhancement of upward streamer initiation from an ESE terminal (compared to a conventional terminal) has a plausible physical basis. However, it would also appear that a complete and universally accepted understanding of how all ESE devices work has not yet been achieved, and it can be argued that a better understanding is needed to make meaningful quantitative comparisons between the performances of ESE and conventional devices. To reach such an understanding it will undoubtedly be necessary to address numerous basic questions such as:

1. What are the predominant streamer initiation mechanisms under different conditions of polarity, atmospheric humidity, air contamination, and terminal geometry?

2. What are the relative roles of ions, electrons, and metastable species on the development and propagation of a streamer discharge from a terminal for different conditions?

3. What is the likelihood of corona formation around a terminal and how will the presence of corona affect the ability of the terminal to launch a streamer upon approach of a lightning stroke?

4. In the case of radioactive terminals, what is the dependence of the streamer initiation probability on the intensity and type of radiation source?

5. In the case of electrically triggered devices, how does the streamer initiation probability depend on the timing and magnitude of the electrically triggered spark?

6. Also for electrically triggered devices, how reliable is the field sensor that controls the triggering, and can its performance be affected by local space charge?

Attempts to find answers to questions like these are the focus of much ongoing experimental and theoretical research, not only on lightning, but on electrical discharge phenomena in general.

D. Validation of ESE System Performance

Three general methods have been used to evaluate and test the performance of lightning protection systems, namely: 1) small-scale laboratory or outdoor tests in which lightning, or the effects of lightning are simulated by applying high-voltage impulses

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lightning seldom hits a terminal regardless of whether or not it is equipped with an ESE device [182,183,215]. Although a few isolated strikes to the mountain were reported to have occurred within the supposed zones of protection of ESE terminals [183,215], it would appear that the overwelming majority of strikes to the mountain were at considerable distance from any terminal. In any case, the failure of air terminals to attract lightning on mountain tops at elevations of 3000 m (9843 feet) or more is obviously disturbing and raises questions about the interpretation of such observations. Before any serious conclusions are drawn about the performance of lightning attractors from tests performed on mountain tops, it may be necessary to consider the perturbing effect of the mountain itself on such parameters as the surface charge distribution and electric-field profile under a thundercloud, as well as the extent that lightning strokes at such high elevations differ from those that normally occur in lower, flatter locations. It would appear that the answers to some of these questions might already be found in the literature.

It is noted in some papers that lightning that occurs at high elevations generally differs on average from that which occurs at sea level, if in no other respect than that it has less distance to cover in going from the cloud to ground [36]. At an elevation of 3000 m, the ground can be quite close to or even engulfed by the base of a storm cloud. Certainly the results from high mountain tests cannot be dismissed, and such tests should continue, as should similar tests underway at other locations [107]. The problem is how to interpret the results of these tests and infer what they might imply about air terminal performance at lower elevations, and what they indicate about the influence of mountainous or rocky terrain on the effective zone of protection of an air terminal.

The unfavorable statistical odds associated with natural lightning can be partially overcome by using artificially triggered lightning. Tests have shown that lightning can be triggered with reasonably high probability by a rocket launched into a thundercloud [124,160,190,193]. A long trailing wire is usually attached to the rocket which provides a low resistance path to guide the initial discharge and define its direction of propagation [45,120,193]. Transportable facilities have been developed for rocket triggering of lightning that can be used for testing at nearly any location [231]. Although tests of air terminals are being made using triggered lightning, there are questions that can be raised about the meaning of such tests. There is evidence that triggered lightning is unlike natural lightning both in its intensity and propagation characteristics. In particular, it has been noted that triggered lightning is of lower current than natural lightning and exhibits characteristics more like those of return strokes observed in natural lightning [78,161]. It has also been argued that triggered lightning does not satisfactorily mimic the primary stroke and is therefore unsuited for investigation of the attachment to a grounded lightning conductors, i.e. its use in evaluating air terminals would appear to be questionable [78]. The extent to which rocket-triggered lightning behaves like natural lightning seems to depend on the length of the trailing wire and the distance of the bottom end of the wire above

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3. Radiation hazards

In the case of ESE devices that employ radioactive materials, issues have been raised in the literature about the possible radiation hazards to humans that the use of these devices present [24,25,39,81,180,196,278]. As noted above, radioactive air terminals are banned in some countries, presumably because of perceived health hazards. It has been noted that ^{241}Am sources used in lightning protection devices are not any more hazardous than similar sources approved for use in smoke detectors or static eliminators [109,167,180]. Nevertheless, there are those who argue that the public may be placed at risk from a proliferation of radioactive materials in devices that can enter the environment without adequate controls [25,81,180]. An evaluation of the health and safety aspects of radioactive sources used in air terminals lies outside the scope of this report. However, we have identified this as a serious issue that the manufacturers and users of radioactive terminals must be prepared to address.

4. Damage and maintenance

Given that ESE devices likely have a structure and associated instrumentation that are more complex than conventional air terminals, questions can be raised about their susceptibility to damage during a lightning strike. The electric current and energy deposited by a lightning stroke can be sufficiently high to actually melt metallic structures and destroy electronic components. There are numerous reports of damage inflicted by the primary lightning stroke to metal parts on aircraft, etc. [70,79,138,209,237,269]. The possibility of damage means that a lightning protection device may require periodic inspection and/or maintenance that is generally not required for conventional terminals. Although this problem is pointed out [155], there seems to be very little discussion about it in the open literature.

IV. CONCLUSIONS

The possible conclusions that can be drawn from an examination of the literature included in the bibliography are discussed in this section. The main conclusions of this report are briefly summarized in Section VI.

Because of the sparsity of information that can be found in the peer-reviewed literature from tests of early streamer emission air terminals, either in the laboratory or in the natural environment, it is nearly impossible to make quantitatively meaningful statements or judgements about the performance of ESE devices in comparison to conventional Franklin rods. In fact, insufficient reliable quantitative data seem to exist about the performance of conventional rods, and there seems to be an ongoing debate about the best geometrical design for conventional terminals required to achieve optimum lightning attraction efficiency.

Nearly all of the information or data that could found on ESE device performance resulted either from tests performed by manufacturers of lightning protection sys-

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tems or by those directly or indirectly employed by such manufacturers. Although abundant criticism is published by non-manufacturers about the performance of ESE devices, especially radioactive air terminals, it is seldom based on actual test data. Those on both sides of the issue invoke lack of evidence in making their case about the performance of ESE terminals. Proponents of these devices claim that a lack of credible statistical data on failure of ESE terminals proves their effectiveness; while critics of these terminals argue that a lack of evidence about the improved performance of ESE terminals over conventional terminals proves their ineffectiveness. In either case, one must beware of faulty logic, in as much as a lack of evidence never proves the lack of something.

There are reports of incidents where ESE devices failed to provide the protection specified by the manufacturer [156,158,165,215]. Statistics on the failure of conventional systems have also been documented [109]. When examining reports of "failures", one can always raise questions about their cause, e.g., whether they are primarily a consequence of exaggerated claims made by the manufacturer or a consequence of misuse (faulty installation) of the device. Reports of isolated failures raise legitimate concerns, but are seldom accompanied by enough supporting data about the event to enable a determination of why the failure occurred. Generally it is difficult to draw significant conclusions from single events that can be used to improve system design or evaluate system performance. There is no reason to believe that an air terminal is 100% efficient in attracting lightning, regardless of what kind of ESE device it uses, if any. Considering the wide range of possible atmospheric conditions and types of lightning behavior that have been recorded, it is not surprising that air terminals of all types will sometimes fail [37,201,271]. Tall structures are reported to be struck occasionally by lightning at points far below the top, i.e., outside of the "protection zone" [173,185,186]. Any claims of 100% efficiency in the performance of a lightning attractor should be viewed with skepticism. In any case, the meaning of the term "efficiency", when specified for an air terminal, should be clearly defined and understood.

A reasonable physical basis for the operation of an ESE device appears to exist in the sense that there is good evidence from laboratory investigations that the probability of initiating a streamer discharge from an electrode can be increased significantly by irradiation or electrical triggering. However, the precise amount by which this enhancement in streamer initiation improves the lightning attraction efficiency of an air terminal remains questionable. There is reason to doubt that it significantly extends the maximum range of protection. A lightning stroke that would not hit a conventional terminal because of the fact that it does not enhance the field at the terminal tip enough to allow streamer formation will also not likely hit a terminal equipped with an ESE device. (The exception would be an ESE device that significantly increases the terminal potential during the approach of a lightning stroke.) In our view, the possible advantage offered by an ESE device, if operated properly, is that it helps to insure that a streamer will be initiated if the field produced by the

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E7365

Date Submitted	11/20/2018	**Section**	3111	**Proponent**	Bryan Holland
Chapter	31	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation Approved as Submitted
Commission Action Pending Review

Comments

General Comments No

Alternate Language Yes

Related Modifications

7345, 7347, 7348

Summary of Modification

This proposed modification updates requirement for solar energy systems in the FBC-B.

Rationale

This proposed modification deletes the current requirements in Section 3111 and replaces them with the updated rules in 3111 of the 2018 IBC that have been correlated and harmonized with current industry standards and other applicable references. This change is similar to those proposed under Mods 7345, 7347, and 7348 for inclusion into the FBC-R. This change will also coordinate the FBC-B with the FFPC.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will not impact the local entity relative to code enforcement.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will not change the cost of compliance to building and property owners.

Impact to industry relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact industry.

Impact to small business relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected to the health, safety, and welfare of the general public by coordinating the FBC-B with the FFPC for life, fire, and property safety related to solar energy system installations.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves and strengthens the code by updating the rules for solar energy systems in the FBC-B.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

Alternate Language

2nd Comment Period

7365-A2

Proponent Bryan Holland **Submitted** 5/22/2019 **Attachments** Yes

Rationale

This alternative language comment simply corrects a pointer to the applicable section of the FFPC in 3111.3.4 related to access and pathways. "Section 1204" is replaced with "Section 11.12.2.2".

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This alternative language comment will have no impact on the local entity.

Impact to building and property owners relative to cost of compliance with code

This alternative language comment will have no impact on building owners.

Impact to industry relative to the cost of compliance with code

This alternative language comment will have no impact on industry.

Impact to Small Business relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This alternative language comment corrects an error in the code which relates directly to the health, safety, and welfare of the public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This alternative language comment improves the code by correcting an error.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This alternative language comment does not discriminate against any materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This alternative language comment enhances the effectiveness of the code by correcting an error.

Alternate Language

2nd Comment Period

7365-A1

Proponent John Hall **Submitted** 5/22/2019 **Attachments** Yes

Rationale

This alternate language does not alter the text of the modification. It only adds references to appropriate code sections to make the modification applicable to the high velocity hurricane zone.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will not impact the local entity relative to code enforcement.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will not change the cost of compliance to building and property owners.

Impact to industry relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact industry.

Impact to Small Business relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected to the health, safety, and welfare of the general public by coordinating the FBC-B with the FFPC for life, fire and property safety related to solar energy system installations throughout Florida including the HVHZ.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves and strengthens the code by updating the rules for solar energy systems in the FBC-B throughout Florida including the HVHZ.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

SECTION 3111

SOLAR ENERGY SYSTEMS

3111.1 General. Solar energy systems shall comply with the requirements of this section.

3111.1.1 Wind resistance. Rooftop-mounted photovoltaic panels and modules and solar thermal collectors shall be designed in accordance with Section 1609.

3111.1.2 Roof live load. Roof structures that provide support for solar energy systems shall be designed in accordance with Section 1607.13.5.

3111.2 Solar thermal systems. Solar thermal systems shall be designed and installed in accordance with the Florida Building Code-Plumbing, the Florida Building Code-Mechanical, and the Florida Fire Prevention Code.

3111.2.1 Equipment. Solar thermal systems and components shall be listed and labeled in accordance with ICC 900/SRCC 300 and ICC 901/SRCC 100.

3111.3 Photovoltaic solar energy systems. Photovoltaic solar energy systems shall be designed and installed in accordance with this section, the Florida Fire Prevention Code, NFPA 70 and the manufacturer's installation instructions.

3111.3.1 Equipment. Photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

3111.3.2 Fire classification. Rooftop-mounted photovoltaic systems shall have a fire classification in accordance with Section 1505.9. Building-integrated photovoltaic systems shall have a fire classification in accordance with Section 1505.8.

3111.3.3 Building-integrated photovoltaic systems. Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Section 1507.18.

3111.3.4 Access and pathways. Roof access, pathways and spacing requirements shall be provided in accordance with Section ~~1204~~ 11.12.2.2 of the Florida Fire Prevention Code.

3111.3.5 Ground-mounted photovoltaic systems. Ground-mounted photovoltaic systems shall be designed and installed in accordance with Chapter 16 and the Florida Fire Prevention Code.

3111.3.5.1 Fire separation distances. Ground-mounted photovoltaic systems shall be subject to the fire separation distance requirements determined by the local jurisdiction.

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~~SECTION 3111~~

~~PHOTOVOLTAIC PANELS AND MODULES~~

~~3111.1 General. Photovoltaic panels and modules shall comply with the requirements of this code and the Florida Fire Prevention Code.~~

~~3111.1.1 Rooftop-mounted photovoltaic panels and modules. Photovoltaic panels and modules installed on a roof or as an integral part of a roof assembly shall comply with the requirements of Chapter 15 and the Florida Fire Prevention Code.~~

SECTION 3111

SOLAR ENERGY SYSTEMS

3111.1 General. Solar energy systems shall comply with the requirements of this section.

3111.1.1 Wind resistance. Rooftop-mounted photovoltaic panels and modules and solar thermal collectors shall be designed in accordance with Section 1609. For buildings and structures located within the high-velocity hurricane zone refer to Section 1620.

3111.1.2 Roof live load. Roof structures that provide support for solar energy systems shall be designed in accordance with Section 1607.13.5.

3111.2 Solar thermal systems. Solar thermal systems shall be designed and installed in accordance with the Florida Building Code-Plumbing, the Florida Building Code-Mechanical, and the Florida Fire Prevention Code.

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3111.3.2 Fire classification. Rooftop-mounted photovoltaic systems shall have a fire classification in accordance with Section 1505.9. Building-integrated photovoltaic systems shall have a fire classification in accordance with Section 1505.8. For buildings and structures located within the high-velocity hurricane zone refer to Section 1516.

3111.3.3 Building-integrated photovoltaic systems. Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Section 1507.18. For buildings and structures located within the high-velocity hurricane zone refer to Section 1518.11.

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3111.3.4 Access and pathways. Roof access, pathways and spacing requirements shall be provided in accordance with Section 1204 of the Florida Fire Prevention Code.

3111.3.5 Ground-mounted photovoltaic systems. Ground-mounted photovoltaic systems shall be designed and installed in accordance with Chapter 16 and the Florida Fire Prevention Code.

3111.3.5.1 Fire separation distances. Ground-mounted photovoltaic systems shall be subject to the fire separation distance requirements determined by the local jurisdiction.

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3111.3.1 Equipment. Photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703. Inverters shall be listed and

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labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

3111.3.2 Fire classification. Rooftop-mounted photovoltaic systems shall have a fire classification in accordance with Section 1505.9. Building-integrated photovoltaic systems shall have a fire classification in accordance with Section 1505.8. For buildings and structures located within the high-velocity hurricane zone refer to Section 1516.

3111.3.3 Building-integrated photovoltaic systems. Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Section 1507.18. For buildings and structures located within the high-velocity hurricane zone refer to Section 1518.11.

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3111.3.5.1 Fire separation distances. Ground-mounted photovoltaic systems shall be subject to the fire separation distance requirements determined by the local jurisdiction.

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TAC: Electrical

Total Mods for **Electrical** in **No Affirmative Recommendation: 9**

Total Mods for report: 13

Sub Code: Building

E7211

5

Date Submitted	11/7/2018	**Section**	464.4.7	**Proponent**	Bryan Holland
Chapter	4	**Affects HVHZ**	No	**Attachments**	Yes

TAC Recommendation No Affirmative Recommendation

Commission Action Pending Review

Comments

General Comments Yes

Alternate Language Yes

Related Modifications

7209, 7210, and 7212

Summary of Modification

This proposed modification adds requirements for lightning and surge protection in ALFs identical to the current and proposed requirements for nursing homes.

Rationale

This proposed modification adds requirements for lightning and surge protection in ALFs identical to the current and proposed requirements for nursing homes in Section 450.3.19. These two occupancy types have very similar uses, occupant loads, construction types, and exposure to the hazards of lightning and transient surges. Currently, ALFs are not afforded the same level of protection as nursing homes are against these hazards. There have been several reported fires as a result of lightning strikes to ALFs all across the state of Florida. These incidents have resulted in significant loss of property and extensive cost to the owners and residents of these properties.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will require the local entity to enforce additional criteria on ALFs similar to nursing homes. This includes additional permitting, plan review, inspection, commissioning, and record-keeping.

Impact to building and property owners relative to cost of compliance with code

This proposal will increase the cost of construction to building and property owners of ALFs. See the attached cost study.

Impact to industry relative to the cost of compliance with code

This proposed modification will increase the cost of compliance to industry. See the attached cost study.

Impact to small business relative to the cost of compliance with code

This proposed modification will likely not impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected to the health, safety, and welfare of the general public and those working, living, and visiting ALFs in the state of Florida.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification strengthens the code by expanding lightning and surge protection into ALFs identical to what is currently required for nursing homes.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code by harmonized the hazard mitigation of lightning and transient surges at both nursing homes and ALFs.

Alternate Language

2nd Comment Period

7211-A2

Proponent Bryan Holland **Submitted** 5/21/2019 **Attachments** Yes

Rationale

This alternative language comment adds an exception to the rule based on the concerns addressed in the public comments submitted and the comments shared by the members of the TAC. This will exempt those assisted living facilities that may not benefit from having a lightning protection system installed. This includes the low-occupancy type facilities that have limited exposure to the hazards of lightning. Only those facilities where the NFPA 780 risk assessment guide indicates a lightning protection systems is needed will be required to install one.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

Approval of tis alternative language comment will have little to no impact on the local entity.

Impact to building and property owners relative to cost of compliance with code

This alternative language comment will increase the cost of compliance with the code for those facilities that will be required to install a lightning protection system. Please see the cost analysis attached.

Impact to industry relative to the cost of compliance with code

This alternative language comment will only impact those large, high-occupancy, high risk assisted living facilities where the hazards of lightning damage exceed the cost of installation a protection system.

Impact to Small Business relative to the cost of compliance with code

This proposed modification will likely not impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This alternative language comment enhances the health, safety, and welfare of some of the most vulnerable citizens in the state of Florida that live in assisted living facilities with a high risk of exposure to lightning.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This alternative language comment improves the code and system of construction at assisted living facilities.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This alternative language comment does not discriminate against any materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This alternative language comment enhances the effectiveness of the code by adding lightning resiliency to certain assisted living facilities.

Alternate Language

1st Comment Period History

7211-A1

Proponent Bryan Holland **Submitted** 1/8/2019 **Attachments** Yes

Rationale

The only alternative language being proposed is under Section 464.4.7.5 where "low voltage system main or branch circuits" is being replaced with "communication systems". No other changes being recommended for this proposed modification. This will match the language in SP7255, SP7218, and a SP7209 comment.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This comment has no impact on the local enforcement entity as it only provides clarity and no new requirements

Impact to building and property owners relative to cost of compliance with code

This comment has no impact on building or property owners.

Impact to industry relative to the cost of compliance with code

This comment has no impact on industry.

Impact to Small Business relative to the cost of compliance with code

This proposed modification will likely not impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This comment provides clarification of the rule which directly relates to health, safety, and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This comment improves the use and clarity of the code.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This comment does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This comment enhances the effectiveness of the code.

2nd Comment Period

E7211-G5

Proponent Douglas Adkins **Submitted** 5/23/2019 **Attachments** No

Comment:
The Florida Statutes 429.01(2) states that Assisted Living facilities "should be operated and regulated as residential environments with supportive services and NOT as medical or nursing facilities". THe statute also describes the ALF as "homelike environment". The petitioner seeking this rule change stand to financially gain from such mandate and seeks a standard or requirement that contravenes the statute in forcing ALFs to be regulated to a standard similar to a skilled nursing home or medical facility. The statute is clear that the regulation should be at the residential level. If adopted then the next extension would be to seek a similar standard be imposed on all new residential construction which would not be practical or logical. This proposed change violates the ban on rules that contravene Florida Statute and would be challenged accordingly. There is an argument that can be made that whatever is required in the ALF setting arguably could be required in all residential settings as these are similar settings each defined as residential. In my opinion the equal protection clause of the US Constitution would require the Building Commission to treat all such structures the same and to impose this same requirement on residential home builders as well. This is an illogical proposal that would adversely affect the cost of care and provide marginal benefit to the facilities and would offer no additional protection or safety for the residents t6o warrant the change and new costs.

2nd Comment Period

E7211-G6

Proponent Michael Riley **Submitted** 5/23/2019 **Attachments** Yes

Comment:
Proposed code modification 7211 does not meet the statutory standards of Chapter 553. See attached comments.

2nd Comment Period

E7211-G7

Proponent Gail Matillo **Submitted** 5/24/2019 **Attachments** No

Comment:
Comment from one of our members:

I would let them know that major changes like this, and the generators, greatly affect our ability to operate at a price point that is beneficial to our residents. I would also let them know that the cost associated with these changes must be passed on to our residents. We have never experienced an incident where this change would've helped us or been beneficial to the residents. So their desire to help the residents in case an occurrence that has never happened before actually happens is outweighed by the additional financial burden they're forcing us to put on our residents on a daily basis. In other words, their desire to help is offset by the real world pain these changes inflict.

2nd Comment Period

E7211-G8

Proponent Gail Matillo **Submitted** 5/24/2019 **Attachments** Yes

Comment:
see attached letter

2nd Comment Period

E7211-G9

Proponent Shaddrick Haston **Submitted** 5/26/2019 **Attachments** Yes

Comment:
The Florida Assisted Living Association objects to the proposed amendment. See attached document.

2nd Comment Period

E7211-G10

Proponent	Bryan Holland	Submitted	5/26/2019	Attachments	Yes

Comment:

Please see the attached for my rebuttal statements to the General Comments submitted (G5-G9). I urge the TAC to disregard these general comments and vote to recommend approval of the alternative language comment (SP7211-A2).

2nd Comment Period

E7211-G11

Proponent	Joe Bigelow	Submitted	5/28/2019	Attachments	Yes

Comment:

Submitted by Shroder Joseph & Associates via FedEX

1st Comment Period History

E7211-G1

Proponent	Vincent Della Croce	Submitted	1/8/2019	Attachments	No

Comment:

I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

1st Comment Period History

E7211-G2

Proponent	James gregory	Submitted	2/16/2019	Attachments	No

Comment:

I do not support adding this requirement to Assisted Living Facilities for the following reasons:
1. ALFs are not health care facilities. They are residential facilities reviewed as either R4 or I-1 of the FBC and Board and Care in the Life Safety Code.
2. Only limited nursing services are provided. All residents must be ambulatory.
3. ALFs do not have any life support or Type I EES unlike nursing homes and hospitals.
4. The large majority of ALFs constructed in the state are small homes from 5 to 7 residents. This is will be a heavy economic impact of those small homes.
5. All new ALFs must be fully sprinklered so there is already ample fire protection.

1st Comment Period History

E7211-G3

Proponent	Deborah Franklin	Submitted	2/18/2019	Attachments	No

Comment:

FHCA does not support adding this requirement to Assisted Living Facilities for the following reasons:
1. ALFs are not health care facilities. They are residential facilities reviewed as either R4 or I-1 of the FBC and Board and Care in the Life Safety Code.
2. Only limited nursing services are provided. All residents must be ambulatory.
3. ALFs do not have any life support or Type I EES unlike nursing homes and hospitals.
4. The large majority of ALFs constructed in the state are small homes from 5 to 7 residents. This is will be a heavy economic impact of those small homes.
5. All new ALFs must be fully sprinklered so there is already ample fire protection.

1st Comment Period History

E7211-G4

Proponent Susan Anderson **Submitted** 2/18/2019 **Attachments** No

Comment:

The Florida Senior Living Association (FSLA) disagrees that placing institutional, nursing homes style regulations on assisted living facilities to protect the building from fire damage is necessary. Further, a review of NFPA records of fire incidents in assisted living facilities in the state of Florida indicates a lack of physical harm to residents over at least, the past two decades, that also informs against the proposed code modification. The intent of the Legislature in Part I of Chapter 429, Florida Statutes, specifically states that assisted living facilities "should be operated and regulated as residential environments with supportive services and not as medical or nursing facilities." S. 429.01(2), Fla. Stat. Section 429.41(1) goes further to state that regulations should "ensure a safe and sanitary environment that is residential and noninstitutional in design or nature." Danger to residents from fire in assisted living facilities in Florida has been successfully addressed by current regulations and the proposed modification is unnecessary and burdensome. In addition, FSLA adopts and incorporates the comments submitted by James Gregory and Debbie Franklin.

464.4.7 Lightning protection.

464.4.7.1

A lightning protection system shall be provided for all new buildings and additions in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

Exception:

Lightning protection shall not be required for any building or addition where determined to be unnecessary by evaluation using the Risk Assessment Guide in NFPA 780, Standard for the Installation of Lightning Protection Systems or an alternative method approved by the authority having jurisdiction.

464.4.7.2

Where additions are constructed to existing buildings, the existing building's lightning protection system, if present, shall be interconnected to the new lightning protection system.

464.4.7.3

Surge protective devices (SPDs) shall be installed in accordance with NFPA 70, National Electrical Code, as required by NFPA 780, Standard for the Installation of Lightning Protection Systems for all normal and emergency electrical services.

464.4.7.4

Additional surge protection shall be provided for all low voltage and power connections to all electronic equipment in critical care areas and life safety systems and equipment such as fire alarm, emergency call and other critical systems. Protection shall be in accordance with NFPA 70, National Electrical Code and the appropriate IEEE Standards for the type of equipment protected.

464.4.7.5

All communication systems entering or exiting the structure shall have surge protectors installed for each pair of conductors and shall have visual indication for protector failure to the maximum extent feasible.

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All communication systems entering or exiting the structure shall have surge protectors installed for each pair of conductors and shall have visual indication for protector failure to the maximum extent feasible.

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464.4.7.5

All low-voltage system main or branch circuits entering or exiting the structure shall have surge protectors installed for each pair of conductors and shall have visual indication for protector failure to the maximum extent feasible.

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Rebuttal Statements to General Comments (SP7211)

SP7211-G5: Neither the alternative language comment nor the original proposed modification are in conflict with F.S. 429 or any other Florida Statute. There is no law or rule in the state of Florida limiting the requirements for lightning protection systems to health care facilities or prohibiting them from residential-type occupancies. The Florida Building Commission is charged with the responsibility of protecting the health, safety, and welfare of the general public. This code modification satisfies that public duty doctrine. As stated by the Florida Assisted Living Association (FALA) in General Comment SP7211-G9, "residents living in these assisted living facilities are becoming frailer, requiring higher levels of care…" This higher level of care needed for these frail residents would likely include assisted evacuation in the case of fire as a result of a lightning strike. This statement by FALA alone is perfect evidence that the residents of an assisted living facility deserve to live in facilities protected from the hazards of lightning. You could even say it is their US Constitutional right to do so. It should also be noted that I have absolutely no financial interest in lightning protection or any other requirement of the Florida Building Code.

SP7211-G6: Florida continues to lead the nation in the number of deaths as result of lightning. More buildings are struck by lightning in Florida than any other state in the nation. Florida ranks #1 in total lightning-related insurance claims, average losses in dollars per insurance claim, total losses in dollars for all insurance claims, and largest total losses in dollars for all insured and uninsured property. Claiming that lightning protection requirements in the state of Florida is not accommodating a specific need of this state or not connected with the safety and welfare of the general public is simply ludicrous. The pointer to the NFPA 780 for installation compliance has been included in the Florida Building Code since the very first, 2001 edition and has been the referenced standard for lightning protection in every edition since then. Section 104.11 addresses alternative materials, design, and methods of construction for this and every other provision of the code. There is no conflict between the NFPA 70 and NFPA 780 when it comes to surge protection requirements. It should be noted that the Chair of the NFPA 780 Technical Committee is also a member of the NFPA 70 Correlating Committee. The cost associated with the installation of a lightning protection system is substantially less than the potential loss of life and property as a result of lightning.

SP7211-G7: Every building that was struck by lightning for the first time had never had that occurrence happen before. There are literally hundreds of requirements in the Florida Building Code with the purpose to protect against events that may never happen. However, when the devastating outcome of those events exceeds the "cost" or "burden" or "pain" the code requirement initially caused, the overall long-term benefit of these code requirements can be understood. I wish we lived in a world where buildings are immune to events such as hurricanes, floods, lightning, fire, sinkholes, termites, mold, and all the other hazards associated with the built environment. Since that world is not our reality, there will be a cost and societal burden to protect buildings from these hazards to at least a minimum standard of performance. Lightning protection is a form of insurance. You purchase that insurance policy when you install the lightning protection system and hope you never need it. Every person that has ever lost a loved one to fire will tell you after experiencing that loss that they would have paid ANY price to have prevented that loss.

SP7211-G8: As noted above, neither the alternative language comment nor the original proposed modification are in conflict with F.S. 429 or any other Florida Statute. Lightning doesn't care if a building is being used for medical care, residential purposes, or any other purpose. Lightning protection is about risk. The residents of

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an assisted living facility are at a much greater risk to the hazards of lightning as compared to those living in other residential-type occupancies due to the vulnerable nature of persons that need "assisted" living. The Florida Building Commission is under no obligation to limit rules and requirements based on the profitability of an industry or the inadequacies of the nation's health care system. I happen to live in the community where the Village Place ALF is located. According the facility's website, one of the living options includes memory care for persons with Alzheimer's or dementia. Don't we owe persons with these unfortunate conditions every possible protection that is available to prevent the unnecessary trauma of experiencing a catastrophic event and displacement that fire from lightning can result in? Shouldn't the Florida Building Code contain rules and requirements to protect the residents of an assisted living facility from hazards they otherwise cannot protect themselves from on their own? Anything less should be considered negligence and nonfeasance.

SP7211-G9: While I appreciate the challenges faced by the assisted living facility industry by what appears to be a host of economic issues, these matters need to be addressed in another forum and have no direct correlation with the Florida Building Code. It seems very inappropriate to me that Florida Medicaid program policies should be considered when determining what building protection features an assisted living facility should have or not have. The emergency power rule has reduced the potential hazards to the residents of an assisted living facility as a result of a power outage to prevent the unfortunate loss of life like we had following Hurricane Irma. This is our opportunity to close another protection gap in these facilities without having to get the state Legislature or Governor involved. This gives the ALF industry the opportunity to self-regulate and be an active participant in the process. By continuing to pursue rejection of this proposed modification and the reasonable alternative language comment, you are further reminding the policy-makers and citizens of this state the profit comes before safety. The exception that I have added to the alternative language comment ensures only those facilities that have sufficient enough risk exposure to the hazard of lightning will be required to install one. It will not apply to every ALF across the board like the emergency generator rule does.

I urge all five parties to withdraw their opposition and support the alternative language comment (SP7211-A2) as a practical and reasonable compromise to the original proposed modification. THANK YOU.

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May 23, 2019

Via Federal Express

Florida Building Commission
Special Occupancy Technical Advisory Committee
2601 Blair Stone Road
Tallahassee, Florida 32399

Via Email (rsbrowdy@aol.com)

Richard S. Browdy
Chairman, Florida Building Commission
2601 Blair Stone Road
Tallahassee, Florida 32399

Re: Comments on Proposed Code Modification 7211, Florida Building Code

Gentlemen:

Our law firm represents Heary Bros. Lightning Protection Co., Inc. ("Heary Bros.") and its division, Lightning Preventor of America®. Heary Bros. offers both NFPA 780 compliant systems as well as its Preventor® system which is an early streamer emission system ("ESE system") that is installed in compliance with its manufacturer's standard, HBP 21. This letter is submitted to comment on proposed Modification 7211 to require that assisted living facilities ("ALFs") install lightning protection systems in accordance with National Fire Protection Association ("NFPA") 780. The modification should not be accepted and instead there should continue to be the ability for the owner, architect and engineer on such projects for ALFs to select the type of lightning protection system that best fits the needs of the project.

Under the rules governing modification of the Florida Building Code, a prerequisite to accepting a proposed modification such as E6460 is that it "DOES NOT DISCRIMINATE AGAINST MATERIALS, PRODUCTS, METHODS, OR SYSTEMS OF CONSTRUCTION OF DEMONSTRATED CAPABILITIES." (553.73 (9) (a) 3 F.S.). It is respectfully submitted, for the reasons discussed in detail below, that Modification 7211 cannot be accepted because it will violate this fundamental prerequisite under Florida State law (553.73 (9) (a) 3 F.S.) by discriminating against manufacturers and installers of Early Streamer Emission ("ESE") lightning protection systems which constitute a competing alternative of "demonstrated

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capabilities." Indeed, there is no reasonable justification for favoring Faraday lightning protection systems installed under NFPA 780 over ESE lightning protection systems installed under HBP 21 or other equivalent standards which have been approved, specified by architects and engineers and successfully used for many decades throughout the United States and the world.

THE NEED TO REJECT THE PROPOSED MODIFICATION

While most if not all companies in the lightning protection industry either exclusively provide either Faraday Systems or ESE Systems, Heary Bros. manufactures both types of lightning protection systems available in the marketplace today: (1) the traditional Faraday lightning protection systems governed by NFPA 780; and (2) its ESE lightning protection systems which have been successfully installed under HBP 21 for over 30 years under its $11 Million Guaranty backed by Travelers Insurance Company without a single documented lost. Proposed Code Modification 7211—as proposed--would eliminate for Florida Building owners the ESE option.

Importantly, Heary Bros. does not seek to exclude other ESE manufacturers or installers by offering its proven standard known as HBP 21, a copy of which is attached as Exhibit A, as one proven alternative standard. **Instead, the Florida Building Commission should accept other alternative equivalent standards and not limit the standard to NFPA 780.** The point is that architects, engineers and owners should be free to make a choice and should not be limited to one option, particularly since modification 7211 was propounded by a representative of the Faraday Industry which stands to obtain an exclusive monopoly under the proposal. Notably, these types of restrictive changes to the Florida Building Code to require that lightning protection systems comply with NFPA 780 have been proposed by the Florida Industry previously and rejected by the Florida Building Commission for sound reasons in 2017. *See, e.g.*, Modification E6460 rejected by the Florida Building Commission in 2017.

There is no reason to adopt Proposed Modification 7211 and limit the lightning protection systems for ALFs to compliance with NFPA 780. Not only does Heary Bros.' HBP 21 have a proven track record, but it also has the support of Traveler's insurance which provides $11 million in coverage to support Heary Bros.' guaranty of its ESE system. This support is documented by Exhibit B. The reason that Heary Bros. offers both options to its customers is because its ESE system offers a much less expensive option while its NFPA 780 Faraday alternative is more expensive with no technical or scientific basis of superior performance to justify the added cost. Heary Bros. believes the consumer should have the option to decide. Modification 7211—which Heary Bros. learned about for the first time in this week—should be rejected or modified so as not to eliminate that choice for Florida owners, architects and engineers.

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As explained below, not only has it been established in the lightning protection industry that there is no scientific basis for preferring the method of installation of the Faraday system whose installations are governed by NFPA 780 over ESE lightning protection systems, but also the installation approach of the Faraday systems (which uses more cable and more terminals) renders the Faraday System more costly with no added benefit to owners and consumers.

Heary Bros. readily concedes that its profit margins with respect to the sale of the components of Faraday systems exceeds the profit margins on ESE systems because the installation design for Faraday systems requires more cables, more down runs and more terminals and connections despite the lack of any scientific basis for claiming a difference in performance of the two systems. It should come as no surprise that the proponent of this change in the Florida Code is the Faraday Industry and those companies that exclusively install only Faraday Systems under the NFPA 780 standards. These entities consistently promote codes based on NFPA 780 and dominate the NFPA 780 committee.

There is no difference between the quality of the components of ESE systems and Faraday systems. Notably, the components of both the Faraday System and the ESE systems have been listed by Underwriters' Laboratories, Inc. pursuant to UL 96 which provides the "quality control" for component parts of lightning protection systems. In contrast, NFPA 780 ONLY governs the method of installation and requires more cabling, terminals, connectors and more grounding because of differences in the terminals used by each of these two competing systems.

Other factors to consider are that NFPA itself discloses that NFPA 780 has no scientific basis and has never recommended that this standard be adopted as "code." Further, the author of this letter made presentations to New York State when it considered adopting a similar code change more than two decades ago and New York State ultimately rejected the very code change now being considered— a change virtually identical to that being proposed here—and ruled that there was "no technical justification" for its adoption. Again, the proposed change in law simply imposes more costs on building owners with no scientific or practical justification.

If there is an argument being made regarding "insurance savings" by the proponents of this change in law, their evidence merely confirms that lightning protection—may in some few instances—results in insurance rebates, but the documentation does not show that only NFPA 780 systems are eligible for such rebates or whether these rebates are applicable solely to surge protection which is a separate and distinct product.. Moreover, what is indisputable is that the Faraday systems governed by NFPA 780 systems are NOT eligible for Heary Bros. $11 million guaranty backed by Travelers Insurance Company which Travelers offers only for ESE systems installed in compliance with Heary Bros.' manufacturer's standard—coverage which is provided based on Heary Bros.' decades of field experience with this type of system that exceeds thirty

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years. Copies of documentation demonstrating this insurance coverage are attached hereto as Exhibit B.

Perhaps the best illustration of burden that Proposed Modification 7211 would impose on building owners is the fact that so many building owners have in the past chosen the ESE system in preference to the Faraday system governed by NFPA 780. I have attached as Exhibit C a list of just a small sampling of Florida projects now enjoying the benefits of Heary Bros.' ESE system and $11 Million Guaranty which include numerous government and municipal buildings, resort and recreational centers, churches and corporate buildings. This constitutes a small sampling of Heary Bros.' ESE installations throughout the State of Florida—all of which have been installed in compliance with Heary Bros.' manufacturer's standard and have NOT been the subject of a single documented failure. Similarly, Federal and State governments have preferred the option of Heary Bros. ESE system with its $11 million guaranty over Faraday systems governed by NFPA 780. A list of a sampling of these projects is attached as Exhibit D which included, by way of illustration, such buildings as the Huntsville Alabama Public Safety Complex, the Los Angeles Federal Building, San Diego V. A. Medical Center, the Cape Canaveral Air Force Station, the Council Building for City of Coconut Creek, Florida, the Tampa Gateway Post Office Building, the Holmes Beach Florida Baseball Field and the U.S. Naval Air Station in Milton Florida. Again, these are just a very few examples of government installations in various States from all over the United States.

NFPA ITSELF MAKES CLEAR THAT NFPA 780 IS NOT SCIENTIFICALLY BASED

The proponents of the Faraday systems governed by NFPA 780 often argue that the existence of "national standards" for Faraday Systems (such as NFPA 780 and its parallel standard UL96A) somehow demonstrates that Faraday Systems are "scientific" and "proven." These types of statements are inconsistent with the very nature of national standards in the United States. NFPA 780 itself makes it very clear in its disclosures that NFPA 780 is NOT based on science, research, records of testing or even field experience. Instead, the NFPA specifically includes in the preamble to NFPA 780 (and in all NFPA consensus standards) the following disclaimers as to the efficacy of such standards:

> "While **the NFPA** administers the process and establishes rules to promote fairness in the development of consensus, it **does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards. The NFPA disclaims liability for any personal injury, property or other damages** of any nature whatsoever….directly or indirectly resulting from the …use of, or reliance on this document. **The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.**"

This excerpt from the preface to NFPA 780 is enclosed as Exhibit E. (Emphasis added.)

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THE LEADING INDUSTRY LITERATURE REJECTS ANY SUPERIORTY OF FARADAY SYSTEMS OVER ESE LIGHTNING PROTECTION SYSTEMS

We have attached the most recognized studies comparing ESE systems to Faraday Systems governed by NFPA 780, including a report generated by the NFPA itself in 1999. Specifically, attached as Exhibits F and G, respectively, are pertinent excerpts from the Report of the National Institute of Standards and Technology, entitled "Literature Review and Technical Analysis of Early Streamer Emission Systems of Lightning Protection" (1995) (hereinafter "NIST Report") and the Report of the NFPA's Third-Party Independent Evaluation Panel entitled "Early Streamer Emission Lightning Protection Technology" (1999) (hereafter "Bryan Report").

Both the NIST and the Bryan Report concluded that ESE systems have both an adequate theoretical basis and laboratory testing. NIST Report at page 25; Bryan Report at page 26. However, the authors of both reports found that there is insufficient field testing of either ESE systems or traditional (also known as "Faraday") systems of lightning protection under natural thunderstorm conditions. NIST Report at page. 16. Bryan Report at page 26. These findings of inadequate field testing of both traditional Faraday systems and ESE systems of lightning protection were based in part on the fact that there have been reported failures of both types of systems, and there was virtually no documentation to determine the cause of the failure.[1] As a result, both reports concluded that no meaningful conclusions regarding the performance of either type of system could be drawn based on either reported failures or lack of failures of either type of system under natural thunderstorm conditions. NIST Report at page 25; Bryan Report pages.23-24.

Based on this lack of field testing---or even laboratory testing—for traditional (Faraday) systems of lightning protection, the NIST Report concluded that "insufficient quantitative data see to exist about the performance of traditional rods…." NIST at page 24. Dr. Bryan, a former member of the NFPA Standards Council, went so far as to conclude that because of a lack of field or laboratory testing, NFPA 780 systems had insufficient scientific validation to warrant an NFPA standard and recommended that NFPA 780 be "downgraded" to a recommended practice. Bryan Report at pages 27-28.

It also is worth noting that both the NIST and Bryan Reports were highly critical of studies, funded by the Faraday industry, conducted by Professor Moore and Dr. Rison of the

[1] Both Faraday and ESE Systems—like other products—sometimes experience failures due to failure to maintain the systems properly or due to installation errors. Faraday Systems rely on their "track record" in field to support their efficacy. ESE Systems, like Faraday System, also have similar field experience. For example, in over twenty years and with thousands of systems installed in the United States, Heary Bros. have had no documented failures and their insurance carriers have paid no claims. Of course, Heary Bros.' ESE systems are installed in compliance with its manufacturer's standard to ensure adequate installation.

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New Mexico Institute of Mining and Technology. The NIST Report questioned whether any meaningful conclusions could be drawn based on tests conducted at elevations of 3000 m, and that the testing at this altitude "raise questions about the interpretation of such observations" NIST Report at 21.

Similarly, the Bryan Report identified several significant problems with the methodology employed by Professor Moore and Dr. Rison. The Bryan Report noted that despite reporting a "failure" of an ESE system, the ESE terminal had been damaged and--as a result--the study failed to document that the ESE terminal was even working at the time of the alleged strike within the zone of protection. Bryan Report at 17. The Bryan Report also noted that Dr. Rison's and Professor Moore's research questioned the efficacy of terminals used in NFPA 780 systems (Faraday Systems), noting that in four years not a single sharp pointed Franklin rod was struck. *Id.* at 18.

The lack of a scientific basis for NFPA 780 and UL 96A also has been confirmed in an article by written by Professor Martin Uman (a leading lightning protection expert who is often quoted by Faraday manufacturers) and published in the December 2002 issue of *American Meteorological Society*. The article states "[t]he theoretical justification of the traditional [Faraday] approach is fairly crude, in part due to our incomplete understanding of lightning's attachment to ground-based objects. Hence, the fact that traditional [Faraday lightning protection] systems have a history of success in preventing or minimizing damage to structures is the primary justification for their use." December 2002 Edition of *American Meteorological Society* at page 1809. Of course, as noted above, Heary Bros.' ESE systems have the same history of success based on field experience now exceeding thirty years—success which has been acknowledged by Heary Bros.' insurance carriers who provide insurance coverage for its ESE systems through Travelers Insurance Company.

CONCLUSION

For all the foregoing reasons, we respectfully request that you reject Proposed Code Modification 7211. Importantly, as explained above, Proposed Code Modification 7211 clearly cannot be adopted under Florida law because it discriminates against manufacturers and installers of ESE lightning protection systems which constitute a competing alternative of "demonstrated capabilities." Florida State law (553.73 (9) (a) 3 F.S.). Moreover, the Proposed Code Modification 7211 should be accepted since it simply is the right thing to do to preserve an option that architects, engineers and owners have chosen for decades with success and—to do otherwise—would provide the Faraday industry with an unfair and unlawful monopoly. Thus, the action proposed by this letter is in the interests of retaining the owners' ability to choose and will avoid the creation of state law that conflicts with federal antitrust laws and imposes

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anticompetitive restraints on the marketplace.

Sincerely,

SCHRODER, JOSEPH & ASSOCIATES, LLP

Linda H. Joseph

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EXHIBIT A

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Manufacturer's Installation Standard
For
Lightning Protection Systems Using
Early Streamer Emission Air Terminals

HBP-21

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Level 2 Installation Standard for Early Streamer Emission Lightning Protection Systems

9. Level 2 General Installation and Component Requirements 23
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Level 3 Installation Standard for Early Streamer Emission Lightning Protection Systems

14. Level 3 General Installation and Component Requirements 34
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INTRODUCTION

1. Scope

1.1 The requirements of this standard cover the design of systems using Early Streamer Emission ("ESE") air terminals for strikes. The Standard is divided into Three Levels of Protection. Electrical transmission lines and equipment are not within the scope of this standard.

1.2 These requirements apply to lightning protection systems that are complete and cover all parts of a structure. Partial systems are not covered by this standard.

1.3 Where fittings, devices or other components required by this standard are available as listed or labeled, such components shall be used. Otherwise the components shall be approved by the authority having jurisdiction (i.e. Engineer of Record, Architect, Owner, Applied Research Laboratories or Underwriter's Laboratories).

1.4 This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's Standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards."

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2. Glossary

2.1 For the purpose of this standard the following definitions apply:

Lightning Protection System is complete system of air terminals(s), conductors, ground terminals, bonding conductors, transient voltage surge suppression devices and other components required to complete a system.

2.2 AIR TERMINAL:

Is the component of the system that is intended to intercept the lightning strokes.

2.3 APPROVED:

Acceptable to the "authority having jurisdiction".

2.4 AUTHORITY HAVING JURISTICTION:

Is the organization, office or individual responsible for "approving" the equipment, and installation or a procedure.

2.5 BONDING:

An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents.

2.6 CABLE: A conductor formed of a number of wires stranded together.

2.7 CHIMNEY:

A smoke or vent stack having a flue with cross sectional area less than 500 sq in (.3 sq m) and a total height of less than 75 feet (23m).

2.8 CONDUCTOR.

The portion of a lightning protection system that is intended to carry the lightning discharge to the ground.

2.8.1 MAIN CONDUCTOR:

A conductor that interconnects air terminals and serves as a down lead to ground.

2.8.2 BONDING CONDUCTOR:

A conductor intended to be used for potential equalization between metal bodies and the lightning protection system. Bonding conductors are not designed or intended to carry main lightning current.

2.9 FASTENER:

An attachment to secure the conductor to the structure.

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2.10 GROUNDED:

Connected to earth or to some conducting body that is connected to earth.

2.10.1 GROUND GRID:

A system of grounding electrodes consisting of interconnected bare cables buried in the earth.

2.10.2 GROUND TERMINAL (ELECTRODE):

The portion of a lightning protection system that is installed for the purpose of providing electrical contact with earth.

2.11 LIGHTNING STRIKE:

The entire lightning event that can consist of one or more lightning strokes.

2.12 LOOP CONDUCTOR:

A conductor that encircles a structure that is used to interconnect ground terminals, main conductors or other grounded bodies.

2.13 METAL FRAME STRUCTURE:

A structure with electrically continuous structure members of sufficient size to provide electrical path equivalent to that of the lightning conductors in this standard.

2.14 SHALL:

Indicates a mandatory requirement of this Standard.

2.15 SHOULD:

Indicates a recommendation or that which is advised but not required.

2.16 SURGE ARRESTORS:

Are devices designed to limit damaging surge voltages by discharging or bypassing the current while maintaining the ability of repeating these functions. Heary Brothers Lightning Protection Co., Inc. and its Division Lightning Preventor of America do not manufacture Surge Arrestors nor do they warranty the equipment.

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3. GENERAL REQUIREMENTS

3.1 GENERAL DESIGN REQUIREMENTS:
A lightning protection system using an Early Streamer Emission Air Terminal (s) shall be designed with provisions for inspection and maintenance.

3.2 Every installation shall be reviewed by a prior study to determine the level of protection required (See Figure 3.5.1).

3.3 The position of the E.S.E. air terminal, including height of above structure shall be determined in accordance with the level of protection required. (See Figure 3.5.1)

3.4 The number of terminals will depend on the system design under the Manufacturer's Standard based upon the dimensions of the area to be protected. (See Figure 3.5.1)

3.5 There are multiple styles of E.S.E. air terminals and systems available. For purposes of this standard they have been divided into separate levels of protection, with each level having its own installation requirements. A chart is provided (See Figure 3.5.1) as a general guideline in determining which level of protection best fits the requirements of the project.

3.6 All bolts on bolt pressure connectors require to be torqued at 150 pound-inches (17N-m).

3.7 This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's Standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgments contained in its codes and standards."

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Figure 3.5.1 Levels of Protection for ESE Lightning Protection Systems

FEATURES	LEVEL 1	LEVEL 2	LEVEL 3
Number of ESE Terminals Required Pursuant to System Design	1 Air Terminal (See Note: A)	1 Air Terminal (See Note: A)	1 Air Terminal (See Note: B)
Grounding Resistance Requirements	10Ω (ohms) or less	10 Ω (ohms) or less	25Ω (ohms) or less
Warranty	15 year material workmanship	15 year material workmanship	5 year material workmanship
Air Terminal height above all roof top projections	20' (6.1m)	20' (6.1 m)	7' (2 m)
Transient Voltage Surge Suppression	Shall be installed on all service entrances of electric, telephone, cable, and antenna lead-in.	Shall be installed on all service entrances of electric, telephone, cable, antenna lead-in.	Shall be installed on all service entrances of electric, telephone, cable, antenna lead-in.
ARL Listing and UL Listing mark on applicable components	Required	Required	Required
Building Height	Unlimited	Unlimited	Under 75' (23m)
Building Types	All	All	Residential, Farm, Agricultural, Small commercial.

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(Note: A)

Manufacturer's Installation Standard HBP-21Level 1 and Level 2 require one (1) ESE Air Terminal to be installed on the roof for every circular area of 337,810 feet. Structures may be on any height and the ESE lightning protection system must comply with all other requirements within this Manufacturer's Installation Standard HBP-21. This Manufacturer's standard is based upon Heary Bros.' 30 years experience in designing lightning protection systems. Because of the lack of a complete understanding of the interaction between lightning and ground based objects and the lightning attachment process, the number and placement of air terminals set forth in this Manufacturer's standard is based solely on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

(Note: B)

Manufacturer's Installation Standard HBP-21 Level 3 requires one (1) ESE Air Terminal to be installed on the roof for every circular area of 70,650 feet. Structures may be of any height and the ESE lightning protection system must comply with all other requirements within this Manufacturer's Installation Standard HBP-21. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lighting protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

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LEVEL 1

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

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4. Level 1 General Installation and Component Requirements

4.1 An ESE lightning protection system installation consists of the following interconnected parts

(a) One or more ESE air terminals
(b) Mast and mounting systems - as required based on level of protection desired.
(c) Bonding conductors - as required based on level of protection.
(d) Ground system – Single grid to loop conductor system.
(e) Equipotential Bonding.
(f) Transient Voltage Surge Suppression.

4.1.1 The number of ESE air terminals will depend on the system design under the Manufacturer's Standard based upon the area indicated in Figure 3.5.1 for Level 1 type systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

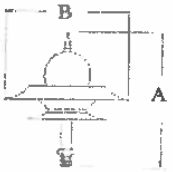
4.1.2 Components Tables 4.1.1.1 and Figure 4.1.1.2 provides minimum sizes and weights for use in ESE lightning protection system installation.

Figure 4.1.1.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	½" /12.7mm	½"/ 12.7 mm	½"/ 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	14AWG 375lbs /1000/ or 558 g/m 115,000 CM / 58 mm ^{2}	13AWG 190lbs/1000/ 283 g/m 192000 CM/ 97 mm ^{2}
Ground Terminals	Ground Rod / Ground Plate	¼" x 10' (20mm x 3000mm)/ 24" x 24"x 20 gauge (600mm x 600mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 4.1.1.2 Early Streamer Emission Air Terminal

A= 12"
B= 9"



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4.2 ESE Air terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of copper, copper alloy, aluminum or stainless steel. The main conductive parts of the ESE air terminal shall have the minimum dimensions in accordance with table 4.1.1.1 and Figure 4.1.1.2 for minimum dimensions of ESE Air Terminal.

4.2.1 Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind.

NOTE: Wind design requirements should be consistent with local building code requirements.

4.2.2 Where an air terminal or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

4.2.3 The tip of any ESE air terminal or mast shall not be less than 20' (6.1m) above the protected structures, including antennas, cooling towers, tanks, roofs and masts.

4.2.4 The ESE air terminal shall be mounted on structures such as flagpoles, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as, sports facilities and stadiums, golf courses, public parks, camping sites and racetracks. The ESE unit shall be mounted at an elevation indicated in Section 4.2.3.

4.3 Storage areas for Flammable and Combustible Liquids or Flammable Gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

4.4 Surge Suppression devices shall be installed on electric and telephone service entrances, antenna lead-ins, and electrical and electronic cables/ conductors entering or exiting the building.

4.4.1 Electrical Surge Suppression device shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty. Units shall be mounted as to minimize inductance installation. (i.e. As close to equipment to be protected or by use of documented low inductance cabling).

4.5 General, In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounded medium.

B. The influence of a non-grounded metal body, such as metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium (Air or solid materials).

D. Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

E. Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall maintain the minimum protection above these objects as specified in Section 4.2.3

NOTE: For additional bonding requirements see Section 5.2 and 5.3.

4.6 Components

4.6.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

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4.6.2 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gasses or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

4.6.3 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding or other aluminum surfaces.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum conductors and components shall not be:

a. Embedded in concrete or masonry.

b. In direct contact with a surface coated with alkaline base paint, or

c. Installed in wet locations, for example eave troughs or downspouts.

d. Installed in direct contact with earth.

D. Components used for connection of aluminum down conductors to copper or copper-clad grounding equipment shall provide separation between aluminum and copper materials. These fittings may be a Stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper components.

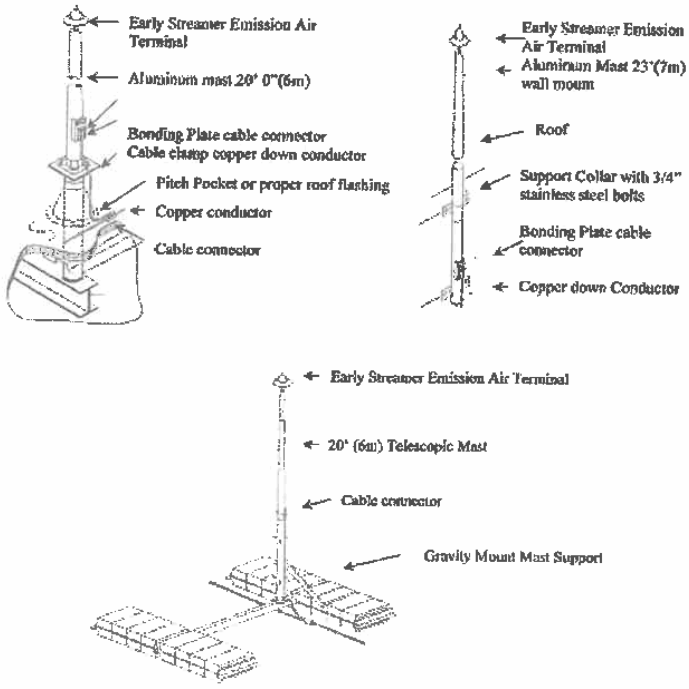
4.6.4 Unless otherwise indicated in this standard, an air terminal shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

5. Level 1 Air Terminal Installation Requirements

5.1 Early Streamer Emission Air Terminals

A. ESE Air Terminals shall be mounted at a height consistent with the requirements of Section 4.2.3 or a minimum of 20' above all projections on the roof.
See Figure 5.1.1 for sample mast mounting details.

Figure 5.1.1

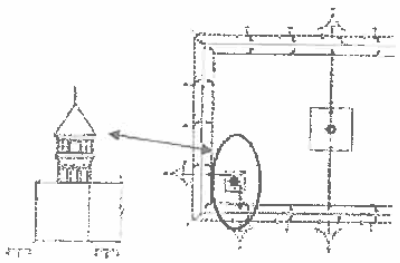


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B. ESE Air Terminals shall be provided in proper quantity and location based on the system design under Manufacturer's Standard. See Figure 3.5.1 Level I requirements. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

C. Additional ESE air terminals shall be provided in situations where steeples, cupolas, crosses, stacks, chimneys, etc. project above the protected roof area. This requirement applies to all projections which could provide a potential upward streamer release. The addition air terminals shall be provided regardless of whether or not the projection is within or outside the area covered by the system design under the Manufacturer's Standard. See Figure 5.1.2. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

Fieure 5.1.2



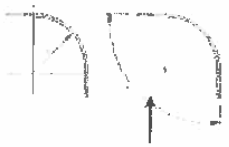
D. Conductors shall be securely fastened to roof or structure at intervals not exceeding 3'0" on center.

E. ESE Air Terminals shall be provided with a minimum of two paths to ground. Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets. See Figure 5.1.4

F. No Bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However conductors may raise a rate of 3" per 12" of run. See Figure 5.1.3 and Figure 5.1.4

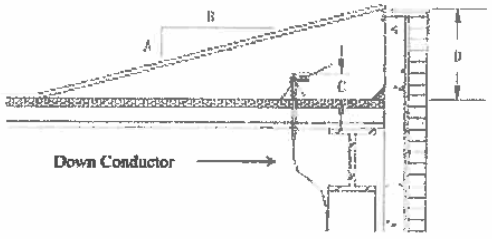
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Figure 5.1.3



NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement

Figure 5.1.4



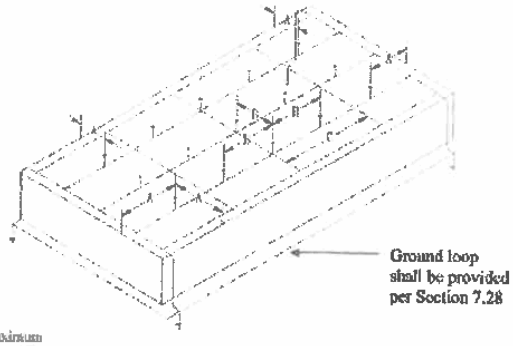
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc., provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in Section 5.1.D

5.1.1 In situations where multiple air terminals are required, the perimeter air terminals shall be positioned so that they are not more than 230' (70m) for the outside edge of the building nor shall the ESE Air Terminals be spaced more than 460' (140m) apart at any time. A cross run cable shall be provided at intervals of 1000' (305m) when building exceeds 2000' (610m) in length in any direction. See Fig 5.1.1.1. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed ho have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

5.1.2 Down Conductors in situations where multiple ESE Air Terminals are required shall be spaced at intervals no more than 500' (152m) apart around the perimeter of the structure. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

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Figure 5.1.1.1



A= 230' (70m) maximum
B= 460' (140 m) maximum
C= 1000' (305m)

6. Level 1 Bonding Requirements

6.1 Roof top Interconnection loop

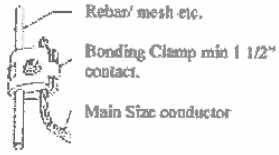
A. An interconnection loop around the perimeter of the roof structure shall be provided to which ESE Ground Conductors shall be bonded.

B. Loops shall be provided at all intermediate and lower roof levels and connected at a minimum of two (2) locations to the down conductors.

a. Bonding connections shall be made with main size conductor to all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, etc. whether exposed or not at all inside and outside corners of structure as a minimum. Additional bonding connections shall be made at intervals not exceeding 60' (18m) around the perimeter of the structure. Care shall be taken to assure that all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, et. Whether exposed or not is electrically continuous or made so. (See Fig. 6.2.4 and Fig 6.25).

b. Down Conductors shall be bonded to the structural steel, reinforcing rod or other structural support at the top and bottom of conductor run.

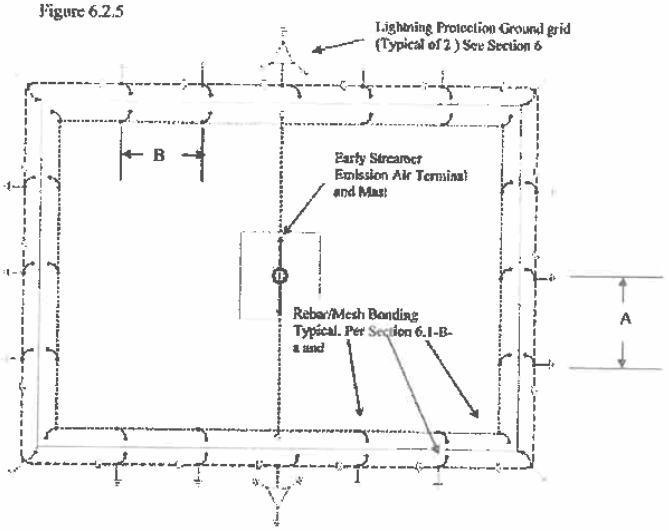
Figure 6.2.4



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Figure 6.2.5



A= 60' (18m) Maximum Spacing
B= 60' (18m) Maximum Spacing

Note: For Base Grounding requirements see Section 7

6.2 Bonding Requirements

A. Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless;

B. Inherently bonded to the lightning protection system.

C. Sanitary vents, roof drains, flashings, copings, etc. located within 6' (1.8m) of a lightning protection conductor, shall be bonded via secondary sized conductor to the lightning protection system.

7. Level 1 Grounding System Requirements

7.1 Down Conductors"

7.1.1 A minimum of Two (2) Down Conductors Shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 5.1.2

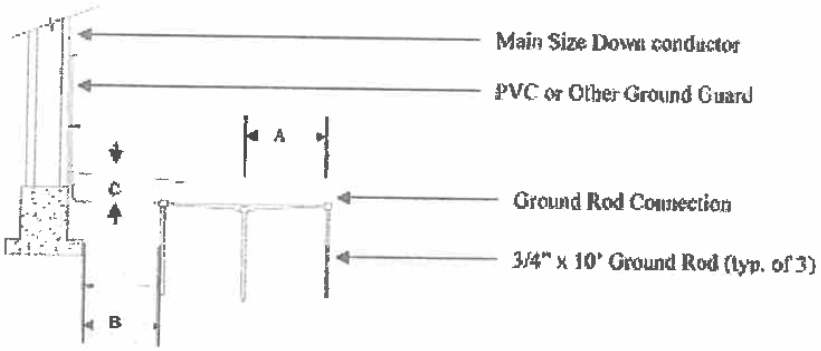
7.1.2 Down Conductors shall be spaced at least 10' (3m) apart.

7.1.3 Down conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, Fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See figure 7.2.1.1

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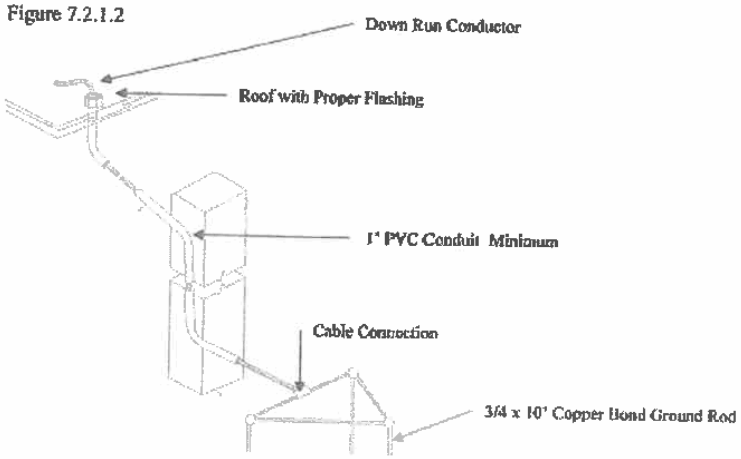
7.1.4 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 7.2.1.2

Figure 7.2.1.1



A= 10' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 3' (0.3m) Minimum

Figure 7.2.1.2



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7.1.5 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

A. If electrically continuous, structural steel shall be permitted to be used as the down conductor.

B. Test joints shall be provided for each down conductor. They shall be accessible and located as near as practicable to the ground termination.

7.1.6 Masonry Anchors used to secure the lightning protection materials shall have a minimum outside diameter of ¼ in. (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed, the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

7.1.7 Connector Fittings shall be used at all "end to end, "tee" or "Y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lbs. Fittings used for required connections shall be of bolted, welded or high compression type and bear the ARL Listing and UL Listing.

7.1.8 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of materials shall be used that forms an electrolytic couple of such nature that, in the presence of moisture, corrosion is accelerated.

7.2 Grounding

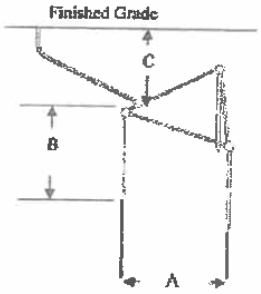
7.2.1 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 10 olums resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

7.2.2 Ground electrodes shall be of copper-bond steel in sufficient number as to achieve a 10-ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 3' (1m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 7.2.1.1

7.2.3 Ground rod terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

7.2.4 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configured either in a straight line or in delta formation. Where the ground terminals are spaced a minimum of 10' (3m) apart. See Figures 7.2.3.1 and 7.2.3.2

Figure 7.2.3.1



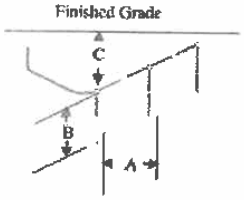
A= 10' (3m) Minimum

B= 10' (3m) Minimum (Typical)

C= 3' (1m) Minimum

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Figure 7.2.3.2



A= 10' (3m) Minimum

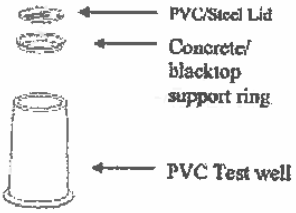
B= 10' (3m) Minimum (Typical)

C= 3' (1m) Minimum

7.2.5 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

7.2.6 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems.
NOTE 1: For Further information, see NFPA 70 National Electric Code, which contains detailed information on the grounding of electrical systems.
NOTE 2: Ground rod or ground ring/loop electrodes should be installed below the frost line where practicable and in accordance with Section 7.2.8

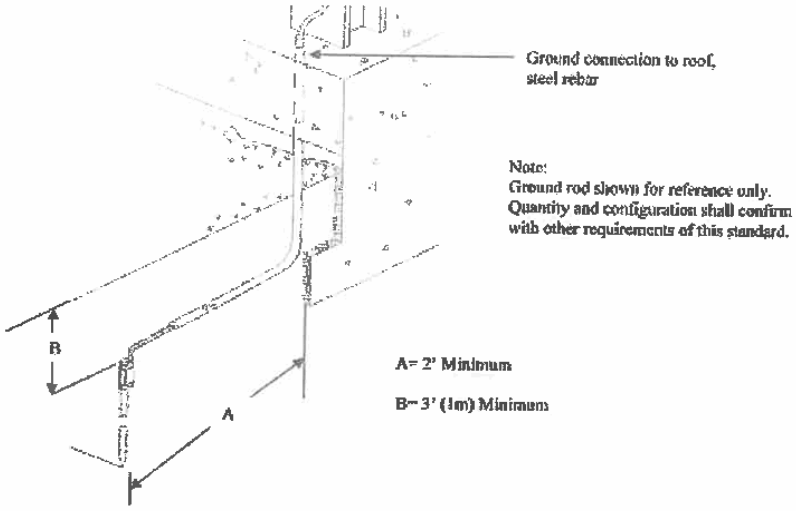
Figure 7.2.6.1



7.2.7 Grounding ring/loop Electrode encircling the structure shall be provided and in direct contact with the earth at a depth of not less than 2ft. The ground ring conductor shall be sized at a minimum of that of the main sized conductor. See Figure 7.2.8.1

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Figure 7.2.8.1



7.2.8 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include, but not be limited to lightning protection, electrical services, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

7.2.9 Common Ground Bonding. If electric telephone or other systems are bonded to metallic water pipe, only one connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

8. Level 1 Structural Steel Systems

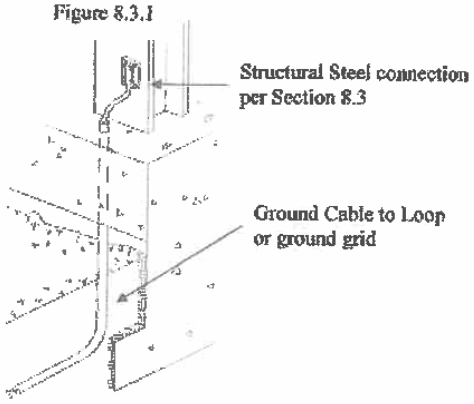
8.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

8.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60ft (18m). Ground terminals shall be connected together via a main size conductor as indicated in sec 7.2. Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

8.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq in (5200mm²). The area of attachment shall be free of paint, grease oil and debris. (See Figure 8.3.1)

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Figure 8.3.1



8.4 Early Streamer Emission Air terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 8.3

8.5 Metal Bodies. Certain Metal bodies located outside or inside the structure contribute to lightning hazards because they are grounded or assist in providing a path to ground for lightning currents. Such metal bodies shall be bonded to the lightning protection system in accordance with Section 4.5.

8.6 Concealment in Steel Reinforced Concrete. Conductors or other components of the lightning protection system concealed in steel reinforced concrete units shall be connected to the reinforcing steel. Concealed down conductors shall be connected to vertical reinforcing steel. Roof conductors or other concealed horizontal conductors runs shall be connected to reinforcing steel/structural steel at intervals not exceeding 60ft (18m) and at all corners. See Section 6.

8.7 Down Conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel and/or structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 200ft (60m). Such connections shall be made using listed clamps or listed bonding plates or by exothermic welding. The use of PVC conduit or other non-metallic chase does not negate the need for these interconnections.

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LEVEL 2

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

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9. Level 2 General Installations and Component Requirements

9.1 An ESE lightning protection system installation consists of the following interconnected parts
(a) One or more ESE air terminals
(b) Mast and mounting systems – as required based on level of protection desired
(c) Bonding conductors – as required based on level of protection.
(d) Ground system – Single grid to loop conductor system
(e) Equipotential Bonding
(f) Transient Voltage Surge Suppression

9.2 The number of ESE air terminals will depend on the system design under the manufacturer's Standard based on the area as indicated in Figure 3.5.1 for Level 2 Systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumer should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

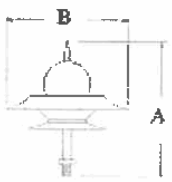
9.3 Components Tables Figure 9.3.1 and Figure 9.3.2 provide minimum sizes and weights for use in ESE lightning protection system installation.

Figure 9.3.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	1/2 "/ 12.7mm	1/2" / 12.7 mm	1/2" / 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	14AWG 375lbs /1400/ or 558 g/m 115,000 CM / 58 mm ^{2}	13AWG 190lbs/1000/ 283 g/m 192000 CM/ 97 mm ^{2}
Ground Terminals	Ground Rod / Ground Plate	¾" x 10' (20mm x 3000mm)/ 24" x 24"x 20 gauge (600mm x 600mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 9.3.2 Early Streamer Emission Air Terminal

A= 12"
B= 9"



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9.4 ESE Air Terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of copper, copper alloy, aluminum or stainless steel. The main conductive parts of the ESE air terminals shall have the minimum dimensions in accordance with Figures 9.3.1 and Figure 9.3.2 for minimum dimensions of ESE Air Terminals Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind

NOTE: Wind design requirements should be consistent with local building code requirements.

9.4.1 Where an air terminal or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

9.4.2 The tip of any ESE air terminal shall not be less than 20' (6.1m) above the protected structures, including antennas, cooling towers, tanks, roof and masts.

9.4.3 The ESE air terminals shall be mounted on structures such as flagpole, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as, sports facilities and stadiums, golf courses, public parks, camping sites and racetracks. The ESE unit shall be mounted at an elevation as indicated in Section 9.4.2.

9.5 Storage Areas for flammable and combustible liquids or flammable gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

9.5.1 Electrical Surge Suppression device shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty. Units shall be mounted as to minimize inductance installation. (I.e. As close to equipment to be protected or by use of documented low inductance cabling.)

Note 1: Electrical systems and utilization equipment within the structure may require further surge suppression. Such protection is not part of this standard. NFPA 70, National Electric Code and ANSI/IEEE C62.41-1991 2nd Edition, shall be consulted for further information and installation requirements.

Note 2: Illustrations shown in this are those of Heary Brothers Lightning Protection Co., Inc. (HBLP) and its division Lightning Preventor of America (LPA). HBLP and LPA do not manufacture or warranty surge protection devices. Warranties required of this standard shall be the responsibility or the surge protection device manufacturer.

9.6 General. In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounded medium.

B. The influence of a non-grounded metal body, such as a metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium (air or solid materials).

(a) Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

(b) Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall still maintain the minimum protection above these objects as specified in Section 9.4.2.

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9.7 Components

9.7.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

9.7.2 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gases or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

9.7.3 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding, or other aluminum surfaces.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum Conductors and components shall not be:

a) Embedded in concrete or masonry;

b) In direct contact with a surface coated with alkaline base paint; or

c) Installed in wet locations, for example eave troughs or downspouts.

d) Installed in direct contact with earth

D. Components used for connection of aluminum down conductors to copper or copper-clad grounding equipment shall provide separation between aluminum and copper materials. These fittings may be a stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper materials.

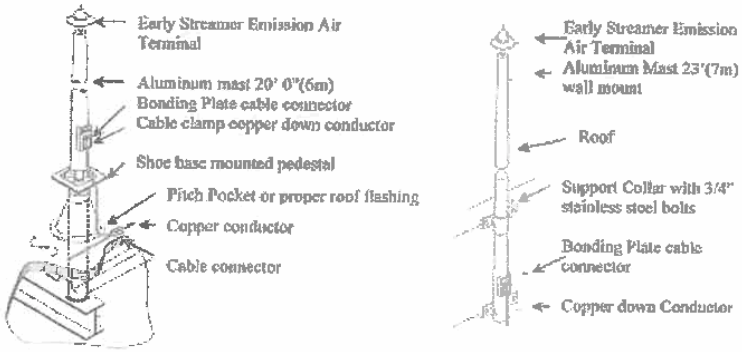
9.7.4 Unless otherwise indicated in this standard, an air terminal shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

10. Level 2 Air Terminals Installation Requirements

10.1 Early Streamer Emission Air Terminals

A. ESE Air Terminals shall be mounted at a height consist with the requirements of Section 9.4.2 or a minimum of 20' above all projections on the roof. See Figure 10.1.1 for sample mast mounting details.

Figure 10.1.1



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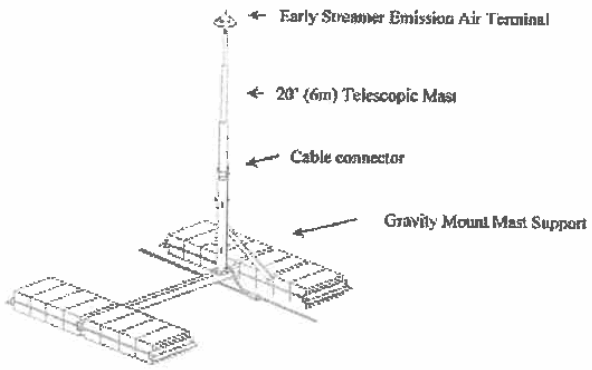
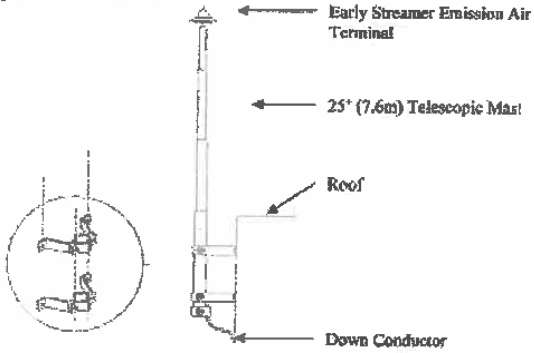


Figure 10.1.1 continued



10.2 ESE Air Terminals shall be provided in proper quantity and location based on the system design under the Manufacturer's Standard. See Figure 3.5.1 for Level 2. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

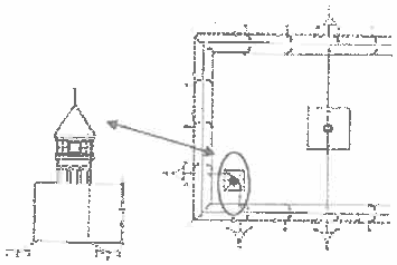
10.3 Conductors shall be securely fastened to roof or structure at intervals not exceeding 3'0" on center.

10.4 Additional ESE air terminals shall be provided in situations where steeples, cupolas, crosses, stacks, chimneys, etc project above a protected roof area. This requirement applies to all projections which could provide a potential upward streamer release. The addition air terminals shall be provided regardless of whether or not the projection is within or outside the area covered by the system design under the Manufacturer's Standard. See Figure 10.2.1. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those

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terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

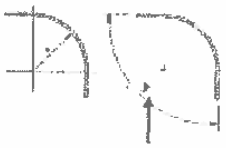
Figure 10.2.1



10.5 ESE Air Terminals shall be provided with a minimum of two paths to ground. Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets.

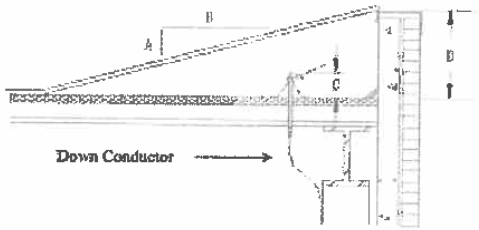
10.6 No Bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However Conductors may rise at a rate of 3" per 12" of run. See Figure 10.5.1 and Figure 10.6.1

Figure 10.5.1



NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement.

Figure 10.6.1



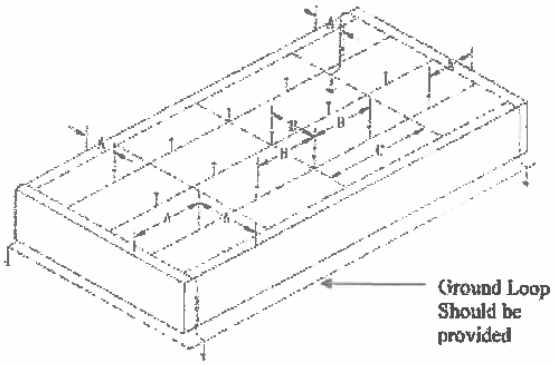
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in

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10.7 In situations where multiple air terminals are required, the perimeter air terminals shall be positioned so that they are no more than 230' (70m) from the outside edge of the building nor shall be ESE Air Terminals be spaced more than 460' (140m) apart at any time. A cross run cable shall be provided at intervals of 1000' (305m) When building exceed 200' (610m) in length in any direction. See Figure 10.8.1. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

10.8 Down Conductors in situations where multiple ESE Air Terminals are required shall be spaced at intervals no more than 500' (152m) apart around the perimeter of the structure.

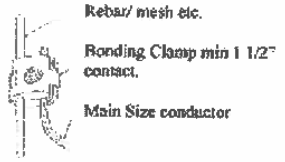
Figure 10.8.1



A= 230' (70m) maximum
B= 460' (140 m) maximum
C= 1000' (305m)

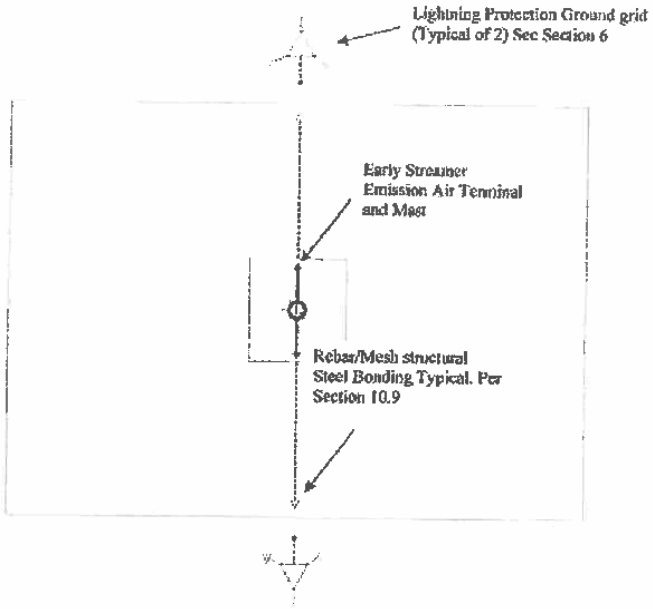
10.9 Bonding connections shall be made with main size conductor to all rebar, reinforcing rod, structural steel, interior wall wire mesh, nylon mesh in stucco walls, etc., whether exposed or not, at the upper and lower extremities of each down conductor. Care shall be taken to assure that all rebar, reinforcing rod, structural steel, interior wall mesh, nylon mesh in stucco walls etc, whether exposed or not is electrically continuous or made so. (See Fig. 10.9.1 and Fig 10.9.2).

Figure 10.9.1



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Figure 10.9.2



11. Level 2 Bonding Requirements

11.1 Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless.

A. Inherently bonded to the lightning protection system.

11.2 Sanitary vents, roof drains, flashings, copings, etc located within 6' (1.8m) of a lightning protection conductor, shall be bonded via secondary sized conductor to the lightning protection system.

12. Level 2 Grounding System Requirements

12.1 Down Conductors and Grounding

12.2 A minimum of two (1) down conductors shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 10.8.

12.3 A single down conductor shall be permitted to be used where the length of run does not exceed 65ft (19m).

12.4 If the horizontal length is greater than the vertical length, two (2) down conductors shall be required and separated a minimum of 10' (3m).

12.4.1 For lengths greater than 65' (19m) two conductors shall be required.

12.4.2 For masts, a single down conductor only shall be required.

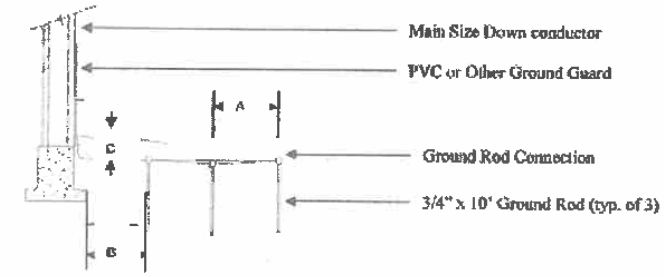
12.4.3 If electrically conductive, the mast shall be permitted to be used as the down conductor.

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12.5 Down Conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, Fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See figure 12.4.1.

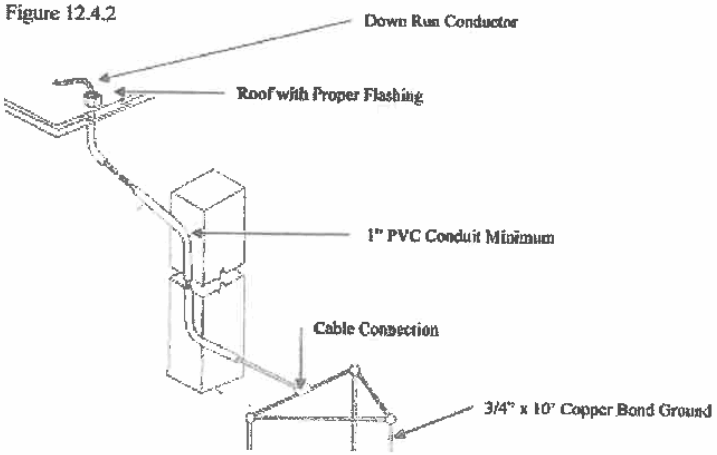
12.6 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 12.4.2.

Figure 12.4.1



A= 10' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 1' (0.3m) Minimum

Figure 12.4.2



12.7 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

12.7.1 If electrically continuous, structural steel shall be permitted to be used as the down conductor.

12.8 Masonry Anchors used to secure the lightning protection components shall have a minimum outside diameter of ¼" (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

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12.9 Connector Fittings shall be used at all "end to end", "tee" or "y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lbs. Fittings used for required connections shall be of bolted, welded, or high compression type and bear the ARL Listing and UL Listing.

12.10 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of materials shall be used that forms an electrolytic couple of such nature that, in the presence of moisture, corrosion is accelerated.

12.11 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 10 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

12.12 Ground electrodes shall be of copper-bond steel in sufficient number as to achieve a 10-ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 1' (0.3m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 12.4.1

12.13 Ground Rod terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

12.14 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configured either in a straight line or in delta formation. Where the ground terminals are spaced a minimum of 10' (3m) apart. See Figures 12.4.1 and 12.4.2.

12.15 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

12.16 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems.

NOTE 1: For further information, see NFPA 70 National Electric Code, which contains detailed information on the grounding of electrical systems.

12.17 Ground ring/loop electrode encircling the structure should be provided and in direct contact with the earth at a depth of not less than 2 ft. The ground ring conductor shall be sized at a minimum of that of the main sized conductor.

12.18 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include lightning protection, electric service, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

12.19 Common Ground Bonding. If electric, telephone or other systems are bonded to metallic water pipe; only on connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

12.20 If the horizontal length is greater than the vertical length, two down conductors shall be required and separated a minimum of 10' (3m).

(a) For lengths greater than 65' (19m) two conductors shall be required.

(b) For masts, a single down conductor only shall be required.

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(c) If electrically conductive, the mast shall be permitted to be used as the down conductor.

13. Level 2 Structural Steel Systems

13.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

13.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60 ft (18m). Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

13.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq inches (5200mm²). The area of attachment shall be free of paint, grease oil and debris.

13.4 Early Streamer Emission Air Terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 13.3.

13.5 Metal Bodies. Certain metal bodies located outside or inside the structure contribute to lightning hazards because they are grounded or assist in providing a path to ground for lightning currents. Such metal bodies shall be bonded to the lightning protection system in accordance with Section 11.

13.6 Concealment in Steel Reinforced Concrete. Conductors or other components of the lightning protection system concealed in steel reinforced concrete units shall be connected to the reinforcing steel. Concealed down conductors shall be connected to vertical reinforcing steel. Roof conductors or other concealed horizontal conductor runs shall be connected to reinforcing steel and structural steel at intervals not exceeding 60ft (18m) and at all corners. See Section 10.9.

13.7 Down Conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel and/or structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 200 ft (60m). Such connections shall be made using listed clamps or listed bonding plates or by exothermic welding. The use of PVC conduit or other non-metallic chase does not negate the need for the interconnections.

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LEVEL 3

MANUFACTURER'S INSTALLATION STANDARD

FOR

EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS

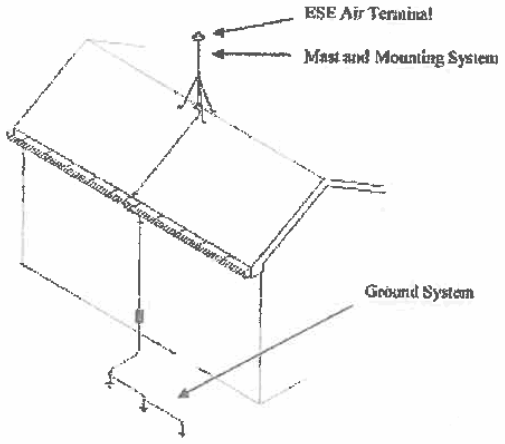
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14. Level 3 General Installation Requirements

14.1 An ESE lightning protection system installation consists of the following interconnected parts see figure 14.1.1.

a. One or more ESE air terminals.
b. Mast and mounting systems – as required based on level of protection.
c. Ground system – Single grid to loop conductor system.
d. Equipotential Bonding.
e. Transient Voltage Surge Suppression.

Figure 14.1.1



14.2 The number of ESE air terminals will depend on the system design under the Manufacturer's Standard based on the area as indicated in Figure 3.5.1 for Level 3 Systems. The recommended number and placement of air terminals is based solely on Heary Bros.' 30 years of experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA, "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

14.3 Components Tables Figure 14.3.1 and Figure 14.3.2 provide minimum sizes and weights for use in ESE lightning protection system installation.

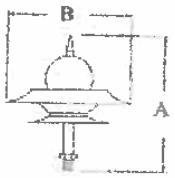
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Figure 14.3.1

Type of conductor	Minimum Diameter	Copper Standard/ Metric	Aluminum Standard/ Metric
ESE Air Terminal	1/2 "/ 12.7mm	1/2" / 12.7 mm	1/2" / 12.7 mm
Main Conductor Cable	Min Size each strand Weight Per Length Cross Sectional area	16AWG 190lbs /1000/ or 278 g/m 61900 CM / 35 mm^2	14AWG 110lbs/1000/ 164 g/m 98600 CM/ 50 mm^2
Ground Terminals	Ground Rod / Ground Plate	5/8" x 8' (16 mm x 2400mm)/ 18" x 18"x 20 gauge (460mm x 460mm) pure Copper plate minimum of 2 contact points each 8 sq inch contact to plate	NA

Figure 14.3.2 Early Streamer Emission Air Terminal

A= 12" (300mm)
B= 9" (230mm)



14.4 ESE Air Terminals shall be sufficiently rigid to withstand mechanical damage. They shall be constructed of aluminum, copper, copper alloy, or stainless steel. The main conductive parts of the ESE air terminal shall have the minimum dimensions in accordance with Figures 14.3.1 and Figure 14.3.2.

14.5 ESE Air Terminals Installation: Air terminals and their supports shall be mounted in such a way as to withstand the lightning currents, electromotive force, corrosion and effects of weather, heat, humidity, snow and wind.

14.5.1 Where an air terminals or mast is supported by conductive guys, the guys shall be connected from their points of anchorage to the closest down conductor(s) by a conductor equivalent in size to that of the down conductor(s).

14.5.2 The tip of any ESE air terminal shall not be less than 7' (2.1m) above the protected structures, including antennas, cooling towers, tanks, roof and masts.

14.5.3 The ESE air terminals shall be mounted on structures such as flagpole, the top of pylons, light standards or on dedicated supports for structures at certain facilities, such as sports facilities and stadium, golf courses, public parks, camping sites and racetracks. The ESE unit shall still be mounted at an elevation as indicated in Section 14.5.2

14.5.4 Storage areas for flammable and combustible liquids or flammable gases. Structures containing these materials shall be grounded, but grounding alone does not constitute sufficient protection against atmospheric discharges.

14.5.5 Electrical Surge Suppression devices shall be internally redundant and modular, in both surge suppression elements and fusing in construction for ease of field reparability. Manufacturers shall warranty the modules and fuse for the lifetime of the unit, with a minimum 10-year full unit warranty.

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Units shall be mounted as to minimize inductance installation. (I.e. As close to equipment to be protected or by use of documented low inductance cabling).

NOTE 1: Electrical systems and utilization equipment within the structure may require further surge suppression. Such protection is not part of this standard. NFPA 70, National Electric Code and ANSI/IEEE C62.41-1991 2nd Edition, shall consulted for further information and installation requirements.

NOTE 2: Illustrations shown in this standard are those of Heary Brothers Lightning Protection Co., Inc. (HBLP) and its division Lightning Preventor of America (LPA). HBLP and LPA do not manufacture or warranty surge protection devices. Warranties required of this standard shall be the responsibility of the surge protection device manufacturer.

14.6 General. In determining the necessity of bonding a metal body to a lightning protection system, the following factors shall be considered:

A. Bonding is required only if there is a likely to be a side flash between the lightning protection system and other grounding medium.

B. The influence of a non-grounded metal body, such as metal window frame in a non-conductive medium, is limited to its effectiveness as a short circuit conductor if a side flash occurs therefore, does not necessarily require bonding to the lightning protection system.

C. Bonding distance requirements depend on the technical evaluation of the number of down conductors and their location, the interconnection of other grounded systems, the proximity of grounded metal bodies to the down conductors and the flashover medium, (Air or solid materials).

D. Metal bodies located in a steel frame structure shall be permitted to be inherently bonded through construction and further bonding shall not be required.

E. Metal antenna masts or supports located on a protected structure shall be bonded to the lightning protection system using main size conductors and listed fittings. The height of the air terminal shall still maintain the minimum projection above these objects as specified in section 14.5.2 and the object shall be bonded to the lightning protection system by means of main sized conductor.

15. Level 3 Components

15.1 A lightning protection system shall be made of components that are resistant to corrosion or shall be acceptably protected against corrosion. The following materials are acceptable:

A. Copper of the grade required for commercial electrical work. Or a copper alloy with similar characteristics. Usually of 98 percent conductivity when annealed.

B. Aluminum conductors as acceptable as electrical grade aluminum.

15.1.1 Components shall be protected against deterioration due to local conditions. Any part of a copper system that is exposed to direct action of chimney gases or other similar corrosive gases shall be protected. Aluminum components are not required to be protected.

15.2 Metals shall be used in combinations that are galvanically compatible.

A. Copper components shall not be installed directly on aluminum roofing, siding, or other aluminum.

B. Aluminum lightning protection components shall not be installed directly on copper roofing material or other copper surfaces or below the run off of a copper surface.

C. Aluminum conductors and components shall not be embedded in concrete or masonry;

a) In direct contact with a surface coated with alkaline base paint; or installed in wet locations, for example eave troughs or downspouts.

b) Installed in direct contact with earth.

c) Components used for connection of aluminum down conductors to copper or copper-bond grounding equipment shall provide separation between aluminum and copper materials. These fitting may be a stainless steel sleeve with internal separation or other connector that provides proper separation of aluminum and copper materials.

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15.2.1 Unless otherwise indicated in this standard, an air terminals shall be provided for each part of a structure that is likely to be damaged by lightning. Based on the individual design requirements of the level of protection required.

16. Level 3 Air Terminal Installation Requirements

16.1 Early Streamer Emission Air Terminals

16.1.1 ESE Air Terminals shall be mounted at a height consistent with the requirements of Section 14.5.2 or a minimum of 7' (2.1m) above all projections on the roof. See Figure 16.1.1 for sample mast mounting details and figure 16.1.2 for installation diagram.

Figure 16.1.1

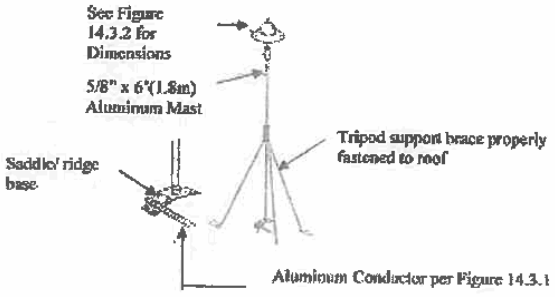
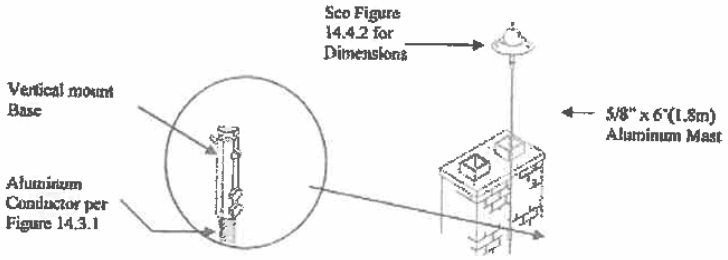
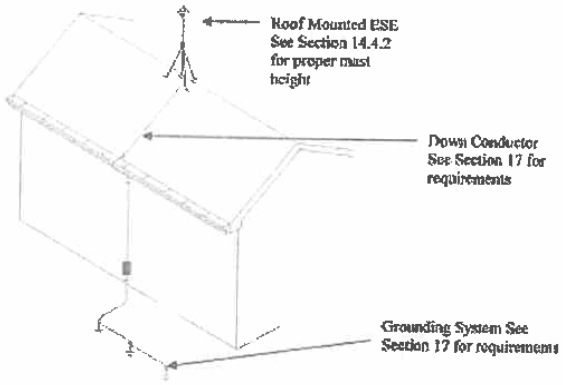


Figure 16.1.1 (Continued)



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Figure 16.1.2



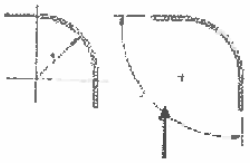
16.1.2 ESE Air Terminals shall be provided in proper quantity and location based on the system design under the Manufacturer's Standard. See Figure 3.5.1 and for Level 3 Systems. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

16.1.3 Conductors shall be securely fastened to roof or structure at intervals not exceeding 3' (1m) on center.

16.1.4 The ESE Air Terminals shall be provided with a minimum of one path to ground. (See Section 17 for additional requirements) Cables shall maintain a horizontal or downward path to ground to avoid "U" and "V" (down and up) pockets. See Figure 16.1.4

16.1.5 No bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches nor shall a conductor rise greater than 8". However Conductors may raise a rate of 3" per 12" of run. See Figure 16.1.3 and Figure 16.1.4

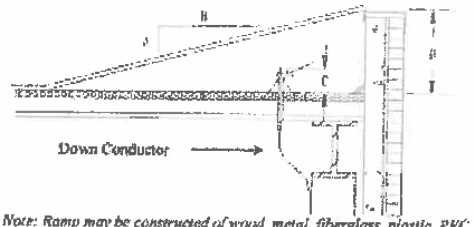
Figure 16.1.3



NOTE: Through roof, through wall and tee type connectors do not need to comply with this requirement.

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Figure 16.1.4



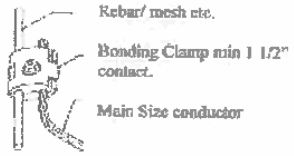
Note: Ramp may be constructed of wood, metal, fiberglass, plastic, PVC etc, provided the construction is such that it will be resistant to corrosion and rot. The conductor shall be attached or support on ramp as required in Section 16.1.3.

16.1.6 In situations where multiple air terminals are required, air terminals shall be positioned so that they are no more than 150' (45m) from the outside edge of the building nor shall they be more than 300' (90m) apart. The recommended number and placement of air terminals is based on Heary Bros.' experience and its air terminals and the configuration of those terminals have not been scientifically proven or guaranteed to have a measurable zone of protection. Consumers should be aware that the NFPA, in issuing its standard for lightning protection, NFPA 780, states that the NFPA "does not independently test, evaluate or verify the accuracy of any information or the soundness of any judgment contained in its codes and standards."

16.1.7 Down Conductors in situations where multiple ESE Air Terminals are required shall be installed in accordance with Section 17.

16.1.8 Bonding connections shall be made to all rebar, reinforcing rod, structural steel etc. at the upper on lower extremities of the down conductor. See Figure 16.18.

Figure 16.18



16.2 Roof Top Bonding Requirements;

16.2.1 Roof top air handling units, equipment, or other roof top equipment shall be bonded to the system where the equipment is within 6' (1.8m) of a lightning protection conductor unless the equipment is inherently connected to the ground system through direct bond or common bond.

16.2.2 Sanitary vents, roof drains, flashings, gutters, copings etc. Located within 6' (1.8m) of the lightning protection system, shall be bonded via a secondary sized conductor to the system unless the equipment is inherently bonded to the lightning protection system.

17. Level 3 Grounding System Requirements

17.1 A minimum of two (2) down conductors shall be provided for each ESE Lightning Protection System. In cases where multiple ESE Air Terminals are used then additional down conductors shall be provided in accordance with Section 16.1.7.

17.2 A single down conductor shall be permitted to be used where the length of run does not exceed 65ft (19m).

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17.3 If the horizontal length is greater than the vertical length, two down conductors shall be required and separated a minimum of 10' (3m).

17.4 For lengths greater than 65' (19m) two conductors shall be required.

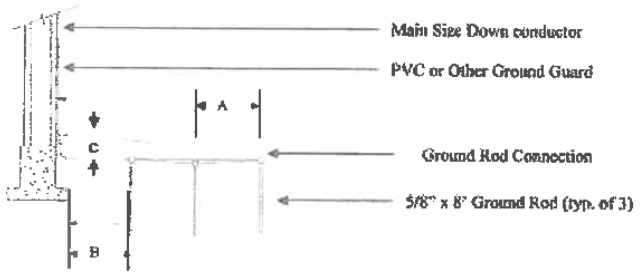
17.5 For masts, a single down conductor only shall be required.

17.6 If electrically conductive, the mast shall be permitted to be used as the down conductor.

17.7 Down Conductors and other conductor where exposed to potential mechanical damage shall be protected against such damage by means of PVC, fiberglass conduit sleeve, or metal conduit. (Metal conduit may be used provided the upper and lower portions are bonded to the down conductor). At ground level the bottom 8' (2.4m) of exposed down conductor shall be protected. See Figure 17.8.1

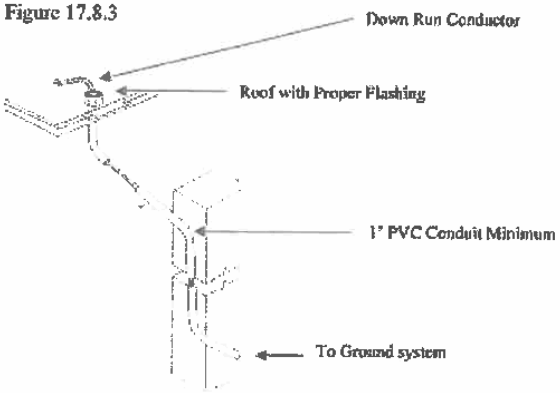
17.8 Down Conductors may be coursed within the construction of the building provided they are properly protected. See Figure 17.8.3.

Figure 17.8.1



A= 8' (3 m) Minimum
B= 2' (0.6m) Minimum
C= 1' (0.3m) Minimum

Figure 17.8.3



17.9 For masts that are electrically conductive then the mast shall be permitted to be used as a down conductor.

17.10 If electrically continuous, structural steel shall be permitted to be used as the down conductor.

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17.11 Masonry Anchors used to secure the lightning protection components shall have a minimum outside diameter of ¼ in. (6.4mm) and shall be set with care. Holes made to receive the body of the anchor shall be of correct size, made with the proper tools and made in brick, stone or other masonry unit. Fasteners shall not be installed in mortar joints. When anchors are installed, the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

17.12 Connector Fittings shall be used at all "end to end", "tee", or "y" splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lb. Fittings used for required connections shall be of bolted, welded or high compression type and bear the ARL Listing and UL Listing.

17.13 Conductors shall be fastened securely to the structure upon which they are placed at intervals not exceeding 3 ft (1m). The fasteners, attached by nails, screws, bolts or adhesives as necessary, shall not be subject to breakage and shall be of the same material as the conductor or of a material as resistant to corrosion as that of the conductor. No combination of components shall be used that forms an electrolytic couple of such nature that in the presence of moisture, corrosion is accelerated.

17.14 Ground Terminations: A study shall be conducted to engineer a grounding system to a maximum of 25 ohms resistance in accordance with IEEE fall of potential ANSI/IEEE 141, *Recommended Practice for Electric Power Distribution for Industrial Power Plants,* method. The components for the grounding system shall be selected to be suitable for the soil conditions and the other side factors such as cathodic protection.

17.15 Ground electrodes shall be of copper-bond steel or copper plate in sufficient number as to achieve a 25 ohm maximum resistance to ground. Ground electrodes shall be installed so that the top of the electrode is a minimum 1' (0.3m) below finished grade minimum and 2' (0.6m) away from the foundation wall. See Figure 17.8.1.

17.16 Ground Rod Terminations. The down conductor shall be attached to the ground rod by mechanical clamp, exothermic welding or brazing. Clamps shall be suitable for direct burial.

17.17 Each down conductor shall terminate at a ground terminal system. A minimum of 3 ground terminals shall be provided per down conductor location. Configures in a straight line. Where the ground terminals are spaced a minimum of 8' (3m) apart. See Figure 17.8.1.

17.18 Ground terminals located under slabs or in crawl spaces shall be installed as near as practicable to the outside perimeter of the structure.

17.19 Electrical system grounding electrodes shall not be used in lieu of lightning ground rods. This provision shall not prohibit the required bonding together of grounding electrodes of different systems. *NOTE 1: For further information, see NFPA 70National Electric Code, which contains detailed information on the grounding of electrical systems.*

17.20 Common Grounding. All grounding media in or on a structure shall be interconnected to provide a common ground potential. This shall include lightning protection, electric service, telephone and antenna system grounds as well as underground metallic piping systems. Such piping systems include water service, well casings located within 25 ft (7.6m) of the structure, underground conduits (not already bonded) etc. Main size lightning conductors shall be used for interconnecting these grounding systems to the lightning protection system.

17.21 Common Ground Bonding. If electric, telephone or other systems are bonded to metallic water pipe; only one connection from the lightning protection system to the water pipe system is necessary, provided that the water pipe is electrically continuous between all systems. In situations where there are separate services for domestic and fire water entering the building both systems shall be bonded to the lightning protection grounding system. This may be accomplished via direct connection or through the ground loop system.

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18. Level 3 Structural Steel Systems

18.1 General. The steel framework of a structure shall be permitted to be utilized as the main conductor of a lightning protection system if it is electrically continuous or is made electrically continuous.

18.2 Steel Structure Terminals. Ground terminals shall be connected to approximately every other steel column around the perimeter of the structure at intervals averaging not more than 60ft (18m). Connections shall be made near the base of the column, with a surface contact area not less than 8 sq inches (5200mm²) or by exothermic welding. Bonding plates shall have bolt pressure cable connectors and shall be bolted securely to the structural steel framework so as to maintain electrical continuity.

18.3 Connections to Framework. Conductors shall be connected to cleaned areas of the structural steel framework by the bonding of plates having a surface contact area of not less than 8 sq inches (5200mm²). The area of attachment shall be free of paint, grease, oil, and debris.

18.4 Early Streamer Emission Air Terminals shall be permitted to be bonded directly to structural, by means of direct attachment through mast or by use of two interconnection wires routed through roof and bonded at the top of the structural steel in the manner described in Section 18.3.

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EXHIBIT B

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USI

April 29th, 2019

Heary Bros Lightning Protection Co Inc
11291 Moore Rd
Springville, NY 14141

To Whom It May Concern:

During the many years we have done business with Heary Brothers Lightning Protection Co. Inc., we have found your commitment to developing quality products for your customers as paramount. Included in that commitment would be the successful line of the Early Streamer Lightning Protection Equipment.

Your dedication has allowed us to establish a comprehensive and cost-effective insurance program for your companies. Because of your dedication, we have been able to secure 11 million dollars of Liability limits. This includes coverage for damage from direct lightning strikes to the structure of any buildings. Please see enclosed America Certificate of Guarantee as additional evidence.

In addition, claims activity has been negligible and we, as your broker, the The Travelers Insurance Company, as your carrier, appreciate your attention to workplace safety and products liability quality control efforts. In today's highly competitive world, this is critical.

Without a doubt, your company was built around a commitment to give customers the products they need and confidence in our ability to meet or exceed expectations. We encourage your efforts and with you continued success.

Sincerely,

Timothy M. Wroblewski
Vice President

TW/lam

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FIRST NIAGARA

April 24, 2015

Heary Bros Lightning Protection Co Inc
11291 Moore Rd
Springville, NY 14141

To Whom It May Concern:

During the many years we have done business with Heary Brothers Lightning Protection Co. Inc., we have found your commitment to developing quality products for your customers as paramount. Included in that commitment would be the successful line of the Early Streamer Lightning Protection Equipment.

Your dedication has allowed us to establish a comprehensive and cost-effective insurance program for your companies. Because of your dedication, we have been able to secure 11 million dollars of Liability limits. This includes coverage for damage from direct lightning strikes to the structure of any buildings. Please see enclosed America Certificate of Guarantee as additional evidence.

In addition, claims activity has been negligible and we, as your broker, the The Travelers Insurance Company, as your carrier, appreciate your attention to workplace safety and products liability quality control efforts. In today's highly competitive world, this is critical.

Without a doubt, your company was built around a commitment to give customers the products they need and confidence in our ability to meet or exceed expectations. We encourage your efforts and with you continued success.

Sincerely,

Timothy M. Wroblewski
Vice President

TW/lam

First Niagara Risk Management, Inc.
726 Exchange Street, Suite 900 • Buffalo, NY 14210
Phone: 716-819-5500 • Toll Free: 800-854-9121 • Fax: 716-819-5140

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EXHIBIT C

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Preventor System Installations In Florida

ProjectName	Address	City	State
7000 Williams Island Building		Adventura	FL
Florida Hospital Altamonte Office		Altamonte Springs	FL
Turner Agriculture Center and Extension Office		Arcadia	FL
Marriott - Aventura Hotel		Aventura	FL
Alliant Food Service		Boca Raton	FL
Boca Museum		Boca Raton	FL
Boca Raton Condos		Boca Raton	FL
Caterpillar C-2 Expansion		Boca Raton	FL
Sears Store	Glades Road	Boca Raton	FL
TAG (The Answer Group) Main Building		Boca Raton	FL
TAG Main Building East Emissions Building		Boca Raton	FL
The Polo Club of Boca Raton		Boca Raton	FL
Bealls Corp Headquarters		Bradenton	FL
Paul Azinger Residence		Bradenton	FL
St. Stephens School		Bradenton	FL
Tara Preserve Golf Clubhouse		Bradenton	FL

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ProjectName	Address	City	State
Suntree Elementary and Chiller Building		Brevard Co	FL
Florida Welcome Center		Campbelton	FL
Advanced Elastomers		Cantonement	FL
Cape Canaveral AF Station Patrick AFB Cape Arrays		Cape Canaveral	FL
Cape Canaveral Station	Patrick Air Force Ba	Cape Canaveral	FL
Satellite Assembly Bldg Cape Canaveral		Cape Canaveral	FL
Kreiseder Residence		Casey Key	FL
Silverstein Residence		Casey Key	FL
Florida Hospital		Celebration	FL
Clyde Dyal Water Treatment Plant		Christmas	FL
Citrus Springs Utilities	1360 N. Citrus Spri	Citrus Springs	FL
Baystreet Plaza @ International Mall		Clearwater	FL
Capitol One Phase IV		Clearwater	FL
Catile Tower		Clearwater	FL
Church of Scientology Sandcastle Addition		Clearwater	FL
Crescent Beach Club		Clearwater	FL
Crescent Beach Club		Clearwater	FL
General Services Bldg		Clearwater	FL

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ProjectName	Address	City	State
Pinellas County Utilities		Clearwater	FL
Ruth Eckerd Hall		Clearwater	FL
Ruth Eckerd Hall - CEP Addition		Clearwater	FL
St. Cecelia Intraparochial School		Clearwater	FL
The Sirata Beach Resort		Clearwater	FL
The Tides@ Feather Sound		Clearwater	FL
Worthington Square Apartments		Clearwater	FL
City of Coconut Creek - Council Building		Coconut Creek	FL
City of Coconut Creek - Motor Pool Building		Coconut Creek	FL
Coconut Creek Public Safety		Coconut Creek	FL
Sabal Pines - Ball Field #2		Coconut Creek	FL
Sabal Pines - Elementary School		Coconut Creek	FL
Sabal Pines - Hockey Rink		Coconut Creek	FL
Sabal Pines - Maintenance Facility		Coconut Creek	FL
Sabal Pines - Pines Pavilion		Coconut Creek	FL
Sabal Pines - Soccer Field #1		Coconut Creek	FL
Body of Christ Family Life Center		College	FL
Stone/Bag Paper Container Facility	Hwy 29 & Becks La	Contonement	FL

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ProjectName	Address	City	State
Alahamra Tower		Coral Gables	FL
The Alhambra Hotel/Office	50 Alhambra Circle	Coral Gables	FL
University of Miami Intra Mural Fields		Coral Gables	FL
Sheik Island Horse Farm		Dade City	FL
BCC Building 27/ New Child Develop. CTR		Davie	FL
BCC Student Services Building		Davie	FL
Nova Southeastern College Parking Garage		Davie	FL
Phil Smith Toyota		Davie	FL
Rolling Hills Golf and Country Club		Davie	FL
Daytona Auto Dealers Exchange		Daytona Beach	FL
Daytona Marriott Hotel	100 N Atlantic Ave	Daytona Beach	FL
Deerfield Beach Grand Hilton	100 Fairway Drive	Deerfield Beach	FL
Granada Royale Hotel	902 S. E. 20th Ave.	Deerfield Beach	FL
Deltona Lake Track "A"	Diamond Street	Deltona	FL
Deltona WWTP	Saxton & Agatha	Deltona	FL
Deltona WWTP	Lombardy Ctr	Deltona	FL
Deltona WWTP	Cortland Blvd	Deltona	FL
Deltona WWTP	Fisher Drive	Deltona	FL

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ProjectName	Address	City	State
Well # 2 & High Service Pump	Unit 21 Sagmore Dr	Deltona	FL
Silver Beach Condominium		Destin Beach	FL
Guardian Angel School		Dunedin	FL
Our Lady of Lourdes		Dunedin	FL
Burdines Dept. Store		Fort Lauderdale	FL
Marriott - Ft Pierce Travel Plaza	Florida Turnpike Mi	Ft Pierce	FL
Granada Royale Hotel	1101 S.E. 17th Stree	Ft. Lauderdale	FL
Riverside Hotel		Ft. Lauderdale	FL
McGregor Point Hotel		Ft. Myers	FL
Raymond Building Products		Ft. Myers	FL
Raymond Building Supply Rack Storage		FT. Myers	FL
Raymond Building Supply Warehouse Building		FT. Myers	FL
Palm Court Yacht Club		Ft. Walton Beach	FL
Holy Faith Church	700 N.W. 39th Roa	Gainesville	FL
Main Library	on SR-26 Across fro	Gainesville	FL
Nordstrom Distribution Center		Gainesville	FL
UF Hotel and Conference Center		Gainesville	FL
Union Street Station		Gainesville	FL

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ProjectName	Address	City	State
Jack Sawyer	608 Fairpoint Drive	Gulf Breeze	FL
Palmento General Hospital	W. 20th & W. 68th	Hialeah	FL
Aqua Penn Water Co.		High Springs	FL
City of Holmes Beach Baseball Field	5901 Marina Drive	Holmes Beach	FL
North Lake Elementary		Indian River	FL
Sebastian Highlands WTP	1001 Prineville Roa	Indian River City	FL
Richard Herrmann II Residence	405 15th Ave	Indian Rocks Beach	FL
Florida Power/Light Co Martin Combined Cycle # 3,4	State Road 710	Indiantown	FL
Martin Plant Combined Cycle 3 & 4		Indiantown	FL
Allbritton Communications	7025 AC Skinner Pk	Jacksonville	FL
Berkman Plaza		Jacksonville	FL
Cathedral Terrace		Jacksonville	FL
Cathedral Towers		Jacksonville	FL
Cathedral Townhouses		Jacksonville	FL
Cypress Village Apartments	4600 Middleton Par	Jacksonville	FL
Sears Logistics Center		Jacksonville	FL
The Pointe		Jupiter	FL
The Phoenix @ Peachtree		Kennesaw	FL

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ProjectName	Address	City	State
Dolphin Hotel - Epcot Center	1500 Epcot Resort	Lake Buena Vista	FL
Dolphin/Swan Hotel Causeway & Grotto	1500 Epcot Resort	Lake Buena Vista	FL
Royal Plaza Hotel	1905 Preview Blvd	Lake Buena Vista	FL
Swan Hotel - Epcot Center	1500 Epcot Resort	Lake Buena Vista	FL
Westgate Lakes Sales Center		Lake Buena Vista	FL
Columbia Correctional Institution		Lake City	FL
Marriott - Lake Worth Travel Plaza	Florida Turnpike Mi	Lake Worth	FL
Publix Deli Plant	PO Box 407	Lakeland	FL
RMC Ewell Corp		Lakeland	FL
FCCI Insurance Group		Lakewood Ranch	FL
US Post Office - Land O Lakes		Land O Lakes	FL
Central Catholic High School		Lecanto	FL
Citrus Co. Landfill		Lecanto	FL
St. Stalastic Church		Lecanto	FL
FDOT District 5		Leesburg	FL
Lehigh Post Office		Lehigh	FL
Ben Price Residence	Gulf of Mexico Driv	Longboat Key	FL
James Gradner Residence		Longboat Key	FL

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ProjectName	Address	City	State
Sea Place Condominium Complex M1 & M2	1945 Gulf of Mexic	Longboat Key	FL
Wagner Residence	5940 Gulf of Mexic	Longboat Key	FL
Albert Whitted Expansion		Longwood	FL
Lowell Correctional Institution		Lowells	FL
St. Timothy's Catholic Church		Lutz	FL
Marco Island Pump Station	RTE 951	Marco Island	FL
South Fork High School		Martin Co.,	FL
Brevard Educational Facility		Melborne	FL
Eau Gallie High School Gymnasium & Auditorium		Melborne	FL
Brickell Station Towers	30 S.W. 8th Street	Miami	FL
Doral Concourse		Miami	FL
La Tour Condo		Miami	FL
Lincoln Financial Center	701 Brickell Ave.	Miami	FL
Marriott - Snapper Creek Travel Plaza	Florida Turnpike Mi	Miami	FL
Metropolitan Sun Bank	777 Brickell Ave	Miami	FL
Porta Vita		Miami	FL
Pro-Player Stadium		Miami	FL
Sienna		Miami	FL

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ProjectName	Address	City	State
Softel Hotel	5800 Blue Lagoon	Miami	Fl
Telemundo Networf		Miami	FL
Tequesta Condominium	808 Bricknell Key D	Miami	FL
Three Tequesta Point		Miami	FL
University of Miami Hecht Athletic Center		Miami	FL
University of Miami Knight Baseball Stadium & Foot		Miami	FL
University of Miami Schiff Tennis Ctr & Hecht Ath		Miami	FL
Loews Hotel & Convention Center		Miami Beach	FL
Portofino Tower		Miami Beach	FL
Sandy Park Health Care Center		Miami Beach	FL
US Naval Air Station Bldg 1406 & 1424	Whiting Field South	Milton	FL
Mulberry Post Office		Mulberry	FL
North Port St. Lucie WTP	Gulf Port Terrace	N. Port St. Lucie	FL
Collier Residence		Naples	FL
Gerry Residence	3400 Gordon Drive	Naples	FL
HorseCreek Properties Collier Equestrian Facility		Naples	FL
Horsecreek Properties Collier Equestrian Facility	Daniels Road	Naples	FL
Naples Cay Seapointe Condo	10 Seagate Drive	Naples	FL

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ProjectName	Address	City	State
Royal Poinciana Country Club	Goodlette Rd	Naples	FL
The Savoy Condo	4041 Gulf Shore Blv	Naples	FL
Blazer Residence		Navarre	FL
Caribbean Resort Condo		Navarre Beach	FL
The Fountaians Condominium		New Smyrna Beach	FL
Implant Innovations Inc.		North Palm Beach	FL
King Plastics Inc.		North Port	FL
Bishop Larkin Pastoral Center	9th Avenue	North St. Petersburg	FL
Lowell Correctional Facility Water Tower		Ocala	FL
Marion Oaks Water TRT Plant	14170 S.W. 39th Av	Ocala	FL
Marriott - Turkey Travel Plaza	Florida Turnpike Mi	Ocee	FL
Marriott - Ft Drum Travel Plaza	Florida Turnpike Mi	Okeechobee	FL
BIC Manufacturing Plant(III) Myerlake		Oldsmar	FL
Florida Hospital East Orlando		Orlando	FL
Florida Hospital Orlando		Orlando	FL
Martin Marietta Conflow Area Site	Kirtland Road	Orlando	FL
Orlando Utilities Commission Power Plant		Orlando	FL
St. Johns Rive Water Management		Palatka	FL

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ProjectName	Address	City	State
St. Johns River Waste Management District Office		Palatka	FL
SWA Tipping Floor Building		Palm Beach	FL
The Diplomat Hotel - Main Building		Palm Beach	FL
SWA West Central Tipping Floor		Palm Beach Co	FL
George Young United Methodist Church		Palm Harbor	FL
St. Mark Village	Rte 19	Palm Harbor	FL
William E. Dunn Water Reclamation Facility		Palm Harbor	FL
Riviera Dunes Marina		Palmetto	FL
St. Andrews Condo		Panama City	FL
Hidden Dunes Condominium		Panama City Beach	FL
Landmark Holiday Beach Resort		Panama City Beach	FL
The Summit Resort	Thomas Drive	Panama City Beach	FL
Camp-O-Pines Pensacola Christian College		Pensacola	FL
Ellyson Industrial Park	Ellyson Field Proj	Pensacola	FL
Gelman Sciences	8730 Fly Road	Pensacola	FL
George Estes Residence		Pensacola	FL
Girls Parking Garage -Pensacola Christian College		Pensacola	FL
H-6 Academic Building		Pensacola	FL

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ProjectName	Address	City	State
McKenzie Building- Pensacola Christian College		Pensacola	FL
Phoenix 10 Condominium		Pensacola	FL
University of West FL Admin. Building		Pensacola	FL
University of West FL Classroom Building		Pensacola	FL
Sabine Yacht & Racquet Club	330 Fort Pickens Rd	Pensacola Beach	FL
Eden Condominium		Peridido Key	FL
St. Clements Catholic Church		Plant City	FL
American Heritage Fine Arts Building		Plantation	FL
Crossroads 4		Plantation	FL
Motorola		Plantation	FL
Motorola Inc.		Plantation	FL
Spa Atlantis		Pompano	FL
Ligi Tool		Pompano Beach	FL
Marriott - Pompano Travel Plaza	Florida Turnpike Mi	Pompano Beach	FL
Charlotte County Public Works		Port Charlotte	FL
Dr. Eugene Gregosh Residence		Port Charlotte	FL
East Port Environmental Services		Port Charlotte	FL
Peace River WTP	Kings Hwy	Port Charlotte	FL

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ProjectName	Address	City	State
Peace River WTP	Intake Structure	Port Charlotte	FL
Port Malabar WTP		Port Malbar	FL
Bishop Larkin School		Port Richey	FL
Charlotte County Sheriff's Administration	Metro Pkwy	Punta Gorda	FL
Chateau Towers	Gulfport Blvd	S. Pasadena	FL
Espirtu Santo Catholic School		Safety Harbor	FL
The Shipley Residence		Sannibel Island	FL
Baker Electronics		Sarasota	FL
C'A' D' Zan John't Mable Rigling Home		Sarasota	FL
Davis Residence		Sarasota	FL
Ed Windemuller Residence	Saddle Oaks Estates	Sarasota	FL
Ken Miller Barn		Sarasota	FL
Lincoln Properties/ NBD Bank Building	240 N Washington	Sarasota	FL
Marina Towers Condominium		Sarasota	FL
Meridian @ The Oaks Building III		Sarasota	FL
Sarasota Herald Tribune		Sarasota	FL
Scott Sign Systems		Sarasota	FL
Scott Signs Phase II		Sarasota	FL

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ProjectName	Address	City	State
Sun Hydraulics Inc.		Sarasota	FL
The Phoenix Condo	Golden Gate Point	Sarasota	FL
The Radisson Hotel Lido Beach	Ben Franklin Drive	Sarasota	FL
The Renaissance		Sarasota	FL
Sebastian WTP	Filbert Street	Sebastian	FL
Lake Jackson Post Office		Sebring	FL
St. Cloud High School		St Cloud	FL
Casa Monica Hotel		St. Augustine	FL
St. Augustine Shores	771 Alahambra	St. Augustine	FL
Marriott - Canoe Creek Travel Plaza	Florida Turnpike Mi	St. Cloud	FL
School "C" Osceola Co. School District		St. Cloud	FL
Incarnation Church		St. Petersburg	FL
Jabil Circuit Inc.	10800 Roosevelt Blv	St. Petersburg	FL
Midcore Parking Garage		St. Petersburg	FL
San Seair Condominiums		St. Petersburg	FL
St. Marks Family Life Center	PO Box 43022	St. Petersburg	FL
Wheelbrator Corp		St. Petersburg	FL
SECO Office Building		Sumterville	FL

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ProjectName	Address	City	State
Capital One Building One	8745 Henderson Ro	Tampa	FL
Capital One Phase II Building 2 Renaissance	8745 Henderson Ro	Tampa	FL
Capital One Phase II Parking Garage	8745 Henderson Ro	Tampa	FL
Capital One Phase III Parking Garage	8745 Henderson Ro	Tampa	FL
Capital One Phase IV Flagpole	8745 Henderson Ro	Tampa	FL
Capital One Softball Field	8745 Henderson Ro	Tampa	FL
Capital One Tai Chi Building	8745 Henderson Ro	Tampa	FL
Florida Aquarium		Tampa	FL
Gateway Post Office		Tampa	FL
Group Tech		Tampa	FL
Lee Moffit Cancer Center Parking Garage		Tampa	FL
Marriott -Tampa		Tampa	FL
Muvico	18002 Richmond Pa	Tampa	FL
Myrtle Oaks		Tampa	FL
Notre Dame High School		Tampa	FL
Seaboard Waste Water TRT Plant	8234 Causeway Blv	Tampa	FL
St. Mary's Episcopal Day School		Tampa	FL
St. Pete Catholic High School		Tampa	FL

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ProjectName	Address	City	State
Tampa Bay Water Groundwater Clear Well Tank		Tampa	FL
Tampa Bay Water Surface		Tampa	FL
Tampa Juvenile Detention Center		Tampa	FL
The Garrison Condo		Tampa	FL
The Sorelle Residence		Tampa	FL
Westshore Plaza Phase III Expansion		Tampa	FL
City of Titusville Blue Heron WRF		Titusville	FL
City of Titusville Blue Heron WRF		Titusville	FL
Reliant Energy Corp. Maintenance Instrumentation B		Titusville	FL
Reliant Energy Corporation Intake Structure	Highway US 1	Titusville	FL
Sipprelle Residence		Ussepa Island	FL
Meridian @ The Oaks		Venice	FL
Woodmere Clubhouse		Venice	FL
Our Lady of the Rosary-Ballfield	21010 S.R. 54	West Land O'Lakes	FL
Our Lady of the Rosary-Flagpole	21010 S.R. 54	West Land O'Lakes	FL
SWA (CMRF)		West Palm Beach	FL
Marriott - Okahumpka Travel Plaza	Florida Turnpike Mi	Wildwood	FL
Florida Hospital		Winter Park	FL

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ProjectName	Address	City	State
Florida Brewing Company		Ybor City	FL

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Preventor 2005 Installations (Government)

Project Name	Address	City	State
Kodiak Building (SCAT) Mobile Structure on Rails		Kodiak	AK
Huntsville Public Safety Complex		Huntsville	AL
New Phoenix City Hall	Package Street	Phoenix	AZ
Phoenix Central Library		Phoenix	AZ
Los Angeles Federal Bldg. GSA	255 E. Temple Street	Los Angeles	CA
GSA Oakland Federal Building		Oakland	CA
California Federal Service Center	1515 Walnut Grove Avenue	Rosemead	CA
V.A. Medical Center		San Diego	CA
FBI Center New 9 Story Office Bldg		Washington	DC
Florida Welcome Center		Campbelton	FL
Cape Canaveral AF Station Patrick AFB Cape Arrays		Cape Canaveral	FL
Cape Canaveral Station	Patrick Air Force Base	Cape Canaveral	FL
Satellite Assembly Bldg Cape Canaveral		Cape Canaveral	FL
General Services Bldg		Clearwater	FL
City of Coconut Creek - Council Building		Coconut Creek	FL
City of Coconut Creek - Motor Pool Building		Coconut Creek	FL

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Project Name	Address	City	State
Coconut Creek Public Safety		Coconut Creek	FL
Marriott - Ft Pierce Travel Plaza	Florida Turnpike Mile Mkr 144	Ft Pierce	FL
City of Holmes Beach Baseball Field	5901 Marina Drive	Holmes Beach	FL
Marriott - Lake Worth Travel Plaza	Florida Turnpike Mile Mrk. 94	Lake Worth	FL
US Post Office - Land O Lakes		Land O Lakes	FL
FDOT District 5		Leesburg	FL
Marriott - Snapper Creek Travel Plaza	Florida Turnpike Mile Mkr 19	Miami	FL
US Naval Air Station Bldg 1406 & 1424	Whiting Field South & North Tower	Milton	FL
Mulberry Post Office		Mulberry	FL
Marriott - Turkey Travel Plaza	Florida Turnpike Mile Mkr 263	Ocee	FL
Marriott - Ft Drum Travel Plaza	Florida Turnpike Mile Mkr 184	Okeechobee	FL
St. Johns Rive Water Management		Palatka	FL
Marriott - Pompano Travel Plaza	Florida Turnpike Mile Mrk 65	Pompano Beach	FL
East Port Environmental Services		Port Charlotte	FL
Charlotte County Sheriff's Administration	Metro Pkwy	Punta Gorda	FL
Marriott - Canoe Creek Travel Plaza	Florida Turnpike Mile Mrk 229	St. Cloud	FL
Gateway Post Office		Tampa	FL
Marriott - Okahumpka Travel Plaza	Florida Turnpike Mile Mrk 299	Wildwood	FL

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Project Name	Address	City	State
Cherokee County Public Safety Complex		Canton	GA
Montgomery County Courthouse		Chula	GA
Paulding County Courthouse	Courthouse Square	Dallas	GA
Handcock Co. Courthouse		Greenfield	IN
Courthouse		Tipton	IN
Campbell County Courthouse	4th Street	Newport	KY
Westover AFB Hangar		Chicopee	MA
Westover AFB Upgrade Hangar B-700		Chicopee Falls	MA
Melrose City Hall	Essex& Main St	Melrose	MA
Natick Municipal Complex		Natick	MA
Mt. Holyoke Summit Lodge	Holyoke State Park	S. Hadley	MA
Wellesley Town Hall	525 Washington St	Wellesley	MA
Bethesda Metro Center	7450 Wisconsin Ave	Bethesda	MD
National Park		Landover	MD
Van Buren County Courthouse		Paw Paw	MI
Public Service of New Hampshire Corporate Hdqrts.		Mancester	NH
Veterans Memorial Home	132 Evergreen Rd	Edison	NJ
Oyster Creek Emergency Bldg	Route 9	Forked River	NJ

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Project Name	Address	City	State
Municipal Complex		Hanover Twp.	NJ
Manchester Town Hall	1 Colonial Drive @ Rte 37	Lakehurst	NJ
Morris County Hall of Records	Ann Street	Morristown	NJ
NJIT Library Bldg	Central Ave	Newark	NJ
South Brunswick Maintenance. Storage Complex		S. Brunswick	NJ
City Hall and Police Dept	Morris & Springfield Aves	Summit	NJ
GTE Government Systems White Sands Missile Range		WSMR	NM
State Legislature Building			NV
Yuca Mountain Test Site			NV
Regional Justice Center		Las Vegas	NV
New Reno Federal Building		Reno	NV
Galena Maintenance Station		Washoe	NV
Broadway Office Complex	625 Broadway	Albany	NY
Transitional Housing	Jackson & Cypress	Bronx	NY
Transitional Housing	141st	Bronx	NY
Transitional Housing for the Homeless	50 W. Mt Eden & Inwood	Bronx	NY
Transitional Housing	Linden Blvd	Brooklyn	NY
Transitional Housing for the Homeless	St. Johns Place & E. NY Ave.	Brooklyn	NY

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Project Name	Address	City	State
Family Court Building		Buffalo	NY
The Rath County Office Building		Buffalo	NY
Tompkins County DOT Admin Facility. Bus Garage	Willow Ave	Ithaca	NY
Police & Hwy Dept Bldg	525 Pavement Road	Lancaster	NY
Niagara Falls Housing Authority-Wrobel Towers	Main Street	Niagara Falls	NY
Orchard Park Municipal Center	S-4295 South Buffalo Street	Orchard Park	NY
Criminal Courts Building		Riverhead	NY
Roosevelt Island Phase II	Building I	Roosevelt	NY
Manhasset Fire House	Prospect Rd	Thomaston	NY
West Valley Nuclear Services		West Valley	NY
Logan County Court House		Bellefontaine	OH
Wood County Court House		Bowling Green	OH
Gurnet County Courthouse		Cambridge	OH
Pickway County Courthouse		Circleville	OH
Fayette County Courthouse		Fayette	OH
Trumbull County Courthouse		Trumbull	OH
Owasso City Hall		Owasso	OK
Coudersport Court House		Coudersport	PA

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Project Name	Address	City	State
Potter County Courthouse	1 East Second Street	Coudersport	PA
Cameron County Courthouse	20 East Fifth St	Emporium	PA
Emporium Court House		Emporium	PA
Valley Forge Plaza	First & Moore rd	King of Prussia	PA
Berks County Courthouse	6th & Court St,	Reading	PA
Berks County Services Center	Reed & Court Sts	Reading	PA
Elk County Court House		Ridgeway	PA
Warren County Courthouse		Warren	PA
City Hall Ave Parking Facility		Norfolk	VA
FBI Firearms Range Renov. [26m Range & Stress Obst		Quantico	VA
National Parks Service bldg	North Cascades Visitor Ctr	New Halem	WA

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Preface from NFPA 780

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REPORT OF THE THIRD-PARTY INDEPENDENT EVALUATION PANEL ON THE EARLY STREAMER EMISSION LIGHTNING PROTECTION TECHNOLOGY

BY

John L. Bryan

Richard G. Biermann

Glenn A. Erickson

Submitted to the National Fire Protection Association Standards Council on September 1, 1999

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Rison (336) reported in 1991 on studies conducted at the Langmuir Laboratory from July 15 to August 23, 1991 to evaluate whether a radioactive ESE air terminal provided protection within a 100 meter radius as reported by the Manufacturer. The ESE device was installed on a twenty foot mast 4 meters below South Baldy Peak. Video cameras were used to record the occurrence of lightning strikes. There were two recorded lightning strikes within the 100 meter radius area during the approximate five week study, one 85 meters from the ESE device and one approximately 78 meters from the device. However, the following statement should be noted from the report:

> Near the end of the test period, it was noticed that the radioactive Preventor had been damaged --the weld had broken between the spherical ball on the Preventor and the nut to which it attached. It is not certain when or how this happened. There was no evidence of tampering or vandalism. Examination of the tip of the Preventor under a microscope showed evidence of melting, such as would occur if lightning were to have struck it. Most likely, the Preventor was struck by lightning at a time when the camcorders were not turned on (when the peak was in a cloud, or a storm occurred in the early morning hours), and the lightning broke the weld.[13]

Thus, it might appear that the ESE device was active in a lightning strike not recorded by the video cameras utilized during the study, since there were periods during the study when the cameras were inactive.

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[13]Rison, William, A Study of Lightning Strikes in The Vicinity of a Radioactive Preventor, Langmuir Laboratory, New Mexico Tech., Socorro, NM, 11-8-91, p. 4.

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Moore *et al.* (248) reported in 1998 a summary of all the field tests of the radioactive "Preventor" ESE device during the summers of 1990, 1991, 1993, 1994, 1995, 1996, and 1997. Moore's analysis is as follows:

> In the six summers during which the "preventor" was exposed to thunderstorms overhead, lightning struck six different sites within 100 meters of the device yet the "preventor" itself was never struck.
>
> Digitized measurements with quarter-microsecond time resolution, of the currents that flowed from the "Preventor" during two nearby lightning strikes in September 1997 showed no indication that the "Preventor" emitted any effective "early streamers". In fact, during one of these discharges, lightning struck a blunt rod located 20 meters distant yet no streamers were emitted from the "Preventor" to connect with this close strike.[14]

It should be noted these seven-year tests involved a single ESE device of a radioactive type. It should also be noted that Moore's (243) field studies under natural lightning conditions have questioned the validity of the effectiveness of the sharp-pointed Franklin air terminal as follows:

> The failure of radioactive-ionizing and of sharply pointed air terminals to participate in lightning discharges by being pre-eminent connectors of lightning to earth is no surprise to scientists studying thunderstorms and lightning. For the past 40 years, I have been measuring the electric currents flowing into the air from both radioactive electrodes and from sharply pointed ones under the influence of the strong electric fields beneath thunderstorms but not one of my well-exposed electrodes has ever been struck by lightning.[15]

[14] Moore, C. B., William Rison, and G. D. Aulich, An Assessment of The Radioactive "Preventor" as an Early Streamer Emitting Lightning Protector, New Mexico Tech., Langmuir Laboratory for Atmospheric Research, Socorro,NM, 12-29-98, pp. 24-25.

[15] 243. Moore, Charles B., New Mexico Tech., "Personal Communication to Subcommittee of NFPA Board of Directors", 9-4-95, p. 1.

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2. Consideration of System Performance

It would appear the ultimate evaluation of any complete lightning protection system would be the performance of the systems as installed on buildings. The submitted materials included one reference to the failure of a conventional system with Franklin rods (328) and there was one newspaper account of a Franklin rod system failure resulting in personnel injuries. (252) There were several studies of failures of ESE lightning protection systems. (146) (220).

The failure of the Franklin rod system resulting in the eleven personnel injuries occurred at the Robert F. Kennedy stadium in Washington, D.C. on June 13, 1998. (252) Richardson reported on the failure of a Franklin rod air terminal located approximately four feet from an externally mounted camera on the building which was damaged by a lightning strike. (328)

Makenras *et al.*, (220) have reported on four cases of lightning striking buildings in Singapore from the late 1960's until the 1980's. Hartono and Robiah (146) have reported on ten cases of failures on buildings protected with ESE lightning protection systems. This study utilized photographs of the building conditions both before and after the reported lightning strikes on the damaged areas of the buildings. It was found from this photographic study the damage appeared to be dependent on the number of strokes received, the strength of the lightning stroke and

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the shape of the structure at the point of the stroke. Although not specified in the study Hartono and Robiah have indicated lightning strike damage was found on buildings protected with Franklin air terminals as indicated in the following statement:

> Studies conducted on the buildings equipped with the standard lightning air terminals (Franklin rod type) also exhibited similar lightning damage locations on or near the rooftop. Based on this comparison, we conclude that no advantage can be obtained by using the ESE device in protecting the building against direct lightning strikes.[21]

It should be noted that all of the incidents of system failure submitted to the panel lacked the necessary detailed documentation to enable a valid analysis as to the effectiveness of the system. Even the most detailed photo study lacked the necessary documentation consisting of the following: The manufacture and model of the air terminal. The date the installation was completed, thus establishing the age of the system when the lightning strike occurred. The maintenance and condition of the system when the strike occurred, including the condition of the down conductors and the grounding system. It would appear that detailed documentation of lightning protection system operations or failures is a needed component for the evaluation of the effectiveness of lightning protection systems of all types on various buildings of differing heights and configurations.

[21]Hartono, Zainal Abidin and Ibrahim Robiah, A Long Term Study on The Performance of Early Streamer Emission Air Terminals in a highly Isokeraunic Region. 2-19-99, p. 2.

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Van Brunt *et al.*, (369) has referenced this problem of adequate data on lightning protection system performance in the following manner:

> There are reports of incidents where ESE devices failed to provide the protection specified by the manufacturer [156,158,165,215]. Statistics on the failure of conventional systems have also been documented [109]. When examining reports of "failures", one can always raise questions about their cause, e.g., whether they are primarily a consequence of exaggerated claims made by the manufacturer or a consequence of misuse (faulty installation) of the device. Reports of isolated failures raise legitimate concerns, but are seldom accompanied by enough supporting data about the event to enable a determination of why the failure occurred. Generally it is difficult to draw significant conclusions from single events that can be used to improve system design or evaluate system performance.[22]

Thus, given the present situation of lightning protection system performance not being a priority of the proponents of the systems, the manufacturers, the insurance companies or public officials it would appear little valid information or data relative to a validation of the theoretical basis of the systems will be obtained.

III. RECOMMENDATIONS TO STANDARDS COUNCIL

Based on a thorough and complete evaluation of the 377 items submitted to the third-party independent panel the members of the panel have agreed in a complete consensus on the following recommendations to the National Fire Protection Association Standards Council. It should be

[22]Van Brunt, Richard J., Thomas L. Nelson, Samar L. Firebaugh, Early Streamer Emission Air Terminals Lightning Protection Systems: Literature Review and Technical Analysis, Quincy, MA, National Fire protection Research Foundation,1-31-95, p. 25.

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recognized the Standards Council is the official designated authority on any action to be taken relative to the NFPA lightning protection documents.

A. Scientific and Technical Basis of ESE

The initial question posed to the third-party independent evaluation panel was stated as: "whether the ESE lightning protection technology is scientifically and technically sound." The panel's review of the submitted materials resulted in the following determinations:

1. The ESE air terminals appear to be technically sound since they are generally equivalent to the conventional Franklin air terminal in laboratory experiments.

2. However, neither the ESE air terminals nor the conventional Franklin rod appear to be scientifically or technically sound when evaluated in field tests under natural lightning conditions.

3. The ESE lightning protection technology as currently developed in the installation of complete systems does not appear to be scientifically and technically sound in relation to the claimed areas of protection or the essentials of the grounding system.

B. Adequacy of Theoretical Basis and Lab Tests

The second specific question posed to the third-party independent review panel was stated as: "whether the ESE lightning protection technology is supported by adequate scientific theoretical basis and

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laboratory testing." The panel's review of the submitted materials resulted in the following determinations:

1. There does appear to be an adequate theoretical basis for the early streamer emission lightning protection air terminal concept and design from a physical viewpoint.

2. There does not appear to be an adequate theoretical basis for the claimed enhanced areas of protection with limited down conductors and grounding system.

3. The high voltage laboratory tests of the ESE air terminals appear to be adequate in scope and quantity, but they are limited in that they are not equivalent to an evaluation of the complete ESE lightning protection system under natural thunderstorm conditions.

C. NFPA Lightning Protection Documents

The third-party independent evaluation panel was also directed in the Settlement Agreement as follows: "This panel, in issuing its report, shall address the following issues, and any other issues it deems relevant:" The panel considered the issues of the existing NFPA 780 document titled: Standard for The Installation of Lightning Protection Systems 1997 edition, (294) and the proposed NFPA 781 document titled: Standard for Lightning Protection Systems Using Early Streamer Emission Air Terminals. (277) The panel considered the need for each document and each committee's membership and balance in accordance with NFPA

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procedures. The panel's review of the submitted materials resulted in the following determinations:

1. The current NFPA 780 Committee should be discharged and the Committee should be completely restructured. The committee needs new and additional memberships in the membership categories of enforcer, consumer, user, insurance, labor, special expert and research/testing..

2. The Council should solicit memberships from prominent users such as: FAA, DOE, DOD, NASA, IBM, Reedy Creek Improvement District, phone, radio, television organizations and electric power utilities.

3. The NFPA 780 document should be reformulated as a Guide or Recommended Practice. It appears to the panel the NFPA 780 document does not meet the NFPA criteria for a standard since the recommended lightning protection system has never been scientifically or technically validated and the Franklin rod air terminals have not been validated in field tests under thunderstorm conditions. The NFPA criteria for a standard as stated in the NFPA 99 Directory (298) is as follows:

> Standard --A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fineprintnote and are not to be consider as part of the requirements of a standard.[23]

[23]NFPA, National Fire Protection Association 1999 Directory, Quincy, MA, 11-98, p. 52.

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EXHIBIT G

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EARLY STREAMER EMISSION AIR TERMINALS LIGHTNING PROTECTION SYSTEMS

LITERATURE REVIEW AND TECHNICAL ANALYSIS

Prepared by

Dr. Richard J. Van Brunt
Thomas L. Nelson
Samara L. Firebaugh



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FIRE PROTECTION
RESEARCH FOUNDATION

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development has been established from laboratory investigations [113], considerably less is known about the dynamics and interactions of these species in a discharge compared to what is known about ions. In particular, very little is known about how they contribute to lightning discharge initiation or propagation under relevant atmospheric conditions. As with negative ions, the metastable content of the air around a lightning terminal will be affected by relative humidity and general air contamination. The influence of metastable species should not extend significantly beyond the end of a lightning rod. Their role, if anything, will be to enhance initial development of a streamer at the rod tip.

In summary, it would appear that enhancement of upward streamer initiation from an ESE terminal (compared to a conventional terminal) has a plausible physical basis. However, it would also appear that a complete and universally accepted understanding of how all ESE devices work has not yet been achieved, and it can be argued that a better understanding is needed to make meaningful quantitative comparisons between the performances of ESE and conventional devices. To reach such an understanding it will undoubtedly be necessary to address numerous basic questions such as:

1. What are the predominant streamer initiation mechanisms under different conditions of polarity, atmospheric humidity, air contamination, and terminal geometry?

2. What are the relative roles of ions, electrons, and metastable species on the development and propagation of a streamer discharge from a terminal for different conditions?

3. What is the likelihood of corona formation around a terminal and how will the presence of corona affect the ability of the terminal to launch a streamer upon approach of a lightning stroke?

4. In the case of radioactive terminals, what is the dependence of the streamer initiation probability on the intensity and type of radiation source?

5. In the case of electrically triggered devices, how does the streamer initiation probability depend on the timing and magnitude of the electrically triggered spark?

6. Also for electrically triggered devices, how reliable is the field sensor that controls the triggering, and can its performance be affected by local space charge?

Attempts to find answers to questions like these are the focus of much ongoing experimental and theoretical research, not only on lightning, but on electrical discharge phenomena in general.

D. Validation of ESE System Performance

Three general methods have been used to evaluate and test the performance of lightning protection systems, namely: 1) small-scale laboratory or outdoor tests in which lightning, or the effects of lightning are simulated by applying high-voltage impulses

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lightning seldom hits a terminal regardless of whether or not it is equipped with an ESE device [182,183,215]. Although a few isolated strikes to the mountain were reported to have occurred within the supposed zones of protection of ESE terminals [183,215], it would appear that the overwelming majority of strikes to the mountain were at considerable distance from any terminal. In any case, the failure of air terminals to attract lightning on mountain tops at elevations of 3000 m (9843 feet) or more is obviously disturbing and raises questions about the interpretation of such observations. Before any serious conclusions are drawn about the performance of lightning attractors from tests performed on mountain tops, it may be necessary to consider the perturbing effect of the mountain itself on such parameters as the surface charge distribution and electric-field profile under a thundercloud, as well as the extent that lightning strokes at such high elevations differ from those that normally occur in lower, flatter locations. It would appear that the answers to some of these questions might already be found in the literature.

It is noted in some papers that lightning that occurs at high elevations generally differs on average from that which occurs at sea level, if in no other respect than that it has less distance to cover in going from the cloud to ground [36]. At an elevation of 3000 m, the ground can be quite close to or even engulfed by the base of a storm cloud. Certainly the results from high mountain tests cannot be dismissed, and such tests should continue, as should similar tests underway at other locations [107]. The problem is how to interpret the results of these tests and infer what they might imply about air terminal performance at lower elevations, and what they indicate about the influence of mountainous or rocky terrain on the effective zone of protection of an air terminal.

The unfavorable statistical odds associated with natural lightning can be partially overcome by using artificially triggered lightning. Tests have shown that lightning can be triggered with reasonably high probability by a rocket launched into a thundercloud [124,160,190,193]. A long trailing wire is usually attached to the rocket which provides a low resistance path to guide the initial discharge and define its direction of propagation [45,120,193]. Transportable facilities have been developed for rocket triggering of lightning that can be used for testing at nearly any location [231]. Although tests of air terminals are being made using triggered lightning, there are questions that can be raised about the meaning of such tests. There is evidence that triggered lightning is unlike natural lightning both in its intensity and propagation characteristics. In particular, it has been noted that triggered lightning is of lower current than natural lightning and exhibits characteristics more like those of return strokes observed in natural lightning [78,161]. It has also been argued that triggered lightning does not satisfactorily mimic the primary stroke and is therefore unsuited for investigation of the attachment to a grounded lightning conductors, i.e. its use in evaluating air terminals would appear to be questionable [78]. The extent to which rocket-triggered lightning behaves like natural lightning seems to depend on the length of the trailing wire and the distance of the bottom end of the wire above

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3. Radiation hazards

In the case of ESE devices that employ radioactive materials, issues have been raised in the literature about the possible radiation hazards to humans that the use of these devices present [24,25,39,81,180,196,278]. As noted above, radioactive air terminals are banned in some countries, presumably because of perceived health hazards. It has been noted that ^{241}Am sources used in lightning protection devices are not any more hazardous than similar sources approved for use in smoke detectors or static eliminators [109,167,180]. Nevertheless, there are those who argue that the public may be placed at risk from a proliferation of radioactive materials in devices that can enter the environment without adequate controls [25,81,180]. An evaluation of the health and safety aspects of radioactive sources used in air terminals lies outside the scope of this report. However, we have identified this as a serious issue that the manufacturers and users of radioactive terminals must be prepared to address.

4. Damage and maintenance

Given that ESE devices likely have a structure and associated instrumentation that are more complex than conventional air terminals, questions can be raised about their susceptibility to damage during a lightning strike. The electric current and energy deposited by a lightning stroke can be sufficiently high to actually melt metallic structures and destroy electronic components. There are numerous reports of damage inflicted by the primary lightning stroke to metal parts on aircraft, etc. [70,79,138,209,237,269]. The possibility of damage means that a lightning protection device may require periodic inspection and/or maintenance that is generally not required for conventional terminals. Although this problem is pointed out [155], there seems to be very little discussion about it in the open literature.

IV. CONCLUSIONS

The possible conclusions that can be drawn from an examination of the literature included in the bibliography are discussed in this section. The main conclusions of this report are briefly summarized in Section VI.

Because of the sparsity of information that can be found in the peer-reviewed literature from tests of early streamer emission air terminals, either in the laboratory or in the natural environment, it is nearly impossible to make quantitatively meaningful statements or judgements about the performance of ESE devices in comparison to conventional Franklin rods. In fact, insufficient reliable quantitative data seem to exist about the performance of conventional rods, and there seems to be an ongoing debate about the best geometrical design for conventional terminals required to achieve optimum lightning attraction efficiency.

Nearly all of the information or data that could found on ESE device performance resulted either from tests performed by manufacturers of lightning protection sys-

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tems or by those directly or indirectly employed by such manufacturers. Although abundant criticism is published by non-manufacturers about the performance of ESE devices, especially radioactive air terminals, it is seldom based on actual test data. Those on both sides of the issue invoke lack of evidence in making their case about the performance of ESE terminals. Proponents of these devices claim that a lack of credible statistical data on failure of ESE terminals proves their effectiveness; while critics of these terminals argue that a lack of evidence about the improved performance of ESE terminals over conventional terminals proves their ineffectiveness. In either case, one must beware of faulty logic, in as much as a lack of evidence never proves the lack of something.

There are reports of incidents where ESE devices failed to provide the protection specified by the manufacturer [156,158,165,215]. Statistics on the failure of conventional systems have also been documented [109]. When examining reports of "failures", one can always raise questions about their cause, e.g., whether they are primarily a consequence of exaggerated claims made by the manufacturer or a consequence of misuse (faulty installation) of the device. Reports of isolated failures raise legitimate concerns, but are seldom accompanied by enough supporting data about the event to enable a determination of why the failure occurred. Generally it is difficult to draw significant conclusions from single events that can be used to improve system design or evaluate system performance. There is no reason to believe that an air terminal is 100% efficient in attracting lightning, regardless of what kind of ESE device it uses, if any. Considering the wide range of possible atmospheric conditions and types of lightning behavior that have been recorded, it is not surprising that air terminals of all types will sometimes fail [37,201,271]. Tall structures are reported to be struck occasionally by lightning at points far below the top, i.e., outside of the "protection zone" [173,185,186]. Any claims of 100% efficiency in the performance of a lightning attractor should be viewed with skepticism. In any case, the meaning of the term "efficiency", when specified for an air terminal, should be clearly defined and understood.

A reasonable physical basis for the operation of an ESE device appears to exist in the sense that there is good evidence from laboratory investigations that the probability of initiating a streamer discharge from an electrode can be increased significantly by irradiation or electrical triggering. However, the precise amount by which this enhancement in streamer initiation improves the lightning attraction efficiency of an air terminal remains questionable. There is reason to doubt that it significantly extends the maximum range of protection. A lightning stroke that would not hit a conventional terminal because of the fact that it does not enhance the field at the terminal tip enough to allow streamer formation will also not likely hit a terminal equipped with an ESE device. (The exception would be an ESE device that significantly increases the terminal potential during the approach of a lightning stroke.) In our view, the possible advantage offered by an ESE device, if operated properly, is that it helps to insure that a streamer will be initiated if the field produced by the

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The controlling statutory standards for approving an amendment or modification to the Florida Building Code are as follows. Proposed code modification 7211 does not meet the statutory standards:

1. *Is needed in order to accommodate the specific needs of this state.*
2. *Has a reasonable and substantial connection with the health, safety, and welfare of the general public.*

It is undisputed that structural fire incidents are declining – not increasing – in the United States from 1977 to 2015 so there is no reason for FBC to impose this new tax for LPS and SPD on Florida's economy. Haynes, *Fire Loss in the United States 2015*, NFPA, September 2016, Figure 1 at p. 11. Haynes concludes that "[t]he total number of fires continues to be on a downward trend, as does the number of outside fires, structure fires and vehicle fires." P. 35. Direct property damage from lightning fires has declined as well from 1977 to 2015 in 2015 dollars. More specifically, the amount of direct property damage to non-home structures caused by lightning fires dropped over 70% annually from 1980 to 2014 ($249 million to $65 million). Ahrens, *Structure Fires Started by Lightning*, NFPA, April 2017, at Table 2, p. 4. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/fire-causes/lightning-fires-and-lightning-strikes

In 2011 Fire Departments reported 27,100 total lightning fires in the United States. Of these reported fires 20,400, or 75% of the total, were outside fires or non-structure fires. Only 7% of lightning fires from 2007-2011 were "non-home structure fires." Ahrens, *Lightning Fires and Lightning Strikes*, NFPA, Fire Analysis and Research Div., June 2013, p. 1. Exhibit C. There were only 1,800 "non-home structure" fires. *Lightning Fires and Lightning Strikes* at Table 4, p. 14. By 2014, the number of "non-home structure fires" was even lower (1,400). *Structure Fires Started by Lightning*, at Table 2, p. 4.

Therefore, the Proposed Code Modification is not needed and does not have a reasonable and substantial connection with the health, safety and welfare of Floridians. The Proposed Code Modification overstates the risk and costs of lightning damage to structures in Florida and given the overstated threat of damage caused by lightning strikes, the costs of complying with the proposed LPS and SPD requirements exceed the benefits of their installation in Florida.

3. *Strengthens or improves the Florida Building Code, or in the case of innovation or new technology, will provide equivalent or better products or methods or systems of construction.*
4. *Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities.*

The restriction of approved LPS to only NFPA 780-compliant systems provides no equivalent products, methods, or systems of construction and is entirely discriminatory as to all other products, methods and systems. The Proposed Code Modification would wholly exclude from Florida construction projects UL Certified Lightning Protection Systems and specific Components and Systems such as UL96A Master Labeled LPSs and UL Letter of Findings LPS. Further the modification excludes LPS such as IEC 62305, DOD DDESB 6055.9, DOE M440.1-

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1, FAA Std – 019e, FAA 6950.19A, NASA E-0012F, API – 2003, and any new LPS technology that may be developed and otherwise certified.

5. *Does not degrade the effectiveness of the Florida Building Code.*

An inherent conflict exists in the Proposed Code Modification. While LPS must be NFPA 780-compliant, SPD must be installed in accordance with NFPA 70, National Electric Code. These codes conflict as to installation of SPDs and where they are required to be installed in a structure.

§553.73 (9) (a)

Further, a proposed amendment must include a fiscal impact statement that documents the costs and benefits of the proposed amendment:

The proposed modification would needlessly – but substantially – unfairly tax the Florida economy. The narrative for Proposed Code Modification 6460 in 2017 providing for new LPS building requirements admitted that "[t]he average cost of a complete LPS is approximately 1% to 5% of total construction cost of the building." Dr. Issa's draft report presented to the Technical Advisory Committee at that time directly acknowledges these additional costs:

> "[t]he largest cost impact for the 2015 Florida specific changes came from proposed code change E6460, the installation of Lightning Protection Systems (LPS). The anticipated cost of the LPS was estimated to add 5% to the buildings total cost. Up to 80% of that cost reportedly could be offset through insurance reductions, **however such insurance reductions are not guaranteed and were therefore omitted from this cost estimate.**" (emphasis supplied) Issa, *Evaluation of the Cost Impact of Florida's specific changes to 2015 I-Codes "Prescriptive Code Changes"*, Draft Final Report, April 17, 2017, at Executive Summary p. 1.

§553.73 (9) (b)

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VILLAGE PLACE

A GRACE MGMT COMMUNITY

18400 Cochran Blvd Port Charlotte, Fl 33948
Phone: (941)255-2000

Village Place
18400 Cochran Blvd.
Port Charlotte, Fl 333948

Gail G. Matillo, MPA
2292 Wednesday St., Suite 1
Tallahassee, Fl 32308
President and CEO

May 23, 2019

Dear Gail,

Village Place disagrees with the Florida Building Code Proposed Code Modification SP 7211, requiring Florida's Assisted Living Facilities (ALFs) to install lightning protection systems, and requests the Proposal be denied for the following reasons:

(1) The Florida Building Code for construction of ALFs is based on a residential model while nursing home construction is based on an institutional model. Residents of ALFs are ambulatory and self-preserving and do not require 24-hour care like those living in nursing homes;

(2) The intent of the Legislature in Part I of Chapter 429, Florida Statutes, specifically states that ALFs "should be operated and regulated as residential environments with supportive services and not as medical or nursing facilities." S. 429.01(2), Fla. Stat. Section 429.41(1) goes further to state that regulations should "ensure a safe and sanitary environment that is residential and noninstitutional in design or nature." Residents of ALFs are ambulatory and capable of self-preservation;

(3) This proposal will greatly increase construction and consumer costs in ALFs for one of Florida's most vulnerable populations. The average cost of a comprehensive facility lightning protection system (FLPS) for a commercial building is typically in the range of $35,000;

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(4) All new ALFs must be fully sprinklered so there is already ample fire protection; a review of NFPA records of fire incidents in ALFs indicates a lack of physical harm to residents over at least the past two decades; and

(5) Implementation of a single-system lightning arrangement limits the discretion of important parties within the ALF construction industry; we believe in an open standard that allows the marketplace to offer competitive solutions on any updated lightning/surge code requirements.

In 2018, the state mandated ALFs install generators and fuel tank systems, costing communities millions of dollars. Additionally, a large number of ALFs rely solely on Medicaid reimbursement to provide care to low-income residents. Proposed Code Modification SP 7211 of the Florida Building Code would impose additional costs to the industry that cannot be absorbed. Adding additional mandated cost to this industry at this time would be a harsh and unwarranted implementation by the state. Many ALFs would be forced to reconsider building new developments and may seek to build in states with less restrictive laws.

Respectfully Yours,

Melody Thornton-Giuliano

Melody Thornton-Giuliano
Executive Director
Village Place
(941)661-4193 cell

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FLORIDA ASSISTED LIVING ASSOCIATION
Promoting Excellence in Assisted Living

Ref: SP7211

Dear Commission:

The Florida Assisted Living Association strongly disagrees with the proposed amendment. The proposal intends to place requirements on assisted living facilities without any safety justifications; and further provides an undue cost burden on new communities. The Florida Legislature has provided that as residential environments with supportive services and not as medical or nursing facilities. *See, 429.01, F.S.* This proposed requirement does no more than attempt to place additional requirements similar to nursing homes.

While this change impacts both private pay assisted living communities, it disproportionately affects small and Medicaid funded assisted living communities. Assisted living facilities providing care to Florida's low-income seniors are at a breaking point. Depending on the area of the state, reimbursement is locked in between $900 - $1,300.00 per month. To compound this problem, residents living in these assisted living facilities are becoming frailer, requiring higher levels of care at the same payment rate received in 2014. During this five-year period there has been no additional funding for yearly cost increases, thus eroding the rate of reimbursement year over year. As the costs of goods and services continue to increase over the last five (5) years, wages have become more stagnant and programs and activities are threatened. In short, there is no way to shift this proposed cost increase to the Florida Medicaid program, which theoretically pays for low income senior care in assisted living facilities.

The Florida Assisted Living Association respectfully request that this modification and undue burden not be placed on assisted living facilities.

Florida Assisted Living Association
1618 Mahan Center Blvd., Suite 103, Tallahassee, FL 32308 • Tel: 850-383-1159 • Fax: 850-224-0448 • www.fala.org

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Lightning Protection Installation Cost Study

Prepared by Michael Chusid, RA FCSI for East Coast Lightning Equipment, Inc.
2015-July

Background

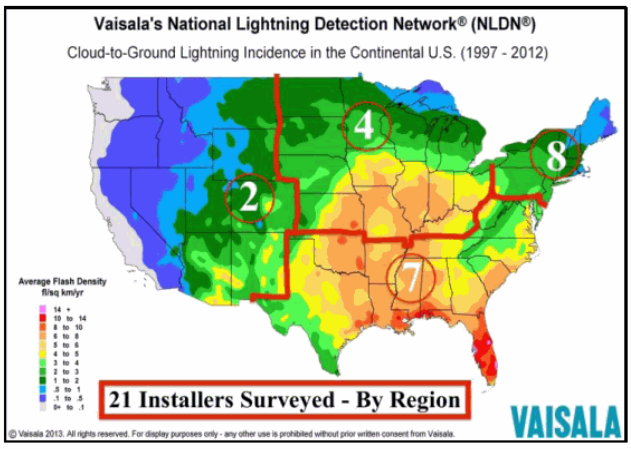
Lightning accounts for about $1 billion a year in homeowner's insurance claims for property damage. Lightning fires in non-residential properties cause an average of over $100 million in direct property damage annually, not including damage due to electrical or equipment malfunctions, non-fire-related structural damage, or consequential damages. Additional risks include injury and death due to lightning strikes.[1]

Fortunately, reliable lightning protection of buildings and structures is available. Data on the cost of installing lightning protection, however, has not been readily available. The purposes of this study, therefore, are 1) to understand the cost of installing lightning protection, and 2) to provide building owners and their architects, engineers, and risk management consultants with cost estimating guidelines for use during the planning and design phases of construction projects.

To prepare this study, East Coast Lightning Equipment, Inc. (www.ecle.biz) collected construction cost data from lightning protection installers throughout the US. The cost data, summarized below, confirms that lightning protection is economical and can be justified on a cost-to-benefit basis in at-risk buildings.

Methodology

During the second quarter of 2015, lightning protection installers were asked to submit "bids" for installation of lightning protection on three hypothetical projects. Prices were to include installer's overhead and profit but not a general contractor's mark-up. The projects include a single-family residence, a low-rise building typical of educational, commercial, and industrial occupancies, and a five story building typical of many office buildings, healthcare, and similar occupancies. See Appendix for survey instrument.



Responses were received from 21 installers that are certified for lightning protection work by the Lightning Protection Institute. The distribution of respondent trade territories is shown on map according to US Census Regions. The distribution of respondents is similar to the frequency of lightning strikes; higher in Eastern and Southern states, least in the West.

The results were tabulated by Michael Chusid, RA, FCSI, an independent construction consultant, www.chusid.com, and are summarized below.

---

[1] www.iii.org/fact-statistic/lightning, accessed 2015-06-03.

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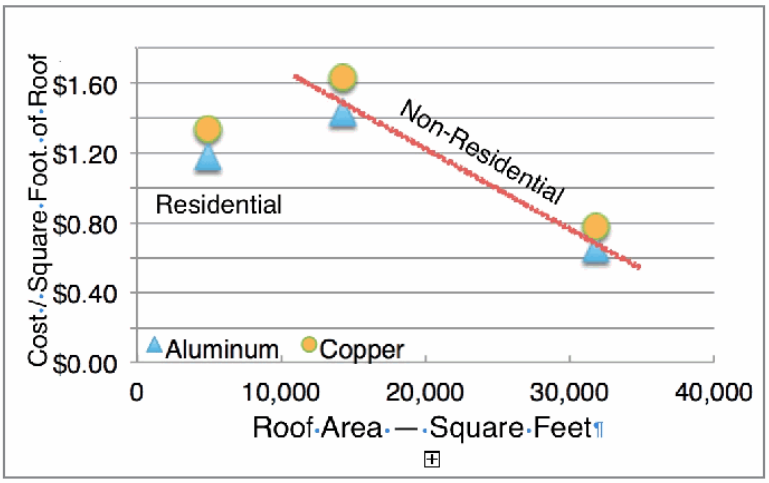
Lightning Protection Installation Cost Study

Key Findings

Lightning Protection Installation Cost Estimates						
	Residential Building		Low-Rise Building		5-story Building	
	Aluminum	Copper	Aluminum	Copper	Aluminum	Copper
Northeast						
$/Sq.Ft. of Roof	$1.56	$1.58	$0.74	$0.89	$1.75	$1.89
$/Sq.Ft. of Floor	$0.94	$0.95	$0.54	$0.65	$0.35	$0.38
South						
$/Sq.Ft. of Roof	$0.98	$1.10	$0.42	$0.50	$1.16	$1.33
$/Sq.Ft. of Floor	$0.59	$0.66	$0.31	$0.37	$0.23	$0.27
Midwest						
$/Sq.Ft. of Roof	$0.88	$1.06	$0.78	$1.02	$1.45	$1.82
$/Sq.Ft. of Floor	$0.53	$0.64	$0.58	$0.75	$0.29	$0.37
West						
$/Sq.Ft. of Roof	$1.60	$1.77	$0.88	$1.04	$1.46	$1.61
$/Sq.Ft. of Floor	$0.96	$1.06	$0.65	$0.76	$0.29	$0.32
National						
$/Sq.Ft. of Roof	$1.18	$1.34	$0.65	$0.78	$1.44	$1.64
$/Sq.Ft. of Floor	$0.71	$0.80	$0.48	$0.58	$0.29	$0.33

Cost of protecting sitework, such as trees, is not included.

Estimated Cost of Lightning Protection per Square Foot of Roof Area, National Averages



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Lightning Protection Installation Cost Study

Analysis

General: Variations between regions are due to regional trade practices, wages and benefits, soil conditions governing the type of ground terminals used, and other factors. Variations within regions can also be significant, especially between urban and rural locations.

Copper lightning protection equipment is generally more expensive than aluminum due to commodity prices. There are also regional biases that favor one material over the other.

Nonresidential Buildings: In nonresidential buildings, roof area is the most significant factor in determining the work required to install lightning protection. Hence, multistory buildings will generally cost less per square foot of interior floor area.

Costs will generally be more in buildings with extensive roof top equipment and demanding architectural considerations; less in building with a modicum of rooftop equipment and a simple configuration.

Buildings over 75 feet in height (Class II) will incur additional expenses. These estimates do not apply to buildings that house explosives and other special occupancies.

Residential Buildings: In most homes with pitched roofs, air terminals need only be installed at the roof ridge, not the perimeter of the roof. This explains why lightning protection costs for the home in our study is below the trend line shown for non-residential construction.

Note, however features such as dormers, chimneys, balconies, skylights, rooftop equipment, and large flat areas can add to the cost.

How to Use

These cost estimates can be used in the early stages of planning or designing a project. Once the overall configuration of a building is determined, consultation with a qualified lightning protection designer or installer will yield a more accurate estimate and identify ways to improve protection while reducing costs.

These cost estimates are subject to change with time and can be adjusted using the *Engineering News Record* Construction Cost Indexes or other databases of historical construction costs. Lightning protection costs are also subject to fluctuations in raw material costs.

For Additional Information

Lightning Safety Alliance, www.LightningSafetyAlliance.org

Lightning Protection Institute, www.lightning.org

East Coast Lightning Equipment, Inc., www.ecle.biz, info@ecle.biz, +1 860-379-2046

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Lightning Protection Installation Cost Study

APPENDIX

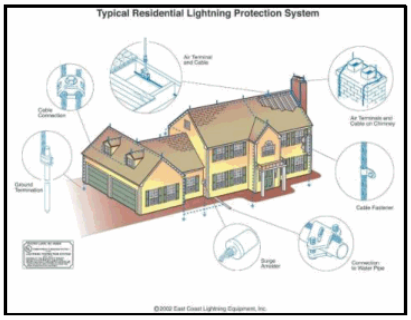
The following survey instrument was sent via e-mail to qualified lightning protection professionals.

ECLE requests your assistance in creating cost estimating guidelines that can be used by architects and engineers. Many designers ask us about the cost of installing lightning protection so they can include lightning protection in their project estimates. Your information will help them make better cost-to-benefit calculations that will, we believe, make it more likely for them to specify lightning protection. Please take a few minutes to look at the three buildings below then send us your price estimate to perform each of the installations.

Your data will be **confidential**. Michael Chusid, RA FCSI, a construction industry consultant, will compile regional and national averages and use the information to write articles for leading construction industry publications. We will send you a copy of his report as our thank you.

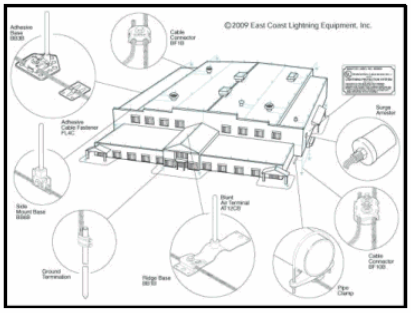
Residential Project

Assume the following:
Normal grounding conditions
Concealed installation - new construction
LPI or UL Certification Required
Please price in copper and aluminum
Price as you would to a GC or EC



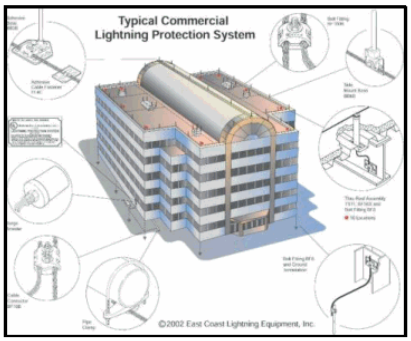
High School Project

Assume the following:
Normal grounding conditions
Exposed installation - existing construction
EPDM Roof
LPI or UL Certification Required
Please price in copper and aluminum
Price as you would to a GC or EC



Government Office Building Project

Assume the following:
Normal grounding conditions
Structural Steel to Ground installation
New construction
Built-Up Roof
LPI or UL Certification Required
Please price in copper and aluminum
Price as you would to a GC or EC
Click to download office dimensions



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Apparent lightning strike caused ALF fire

By Austin L. Miller
Posted Jun 16, 2017 at 4:27 PM
Updated Jun 16, 2017 at 6:48 PM

The fire that forced the evacuation of residents and staff at an assistant living facility in Belleview was apparently caused by Mother Nature.

According to a spokesperson from the State Fire Marshal's Office, it appears the fire was caused by a lightning strike. Damage to the attic area is approximately $30,000. The exact cause of the fire won't be determined until the investigation is complete.

Marion County Fire Rescue officials said Friday there were reports of heavy weather with lightning in the area prior to the fire. Fire officials said the blaze started in the attic above the electric panels and moved along the trusses.

Firefighters, sheriff's deputies and others placed 56 residents from Hampton Manor Assisted Living, 10590 SE 62nd Avenue Road, onto buses that transported them to another Hampton Manor facility.

Fire officials said they received the call about 5:05 p.m. and arrived on scene at 5:11 p.m. The fire was under control at 5:29 p.m.

Beatrice Kelty, community director at Hampton Manor, told the Star-Banner that Donna Clifford was in the kitchen when she heard a pop sound in the breaker and then saw fire in the ceiling. Clifford, the dietary supervisor, immediately pulled the alarm. There were seven staff members on duty at the time of the fire.

Kelty said she quickly went to the kitchen and doused the blaze with a fire extinguisher. Kelty said she and the other team members, including Dawn Crossley, a resident care manager, went to get the residents and evacuate them.

None of the residents were in the kitchen at the time of the fire. When the fire started, Kelty said, they were in the middle of dinner.

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"My team was excellent and the residents cooperated," Kelty said.

According to a fire report, as the fire made its way through the attic, a single fire sprinkler was activated and it contained the fire to the general area until firefighters arrived. The report also said that as soon as flames were seen in the attic, a staff member pulled the kitchen pull station that activated the hood. Though no fire was present in the hood, fire officials said it prevented the gas from going into the kitchen.

"The early actions by the staff to activate the fire alarm and notify MCFR along with the operation of the sprinkler system allowed for a quick response and to contain the damage," according to the report.

Cindy Campbell, director of operations, told the Star-Banner that all the residents remain at the Hampton Manor at 1500 SE 24th Road because the Belleview building sustained significant damage in the kitchen area.

Campbell said its unknown when the repairs will begin or end or when residents will be able to return to the Belleview building. For now, she said, they're looking for an alternate location, and the residents at the Southeast 24th Road facility are adjusting well.

Contact Austin L. Miller at 867-4118, austin.miller@starbanner.com or @almillerosb.

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E7370

Date Submitted	11/20/2018	**Section**	412.6.7	**Proponent**	Bryan Holland
Chapter	4	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation No Affirmative Recommendation
Commission Action Pending Review

Comments

General Comments Yes

Alternate Language No

Related Modifications

Summary of Modification

This proposed modification adds electrical classification criteria to the rules for aircraft paint hangers.

Rationale

This proposed modification provides some needed guidance for classifying the hazardous location within an aircraft paint hanger. these requirements will harmonize the FBC-B with the FFPC and NFPA 70.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will not impact the local entity relative to code enforcement.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will not change the cost of compliance to building and property owners.

Impact to industry relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact industry.

Impact to small business relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected to the health, safety, and welfare of the general public by providing needed guidance on the classification of hazardous location at and around aircraft paint hangers.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves and strengthens the code.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

2nd Comment Period

E7370-G1

Proponent Jennifer Privateer **Submitted** 5/22/2019 **Attachments** No

Comment:

agree as proposed

2nd Comment Period

E7370-G2

Proponent Harold Barrineau **Submitted** 5/25/2019 **Attachments** No

Comment:

I agree with this modification

[F] 412.6.7 Electrical. Electrical equipment and devices within the aircraft paint hangar shall comply with NFPA 70.

[F] 412.6.7.1 Class I, Division I hazardous locations. The area within 10 feet (3048 mm) horizontally from aircraft surfaces and from the floor to 10 feet (3048 mm) above the aircraft surface shall be classified as a Class I, Division I location.

[F] 412.6.7.2 Class I, Division 2 hazardous locations. The area horizontally from aircraft surfaces between 10 feet (3048 mm) and 30 feet (9144 mm) and from the floor to 30 feet (9144 mm) above the aircraft surface shall be classified as a Class I, Division 2 location.

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E7385

Date Submitted	11/21/2018	**Section**	917	**Proponent**	Bryan Holland
Chapter	9	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation No Affirmative Recommendation
Commission Action Pending Review

Comments

General Comments Yes **Alternate Language** No

Related Modifications

Summary of Modification

This proposed modification adds a new Section on "Mass Notification Systems" to the code.

Rationale

The need for real-time effective emergency communications in the United States came into sharp focus in the 20th century in response to threats to homeland security and our educational occupancies. We have learned from the recent incidents that occurred in our college/university campuses and other buildings, and have created installation guidelines to be followed for Life Safety. When a mass disaster event occurs, the need for real time information communicated in a clear and concise method via various paths is very critical to Life Safety. The Risk Analysis and the Emergency Response Plan have been shown to be the needed steps to take in this complicated life safety concern today and in the future. This action will NOT require a mass notification system to be installed; it requires the Risk Analysis which is outlined in detail within NFPA 72. That analysis prepared by a registered design professional along with stakeholders of the college and AHJ that will outline what is needed for this location and application. This code change proposal provides a requirement that a Risk Analysis be created for every new building of size that requires a fire alarm system in college's campuses. NFPA 72 has a chapter dedicated to Emergency Communication Systems-Mass Notification. The requirements for Risk Analysis and qualifications for those performing these services are within NFPA 72; they are matured and are in the 3rd cycle of revisions. Mass Notification can cover One Way, Two Way, Wide Area (outside) In-Building Mass Notification and Distributed Recipient (Cell phone, laptop) forms of communication. All of this is covered in detail in NFPA 72. Mass Notification is a subset of ECS for all hazards concerns. Another is EVACS which is the Em Voice Alarm Communication System which is defined for FIRE incidents, and now can be utilized for mass notification.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will not impact the local entity relative to code enforcement other than verifying the risk analysis has been completed and acted upon accordingly.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will not change the cost of compliance to building and property owners unless the mass notification system is recommended by risk analysis and the cost of the system is absorbed by the building and property owners.

Impact to industry relative to the cost of compliance with code

This proposed modification will increase the cost of compliance with the code as a risk analysis will be required for qualifying occupancy types and the outcome may result in a required mass notification system to be installed.

Impact to small business relative to the cost of compliance with code

This proposed modification will not change the cost of compliance or impact small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected to the health, safety, and welfare of the general public by addressing a growing need for mass notification in certain occupancies to warn the public of a hazard or danger.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves and strengthens the code by giving the user of the code a pointer to the applicable industry standard (NFPA 72) to perform a risk analysis.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

2nd Comment Period

Proponent Bryan Holland **Submitted** 5/21/2019 **Attachments** No

E7385-G1

Comment:

Please reconsider this proposed modification for approval. The rule only applies to college and university campuses where the life-saving benefits of a mass notification system have been proven by case study. The rule does not mandate the installation of a mass notification system but rather mandates an industry recognized risk assessment outlined in the NFPA 72 be performed. Only those campuses where it is shown that a mass notification system will enhance the evacuation, rescue, and other life-saving communications will be required to install one.

2nd Comment Period

E7385-G2

Proponent Jennifer Privateer **Submitted** 5/22/2019 **Attachments** No

Comment:

I strongly agree with this proposed modification as written

2nd Comment Period

E7385-G3

Proponent Harold Barrineau **Submitted** 5/25/2019 **Attachments** No

Comment:

I agree with this modification

SECTION 917

MASS NOTIFICATION SYSTEMS

[F] 917.1 College and university campuses. Prior to construction of a new building requiring a fire alarm system on a multiple-building college or university campus having a cumulative building occupant load of 1,000 or more, a mass notification risk analysis shall be conducted in accordance with NFPA 72. Where the risk analysis determines a need for mass notification, an approved mass notification system shall be provided in accordance with the findings of the risk analysis.

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E7208

Date Submitted	11/7/2018	**Section**	2703	**Proponent**	Bryan Holland
Chapter	27	**Affects HVHZ**	No	**Attachments**	Yes

TAC Recommendation No Affirmative Recommendation
Commission Action Pending Review

Comments

General Comments No

Alternate Language Yes

Related Modifications

7207

Summary of Modification

This proposed modification will add mandatory surge protection requirements to buildings under the scope of the FBC-B.

Rationale

This revision is intended to address the recognized need for surge protection to protect the sensitive electronics and systems found in most modern appliances, safety devices (such as AFCI, GFCI and smoke alarms) and equipment used in buildings. Additionally, the expanding use of distributed energy resources (DER) within electrical systems often results in more opportunity or greater exposure for the introduction of surges into the system.

Electronic life-saving equipment such as fire alarm systems, IDCI's, GFCI's, AFCI's and smoke alarms, may be damaged when a surge occurs due to lighting, internal local switching as well as external utility switching. Other equipment is also damaged when subjected to surge. In many cases, electronic devices and equipment can be damaged and rendered inoperable by a surge and yet this damage is undetected by the owner. It is practical to require a SPD to provide a general level of protection. In almost all new service installations, as well as service upgrades, no consideration is given to providing a general level of protection to the "whole structure" which would include those devices that cannot be afforded a cord connected Type 3 SPD protection. 2703.4 is included to require that when a service is upgraded, an SPD is to be installed.

Studies by recognized authorities including NEMA, IEEE, and UL, all substantiate the fact that surges can and do cause significant damage. Nationwide Insurance organizations recognize the need for effective surge protection as well and have published recommendations that include point-of-use surge protectors and installation of surge protection at service equipment.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will require additional enforcement requirements related to electrical services. The impact will be minor.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will increase the cost of compliance to building and property owners where the cost of providing a mandatory SPD is passed-on to the consumer.

Impact to industry relative to the cost of compliance with code

SPDs are available with a large variety of ratings, configurations, and options. The cost can be as low as $25 per device to several hundred-dollars where higher levels of protection or other performance features are selected.

Impact to small business relative to the cost of compliance with code

This proposed modification will increase the cost to small business owners where the cost of providing a mandatory SPD is passed-on to the consumer.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification will enhance the health, safety, and welfare of the general public by reducing the negative impacts of transient surges to a building's premises wiring system and equipment.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification strengthens and improves the code by closing an essential life and property saving protection gap in the current code.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against any material, product, method, or system of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code by adding life and property saving surge protection.

2nd Comment Period

Proponent Bryan Holland **Submitted** 5/21/2019 **Attachments** Yes

7208-A1

Rationale

This alternative language comment addresses the concerns made by the public and the TAC by adding an exception to the rule where the NFPA 780 Risk Assessment indicates surge protection would not be needed based on the low risk of exposure to the hazard of lightning. Please see the rationale submitted with the original modification and the guide attached to this comment on how to specify surge protection.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This alternative language comment will have little to no impact on the local entity.

Impact to building and property owners relative to cost of compliance with code

This alternative language comment will increase the cost of code compliance for those buildings that would benefit from surge protection as determined by risk assessment. The most expensive SPD on the market today costs less than the average lightning damage insurance claim in the state of Florida.

Impact to industry relative to the cost of compliance with code

This alternative language comment will have no impact on industry.

Impact to Small Business relative to the cost of compliance with code

This proposed modification will increase the cost to small business owners where the cost of providing a mandatory SPD is passed-on to the consumer.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This alternative language comment improves the health, safety, and welfare of the general public by providing surge protection where it will be most beneficial in reducing damages and losses to transient energies.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This alternative language comment strengthens the code by adding additional protective measures against a real and serious hazard to electrical systems.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This alternative language comment does not discriminate against any materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This alternative language comment enhances the effectiveness of the code.

1st Comment Period History

Proponent Vincent Della Croce **Submitted** 1/8/2019 **Attachments** No

E7208-G1

Comment:

I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

Section 2703
Surge Protection

2703.1 Surge Protective Device.
All services supplying buildings under the scope of this code shall be provided with a surge protective device (SPD).

2703.2 Location.
The surge protective device shall be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The surge protective device shall not be required to be located in the service equipment if located at each next level distribution equipment downstream toward the load.

2703.3 Type.
The surge protective device shall be a Type 1 or Type 2 SPD.

2703.4 Replacement.
Where service equipment is replaced, all of the requirements of this section shall apply.

Exception:

Surge protection shall not be required where determined to be unnecessary by evaluation using the Risk Assessment Guide in NFPA 780, Standard for the Installation of Lightning Protection Systems or an alternative method approved by the authority having jurisdiction.

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Section 2703
Surge Protection

2703.1 Surge Protective Device.
All services supplying buildings under the scope of this code shall be provided with a surge protective device (SPD).

2703.2 Location.
The surge protective device shall be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The surge protective device shall not be required to be located in the service equipment if located at each next level distribution equipment downstream toward the load.

2703.3 Type.
The surge protective device shall be a Type 1 or Type 2 SPD.

2703.4 Replacement.
Where service equipment is replaced, all of the requirements of this section shall apply.

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NEMA SPD 1.1-2019

Part 1—Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems

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Rosslyn, Virginia 22209

www.nema.org

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Foreword

This foreword is not part of NEMA SPD1.1—*Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems—Part 1*.

A properly derived and professionally presented product specification enhances the credibility of a manufacturer as it clarifies and verifies the characteristics and capabilities of their product. A manufacturer should completely describe the product by using an accurate product specification sheet.

This guide represents the consensus of NEMA's Low Voltage Surge Protective Device (SPD) Section 5VS. It is intended to serve primarily as a guide for those who use or specify SPDs and others affiliated with the Low Voltage SPD marketplace so that uniformity of specifications, in terms of valid, understandable parameters, will improve the comprehension, application, and utilization of SPDs. The parameters will be defined in adequate detail to allow the user to make a proper interpretation of the relevant specifications and evaluation of aspects necessary for the application. The methods associated with their measure or derivation will be referenced, though most are extensively addressed, since adequate procedural definition and discussion is already available in NEMA, ANSI, IEEE, UL and IEC technical publications.

Historically, SPDs have been known as a Transient Voltage Surge Suppressors (TVSS) or Secondary Surge Arresters (SSA). To harmonize with modern technical literature and international nomenclature, the term "Surge Protective Device" or "SPD" has been adopted to refer to the same product.

NEMA Standards Publications are subject to periodic review. They are revised frequently to reflect user input and to meet changing conditions and technical progress. Proposed revisions to this Standard Publication should be submitted to:

Technical Director, Operations
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

The information detailed in this guide is intended to identify the system compatibility and performance ratings of a surge protective device (SPD) that should be addressed by the manufacturer of the SPD. As such, the ratings detailed herein may not apply to every SPD and/or SPD application. In other applications, the complete list of ratings detailed herein, plus others, may be required to meet the protection needs of the end-use equipment or power distribution system.

For safety requirements of the SPD (i.e., electric shock, overcurrent protection and protection against fire hazard) this document references testing and evaluation to the appropriate safety standards. In the US, the primary standard is ANSI/UL 1449. In Canada, the primary standard is CSA C22.2, No. 269 series. In some countries, the primary standard is IEC 61643-11. The requirements of the above standards do not evaluate the effect of SPDs on connected loads, the effect of SPDs on harmonic distortion of the supply voltage, the degree of attenuation provided by SPDs, nor the adequacy of the Voltage Protection Rating of SPDs to protect specific connected equipment from upset or damage.

This Specification Guide supersedes the rescinded LS1-1992 Standard.

References to the *National Electrical Code*® (NEC) are from the 2017 Edition unless otherwise indicated. NFPA 70®, *National Electrical Code*® and NEC are registered trademarks of the National Fire Protection Association, Quincy, MA.

This document consists of: a) Specifications Introduction—Terms, definitions and acronyms, b) Specification documentation, c) SPD ratings, and d) Specification Format—a standard format is

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presented for specifying, defining requirements and reporting SPD specifications and applications. This Specification Guide was developed by NEMA Low Voltage Surge Protective Devices Section (5VS). The section approval of the guide does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the section was composed of the following members:

ABB Industrial Solutions	Plano, TX
ABB Power Protection, LLC.	Richmond, VA
ASCO Power Technologies	Clearwater, FL
CITEL Inc.	Miramar, FL
Eaton Corporation	Pittsburgh, PA
Emerson Automation Solutions	Rosemont, IL
Hubbell Inc.	Shelton, CT
Legrand/Pass & Seymour	Syracuse, NY
Leviton Manufacturing	Chula Vista, CA
Littelfuse, Inc.	Chicago, IL
Mersen USA	Newburyport, MA
MVC-Maxivolt	Amarillo, TX
Pentair Engineered Electrical & Fastening Solutions	Solon, OH
Phoenix Contact	Middletown, PA
Raycap, Inc.	Post Falls, ID
Schneider Electric USA	Salt Lake City, UT
Siemens Industry, Inc.	Norcross, GA
Southwire Company	Clearwater, FL
Space Age Electronics	Sterling, MA
Surge Suppression, LLC	Brooksville, FL

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Section 1
General

1.1 Scope

This specification guide is Part 1 of a series of such guides that is intended to provide guidance on the evaluation, specification and/or use of surge protective devices (SPDs) deployed in low voltage power distribution system applications. This specification guide describes a uniform specification methodology for SPDs, containing at least one non-linear component, that are connected to or within a 50/60 Hz power distribution equipment that is rated up to 1000 Vac. Such SPDs are specifically intended to mitigate the transient overvoltage effects to end-use equipment.

This guide is not intended to introduce new standards, derive tests, create an evaluation methodology, or define extensive vocabulary. It is intended to guide those who are evaluating and/or comparing the essential parameters of SPDs. The parameters being compared are measurable using available commercial test equipment and/or established standards and measurements as referenced in Section 1.2.

1.1.1 Purpose

The purpose of this specification guide is to complete the Specification Checklist included in Section 4. Sections 1-3 and the included annexes are to provide guidance and definition for the compilation of the data required to complete the Specification Checklist.

> Note: Locating the checklist at the end of the guide encourages the user to consider the guidance provided ahead of the checklist.

1.2 References

The following publications are adopted in part, by reference in this publication, and are available from the organizations below.

1.2.1 Normative References

The following normative documents contain provisions, which through reference in this text, constitute provisions of this standards publication. By reference herein, these publications are adopted, in whole or in part as indicated, in this standards publication.

The Institute of Electrical and Electronics Engineers
Three Park Avenue
New York, NY 10016-5997 USA

ANSI/IEEE Std. C62.41.2	*IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits*
ANSI/IEEE Std. C62.45	*IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits*
ANSI/IEEE Std. C62.62	*IEEE Standard Test Specifications for Surge-Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits*
ANSI/IEEE Std. C62.72	Guide for the Application of Surge-Protective Devices for Use on the Load Side of the Service Equipment in Low-Voltage (1000 V or Less, 50 or 60 Hz) AC Power Circuits

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ANSI C84.1	*Electrical Power Systems and Equipment—Voltage Ratings (60Hz).*
NEMA 250	*Enclosures for Electrical Equipment (1000 Volts Maximum)*

Underwriters Laboratories
333 Pfingsten Road
Northbrook, IL 60062-2096 U.S.A.

ANSI/UL 1449	*Standard for Safety - Surge Protective Devices*

1.3 Definitions

Category A, B, or C: Categories (as defined by ANSI/IEEE Std. C62.41.2) used to classify the expected electrical surge environment at which the SPD might be installed. Category A refers to power outlets and long branch circuits. Category B refers to short branch circuits near the branch distribution panel, and those feeders approaching the service entrance panel. Category C refers to the area where external power services or the primary service entrance panel to the facility to those feeders approaching the distribution panel.

Combination Wave: A surge delivered by a generator which has the inherent capability of applying a 1.2/50 µs voltage wave across an open circuit, and delivering an 8/20 µs current wave into a short-circuit. The exact wave that is delivered is determined by the generator and instantaneous impedance to which the combination surge is applied.

Degradation: Change of original performance parameters as a result of exposure of the SPD to surge, service, or unfavorable environment. (ANSI/IEEE C62.62-2010)

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In-Line SPD: A two-port surge-protective device (SPD) connected in series between the power supply and a load where the load current passes through the conductive terminals of the SPD such that the removal of the SPD opens the circuit but has no intended impedance. (ANSI/IEEE C62.62-2010).

Note: 1—In-line SPDs were formerly referred to as “Kelvin-Connected SPDs.”
Note: 2—ANSI/IEEE C62.62-2010. Reprinted with permission from IEEE. Copyright IEEE 2010 - All Rights Reserved.

Leakage Current: Current flowing from the live parts of the installation to earth, in the absence of an insulation fault.

Listed (certified): Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services either meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Maximum Continuous Operating Voltage (MCOV): The maximum rms voltage that may be continuously applied to the SPD for each connected mode.

Note: MCOV is evaluated by the certifier and is published as part of the product certification. The symbol, U_C, is used in some international standards to represent MCOV.

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Measured Limiting Voltage (MLV): The maximum magnitude of voltage that is measured across the leads, terminals, receptacle contacts, or similar locations of the SPD during the application of impulses of a specified wave shape and amplitude.

Mode of Protection: An SPD's protective component(s) might be connected wherever defense is desired against transient over voltages. These can include Line to Neutral (L-N), Line to Ground (L-G), Line to Line (L-L) and Neutral to Ground (N-G).

Nominal Discharge Current (i_n) Rating: Peak value of the surge current through the SPD, selected by the manufacturer from a list of predetermined values, having a short-circuit current wave shape of 8/20 µs where the SPD remains functional after 15 surges

Note: Nominal Discharge Current Rating is evaluated by the certifier and is published as part of the product certification.

Nominal System Voltage (V_O): A value assigned to designate a system of a given voltage class in accordance with ANSI C84.1, Table 1.

Open-Type SPD: A Type 1, 2 or 3 SPD, with an incomplete or partial enclosure and with field wiring terminals and/or leads, suitable for field installation, in accordance with the ANSI/NFPA 70 - National Electrical Code®, within a suitable enclosure. (ANSI/UL 1449)

Note: References to the National Electrical Code® (NEC®) are from the 2017 Edition unless otherwise indicated. NFPA 70®, *National Electrical Code®,* and *NEC®* are registered trademarks of the National Fire Protection Association, Quincy, MA.

One-Port SPD: A surge protective device (SPD) connected in shunt with the circuit to be protected. (ANSI/IEEE Std C62.62)

Rated Load Current (I_L): Maximum continuous rated rms current that can be supplied to a load connected to the output of a two-port or in-line SPD.

Secondary Surge Arrester (SSA): An SPD intended for connection on the line side of the service equipment that has not been listed/certified to ANSI/UL 1449.

Note: The term secondary surge arrester is a legacy term (often used by utilities). The term Type 1 SPD is intended to replace this term.

Service Equipment: The necessary equipment, consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the utility electric system and intended to constitute the main control and disconnect of the utility electric system. (NFPA 70®-2017, National Electrical Code®)

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Short-Circuit Current Rating (SCCR): The suitability of an SPD for use on an AC power circuit that is capable of delivering not more than a declared rms symmetrical current at a declared voltage during a short-circuit condition. (ANSI/UL 1449)

Note: Often short-circuit current ratings are confused with surge current ratings. The two ratings are not the same.

SPD Enclosure Protection Rating: Describes the degree of environmental protection provided by the enclosure per NEMA 250 of the SPD final assembly as it leaves the manufacturing facility and is installed per manufacturers' recommendation.

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SPD Location: The intended placement of the SPD, either external or internal to power distribution or end-use equipment.

Note: See also IEEE Category Locations A, B, C.

SPD Types: A term originating from ANSI/UL 1449 to describe the intended application location of the SPD, either upstream or downstream of the main overcurrent protective device of the facility. Refer to the definitions for Type 1, Type 2, and Type 3 SPDs, Type 4 Component Assembly, and Type 5 Components.

Status Indicator: A device that indicates the operational condition of an SPD, or a part of an SPD.

Surge Protective Device (SPD): A device that contains at least one nonlinear component and is intended to limit surge voltages and divert surge currents.

Type 1 SPD: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and Molded Case SPDs intended to be installed without an external overcurrent protective device. (ANSI/UL 1449)

Type 1 Component Assembly: Consists of a Type 4 Component Assembly with internal short-circuit protection or [safety] disconnector that is intended for use as a Type 1 SPD. (ANSI/UL 1449)

Note: Type 1 Component Assemblies are recognized components rather than listed/certified. These components assemblies have conditions of acceptability that are usually related to having exposed terminals or the requirement to be installed within another enclosure.

Type 2 SPD: A permanently connected SPD intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel and Molded Case SPDs. (ANSI/UL 1449)

Type 2 Component Assembly: Consists of a Type 4 Component Assembly with internal or external short-circuit protection or [safety] disconnector that is intended for use as a Type 2 SPD. (ANSI/UL 1449)

Note: Type 2 Component Assemblies are recognized components rather than listed/certified. These components assemblies have conditions of acceptability that are usually related to having exposed terminals, the requirement to be installed within another enclosure or a requirement for external/supplemental overcurrent protection.

Type 3 SPD: Point of utilization SPDs, installed at a minimum conductor length of 10 m (30 ft) from the electrical service panel (service equipment) to the point of utilization - for example, cord-connected, direct plug-in, receptacle type, and SPDs installed at the utilization equipment being protected. (ANSI/UL 1449)

Note: The distance (10 m) is exclusive of conductors provided with or used to attach SPDs. If the Nominal Discharge Current test is performed on a Type 3 SPD, the minimum distance from the service equipment does not apply.

Type 3 Component Assembly: Consists of a Type 4 Component Assembly with internal or external short-circuit protection or [safety] disconnector that is intended for use as a Type 3 SPD. (ANSI/UL 1449)

Note: Type 3 Component Assemblies are recognized components rather than listed/certified. These components assemblies have conditions of acceptability that are usually related to having exposed terminals, the requirement to be installed within another enclosure or a requirement for external/supplemental overcurrent protection.

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Type 4 Component Assembly: Component assembly consisting of one or more Type 5 components together with a [safety] disconnector (integral or external) or a means of complying with the limited current abnormal overvoltage tests. (ANSI/UL 1449)

Type 5 Component: Discrete component surge protective components, (such as MOVs, gas [discharge] tubes, ABDs, etc.) that may be mounted on a printed wiring board, connected by its leads or provided within an enclosure with mounting means and wiring terminations. (ANSI/UL 1449)

Two-port SPD: SPD with two sets of terminals, input, and output. A specific series impedance is inserted between these terminals. (ANSI/IEEE C62.62-2010)

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Voltage Protection Rating (VPR): A rating per ANSI/UL 1449, signifying the average Measured Limiting Voltages of a mode of protection within an SPD when the SPD is subjected to the surge produced by a 6 kV, 3 kA Combination Waveform generator.

Note: The VPR is determined by averaging the Measured Limiting Voltages of a particular mode and selecting the next highest rating from a list of preferred values. The VPR is evaluated by the certifier and is published as part of the product certification.

Voltage Regulation (V_L): A variation in the output voltage of a two-port or in-line SPD when subjected to maximum rated load condition, measured in percent of the source voltage applied to the input terminals of the SPD.

1.4 Acronyms

ABD	Avalanche Breakdown Diode
AC	Alternating Current
ANSI	American National Standards Institute
GDT	Gas Discharge Tube
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
MCOV	Maximum Continuous Operating Voltage
MLV	Measured Limiting Voltage
MOV	Metal Oxide Varistor
NEC®	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
OSHA	Occupational Safety and Health Administration
PDS	Power Distribution System
RMS	Root Mean Square
SCCR	Short-Circuit Current Rating
SP	Standards Publication
SPC	Surge Protective Component
SPD	Surge Protective Device
SSA	Secondary Surge Arrester
TVSS	Transient Voltage Surge Suppressor
UL	Underwriters Laboratories
VPR	Voltage Protection Rating

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Section 2
SPD Specification Documentation

For each SPD specified, documentation of the product's performance and safety are to be provided. The system compatibility and product performance characteristics of an SPD are:

a. Nominal system voltage (V_O)
b. Power distribution system configuration of the SPD
c. SPD Type
d. SPD Location
e. Rated load current (I_L) (two-port and In-line SPDs only)
f. Voltage regulation (V_L) (two-port and In-line SPDs only)
g. Maximum Continuous Operating Voltage (MCOV)
h. Short Circuit Current Rating (SCCR)
i. Voltage Protection Rating (VPR)
j. Measured Limiting Voltage(s) and the description of the test(s) used
k. Modes of protection
l. SPD enclosure rating
m. SPD Safety Agency Certifications
n. Nominal Discharge Current (I_N)
o. Description of external SPD safety disconnector (if required)
p. Surge Current Rating
q. Leakage Current
r. Status Indicator

For each SPD performance characteristic specified, the following information should be included if requested:

a. The test procedures used
b. A checklist detailing the features of the SPD that were installed during the testing of the device, e.g., fuses, circuit breakers, capacitors, status circuitry, etc.
c. The test results that show compliance to the published specifications
d. Agency Approvals

Note: Although this NEMA Guide does not require independent third-party testing, a list of nationally recognized testing laboratories (NRTL's) are identified by OSHA at http://www.osha.gov/dts/otpca/nrtl/

Documentation that provides evidence of the SPD performance characteristics should include relevant test procedures, atmospheric conditions, test equipment, measurement methods, calibration data, performance data, summary results, and any additional support information required to analyze the performance of the SPD under specific conditions.

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Section 3
SPD Ratings

3.1 Introduction

There are two sets of ratings for an SPD. Some ratings relate to the operating system (Section 3.2) in which the SPD is to be installed and are used to coordinate the SPD with the power distribution system at the point of application. Others relate to SPD performance (Section 3.3). These characteristics include features of the SPD and its ability to limit specific transients. It is highly recommended that the grounding and bonding system be verified.

3.2 SPD Ratings Related to the Operating System

System-related operating ratings are required to ensure that the SPD specified or chosen is appropriate for the installation location in the power distribution system within a facility. The system related operating ratings for the SPD include:

a. Power distribution system configuration of the SPD and Nominal system voltage (V_O)
b. SPD Location and Type
c. Maximum Continuous Operating Voltage (MCOV)
d. Short Circuit Current Rating (SCCR)
e. Rated load current (I_L), (two port and in-line SPDs only)
f. Voltage regulation (V_L), (two port and in-line SPDs only)

It is important to note that the correct selection of the ratings for the SPD depends on the configuration of the power distribution system to which it is connected.

3.2.1 Power Distribution System Configuration and Nominal System Voltage

The power system configuration of the SPD dictates what type of power distribution system to which it can be applied. This configuration is commonly part of the nomenclature or description of the SPD itself. When specifying an SPD, the configuration of the SPD should match the configuration of the power distribution system. Further, in some cases such as the ungrounded delta system, the SPD must be specifically listed for this power system configuration as noted in NFPA 70 Article 285.3(2). Examples of power distribution system and SPD configurations are given below. Often these are referred to more generically as a “single phase,” “wye” or “delta” connected SPD.

Nominal System Voltage (V_O) is a value assigned to designate a system of a given voltage class in accordance with ANSI C84.1, Table 1.

A non-exhaustive list of example power distribution system configurations and nominal system voltages is provided in Table 3-1.

Table 3-1
Common Power Distribution System Voltages

Nominal System Voltage	Power Distribution System Configuration	Number of Conductors
120	Single phase	2W+G
120D	3-phase ungrounded delta	3W+G
127	Single phase	2W+G
120/240	Single (split) phase	3W+G
208Y/120	3-phase wye	4W+G
208D	3-phase ungrounded delta	3W+G
220Y/127	3-phase wye	4W+G
220	Single phase	2W+G

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Nominal System Voltage	Power Distribution System Configuration	Number of Conductors
230	Single phase	2W+G
240	Single phase	2W+G
240D/120	3-phase high-leg delta	4W+G
240D	3-phase ungrounded delta	3W+G
240D	3-phase corner grounded delta	3W+G
380Y/220	3-phase wye	3W+G
400Y/230	3-phase wye	4W+G
480Y/277	3-phase wye	4W+G
480D	3-phase ungrounded delta	3W+G
480D	3-phase corner grounded delta	3W+G
600Y/347	3-phase wye	4W+G
600D	3-phase ungrounded delta	3W+G

All points within the power distribution system, including the SPD, are to be installed and maintained in accordance with the local code and/or appropriate national electrical code.

3.2.2 SPD Locations and Types

SPDs (including Open-Type SPDs) can be located throughout the power distribution system. They can be connected upstream (on the line or utility side) of the service equipment or downstream (on the load side) of the service equipment for the facility. In either case, the local code and/or appropriate national electrical code govern the applications of SPDs in these locations.

SPD installation locations are referred to by SPD Type in ANSI/UL 1449. SPDs permitted to be installed on the line side of the service equipment are denoted as Type 1 SPDs and Open-Type 1 SPDs. Type 1 SPDs are also permitted to be installed on the load side of the service equipment. Type 2 SPDs and Open-Type 2 SPDs are only permitted to be installed on the load side of service equipment and might require an external safety disconnector. Type 3 SPDs and Open-Type 3 SPDs are installed on the load side of the service equipment. Type 1, 2 and 3 SPDs, Open-Type 1, 2, and 3 SPDs, and Component Assemblies are marked with Voltage Protection Ratings (VPRs) when listed/certified to ANSI/UL 1449.

> Note: The terms “service equipment” and “service disconnect” are used interchangeably in Clause 285 of the NEC (2017 revision). Therefore, references in this standard to the “service equipment” are to be understood to include what is referred to as the “service disconnect.”

Another recent addition to the UL SPD types are the Open-Type SPDs. For example, an Open-Type 1 SPD is similar to a Type 1 SPD except that it does not have a complete enclosure. The SPD must meet the full requirements like that of a complete SPD, but it is intended to be installed into an existing enclosure. The Open-Type 1 SPD must have suitable field or factory wiring terminations included on the device.

> Note: Although outside the scope of this standard, Type 4 Component Assemblies and Type 5 Components are defined as partial assemblies or surge protective components that require additional packaging and testing in order to be installed on the electrical distribution system. Type 4 and 5 SPDs have Measured Limiting Voltage (MLV) ratings determined at various surge levels only and not VPRs when listed/certified to ANSI/UL 1449. These ratings might be determined at different levels than those reported in Section 5.

SPDs can be installed either internal or external to switchgear, panelboards, end-use equipment, etc. Some SPDs (component assemblies and recognized components) have conditions of acceptability that must be met to permit their use in particular applications. Consult the SPD manufacturer regarding how to address conditions of acceptability for SPD component assemblies. Further, consult with the manufacturer when installing SPDs internal to end-use equipment. See Section 2 for the definitions of SPD Types.

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Note: Procuring SPDs and SPD installation may be simplified by appreciating that the term “single phase” may have colloquial meanings of ‘true single phase’ or ‘split phase.’ Also, be aware that many SPDs are voltage specific and may have specific wiring instructions for Corner Grounded Delta’s (Phase B is normally grounded) and Hi-Leg Delta’s (Phase B is normally the Hi-Leg).

3.2.3 Maximum Continuous Operating Voltage (MCOV)

The SPD has a characteristic of being able to withstand a continuous voltage that is greater than the nominal system voltage of the power distribution system. It is recommended that the Maximum Continuous Operating Voltage be greater than or equal to 115 percent of the nominal system voltage to accommodate normal fluctuations within a power system.

The Maximum Continuous Operating Voltage is required to be on the product data label of the SPD and in the installation instructions and/or operation manual.

Maximum Continuous Operating Voltage is a parameter declared by the manufacturer on the basis of several considerations, e.g., ambient temperature, exposure to surges, actual system voltage, definition of an end of life criteria, SPD topology.

For SPDs listed/certified to ANSI/UL 1449 (and/or tested in accordance with ANSI/IEEE Std. C62.62), the MCOV is a required marking, and the declared value is verified during the Nominal Discharge Current Test.

3.2.4 Short Circuit Current Rating (SCCR)

The SPD is required to be marked with a Short Circuit Current Rating (SCCR). As per NFPA 70, Article 285, the SCCR of the SPD shall be equal to or greater than the available short-circuit current of the system at the point of installation. The Short Circuit Current Ratings detailed in ANSI/UL 1449 for SPDs (in thousands of amperes, kA) include:

5, 10, 14, 18, 22, 25, 30, 42, 50, 65, 85, 100, 125, 150, 200

The testing methodology is specified in ANSI/UL 1449, Standard for Safety for Surge Protective Devices.

3.2.5 Rated Load Current (Two-Port and In-Line SPDs Only)

The rated load current of the SPD applies to two-port SPDs (which have an intended series impedance) and In-line SPDs (which have separate input and output terminals but no intended series impedance). The rated load current is the amount of steady-state current that the SPD can conduct through to the load without causing damage to the SPD due to excess heat buildup or mechanical stress. It is important to ensure that for a two-port or in-line SPD operating at rated load current, that the series voltage drop or voltage regulation is acceptable to the load. Common rated load currents, in amps, of two-port or in-line SPDs include:

5, 10, 15, 20, 30, 50, 75, 100, 200, 225, 250, 400, 600, 800, 1,000, 1,200, 1,600, 2,000, 3,000, 4,000

3.2.6 Voltage Regulation (Two-Port and In-Line SPDs Only)

Voltage regulation (V_L) is calculated by the equation:

$$\%V_L = \left[\frac{|V_{IN} - V_{OUT}|}{V_{IN}}\right] * 100$$

Where V_{IN} is the voltage across the input terminals, and V_{OUT} is the voltage across the output terminals.

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Common voltage regulation values of two-port and in-line SPDs includes: 1%, 3%, and 5%

3.3 SPD RATINGS RELATED TO PERFORMANCE

These ratings and characteristics provide data to help quantify an SPD's ability to divert or attenuate and mitigate the effects of transients under parameters given by specific industry standards or items that are relevant to the SPD's application and for comparison purposes. The electrical industry has used these specific parameters for many years. The common parameters include:

a. Measured Limiting Voltage(s) (MLVs)
b. Voltage Protection Rating (VPR)
c. Nominal Discharge Current (I_N)
d. Modes of protection
e. Enclosure rating
f. Safety agency certifications
g. Safety disconnector description
h. Surge current rating

3.3.1 Measured Limiting Voltage(s)

Measured Limiting Voltage (MLV) is defined as the maximum magnitude of voltage that is measured across the terminals of the surge-protective device (SPD) during the application of a series of impulses of specified wave shape and amplitude. MLVs are peak voltages, not rms voltages. The Measured Limiting Voltages can be used to analyze the capability of an SPD to limit transients (test wave shapes and amplitudes) defined in ANSI/IEEE Std. C62.41.2 and ANSI/IEEE Std. C62.62. The standard test waveforms are the:

a. Category A 100 kHz Ring Wave
b. Category B 100 kHz Ring Wave
c. Category A Combination Wave
d. Category B Combination Wave
e. Category C Low Combination Wave
f. Category C High Current Driven Test

Further, the tests listed above are the "standard" tests from ANSI/IEEE Std. C62.41.2 and ANSI/IEEE Std. C62.62. These standards also contain "additional" and "optional" tests that might be selected by mutual agreement. In these cases, these tests can be added to the specification checklist (Section 5) as needed. The additional waveforms identified are the:

a. EFT Burst
b. Unidirectional 10/1000 µs Long Wave

Testing of the SPD is conducted using all overcurrent components, over-temperature components, EMI capacitors, status indication, disconnects, SPD safety disconnectors, etc.

The testing methodology used is defined in ANSI/IEEE Std. C62.45 (testing of equipment) and ANSI/IEEE Std. C62.62 (testing of SPDs). The point of application of the surge voltage and the resultant Measured Limiting Voltages are defined in UL 1449 and ANSI/IEEE Std. C62.62. In particular, the Measured Limiting Voltages for a parallel (one-port) connected SPD are measured at a point of 150 mm (6 inches) from where the conductors exit the enclosure of the SPD. The Measured Limiting Voltages of a series (two-port) connected SPD are measured at the output terminals of the SPD. See ANSI/IEEE Std. C62.62 for specific details, illustrations, and examples. Further, ANSI/IEEE Std. C62.62 provides specific requirements on the measurement equipment, measurement methods, and methods of reporting the results of surge testing SPDs.

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By mutual agreement between end-user and manufacturer, the appropriate wave shapes and amplitudes for the specific application are to be selected from ANSI/IEEE Std. C62.41.2 and/or ANSI/IEEE Std. 62.62. Not all the test waveforms are appropriate for every application. For example, a Type 3 SPD might not need to be tested to the Category C Current Driven Test.

3.3.2 Voltage Protection Rating (VPR)

The VPR utilizes MLVs from a sampling of SPDs when subjected to a specific set of transient wave shapes and (e.g., voltage and current). Once the MLVs are obtained, then the VPR can be determined from a list of values and assigned by an NRTL.

The VPR is to be determined using the procedure in ANSI/UL 1449. A brief outline of the procedure is listed here. The same samples used to determine the VPR are used for the Nominal Discharge Current Test as described in ANSI/UL 1449 and in Section 3.3.3 of this Guide.

Testing, using a 6 kV, 3 kA Combination Wave generator, is conducted on three SPD samples for each mode of protection (see Section 3.3.4) declared by the manufacturer. The MLVs of the tests are recorded and averaged. The averaged value of the MLVs for a particular mode of protection is then utilized to determine the VPR for that mode of protection—which is equal to or lower than a selected value from a list of values in ANSI/UL 1449. VPRs are marked on the product. The VPR indicated in volts (V) are as shown in Table 3-2. For example, if the average MLV of three impulses is 598 V, the NRTL would assign a VPR of 600. If the average MLV of three impulses is 602 V, the NRTL would assign a VPR of 700 (because it is over 600 V).

Table 3-2
VOLTAGE PROTECTION RATINGS

330	400	500	600	700	800	900	1000	1200
1500	1800	2000	2500	3000	4000	5000	6000	–

3.3.3 Nominal Discharge Current (I_n)

The following is an excerpt from ANSI/IEEE Std. C62.62 describing the purpose and rationale for the Nominal Discharge Current Test:

> *The Nominal Discharge Current Test exercises an SPD's ability to be subjected to repetitive current surges of a selected value without degradation in performance by comparing a pre-test and post-test baseline averaged Measured Limiting Voltages per mode of a mode of protection (e.g., A-N pre-test versus A-N post-test).*
>
> *The purpose of these tests is to demonstrate the performance (repetitive surges, energy handling capability, and absence of undesirable side effects) of an SPD in response to surges that can be expected at the service equipment and/or within a building.*
>
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The manufacturer declared Nominal Discharge Current is verified by a listing agency using the procedure in ANSI/UL 1449 in conjunction with the determination of the VPR. (The same test is included in ANSI/IEEE Std. C62.62.) The test amplitudes from ANSI/UL 1449 are listed below. Other standards may have additional values. The test short-circuit current wave shape is 8/20 µs.

10 kA or 20 kA for Type 1 SPDs, and
3 kA, 5 kA, 10 kA or 20 kA for Type 2 SPDs
3 kA for Type 3 SPDs (optional)

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Some Type 3 SPDs are tested to the 3 kA test value for Nominal Discharge Current. This is an optional test from ANSI/UL 1449. Other Type 3 SPDs listed/certified to ANSI/UL 1449 are subjected to the Duty Cycle Test as defined in ANSI/UL 1449 which uses a 6 kV, 3 kA Combination Wave test rather than a 3 kA Current Driven Test.

3.3.4 Modes of Protection

The modes of protection for the SPD shall be appropriate for the installation. In most North American grounded power systems, the line-to-neutral (L-N), line-to-line (L-L), and line-to-ground (L-G) modes of protection are all that are available for an SPD applied at the service equipment. The neutral-to-ground (N-G) bond in grounded wye systems (208Y/120, 3Φ, 4w) ensures that the neutral (grounded) conductor and the grounding conductor are at the same potential (bonded) at this point in the power system. Therefore, the existence of the N-G mode at the service equipment is not required but does not need to be specifically excluded.

When the distance of the SPD from the neutral-ground bond exceeds two meters, additional modes of protection should be considered. This includes common modes of protection, e.g., line-to-ground (L-G), and neutral-to-ground (N-G).

There are also cases where the power system is ungrounded. In these cases, line-to-line (L-L) protection and line-to-ground (L-G) protection are the available modes of protection.

Further, it is important to understand how test results are reported with regard to the modes of protection. For additional detail on this topic, see Appendix A.2 and A.3.

The modes of protection are declared by the manufacturer. The existence or effectiveness of the modes of protection can be verified through Measured Limiting Voltages and the Nominal Discharge Current Test results.

3.3.5 SPD Enclosure Protection Rating

The SPD enclosure protection rating is very similar to the NEMA 250 enclosure ratings used for electrical enclosures and determines if it is appropriate to apply the SPD at specific locations within the power distribution system. The SPD enclosure protection rating is not the same as the NEMA enclosure rating but differs only because the rating is obtained after the SPD manufacturer has installed all components and status features that make up the entire SPD package. Some common SPD enclosure ratings are shown in Table 3-3.

Table 3-3
Common SPD Enclosure Protection Ratings

SPD Enclosure Protection Rating (NEMA)	Location for Use
1	General Purpose - Indoor
3R	Rainproof, Sleet Resistant - Outdoor
4	Watertight, Dust-tight, Sleet Resistant - Indoor & Outdoor
4X	Watertight, Dust-tight, Sleet Resistant, Corrosion Resistant – Indoor & Outdoor
12, 13	Industrial Use, Dust-tight & Drip-tight - Indoor

There is no direct equivalency between NEMA and IEC IP ratings. See Table A-1 of https://www.nema.org/Products/Documents/nema-enclosure-types.pdf.

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The SPD enclosure protection rating should be detailed on the product and documentation provided with all submittal packages. To determine the actual details of the appropriate NEMA ratings, consult NEMA 250.

3.3.6 SPD Safety Agency Certifications

SPDs undergo safety agency certifications for application and installation in various locations. The applicable national safety standards, unlike this guide, dictate requirements for the safety of the SPD including acceptable end-of-service or failure conditions. The certifications carried by a product are to be provided.

> Note: In the US, the United States Department of Labor through the Occupational Safety and Health Administration (OSHA) oversees safety agency certifications through its Nationally Recognized Testing Laboratory (NRTL) program. An NRTL is by its definition a third party, independent organization as defined below by OSHA:

A Nationally Recognized Testing Laboratory (NRTL) is a private-sector organization that OSHA has recognized as meeting the legal requirements in 29 CFR 1910.7 to perform testing and certification of products using consensus-based test standards. These requirements are:

a. The capability to test and evaluate equipment for conformance with appropriate test standards;
b. Adequate controls for the identification of certified products, conducting follow-up inspections of actual production;
c. Complete independence from users (e.g., employers subject to the tested equipment requirements) and from any manufacturers or vendors of the certified products; and
d. Effective procedures for producing its findings and for handling complaints and disputes.

An organization must have the necessary capability both as a product safety testing laboratory and as a product certification body to receive OSHA recognition as an NRTL.

See https://www.osha.gov/dts/otpca/nrtl/nrtl_faq.html for additional details.

3.3.7 SPD Safety Disconnector Description

Some SPDs require an external safety disconnector (usually an external circuit breaker or fuse). This requirement is part of the SPDs certification, and the safety disconnector is required to maintain the listing of the SPD in end use applications. If applicable, the external safety disconnector is to be specified or supplied by the SPD manufacturer.

3.3.8 Surge Current Ratings

The following is an excerpt from ANSI/IEEE Std. C62.72-2016 (Clause 13.2):

When an SPD operates to limit a transient overvoltage, the SPD mitigates the impact of the overvoltage surge by conducting current. It is important for specifiers and users of SPDs to understand the term surge current. Surge current ratings, or the surge current capability of an SPD is one of the most common specification parameters of an SPD. At the release date of this publication, there is no standardized test for determining maximum or peak surge current ratings of SPDs within IEEE standards that apply to SPDs within the scope of this guide. However, the Nominal Discharge Current Rating is well defined (see ANSI/IEEE Std. C62.62™). Users and specifiers should consult the SPD manufacturer to determine how this rating [surge current rating] is determined for a particular SPD. The surge current rating of an SPD can refer to the amount of current that the SPD can divert resulting in the following conditions or based upon:

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- *No damage or degradation to the SPD without the operation of an internal or external SPD [safety] disconnector*
- *No damage or degradation to the surge protective components within an SPD but with the operation of an internal or external SPD [safety] disconnector not resulting in an undesirable end of service condition*
- *Damage or degradation of the SPD, surge protective components within the SPD, and/or internal or external SPD [safety] disconnector not resulting in an undesirable end of service condition*
- *The sum of the component manufacturer's surge current ratings of the individual surge protective components within the SPD with or without consideration of an internal or external SPD [safety] disconnector surge current rating*

Note: ANSI/IEEE Std. C62.72-2016. Reprinted with permission from IEEE. Copyright IEEE 2016 - All Rights Reserved.

For additional information on per mode and per phase surge current ratings, see Annex A Section A.2.

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Section 4
Specification Checklist

SPD Manufacturer _____

SPD Model Number _____

NOTE: The corresponding section numbers for each item in Table 4-1 are listed to the left of each heading.

Table 4-1
Specification Checklist

4.1 SPD Ratings Related To The Operating System	
3.2.1 Power Distribution System Configuration	

3.2.1 Nominal system voltage	

3.2.2 SPD Location/Type	

3.2.3 SPD Maximum Continuous Operating Voltage (MCOV)							
L-N		L-G		N-G		L-L	

3.2.4 SPD Short Circuit Current Rating (SCCR) - see 3.3.7 in this Table	

3.2.5 SPD Rated Load Current (I_L) (Two-Port and In-Line SPDs only)	

3.2.6 SPD Voltage Regulation (V_R) (Two-Port and In-Line SPDs only)	

4.2 SPD Ratings Related To Performance							
Measured Limiting Voltages (MLV) (add lines as necessary):							
3.3.1 IEEE Category A 100 kHz Ring Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Phase Angle			
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category B 100 kHz Ring Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Phase Angle			
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category A Combination Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Short Circuit Current			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category B Combination Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Short Circuit Current			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category C Low Combination Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Short Circuit Current			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category C High Current Drive Test Measured Limiting Voltages (if applicable)

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Voltage				Current Through SPD			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 Additional and Optional IEEE Tests - Measured Limiting Voltages (if applicable)							
Test Waveform/Description							
Voltage Amplitude				Short Circuit Current			
Phase Angle							
Notes:							
L-N		L-G		N-G		L-L	

3.3.2 Voltage Protection Rating (VPR) – ANSI/UL 1449							
L-N		L-G		N-G		L-L	

3.3.3 Nominal Discharge Current Rating (I_n)	

3.3.4 Modes of Protection (Check those that apply)							
L-N		L-G		N-G		L-L	

3.3.5 SPD Enclosure Rating	

3.3.6 SPD Safety Agency Listings/Certifications (list all standards the SPD is listed/certified to, file numbers, links to certification pages, etc.)	Check all that apply: ☐ NEMA 1 ☐ NEMA 3R ☐ NEMA 4 ☐ NEMA 4X ☐ NEMA 12,13 ☐ Other:_____

3.3.7 SPD Safety Disconnector/Overcurrent Protection Device Requirements (if applicable), i.e., fuse or circuit breaker	Select/provide as applicable: ☐ No Additional Safety Disconnector Required ☐ External Fuse Required Type and Size: _____ Manufacturer Part Number: _____ ☐ External Circuit Breaker Required Type and Size: _____ Manufacturer Part Number: _____
4.2.8 SPD Surge Current Rating	Select/provide as applicable: ☐ Per Phase: _____kA ☐ L-N Mode: _____kA ☐ L-G Mode: _____kA ☐ N-G Mode: _____kA ☐ L-L Mode: _____kA

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Annex A
Additional Information
(Informative Only)

The following annex is provided as additional information only and is not a normative part of NEMA SPD1.1, *Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems–Part 1*.

A.1 Surge Current Ratings

SPD surge current ratings are subjective based on multiple factors such as surge amplitude, level of redundancy, projected life expectancy, anticipation of degradation, value of protected load, value of avoided downtime losses, etc.

Within structures, ANSI/IEEE standards defining the expected surge environment state that system inductance and impedance limit the expected surge current to levels around 10 kA. ANSI/UL 1449 includes repetitive surge current testing up to 20 kA. Surge current levels in outdoor equipment environments from direct lightning strikes are not well documented but may exceed these values. Similarly, a direct lightning stroke to earth can create momentary, localized increases in ground potential (Ground Potential Rise), which may also exceed these values.

SPDs are purposely placed in harm's way. It is generally good engineering practice to specify sufficient surge current capacity, plus margin for error and/or redundancy. Additional and/or multiple internal suppression components will share surge current, thus reducing stresses on individual components leading to longer SPD life. For similar reasons, lower measured limiting voltages are sometimes achievable. There are instances where additional and/or larger surge protective components provide safety benefit, and/or reduce degradation effects from usage.

Geographic considerations may apply. For example, the southeastern United States is prone to numerically-higher rates of lightning strokes, although most regions can expect to receive equally large lightning in terms of kA amplitude. The physical proximity of SPD and load to outdoors is also a consideration based on the likelihood of additional stresses.

The user or specifier should consult the SPD manufacturer for application guidance.

A.2 Per Mode And Per Phase Ratings

A 'Per Mode' surge current rating is the summed rating of suppression elements connected directly from one power system terminus to a second. Modes may be line-to-neutral (L-N), line-to-ground (L-G), neutral-to-ground (N-G) or line-to-line (L-L). (It is to be understood that "line" and "phase" are often used interchangeably to indicate the connection to a particular phase of the system.) For example, L-N may be specified as 100 kA, suggesting ten 10 kA MOVs, or two 50 kA MOVs, etc. connected in parallel to the specified mode.

a. 'Per Mode' ratings are not intended to include indirectly connected suppression elements. For example, the L-G per mode rating is not intended to include compound-connected suppression elements configured as L-N-G for L-G. Similarly, the L-L per mode rating is not intended to include compound-connected suppression elements such as L1-N-L2 and/or L1-G-L2 for the L-L mode.
b. In a given manufacturer declaration, no individual suppression element may be double counted to obtain 'Per Mode' ratings.
c. Determination of any L-L 'Per Mode' rating is the number of suppression elements connected directly from one energized power system terminus to a second energized power system terminus. The L-L 'Per Mode' rating is not intended to include L1-N-L2 and/or L1-G-L2, etc.

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A 'Per Phase' surge current rating is the summed rating of suppression elements connected directly from one energized power system terminus to another terminus, which may or may not be energized. For example, Phase A might have five 10 kA MOVs connected Phase A-Neutral, and five 10 kA MOVs connected Phase A-Ground for a per phase rating of 100kA.

a. N-G suppression elements are not to be included in 'Per Phase' surge current ratings.
b. For 'Per Phase' surge current rating calculation purposes, any contribution of L-L suppression elements should be limited to one phase to a second phase, and not one phase to multiple other phases.

Calculations of surge current ratings for SPDs including derived neutral connections and/or compound-connected should clearly indicate such and identify any suppression elements that are counted more than once.

A.3 SPD Modes Of Protection

A mode of protection is defined as how an SPD's protective components might be connected line to line, line to ground (earth), line to neutral, or neutral to ground (earth), and any combination thereof. A mode of protection can be established using directly connected surge protective components in a particular mode or through a combination of surge protective components connected between other modes that when used in a series combination also covers other modes. This is different than a "per mode" or "per phase" surge current rating. A mode of protection offers defense against surges propagating in that mode.

For example, an SPD with SPCs directly connected in ten modes provides protection for all ten modes of the wye configured PDS. Similarly, an SPD with SPCs directly connected in seven modes (i.e., each phase to neutral, each phase to ground and neutral to ground) provides protection for all ten modes for the wye configured PDS; however, the phase to phase mode of protection is accomplished through the series combination of the phase to neutral (or ground) SPCs. For example, the phase A to phase B mode of protection is completed by the series connection of the SPCs connected phase A to neutral to phase B (or via the phase to ground SPCs in a similar fashion). In this case, the phase to phase MCOV would be the MCOV of phase A to neutral (or ground) plus phase B to neutral (or ground).

Likewise, an SPD with SPCs directly connected in four modes (i.e., each phase to neutral and neutral to ground for a Wye configured SPD) also provides protection for all ten modes of the wye configured PDS. In this case, the phase to phase mode of protection is completed in the same way as the SPD with SPCs directly connected in seven modes; however, the phase to ground mode of protection is completed by the series combination of the phase to neutral and neutral to ground SPCs. The phase to ground MCOV would be the MCOV from phase to neutral plus neutral to ground. This compounding of MCOVs may increase Measured Limiting Voltages, which may or may not be desirable in some circumstances.

All three of these designs offer defense in all the modes of protection available for the PDS; however, they accomplish this through different means. The specifier or user of SPDs should understand how a particular SPD provides protection (what modes of protection exist and how they are accomplished) for the equipment connected to the PDS. There are differing philosophies as to which approach is preferred. The user or specifier should consult the SPD manufacturer to understand the design philosophy of a particular SPD.

For additional information regarding MLVs and VPRs, see Table 4-1.

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Annex B
General Earthing (Grounding) Practices (Informative Only)

The following annex is provided as additional information only and is not a normative part of NEMA SPD1.1 *Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems—Part 1*.

B.1 Description

Network systems are classified by the International Electrotechnical Commission (IEC) in IEC 60364-1 (Low-voltage electrical installations—Part 1: Fundamental principles, assessment of general characteristics, definitions) according to the type of grounding, or *earthing*, practices used in the PDS and the methods used for protection against electrical shock in the installation. Although all IEC network systems are not currently used within the United States, some classifications can be applied.

An important note is the difference in language, between IEC countries and that of North America, for terms having the same meaning. In this annex, the terms *earthed* and *unearthed* have the same meaning as *grounded* and *ungrounded*. For clarity to the readers, this guide will substitute the IEC term, *earthed*, for the common North American term, *grounded*, and the IEC term, *unearthed*, for the common North American term, *ungrounded*.

PDSs are divided into grounded and ungrounded systems. IEC 60364-1 classifies network systems according to the configuration of live conductors (including the neutral) and the type of grounding system used. As part of the classification, the following nomenclature is used. The first letter, I or T, shows the relationship between the current carrying conductors and the grounding system. The second letter, T or N, shows the relationship of the accessible conductive parts, including a metallic frame, of the component or equipment in the installation with respect to the grounding system.

> Note: “Grounded” or “ungrounded” refers to the power system’s reference to ground. This is different than an incorrect colloquial understanding where there is, or is not, a ground conductor. All equipment requires a ground conductor. Reference to ground refers to the connection of the secondary side of a transformer to ground. Among other things, this provides system voltage stability particularly for L-G and N-G modes.

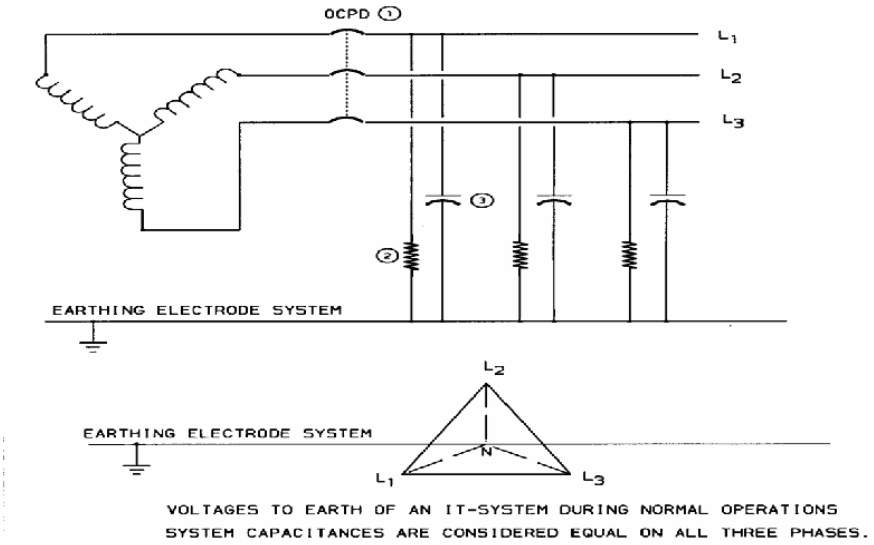
For the purposes of this discussion, a “bolted” fault is a short-circuit condition. Per ANSI/NEMA FU 1-86, the definition for a bolted fault refers to a zero impedance fault considered at locations in a power system where the maximum value of available fault current is calculated.

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First letter (I or T)

The first letter “I” represents *isolation*. The letter “I” signifies that all live parts are isolated from ground or earth, or that points of the network are connected to earth through some impedance as a surge arrester or air gap. The first letter “T” represents the Latin word, *terra*, meaning earth. The “T” signifies a direct connection of at least one point in the network to earth. Special grounding requirements or practices may be necessary depending on the type of network system used. See Figure B.1 through Figure B.3.

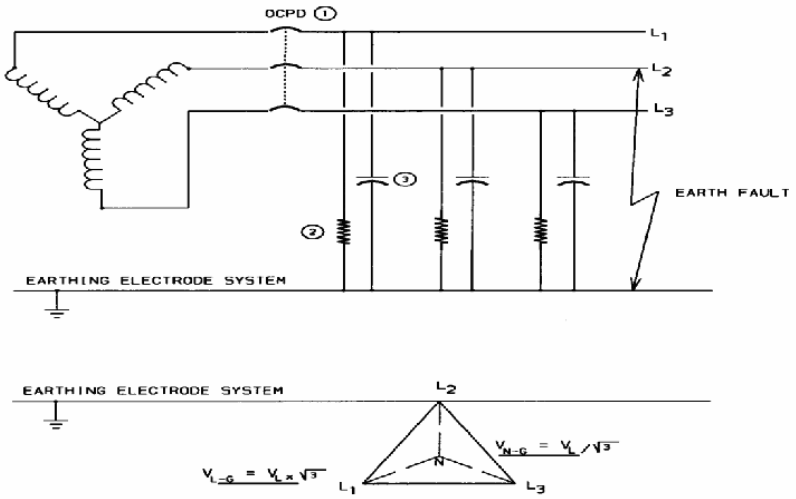


NOTE.
1. OVER CURRENT PROTECTIVE DEVICE
2. INSULATION RESISTANCE OF CONDUCTOR WITH RESPECT TO EARTH (TYPICAL FOR ALL PHASES)
3. CAPACITIVE REACTANCE IN SYSTEM (TYPICAL FOR ALL PHASES)

Figure B.1 - Typical IT System During Operation

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VOLTAGES TO EARTH OF AN IT-SYSTEM DURING A BOLTED FAULT TO EARTH CONDITION. WHEN A SOLID BOLTED FAULT OCCURS ON ONE PHASE THE PSEUDO NEUTRAL POINT IS DISPLACED AND THE VOLTAGE ON THE UNGROUNDED PHASES IS ELEVATED.

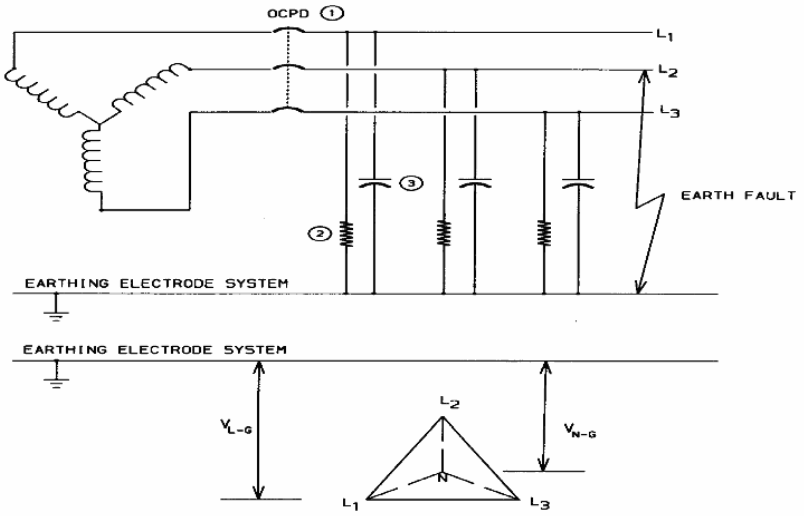
NOTE.

1. OVER CURRENT PROTECTIVE DEVICE
2. INSULATION RESISTANCE OF CONDUCTOR WITH RESPECT TO EARTH (TYPICAL FOR ALL PHASES)
3. CAPACITIVE REACTANCE IN SYSTEM (TYPICAL FOR ALL PHASES)

Figure B.2- IT System with a Bolted Fault

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VOLTAGES TO EARTH OF AN IT-SYSTEM DURING AN ARCING FAULT TO EARTH CONDITION. AN ARCING FAULT TO EARTH IS POTENTIALLY MORE DESTRUCTIVE BECAUSE THE PSEUDO NEUTRAL POINT CAN BE OFFSET SIGNIFICANTLY FARTHER FROM THE GROUND PLAIN EACH TIME THE ARC RESTRIKES.

NOTE:

1. OVER CURRENT PROTECTIVE DEVICE
2. INSULATION RESISTANCE OF CONDUCTOR WITH RESPECT TO EARTH (TYPICAL FOR ALL PHASES)
3. CAPACITIVE REACTANCE IN SYSTEM (TYPICAL FOR ALL PHASES)

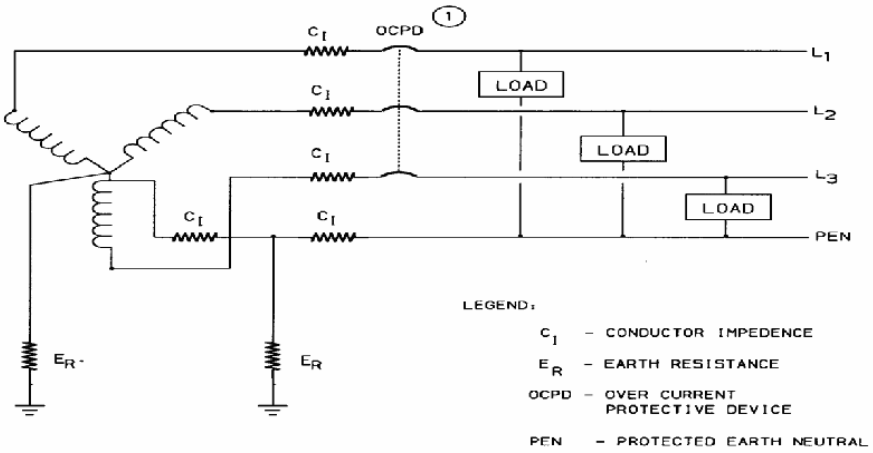
Figure B.3 - IT System with an Arcing Fault

Second Letter (T or N)

The second letter designates the type of connection between the protective equipment—grounding conductor used in the installation and earth. The second letter “T” signifies a direct connection between accessible conductive parts of connected equipment and ground (terra), which is independent of the grounding system that may or may not exist on current carrying conductors of the system. The second letter “N” signifies a direct connection of accessible conductive parts to the ground points of the PDS by means of a PEN (protected earth neutral) or PE (protected earth) conductor. The PDS is then connected to ground. See Figure B.4 through Figure B.7.

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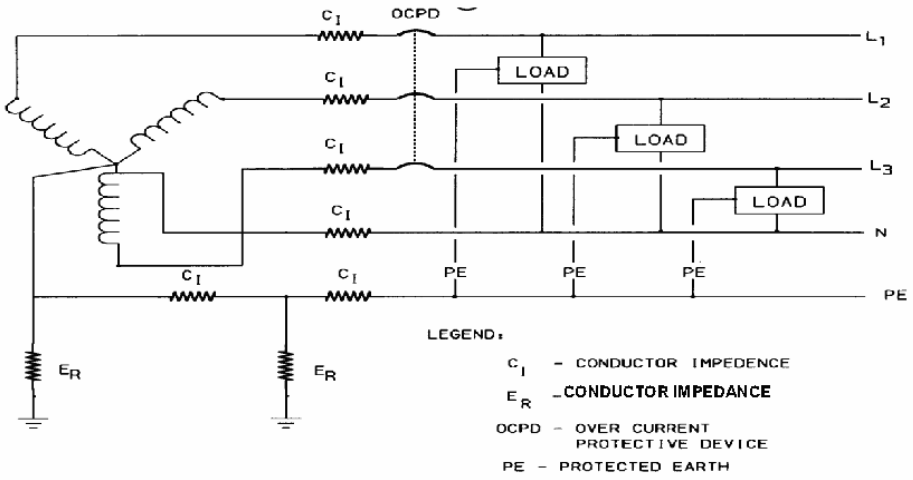


TYPICAL EXAMPLE OF A TN-C SYSTEM

NOTE:

1. MAIN OVERCURRENT PROTECTIVE DEVICE SHOULD NOT HAVE GROUND FAULT PROTECTION

Figure B.4 - Typical TN-C System



TYPICAL EXAMPLE OF A TN-S SYSTEM

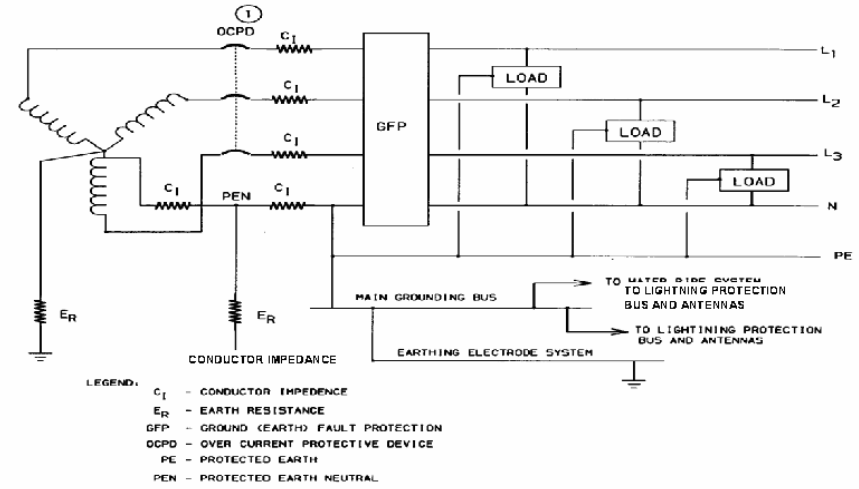
NOTE:

1. OCPD CAN INCLUDE, OR NOT INCLUDE, GROUND FAULT PROTECTION

Figure B.5 - Typical TN-S system

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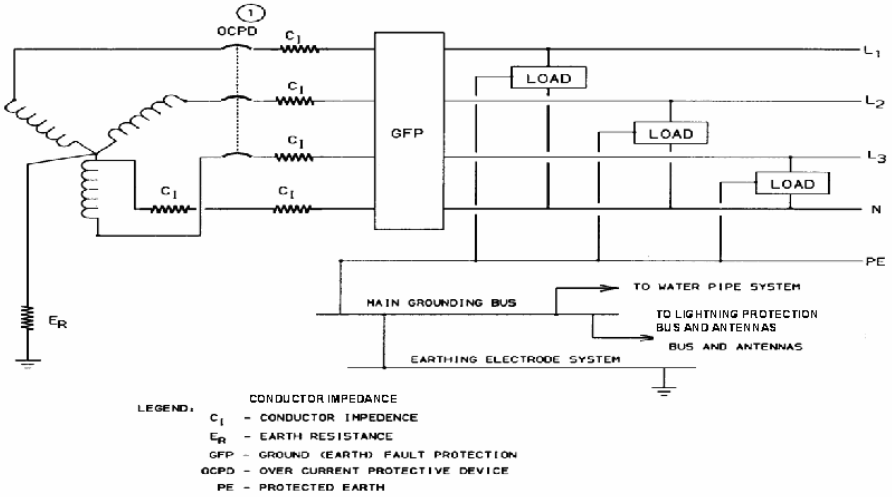


TYPICAL EXAMPLE OF A TN-C-S SYSTEM

NOTE:

1. OCPD CAN INCLUDE, OR NOT INCLUDE, GROUND FAULT PROTECTION

Figure B.6 - Typical TN-C-S system



TYPICAL EXAMPLE OF A T-T SYSTEM

NOTE:

1. OCPD CAN INCLUDE, OR NOT INCLUDE, GROUND FAULT PROTECTION

Figure B.7 - Typical T-T system

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In IEC network systems, the grounding of the PDS and the means of protection against electric shock are independent considerations. Distribution systems are grounded to limit the voltage rise that can develop from lightning, transient over voltages, contact with higher voltage(s), or ground faults that may occur in a PDS. The PDS can be intentionally ungrounded to avoid service interruption when a single ground fault occurs. See Table B.1.

Table B.1

IEC Systems And Equipment Grounding

System designation	System grounding	Equipment grounding
IT	No direct system grounding. Can be connected to earth through impedance or gap.	Independently and directly connected to earth
TT	Connected to earth at one or more points in the PDS outside of the premises wiring.	Independently and directly connected to earth.
TN	Connected to earth at one or more points in the PDS and at one or more points in the premises wiring.	Connected to the PDS via a PEN or PE conductor.

Third Letter (C or S)

In TN systems, a third letter designates the possible configuration of, as well as the relationship between, the neutral conductor, the PE-conductor, and the PEN-conductor.

In a “TN-C”-type PDS, the suffix “C” represents a common function. The PEN-conductor is used to serve the common function of a grounding or protective earthing conductor as well as the neutral conductor for the PDS. In a “TN-C”-type PDS, ground-fault current and neutral current use the same return path. In such installations, the neutral conductor would be bonded to the frame of the equipment or apparatus at each utilization point. In a “TN-C”-type PDS, the application and installation of ground-fault protective devices are not indicated or recommended because such devices would never reliably function as intended. (In North America, older low-voltage appliances with metallic frames represent a single-phase circuit in a “TN-C” system and residential two-prong receptacle circuits where a separate grounding conductor is not used.)

In a “TN-S”-type PDS, the suffix “S” represents a separate grounding or protective earthing conductor. There is no PEN-conductor. The PE-conductor is only bonded once to the neutral conductor and only at the neutral terminal of the supply transformer for the PDS. In a “TN-S”-type PDS, ground-fault current and neutral current use separate conductive paths. In such installations, a separate grounding conductor would be bonded to the frame of the equipment or apparatus at each utilization point for the conduction of ground-fault current. In a “TN-S”-type PDS, the separation of the PE-conductor and the neutral conductor allows for the successful application and utilization of a ground-fault protection system.

TN-C-S Systems

A “TN-C-S”-type PDS is a combination of a “TN-C”- and a “TN-S”-type system. The “TN-C-S”-type PDS is the most commonly used earthing system. In a “TN-C-S”-type PDS, there is a PEN-conductor, a separate PE-conductor, and a separate neutral conductor. The PEN-conductor is used only between the supply transformer and the service equipment. The actual connections to earth of the PEN-conductor are commonly made at the neutral terminal of the supply transformer and on the neutral conductor in the service equipment. Beyond the service equipment, only separate neutral conductors and PE-conductors

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are used. In a “TN-C-S”-type PDS, the separation of the PE-conductor and the neutral conductor allows for the successful application and utilization of a ground-fault protection system as those used in a “TN-S” type system. However, a ground-fault protection system can only be used downstream or on the load side of the PEN-conductor. In addition, any electrical connections between, or bonding of, a PE-conductor and a neutral conductor downstream of the PEN-conductor could cause dysfunction in a ground-fault protection system installed in the “TN-C-S” system.

Differences Highlighted

The following illustrations serve to show the differences between some of the common systems.

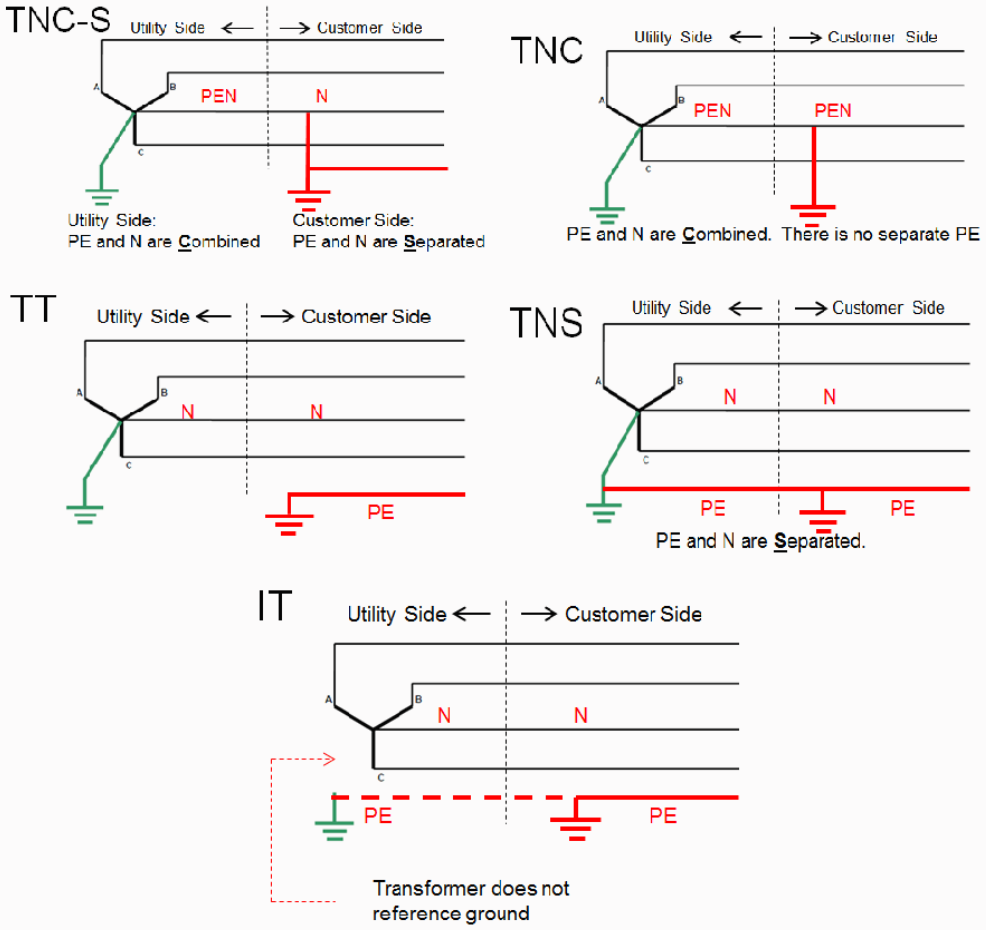


Figure B.8 - Differences in Common Systems

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A NEMA Low Voltage Surge Protective Devices Section White Paper
VSP 1-2017

Susceptibility of Electrical and Electronic Components to Surge Damage

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Foreword

This is a new NEMA white paper based on member-supported testing. To ensure that a meaningful publication was developed, draft copies were distributed to groups within NEMA that have an interest in this topic. Their comments and suggestions provided vital input prior to final NEMA approval and resulted in a number of substantive changes in this publication. To remain up to date with advancing technology, this publication will be periodically reviewed by the Low Voltage Surge Protective Devices Group of the NEMA Commercial Products Division.

Proposed or recommended revisions should be submitted to:

Senior Technical Director, Operations
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This white paper was developed by the Low Voltage Surge Protective Devices Group of the NEMA Commercial Products Division. Approval of this white paper does not necessarily imply that all members of the Product Group voted for its approval or participated in its development.

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The National Electrical Manufacturers Association (NEMA) provides information to assist with answering various questions related to the application and use of surge protective devices.

Executive Summary

The NEMA Low Voltage Surge Protection Devices, 05VS, has been asked to provide an overview of electrical and electronic equipment surge susceptibility. This overview will help the electrical community, engineers, consumers, and technicians understand the various transient conditions to which electrical and electronic equipment may be subjected. The intent is not to evaluate individual companies' equipment as to safety or product performance, but to create awareness and offer guidance based on real-world testing on protection. This will be helpful in preventing problems with products. While there are many documents, papers, standards, web sites, and other media that talk about the harmful effects of transient impulses practical and empirical data is not readily available. Some of the explanations for this lack of data are the variable conditions electrical equipment is subjected to events such as electrical equipment failure, electronic equipment process interruption, insulation breakdown in electric conductors and electronic circuits, electronic component breakdown, premature aging of electrical and electronic components, etc. The standards community has many test procedures and evaluation practices for a prescribed environment. The challenge is that these environments are normally under standard test conditions, for example, 25°C. There are two are issues that are not covered under these standard test conditions.

a. What is the upset capability of the equipment?
b. What level of voltage or current would cause damage to equipment?

Quantitative data on how big or how many transient impulses are required to significantly reduce the life of or cause failure of an electrical or electronic device is almost nonexistent. Reasons for this lack of available information are the variable conditions under which an electrical device is subjected, i.e., at one location normal operating voltage might have a range of 110 to 135 Vac. Other locations may have more consistent supply voltage, but how many times does it fluctuate? When it does change, how long was the unstable condition? How large was the transient condition? When a system is influenced by another device or system, how large is the impact on the rest of the equipment?

The 05VS section understands that every possible combination of events and test equipment cannot be tested. The burden placed upon manufactures and consumers would be impractical. For instance, what happens when a transient impulse occurs to an electrical device when it is at its maximum operating temperatures, upper and lower boundaries? As every electrical device has its own unique set of environmental conditions, a frequent request is, "How many surges does it take to damage my equipment" or "How much longer will my equipment last with and without surge protection?"

Another missing piece of information is data on the cumulative effect of transient impulses. The average person, unless taught otherwise, often believes that surge damage is a one-time event. When lightning strikes and a piece of equipment is damaged, the damage may be attributed to a transient impulse. But when a piece of equipment fails due to the accumulation of numerous smaller magnitude surges, the failure is attributed to the age of equipment, poor quality of the equipment, or a hundred other unexplained conditions.

For this paper, the term "surge" and "transient" are used interchangeably.

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Scope

The purpose of this paper is to present the test results of actual devices in a real-world surge environment. This white paper will generate some information on the surge susceptibility for various electrical components. This white paper is not meant to be an exhaustive study, nor a complete test spectrum. It is merely a means to provide useful information to the electrical community, both for those who design electronic and electrical equipment and for those who install and use electronic and electrical equipment. The tests were performed in certified testing laboratories. The tests were completed using standardized test sequences and parameters. The test specimens used were off-the-shelf devices; they were not modified or altered in any way. The electrical products used were selected to represent a broad spectrum of common electrical components familiar to all users of electrical appliances.

The results obtained by this testing can be used as a guide to the reaction of electrical devices under various conditions. Some devices might show malfunctions, and some may experience upset events caused by surge events in actual installations. Upset conditions will be a concern if any other electronics are controlling a critical safety component. For example, a control transformer with an upset output could cause process failure for equipment being run by the transformer.

Test Methodology

A variety of waveforms were selected to represent surge conditions. These waveforms are based on the standard waveforms found in the current edition of IEEE C62.41.2 with the addition of some intermediate waveforms from an earlier version of this standard. They are a representation of impulse events created by interruptions in the electrical system. Most equipment is designed to handle minor variations in nominal operating voltages. However, surges can range in impact and adversity and may affect nearly all equipment under certain conditions. Here are some of the standard waveforms for equipment surge susceptibility. While most equipment has a nominal level of intrinsic resistibility, based on environment, application, and installation, additional or redundant levels of surge protection may be recommended.

The following standard waveforms were used in the testing protocol:

a) Category C Low / Category B Combination Wave (6,000 V / 3,000 A)
b) Category C Low / Category B Combination Wave (4,000 V / 2,000 A)
c) Category B Combination Wave (2,000 V / 1,000 A)
d) Category B Ring Wave (6,000 V / 500 A)
e) Category B Ring Wave (4,000 V / 333 A)
f) Category B Ring Wave (2,000 V / 167 A)
g) Category A Ring Wave (6,000 V / 200 A)
h) Category A Ring Wave (4,000 V / 133 A)
i) Category A Ring Wave (2,000 V / 67 A)

Note: See IEEE Std. C62.41.2 TM-2002 especially Clause 6.2; Tables 2, 3 and 4; and the notes associated with those tables for further explanation of the surge test levels selected.

The 6,000 V combination wave was developed to represent a variety of surge events. These events may be externally or internally generated electrical surges, such as when a utility capacitor bank is switched into or out of an electrical system. Internal events can come from inductive load switching. This surge is not meant to be a replication of lightning impulses, but rather a representation of the energy produced from an impulse during normal electrical operating conditions. For additional information on lightning impulses, please see NFPA 780 *Standard for the Installation of Lightning Protection Systems*.

These tests were designed to determine the number and magnitude of surges some common electrical devices used in residential, commercial and industrial applications could withstand before failure. Each

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sample was tested starting with the highest magnitude IEEE C62.41.2 waveform from the list above, the 6,000 V / 3,000 A Category C Low Combination Wave. If the sample could withstand 300 surges, the test was stopped.

If the sample failed before 300 surges in this category were applied, then the surge generator was re-calibrated to output the next lower surge waveform. This continued until the sample withstood 300 surges.

The following common electrical and electronic devices were tested:

a) Incandescent Bulb
   - Common 120 V, 60 W screw-base bulb
b) Compact Fluorescent Bulb
   - Common 120 V, 60 W (equivalent) screw-base bulb
c) Electronic Ballast & Fluorescent Bulb
   - Common 120 V electronic ballast with two 25 W, 36 inch fluorescent tubes
d) LED Bulb
   - Common 120 V, 60 W (equivalent) screw-base bulb
e) Control Transformer
   - Industrial 50 VA, 120 V to 24 V transformer
f) Variable Frequency Drive (VFD)
   - Industrial 120 V single-phase, 0.33 HP VFD
g) Uninterruptable Power Supply (UPS)
   - Common 120 V, 500 VA, off-line UPS

The test procedure was designed to subject the test samples to a range of surges of different types and magnitudes representing real-world applications. The testing started with IEEE Category C and then proceeded to Categories B and A (decreasing in severity). If the sample failed during the first series of test surges, a new sample was tested with surges of the next lower level until the test sample passed 300 surges without issue.

Note: that the test samples were not directly connected to the surge generator. The samples were connected through a 10 meters (30 feet) length of cable. This is a better representation of a practical and actual electrical installation.

The following steps were taken to conduct the test on each device:

a) The open circuit voltage waveform and short circuit current waveform were measured to verify the test waveform.
b) The sample to be tested was attached to the output of the generator using a 10 meters cable (12-2 non-metallic sheathed cable).
c) Apply the highest combination surges from Table 1 to the first test sample. Perform up to 300 strikes unless the sample fails. The impulses are injected at 60 second intervals and are applied at the peak of the AC sine wave (90 degrees of the power frequency).
d) If the sample fails, apply the surge waveform in the next column to the right in Table 1 in 60 second intervals at 90 degrees of the power frequency for up to 300 strikes or until the device fails and record results.
e) Continue testing with the test waveform in the next column to the right in Table 1 until one sample passes the test of 300 surges.

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Test Results

Table 1 contains the compiled results of the surge susceptibility testing. The first column describes the device being tested. The devices tested were all commercially available products manufactured by a variety of companies. The second column lists the number of the sample being tested. This is followed by the nine different surge waveforms used in the testing, starting with the highest voltage and current waveforms on the left and working to the lowest magnitude waveforms on the right.

The number in the columns under the different test waveforms are the number of surges of that surge type when the sample failed. None of the samples survived more than one of Category C Low Combination Wave (6,000 V / 3,000 A) waveform. When a number “1” appears in a column, then the test sample failed on the first surge in that category. When there is a “300” in a column under one of the test waveforms, then the test sample survived 300 of those waveforms without damage. At that point, the testing was stopped, as the sample would have passed all the surge waveforms to the next lowest value (to the right in Table 1).

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Table 1: Test Results

Sample	Sample Number	Category C Low / Category B Combination Wave			Category B Ring Wave			Category A Ring Wave		
		6 kV 3,000 A	4 kV 2,000 A	2 kV 1,000 A	6 kV 500 A	4 kV 333 A	2 kV 167 A	6 kV 200 A	4 kV 133 A	2 kV 67 A
Incandescent Bulb	1	1								
	2		1							
	3			1						
	4				1					
	5					1				
	6						1			
	7							44		
	8								300	
Compact Fluorescent Bulb	1	1								
	2		1							
	3			1						
	4				300					
Electronic Ballast & Fluorescent Bulb	1	1								
	2		1							
	3			1						
	4				300					
LED Bulb	1	1								
	2		1							
	3			1						
	4				300					
50 VA Control Transformer	1				53					
VFD 0.33 HP	1	1								
	2				300					
	3*				20, L-G					
500 VA UPS	1				300					

Note: All VFD surges were performed Line to Neutral in positive polarity except for VFD sample number 3 which was tested Line to Ground.

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Conclusions

Table 1 in this document shows the surge test results for some common products. They cover a range of products from an incandescent light bulb to an uninterruptible power supply. These are common devices that are connected to an electrical supply and are exposed to everyday electrical surges that can be damaged by these events. The surges applied in this testing are at the same levels to be expected in common electrical installations.

As documented in the test results, the surge environment can produce a variety of effects. Surge damage can be experienced in a single event or as the result of an accumulation of surges. For example, in the case of an incandescent light bulb, the damage can be immediate or from repeated surges as shown by the quantity of the 44 surges in the Category A environment (i.e., test sample 7 in the table above). The application of a quality surge protective device can prevent damage to common electrical or electronic products. Surge protection is just as effective when used in commercial and industrial environments.

Electrical equipment is subject to surge damage, and these results show conclusively that everyday electrical devices are damaged by surges of the level expected in a normal electrical distribution system. The application of a surge protective device within a home or facility can alleviate the effects and save the cost or replacement for many electrical or electronic devices. For additional information on surge protection and its applications, visit www.NEMASurge.org.

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Data Assessment for Electrical Surge Protection Devices

Phase 1
Final Report

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FOREWORD

Every year there are widespread anecdotal reports of homeowners' property damage to electrical and electronic equipment resulting from electrical surges. The revision cycle of the 2011 edition of NFPA 70, *National Electrical Code®* (NEC®) included several proposals (e.g. NEC 4-53 and NEC 4-127) to add new requirements for a Surge Protective Device for all dwelling units. These proposals were rejected by the respective Code Making Panel (i.e., CMP-4) due to a lack of reliable data to support such requirements.

The goal of this project is to develop a data collection plan to assess loss related to electrical surge in homes, and address the potential impact electrical surge protection devices would have in mitigating these losses. The deliverables from this project represent a Phase I study in support of a potential second phase (not included in the scope of this effort).

The Research Foundation expresses gratitude to the report authors Eddie Davis, Nick Kooiman, and Kylash Viswanathan, all with Hughes Associates, Inc. Likewise, appreciation is expressed to the Project Technical Panelists and all others who contributed to this research effort for their on-going guidance. Special thanks are expressed to the project sponsors Eaton Corporation and the National Electrical Manufacturers Association for providing the funding for this phase 1 project.

The content, opinions and conclusions contained in this report are solely those of the authors.

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Data Assessment for Electrical Surge Protective Devices

Prepared for:

The Fire Protection Research Foundation
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Project Number: 1ELD62001.001
October 2014

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EXECUTIVE SUMMARY

Purpose

The Fire Protection Research Foundation sponsored this project to address electrical surge protection for residential dwelling units. The goal of the project is to develop a data collection plan to assess loss related to electrical surges in homes, and address the potential impact electrical surge protection devices (SPDs) would have in mitigating these losses. The deliverables from this project represent a Phase I study (this report) in support of a potential second phase (not included in the scope of this effort).

Report Content

This report provides information regarding:

- Surge phenomena and their sources.
- Surge protection methods.
- Surge protection strategies recommended by various sources.
- Industry standards and their recommendations.
- Available data associated with electrical surges and their impact.
- Recommended data collection in support of code-making efforts.

Surge Protection

Sources of Surges

A surge is a transient wave of voltage or current. The duration is not tightly specified but is usually less than a few milliseconds. The following are typical sources of surges:

- Lightning.
- Utility switching, including capacitor switching.
- Equipment switching and switching inductive loads within a facility.

Protection against surges is referred to as *surge protection*, and includes protection against both surge voltages and currents. The devices used to protect against surges are referred to as *surge*

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protective devices, or SPDs. A surge of duration longer than a few milliseconds is referred to as a swell or temporary overvoltage (TOV) and requires a different type of protection design; SPDs can fail if exposed to long duration TOVs.

Surge Effects

Surges can cause equipment damage. Large surges damage equipment and other components in the electrical distribution system. Smaller surges can cumulatively damage equipment and can cause nuisance equipment tripping. Both surge voltage and current can be damaging. In the case of lightning strokes, the surge can be carried into a facility via all of the connected conductive paths.

There is a limit on how high of a voltage can be transmitted into a facility or residence. Above a certain level, a high voltage will result in flashover in the insulation system of electrical equipment and conductors. A flashover can cause insulation damage, electric shock, and fire.

NEMA surveys of facility managers confirmed catastrophic failure or damage of electrical or electronic equipment due to a lightning event or voltage surge and premature failure of electrical or electronic equipment, including failure of life safety equipment.

The Insurance Information Institute report for 2013 identified 114,740 insurer-paid lightning claims for residential locations. The average lightning paid-claim amount was $5,869.

Residential Surge Protection

Residential surge protection has long been viewed as an important safety consideration and guidance has been issued by IEEE and NIST to help homeowners protect their house and its contents. This protection has often been described as being similar to an insurance policy, partly because there is not an NFPA code requirement for SPD installation in residences. Today's residences often contain electronic equipment throughout, including appliances, computers, security systems, life safety equipment, automation systems for internet-enabled applications, and home entertainment systems.

Industry Standards

SPDs are routinely used in facilities that are potentially exposed to voltage or current surges from nearby lightning, utility switching, or other sources; and there are many manufacturers of SPDs and these manufacturers often offer guidance regarding SPD installation ratings and recommended applications. However, industry codes and standards provide limited guidance regarding selection, rating, and application.

One limitation with surge protection design is that there is no industry standard that describes what is an acceptable level of surge protection for standard facilities or residential locations. Although industry codes and standards are available that establish standardized surge criteria and assist with the application of specific surge protector types, these standards do not provide adequate design guidance that ensures a facility is properly protected against surges. There is no existing industry guidance for surge protection of residential facilities.

Refer to Section 3 for an overview of the available industry standards.

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Data Acquisition Plan

Surge Data and Its Effects

Lightning strokes, either direct, nearby, or some distance away can cause voltage and current surges into a facility. Information is available regarding lightning strokes and their intensity. But, less information is available regarding the extent to which these surges are transmitted into commercial facilities, industrial facilities, or residences. Section 4.2 describes the difficulty associated with obtaining this data.

Available Data

Vaisala owns and operates the National Lightning Detection Network (NLDN) that provides accurate lightning data information across the USA. And, Vaisala can provide lightning location reports that provide individual cloud-to-ground lightning strikes and the intensity of strike at a specific location on the date of loss. This capability represents the largest and most complete source of lightning surge location and intensity.

Data for lightning surges that extend to the inside of facilities is not readily available. Published papers and IEEE C62.41.1 provide information regarding the expected surge levels within a facility or residence, but extensive data is not available.

Switching-related surge data, either internally or externally generated, is sparse. The added difficulty with this data is that these surges often do not cause immediate failure of electrical and electronic equipment; the damage occurs as a cumulative effect.

The largest documented source of surge effects is contained within the insurance claim documents for damage caused by surges. The Insurance Information Institute in collaboration with State Farm® produces annual reports of insurance claims associated with lightning-induced damage.

Data Acquisition Plan

There are challenges in obtaining usable data applicable to residential applications, such as:

- Confirming that equipment failures were a direct result of a surge event.
- Establishing any median and upper bounds to actual surge levels since this is not recorded inside facilities.
- Defining the protection improvement realized by applying SPDs.

Given the scarcity of real data relating to surges and the effects of surges, the approach described below is recommended.

The purpose of the recommended data acquisition approach is to produce real data regarding damage and injuries caused by surges. This information is intended to assist the NFPA 70 code-making committees with additional technical data to support a decision to require or not require SPDs for the variety of electrical applications proposed in past NFPA 70 update cycles (refer to Section 1.2).

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The starting point for this project is to acquire the nationwide lightning stroke data for the continental USA for 2013 (or 2014 if the project starts in 2015). This information can tie back to insurance claim data and possibly provide surge current values for the locations of interest.

The Insurance Information Institute is proposed to manage the insurance industry claim data. Their involvement assures that the insurance industry claim reports can remain confidential while allowing access to additional data that might be contained in the claim reports.

The Insurance Information Institute already publishes annual summaries of the number of lightning-related insurance claims and the claim amount. Additional information of interest that might be available in the claim data includes:

- Date and location of surge event (to establish geographical correlations).
- Electronic equipment and appliances damaged.
- Life safety equipment damaged – smoke detectors, CO or CO_2 detectors, or other equipment.
- Fires caused by surge effects.
- Personal injuries associated with the surge event.
- Presence of or lack of installed SPDs.

Life safety equipment damage, fires caused by surge events, and personal injuries are of particular interest for code-making efforts.

Although the annual Insurance Information Institute survey has historically focused on residential claims, the survey for this project should include commercial and industrial claims also. NEMA assistance and direction with this effort will be helpful.

NEMA Low Voltage Surge Protective Devices Section (5-VS) participation is recommended for the following:

- Assisting with project scope, including commercial and industrial users.
- Reviewing the project checklist for the type of information to be obtained from the insurance industry.
- Reviewing failure data report summaries.
- Considering recommended SPD design principles, including the specification of surge protection in low-lightning flash density areas versus high-lightning flash density areas. Should NFPA elect to require SPDs in dwelling units or other applications, then minimum surge protection current limits should also be addressed, similar to the method provided in NFPA 780. As SPD surge current rating increases (and the degree of protection), the SPD cost also increases.

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1

INTRODUCTION

1.1 Project Overview

The Fire Protection Research Foundation sponsored this project to address electrical surge protection for residential dwelling units. The goal of the project is to develop a data collection plan to assess loss related to electrical surges in homes, and address the potential impact electrical surge protection devices (SPDs) would have in mitigating these losses. The deliverables from this project represent a Phase I study (this report) in support of a potential second phase (not included in the scope of this effort).

The project includes the following activities that are documented in this report:

- Literature review – review of literature to include fundamental factors contributing to electrical surges, existing data associated with losses, case studies of SPD effectiveness, and overview of SPD designs.
- Preliminary data collection plan – develop a preliminary data collection plan that will address the identified data gaps. When implemented, the data collection plan should provide a comprehensive review of electrical surge related losses in homes in the United States and address the potential impact of electrical surge protection devices in mitigating these losses.
- Final report – to be issued after review of the draft report.

1.2 NFPA 70 Committee Report on Proposals – 2013

Each update cycle for NFPA 70, *National Electrical Code®*, includes numerous proposals for changes throughout the document. In particular, the installation of SPDs has been proposed for virtually all low-voltage (600 volts or less) electrical distribution equipment. Because of the breadth of these recommendations, the proposals and their reasons for rejection are summarized here. Although this Fire Protection Research Foundation report is focused on SPDs for residential dwelling units, the proposals for SPDs cover a much broader set of electrical distribution equipment.

The *National Electrical Code® Committee Report on Proposals – 2013 Annual Revision Cycle*[1] provides a summary of all proposals and their disposition in support of the 2014 edition of NFPA 70. With respect to the application of SPDs, the following proposals were submitted:

[1] The *National Electrical Code® Committee Report on Proposals – 2013 Annual Revision Cycle*. The 2010 version provided similar recommendations.

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- Proposal 4-65 Log #3318 NEC-P04 – New Article 225.41 Surge Protection. A Type 1 or Type 2 listed SPD shall be installed on all outside branch circuits and feeders and shall be located at the point where the outside branch circuits and feeders receive their supply.

- Proposal 4-143 Log #3319 NEC-P04 – Article 230.67 Surge Protection. A Type 1 or Type 2 listed SPD shall be installed on all services.

- Proposal 4-143a Log #3504 NEC-P04 – Article 230.67 Dwelling Unit Surge Protection.
  (A) Surge Protective Device. All dwelling units shall be provided with a surge protective device (SPD) installed in accordance with Article 285.
  (B) Location. The surge protective device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto.
  (C) Type. The surge protective device shall be a Type 1 or Type 2 SPD.
  (D) Replacement. Where service equipment is upgraded, all of the requirements of this section shall apply.

- Proposal 5-244 Log #3320 NEC-P05 – New Article 285.2 Required uses. A listed SPD shall be installed in or on the following equipment that is rated at 1000 volts or less.
  (1) Switchboards and panelboards
  (2) Motor control centers
  (3) Industrial control panels
  (4) Control Panels for elevators, dumbwaiters, escalators, moving walks, platform & stairway chairlifts
  (5) Power distribution units supplying information technology equipment in information technology rooms
  (6) Solar photovoltaic (PV) combiner boxes, recombiner boxes, and inverters
  (7) Roof-top air conditioning and refrigerating equipment
  (8) Adjustable-speed drive systems
  (9) Burglar alarm panels
  (10) Fire alarm panels
  (11) Critical Operations Power Systems
  (12) Small Wind Electric Systems

- Proposal 9-117 Log #3321 NEC-P09 – Article 408.6 Surge Protection. A listed SPD shall be installed in or on all switchboards and panelboards.

- Proposal 11-14 Log #3322 NEC-P11 – Article 409.70 Surge Protection. A listed SPD shall be installed in or on all industrial control panels.

- Proposal 11-42 Log #3323 NEC-P11 – New Article 430.92 Surge Protection. A listed SPD shall be installed in or on all motor control centers.

- Proposal 11-55 Log #3324 NEC-P11 – New Article 430.121 Surge Protection. A listed SPD shall be installed in or on all adjustable-speed drive systems.

- Proposal 11-84 Log #3325 NEC-P11 – New Article 440.9 Surge Protection. A listed SPD shall be installed in or on all roof-top air-conditioning and refrigerating equipment.

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- Proposal 12-49 Log #3326 NEC-P12 – New Article 620.56 Surge Protection. A listed SPD shall be installed in or on control panels for elevators, dumbwaiters, escalators, moving walks, platform and stairway chairlifts.

- Proposal 12-140 Log #3327 NEC-P12 – New Article 645.18 Surge Protection. A listed SPD shall be installed in or on all switchboards, panelboards, and power distribution units supplying information technology equipment in information technology rooms.

- Proposal 12-169 Log #3328 NEC-P12 – New Article 670.6 Surge Protection. A listed SPD shall be installed in or on all industrial machinery.

- Proposal 4-254 Log #3329 NEC-P04 – New Article 690.12 Surge Protection. A listed SPD shall be installed in or on all solar photovoltaic (PV) combiner boxes, recombiner boxes, and inverters.

- Proposal 13-98 Log #3330 NEC-P13 – New Article 700.8 Surge Protection. A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.

  Note: Although the *Committee Report on Proposals* lists the Final Action as Reject, the 2014 edition of NFPA 70 does include a new Article 700.8 that states:

  700.8 Surge Protection
  A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.

- Proposal 4-405 Log #3331 NEC-P04 – New Article 705.13 Surge Protection. A Type 1 listed SPD shall be installed at the point of connection of all interconnected electric power production sources.

- Proposal 3-131 Log #3332 NEC-P03 – New Article 725.36 Surge Protection. A listed SPD shall be installed in or on all burglar alarm control panels.

- Proposal 3-179 Log #3333 NEC-P03 – New Article 760.36 Surge Protection. A listed SPD shall be installed in or on all fire alarm control panels.

The NFPA 70 Panel rejected the above proposals on various bases, including:

- *Surge protection is permitted to be installed and should not be required, as surge probabilities vary by locality, and different types of electrical loads have differing surge protection requirements. Surge protection must also be periodically maintained or replaced. The user should make the decision to install this protection.*

- *While the use of SPD's is appropriate in many instances, it is not always needed in every installation. System designers should apply SPD's where needed. Equipment manufacturers frequently provide integrated surge protection when it is deemed appropriate. The substantiation provided does not warrant the imposition of this new requirement.*

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- *Surge protective devices have proven to provide benefits for components and systems against the damages of voltage surges, but the substantiation for this proposal does not document that such protection would specifically benefit HVAC equipment installed on a roof. In addition this may not work with high resistance, impedance or ungrounded systems. The NFPA FPRF is working on a project in this area which may provide information in the future.*

- *CMP-13 acknowledges that surges may result in failures. However, the proposal does not state what type or level of protection should be required. Further substantiation through a formal research report that presents evidence of the type of SPD and the level of protection required would present the opportunity for the panel to reconsider the proposal.*

Miscellaneous changes were made to the 2014 edition of NFPA 70 Article 285, *Surge-Protective Devices (SPDs), 1000 Volts or Less*, but these changes do not affect the locations where surge protection has been required.

1.3 Report Content

This report provides information regarding:

- Surge phenomena and their sources.
- Surge protection methods.
- Surge protection strategies recommended by various sources.
- Industry standards and their recommendations.
- Available data associated with electrical surges and their impact.
- Recommended data collection in support of code-making efforts.

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2

SURGE PROTECTION FUNDAMENTALS

Section 2 provides an overview of electrical surges and protection against the effects of these destructive surges.

2.1 Sources of Surges

A surge is a transient wave of voltage or current. The duration is not tightly specified but is usually less than a few milliseconds. The following are typical sources of surges:

- Lightning.
- Utility switching, including capacitor switching.
- Equipment switching and switching inductive loads within a facility.

The following summarizes the effects of these various surge sources.

Table 2-1
Sources of Surges

Source of Surge	Peak Voltage Magnitude	Frequency of Occurrence	Comments
Lightning	<1,000 volts to >40,000 volts with average of about 20,000 volts	Weekly to rarely, depending on location	Magnitude depends on proximity of stroke to facility and coupling of stroke to facility electrical system. Voltages within a facility above 6,000 volts are unlikely due to flashover.
Utility Capacitor and System Switching	Up to 1,300 volts on a 480 volt system	Never to several times a day, depending on utility	Capacitors might or might not be installed nearby.
Facility Equipment Switching	Up to 2,000 volts on a 480 volt system	Many times a day	Magnitude is small compared to lightning-induced transients, but switching can occur frequently.

Protection against surges is referred to as *surge protection*, and includes protection against both surge voltages and currents. The devices used to protect against surges are referred to as *surge protective devices*, or SPDs. A surge of duration longer than a few milliseconds is referred to as a swell or temporary overvoltage (TOV) and requires a different type of protection design; SPDs can fail if exposed to long duration TOVs.

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2.1.1 *Lightning Surges*

Lightning-induced surges into an electrical system are caused by lightning strokes to the ground, towers, or structures. A lightning stroke can produce peak discharge currents ranging from a few thousand amperes to 200,000 amperes, or higher. This lightning discharge current is developed within a few microseconds and typically discharges most of its energy within a millisecond. The location where a lightning stroke will occur is not completely predictable; cloud-to-ground strokes have been recorded almost 20 miles from the base of the source cloud.

The frequency of lightning strokes varies with geographical location. Figure 2-1 shows the Vaisala lightning flash density map for the United States. Lightning strokes are a rare occurrence in Portland Oregon while they can be a routine event in Orlando Florida.

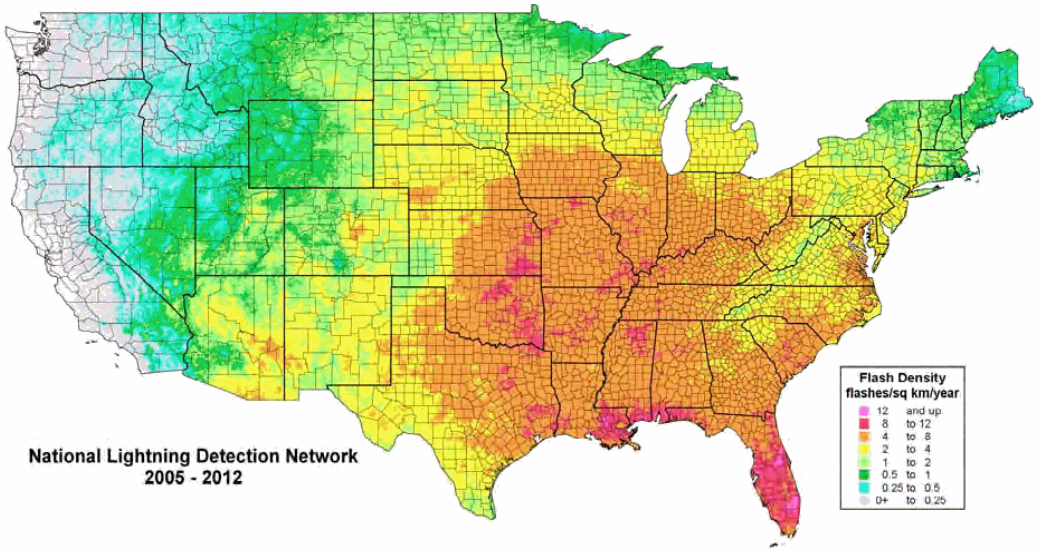


Figure 2-1
Lightning Flash Density Map
Courtesy Vaisala

A single intense storm can produce thousands of lightning strokes. Schneider Electric Data Bulletin DB03A, *Surge Protection: Measured Lightning Stroke Data*, describes a July 2000 storm in Tampa Florida that recorded 33,863 lightning strokes during a 14 hour period. Both positive and negative polarity strokes were detected,[2] with the following recorded surge currents:

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[2] A lightning stroke is a lightning discharge between a thundercloud and the ground and commonly referred to as cloud-to-ground lightning. The most common type of lightning stroke is referred to as a negative lightning stroke and usually originates near the bottom of the cloud with a large concentration of negative charge in the cloud base. The term *negative lightning* means that there is a net transfer of negative charge from the cloud to the ground. Positive lightning strokes represent only about 5% of the lightning strokes and tend to originate in the more positively charged top of the cloud.

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Positive Lightning Stroke Surge Currents

- 95% – less than 30 kA
- 98% – less than 60 kA

Negative Lightning Stroke Currents

- 82% – less than 30 kA
- 98% – less than 60 kA

For this Tampa Florida storm, notice that the above results show that 2% of the lightning strokes produced surge currents greater than 60 kA. A few lightning strokes approached 200 kA. But, over 80% of the lightning strokes produced surge currents less than 60 kA.

This data correlates reasonably well with a report from the IEEE Lightning and Insulator Subcommittee of the T&D Committee that showed a 50% probability of less than about 20 kA, a 95% probability of less than about 60 kA, and a 99% probability of less than about 100 kA.[3]

A lightning-induced surge is a high magnitude impulsive transient of very short duration, typically measured in microseconds or milliseconds. But, during this short period, significant system damage can occur. Figure 2-2 shows an example.

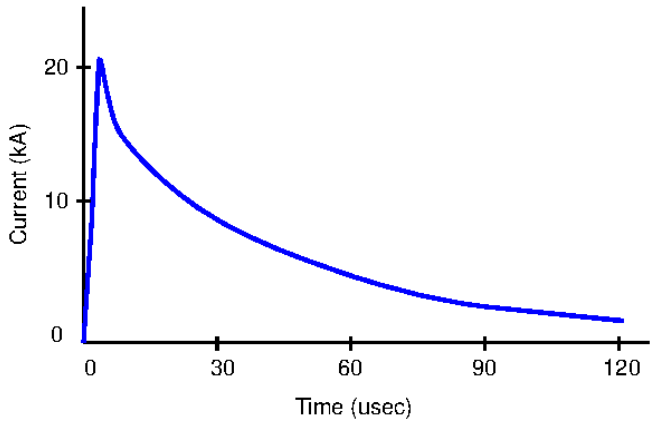


Figure 2-2
Typical Lightning Surge Current

Lightning-induced surges can be introduced into the electrical distribution system by any of the following methods, either alone or in combination:[4]

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[3] Refer to Lightning and Insulator Subcommittee of the T&D Committee, *Parameters of Lightning Strokes: A Review*, IEEE Transactions on Power Delivery, Vol. 20, No. 1, January 2005, for the actual range of values.

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- Direct lightning strokes to the service entrance, either at low voltage lines or on the high voltage windings of service entrance transformers.
- Nearby strokes that induce voltages in distribution transformer secondary circuits.
- Strokes near the service entrance that induce surges onto the electrical system.
- Strokes to a building that induce surges in the system ground with respect to power supplies.
- Surges that cause surge protector operation, thereby placing a surge on the ground and neutral wire common to the low voltage system.

The greatest number of lightning-caused surges that will be seen originate on the high voltage side of the distribution transformer. Far less often, the surges will be caused by a local stroke impinging on the facility, service entrance transformer, or nearby equipment. Most surges, regardless of whether they originate on the primary or secondary side of the transformer are not from a direct stroke; usually, the surge is caused by a stroke to the pole, tower, ground wire, or nearby object with the surge electromagnetically coupled into the distribution or service conductors. Once into the electrical system wiring, surges on the high side of the transformer are coupled into the secondary and transmitted throughout a facility.

2.1.2 *Utility Switching*

Utility switching is a broad term that applies to how utility configurations are occasionally changed. Each switching operation can produce a transient that can momentarily exceed equipment voltage ratings. Although the transients are not as large in magnitude as a nearby lightning stroke, switching transients can cause cumulative damage to electrical equipment. And, if switching results in a temporary overvoltage (TOV), it can also cause SPD failure.

Capacitor switching is a special case of utility switching. Capacitors might also be switched periodically by large industrial power customers. Capacitor switching can be a common every-day event, occurring several times each day in some locations, as a utility adjusts system voltage and compensates for inductive loads.

Capacitor switching causes a surge voltage by the following process. The voltage across a capacitor is zero before it is switched into the circuit. As a capacitor is switched, there is a momentary short circuit across the capacitor as the system voltage is applied to the zero voltage of the capacitor. At the capacitor location, the bus voltage momentarily experiences a step change to zero volts. After the initial step change, the voltage recovers and then overshoots as the system eventually return to its steady state value. Thereafter, the system oscillates until damping returns the voltage to its steady-state value. During the initial oscillation period, the peak transient voltage can approach 200 percent of the normal peak system voltage (common peak surge voltages can range from 150 percent to 180 percent of normal). Another factor contributing to the transient is the inrush current as the capacitor energizes; this inrush current

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[4] IEEE C62.41.1, *Guide On The Surge Environment In Low-Voltage (1000V And Less) AC Power Circuits*, uses the terms “direct flash”, “near flash”, and “far flash” to distinguish between lightning strokes and how they induce a surge on a facility.

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can have a resonant frequency anywhere from 300 hz to 1,000 hz depending on the installed inductance and capacitance, which adds to the system oscillations. Figure 2-3 shows an example of a capacitor switching transient.

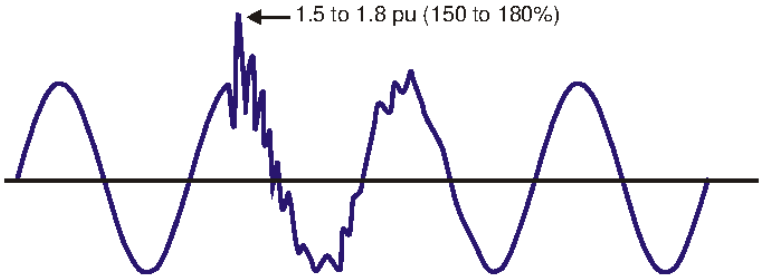


Figure 2-3
Voltage Waveform for Capacitor Switching Transient

Capacitors inside a facility can resonate with the switching-induced oscillations, thereby magnifying the peak voltage and extending the period until the voltage returns to normal. Magnification of the switching transient can occur if the utility switched capacitor bank is much larger than the facility capacitor bank and there is little resistive load (mostly motor load) to provide a damping mechanism.

2.1.3 *Facility Internal Switching*

Switched equipment in a facility electrical system or residence results in the inductive release of energy that creates a momentary voltage surge. Even minor switching, such as deenergizing lighting loads, can cause a significant inductive surge in the system. This type of switching accounts for the overwhelming majority of switching transients. However, the magnitude of this type of surge is much smaller than for lightning-induced surges.

2.2 Surge Effects

Surges can cause equipment damage.[5] Large surges damage equipment and other components in the electrical distribution system. Smaller surges can cumulatively damage equipment and can cause nuisance equipment tripping. Both surge voltage and current can be damaging. In the case of lightning strokes, the surge can be carried into a facility via all of the connected conductive paths. The following figures show examples of damage caused by surges.

[5] Refer to IEEE 1100, *Powering and Grounding Electronic Equipment*, for additional information regarding the effects of surges.

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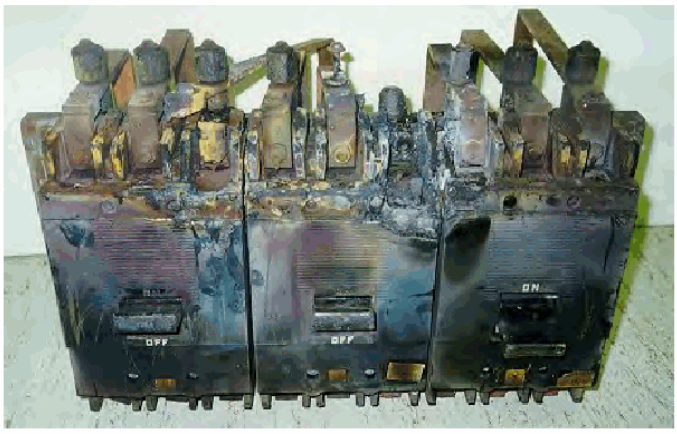


Figure 2-4
Circuit Breaker Failure Caused by Surge Voltage



Figure 2-5
Copper Busbar Melted by Surge Current

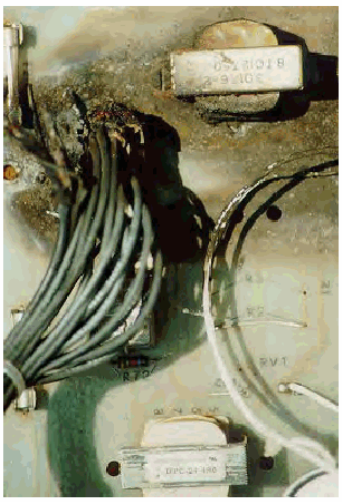


Figure 2-6
Circuit Board Damage Caused by Surge Voltage

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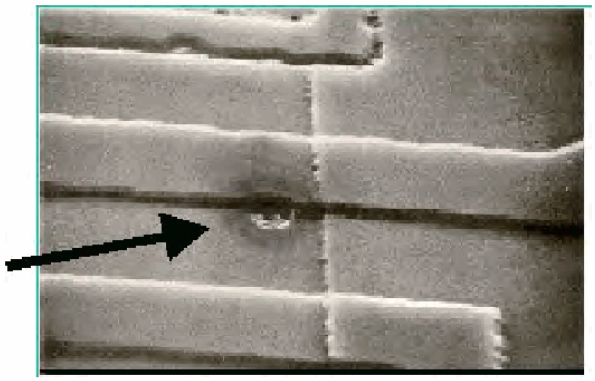


Figure 2-7
Micro Circuit Damage Caused by Surge Voltage

Electronic equipment is susceptible to surge transients. Computers and internet-enabled devices are not only at risk in the power supply but can also be damaged by surges that propagate into the equipment via the communications link.

There is a limit on how high of a voltage can be transmitted into a facility or residence. Above a certain level, a high voltage will result in flashover in the insulation system of electrical equipment and conductors. A flashover can cause insulation damage, electric shock, and fire.

2.2.1 *NEMA Surveys*

The NEMA Low Voltage Surge Protective Devices Section (5-VS) sponsored surveys of surge damage in 2013 and 2014.[6] The surveys were targeted towards facility managers and attempted to accomplish the following:

- Determine if SPDs are installed.
- Obtain failure data for electrical or electronic equipment due to a lightning event or voltage surge.
- Determine the frequency of damage incidents.
- Address the type of equipment damaged.
- Summarize the cost of damage.

The following summarizes the 2014 survey results:

- 100 respondents completed the survey.

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[6] NEMA 2013 *U.S. Surge Protection Damage Survey* and NEMA *Surge Damage Survey Results – Wave 2*. Refer to http://www.nemasurge.org for reports.

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- A plurality (48%) of respondents noted that their facility had experienced unexplained process interruptions. Catastrophic failure or damage of electrical or electronic equipment due to a lightning event or voltage surge and premature failure of electrical or electronic equipment were both frequently reported (41%) events. More than a third (38%) noted the occurrence of lockup of computer or industrial process systems.

- For most respondents (61%), it cost less than $10,000 to repair the damage resulting from voltage surges, but a sizable number (16%) reported damage costing in excess of $50,000 to fix.

- Nearly 95% of those who reported having experienced a surge event resulting in equipment damage indicated that they subsequently purchased surge protection. Virtually all of those who did so, purchased immediately or within three months of the event.

- Over 65% reported downtimes associated with voltage surges of 6 hours or more.

- Respondents reported damage or loss of function of the following types of life safety equipment because of voltage surges:

  - Smoke detector (34.7%)
  - CO2 detector (18.7%).
  - Fire alarm system (41.3%).
  - Security system (49.3%).
  - Ground fault circuit interrupters (22.7%).
  - Emergency lighting (32.0%)
  - Emergency generators or backup power (33.3%).
  - Fire pumps (12.0%).
  - Elevators or escalators (24.0%).
  - Safety interlocking systems on machines (26.7%)

  Of the respondents, only 14.7% stated that no life safety equipment was damaged or lost function.

- When asked if anyone had been injured, either directly or indirectly, as a result of a voltage surge, 10.7% replied yes.

The NEMA survey is significant in that it shows the effect of surges on life safety equipment and the potential impact to personnel in a facility.

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2.2.2 *Insurance Information Institute Surveys*

The Insurance Information Institute[7] provides periodic reports of homeowner insurance claims associated with lightning-induced damage. Their report for 2013, produced in collaboration with State Farm®, included the following:

- There were 114,740 insurer-paid lightning claims in 2013, down 24% from 2012.
- The average lightning paid-claim amount was also down in 2013, slipping by 8.3% to $5,869 from $6,400 in 2012.
- The decline in lightning damage last year is consistent with data from the National Weather Service, which recorded 137 days in 2013 with lightning causing property damage, while 160 such days were recorded in 2012—a 14 percent decrease.
- Despite the drop in the number of paid claims in 2013, the average cost per claim rose nearly 122% from 2004-2013. The average cost per claim has generally continued to rise, in part because of the huge increase in the number and value of consumer electronics in homes.

2.3 Surge Protective Devices (SPDs)

2.3.1 *Typical Configuration*

Most SPDs in use for the applications covered by this report use metal oxide varistors (MOVs) to accomplish surge suppression in the electrical power system. MOVs exhibit nonlinear resistance characteristics as a function of voltage. Within the MOV voltage rating, the resistance usually exceeds 10,000,000Ω, but the resistance drops to less than 0.1Ω when the MOV is exposed to an overvoltage, such as a transient voltage spike due to a nearby lightning stroke. It is this characteristic that makes MOVs an effective protection element.

The MOV is essentially a matrix of zinc oxide grain boundaries that have a nonlinear resistance characteristic. The series combination of the boundaries defines the MOV voltage rating, the parallel combination defines the total current that can be passed, and the bulk volume determines how much energy that it can absorb. When an MOV is energized with an AC voltage, resistive and reactive current flows through the highly capacitive disc.

Most SPDs are connected in parallel with the circuit and operate when a transient voltage exceeds the voltage protection rating. Parallel surge protectors have little interaction with the circuit under normal conditions.

A different technology is commonly used for communications lines, referred to as a gas discharge tube (GDT), which is a spark gap type of surge suppression device. When subjected to a surge voltage, the gas discharge tube sparks over, thereby causing an arc to ground. The hermetically sealed tubes used today can have a precise and repeatable turn-on voltage. Gas discharge tubes consist of a spark gap in series with a resistance or varistance to limit the discharge current to safe levels.

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[7] Their reports are accessible at http://www.iii.org/.

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2.3.2 *SPD Classification*

UL 1449 classifies SPDs by type depending, in part, on their location in the system and their level of internal protection:

- Type 1 – Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device. They must have overcurrent protective devices either installed internally on the SPD or included with it. While these are primarily intended for installation before the main service disconnect, Type 1 SPDs can be installed in Type 2 and Type 4 locations such as distribution panels, end-use equipment. Residential installations are often Type 1, installed near the incoming meter.

- Type 2 – Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device; including SPDs located at the branch panel. While some will have internal overcurrent protective components, Type 2 SPDs can rely on the service entrance overcurrent disconnect device for over current protection. These SPDs can be installed in service equipment, distribution panels, and end-use equipment.

- Type 3 – Point of utilization SPDs, installed at a minimum conductor length of 10 meters (30 feet) from the electrical service panel to the point of utilization, for example cord connected, direct plug-in, receptacle type and SPDs installed at the utilization equipment being protected.

- Type 4 – Component SPDs, including discrete components as well as component assemblies.

Permanently installed self-contained SPDs are usually Type 1 or Type 2.

2.3.3 *SPD Ratings*

SPDs are tested and rated in accordance with UL 1449. The following ratings are normally provided for each model and size of SPD:

- Nominal voltage and frequency.

- Maximum continuous overvoltage (MCOV) – defines the voltage at which the SPD will start conducting to ground. Continuous operation above the MCOV will lead to SPD failure.

- Voltage protection rating (VPR) – a UL 1449 rating of the limiting voltage measured during the transient-voltage surge suppression test using the combination wave generator at a setting of 6kV, 3kA. A lower VPR is better.

- Surge current rating – the maximum surge current that an SPD is rated to carry without excessive overheating and consequent premature breakdown or combustion risk. The surge current rating is expressed in thousands of amps (kA) and is an indicator of how many MOVs are installed in parallel inside the device. SPDs are readily available rated for as low as ≤20 kA up to ≥600 kA. SPD price tends to increase as surge current rating increases.

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- Protection modes – line-to-line, line-to-ground, line-to-neutral, neutral-to-ground.
- Short circuit current rating (SCCR).
- Surge life – expected number of surges that the SPD can withstand.

Other important attributes include monitoring and design for the environment at the installation location.

2.4 Residential Surge Protection

Residential surge protection has long been viewed as an important safety consideration and guidance has been issued in the past to help homeowners protect their house and its contents[8]. This protection has often been described as being similar to an insurance policy, partly because there is not an NFPA code requirement for SPD installation in residences. Today's residences often contain electronic equipment throughout, including appliances, computers, security systems, life safety equipment, automation systems for internet-enabled applications, and home entertainment systems.

2.4.1 *Design*

SPDs used in residential applications are typically designed for 240/120 volts with the electrical power neutral bonded to ground at the service entrance. A permanently-installed SPD can be installed at the incoming meter (Type 1) or at the service entrance (Type 2). Type 3 SPDs can still be installed at the point of use for electronic equipment also.

The IEEE document, *How to Protect Your House and Its Contents from Lightning, IEEE Guide for Surge Protection of Equipment Connected to AC Power and Communication Circuits*, provides an excellent overview of the design and installation considerations for SPDs. A permanently-installed SPD should be installed by a qualified electrician and should consider quality of the grounding system, lead length for connections, overcurrent protection, and disconnect capability. Installation in accordance with NFPA 70 is a requirement.

2.4.2 *General Cost*

Prices vary widely for SPDs. An SPD intended for residential use (240/120 volts) and rated for 50 kA surge current can cost as little as $125 and as much as $500. Integrated protection to protect the incoming power lines as well as the phone/internet communication lines can cost an additional $100. A reasonable level of protection can typically be realized for about $500.

One consideration is how high of a surge current rating to specify. Cost tends to increase as the surge current rating increases because of the additional MOV modules that are required. The cost can be considerably higher for three-phase circuits, partly because there are more protection

[8] Key documents include *How to Protect Your House and Its Contents from Lightning, IEEE Guide for Surge Protection of Equipment Connected to AC Power and Communication Circuits*, by Richard L. Cohen and others, ISBN 0-7381-4634-X, 2005 and NIST Special Publication 960-6, *Surges Happen! How to Protect the Appliances in Your Home*, 2001. Some insurance companies also provide guidance on their websites.

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modes to consider compared to a single-phase application and partly because the surge current rating might be higher. For residential applications, a surge current rating above 30 kA likely is adequate for 80% to 90% of lightning strokes.[9] A surge current rating above 60 kA likely is adequate for virtually all lightning strokes. In lightning-prone areas (refer to Figure 2-1), a higher surge current rating can also provide a longer SPD life if it is exposed to repeated surges.

[9] Lightning strokes produce the largest surges.

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3

INDUSTRY STANDARDS

Section 3 provides an overview of industry codes and standards that apply to SPDs.

SPDs are routinely used in facilities that are potentially exposed to voltage or current surges from nearby lightning, utility switching, or other sources; and there are many manufacturers of SPDs and these manufacturers often offer guidance regarding SPD installation ratings and recommended applications. However, industry codes and standards provide limited guidance regarding selection, rating, and application.

One limitation with surge protection design is that there is no industry standard that describes what is an acceptable level of surge protection for standard facilities or residential locations. Although industry codes and standards are available that establish standardized surge criteria and assist with the application of specific surge protector types, these standards do not provide adequate design guidance that ensures a facility is properly protected against surges. There is no existing industry guidance for surge protection of residential facilities.

3.1 NFPA Codes and Standards

3.1.1 *NFPA 70*

NFPA 70 distinguishes between surge arresters for applications over 1,000 volts (Article 280) and SPDs for applications 1,000 volts or less (Article 285). Each Article provides installation requirements.

NFPA 70[10] requires SPDs for the following applications:

- Article 501.35, Surge Protection – required Class I Division 1 and 2 locations.
- Article 694, Wind Electric Systems. Article 694.7(D) requires, "*A surge protective device shall be installed between a small wind electric system and any loads served by the premises electrical system. The surge protective device shall be permitted to be a Type 3 SPD on a dedicated branch circuit serving a small wind electric system or a Type 2 SPD located anywhere on the load side of the service disconnect.*"
- Article 700, Emergency Systems. New Article 700.8, Surge Protection, was added in 2014 and requires, "*A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.*"

[10] The *National Electrical Code® Handbook* provides additional discussion of surge protection requirements.

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- Article 708, Critical Operations Power Systems (COPS). Article 708.20(D) requires, "*Surge protection devices shall be provided at all facility distribution voltage levels*".

- If surge protection is provided, Article 646, Modular Data Centers, requires that SPDS are listed, labeled, and installed in accordance with Article 285.

Article 285 provides requirements regarding the installation of SPDs, but it provides limited guidance for when a SPD is required or recommended ratings. The NFPA 70 Handbook also avoids discussion regarding the application of SPDs. In other words, NFPA 70 provides guidance regarding SPD installation, but provides no information regarding SPD selection and rating.

3.1.2 *NFPA 780*

NFPA 780[11], *Standard for the Installation of Lightning Protection Systems*, is more specific regarding the application of SPDs for lightning protection systems. This standard provides detailed requirements for the application of SPDs in support of a lightning protection system, including SPD rating information. Key requirements include:

- SPDs shall be installed at all power service entrances.

- The SPD shall protect against surges produced by a 1.2/50 µs and 8/20 µs combination waveform generator.

- SPDs at the service entrance shall have a nominal discharge current (I_n) rating of at least 20 kA 8/20 µs per phase.

- Signal, data, and communications SPDs shall have a maximum discharge current (I_{max}) rating of at least 10 kA 8/20 µs when installed at the entrance.

- The published voltage protection rating (VPR) for each mode of protection shall be selected to be no greater than those given in Table 4.20.4 for the different power distribution systems to which they can be connected. The maximum allowed VPR per mode of protection varies from 600 to 1,800 volts, depending on the service voltage and connection type.

- The maximum continuous operating voltage (MCOV) of the SPD shall be selected to ensure that it is greater than the upper tolerance of the utility power system to which it is connected.

- SPDs at grounded service entrances shall be wired in a line-to-ground (L–G) or line-to-neutral (L–N) configuration. Additional modes, line-to-line (L–L), or neutral-to-ground (N–G) shall be permitted at the service entrance. For services without a neutral, SPD elements shall be connected line-to-ground (L–G). Additional line-to-line (L–L) connections shall also be permitted.

[11] NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2014 Edition.

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- Installation of surge suppression hardware shall conform to the requirements of NFPA 70, *National Electrical Code*. SPDs shall be located and installed so as to minimize lead length. Interconnecting leads shall be routed so as to avoid sharp bends or kinks.

Although NFPA 780 only applies to lightning protection systems, it provides clear SPD design, rating, and installation guidance for these systems.

3.2 IEEE Standards

IEEE has historically taken the lead with respect to characterizing the surge environment. The following sections discuss key IEEE documents that apply to SPDs.

3.2.1 *IEEE C62.41.1*

IEEE C62.41.1, *Guide On The Surge Environment In Low-Voltage (1000V And Less) AC Power Circuits*, provides comprehensive information about surges and the environment in which they occur. This guide form the basis for IEEE surge testing criteria and is recommended for any review of surge characteristics. IEEE C62.41.1 is also valuable as a source of recorded data of surge events. Temporary over-voltages are also discussed, including their potential impact on SPDs.

3.2.2 *IEEE C62.41.2*

IEEE C62.41.2, *Recommended Practice On Characterization Of Surges In Low-Voltage (1000V And Less) AC Power Circuits*, presents recommendations for selecting surge waveforms, and the amplitudes of surge voltages and currents used to evaluate equipment immunity and performance of SPDs. The following figures show the surges recommended by IEEE C62.41.2 for consideration.

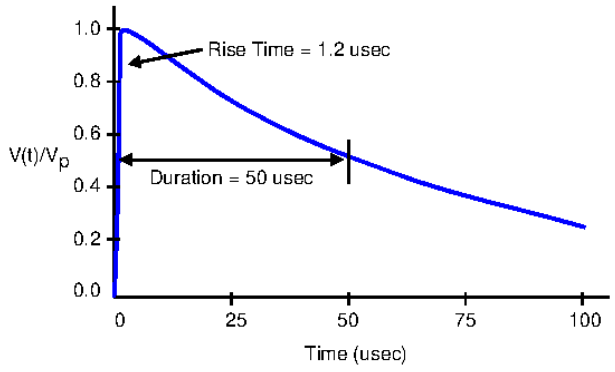


Figure 3-1
Combination Wave—1.2 x 50 µsec, Open Circuit Voltage

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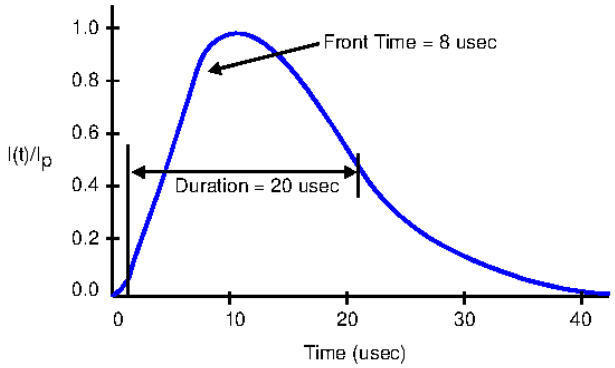


Figure 3-2
Combination Wave—8 x 20 µsec, Short Circuit Current

The second type of IEEE C62.41.2 surge voltage is called a 100 khz ring wave with a waveform below.

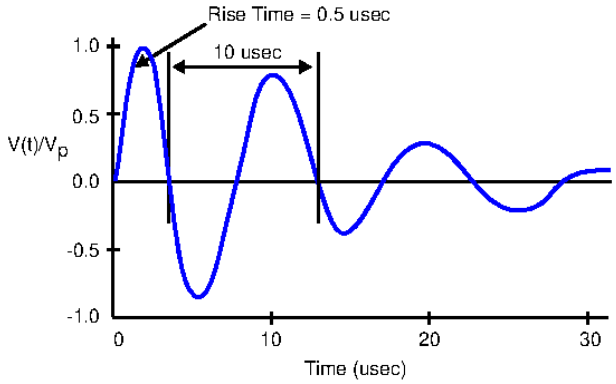


Figure 3-3
100 khz Ring Wave—Open Circuit Voltage

The combination and ring waves are intentionally generic in shape, in that peak magnitudes are not provided. Voltage and current values are assigned according to distance into the distribution system.

3.2.3 *IEEE C62.45*

IEEE C62.45, *Recommended Practice On Surge Testing For Equipment Connected To Low-Voltage (1000V And Less) AC Power Circuits*, describes surge testing procedures using simplified waveform representations (described in IEEE C62.41.2) to obtain reliable measurements and enhance operator safety.

3.2.4 *IEEE 1100*

IEEE 1100, *Powering and Grounding Electronic Equipment*, provides guidance regarding SPDs. Unfortunately, the information provided in IEEE 1100 is dated and does not reflect the current SPD products that arevavailable; much of the information provided is over 15 years old. But,

http://www.floridabuilding.org/Upload/Modifications/Rendered/Mod_7208_Rationale_RFDataAssessmentforElectricalSurgeProtectionDevices_35.png

IEEE 1100 provides a good discussion of surge effects and protecting against surges.

3.2.5 *IEEE 1692*

IEEE 1692, *IEEE Guide for the Protection of Communication Installations from Lightning Effects*, provides design guidelines to help prevent lightning damage to communications equipment within structures.

3.3 UL Documents

3.3.1 *UL 1449*

In the USA, SPDs are manufactured and specified in accordance with UL 1449, Third Edition, *Surge Protective Devices*, which was issued on September 29, 2006 with an effective date of September 29, 2009. This revision to UL 1449 changed how surge protective devices (SPDs) are named, tested, and rated. UL 1449 listing is specifically required by NFPA 780 and SPD listing (presumably to UL 1449) is required by NFPA 70. UL 1449 defines the performance requirements for an SPD; however, it does not address the engineering application of SPDs. UL also addresses additional related product performance criteria in UL 1283, *Electromagnetic Interference Filters*, and the UL 497 series, *Protectors for Fire Alarm Signaling Circuits*.

UL 1449, Third Edition, improved the harmonization of methods with IEC 61643 series, *Low Voltage Surge Protective Devices*, but there still remain some differences in approach between the UL and IEC test methods.

UL 1449, Third Edition, changed testing and rating requirements such that an SPD listed to UL 1449, Second Edition, cannot be compared to an SPD listed to UL 1449, Third Edition; the differences are too significant. Some of the key changes include:

- New performance tests use more surge current, resulting in higher let-through voltages. The older tests were performed at 500 amperes and 6,000 volts. The new tests are performed at 3,000 amperes and 6,000 volts.
- Test results for the new performance tests in the Third Edition are higher than the equivalent tests in the Second Edition, which has resulted in manufacturers changing their product literature. With a surge current of 6 times the Second Edition level, the Third Edition results for let-through voltage must be higher (the let-through voltage or clamping voltage was referred to as suppressed voltage rating in the Second Edition and is referred to as voltage protection rating in the Third Edition).
- Terminology has changed.
- UL 1449 is now ANSI-approved.

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3.3.2 *UL 497*

The UL 497 series, *Protectors for Fire Alarm Signaling Circuits*, provides performance standards and testing procedures for enclosures, corrosion protection, field wiring connections, and components of SPDs, as well as product labeling and installation instructions.

3.3.3 *UL 1283*

UL 1283, *Electromagnetic Interference Filters*, provides requirements for electromagnetic interference (EMI) filters. It addresses filters installed on, or connected to, 600 V or lower voltage circuits and 50-60 Hz frequency. These filters are used to attenuate unwanted radio frequency (RF) signals, such as noise or interference generated from electromagnetic sources. They consist of capacitors and inductors used alone or in combination with each other and may be provided with resistors.

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4

DATA ACQUISITION PLAN

Section 4 provides an overview of the recommended data acquisition plan for SPDs.

4.1 Type of Desired Data

In order to address fully the potential application of SPDs as a code requirement, the following types of data would be especially helpful:

Installations With SPDs Installed

- Characterization of surge events that were successfully diverted without damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that occurred with subsequent damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that resulted in damage or loss of function to life safety equipment.

Installations Without SPDs Installed

- Characterization of surge events that did not cause damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that occurred with subsequent damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that resulted in damage or loss of function to life safety equipment.

Surge Characterization

- Real data recording of lightning-induced surges.
- Real data recording of switching-induced surges, either internally generated (appliances or motors turning on or off) or externally generated (such as capacitor switching).

The problem lies in acquiring the above data, which is the goal of this project. The above information does not really exist, except in a few limited scope studies and in insurance claim documents. Refer to the following sections for more information.

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4.2 Data to Characterize the Nature of Surges

Lightning strokes, either direct, nearby, or some distance away can cause voltage and current surges into a facility. Information is available regarding lightning strokes and their intensity. But, less information is available regarding the extent to which these surges are transmitted into commercial facilities, industrial facilities, or residences. The IEEE paper, *A Field Study of Lightning Surges Propagating Into Residences*[12], provides an outstanding view into the effort needed to acquire even limited amounts of real-world data. This paper provides the following insights:

- When a home appliance malfunctions due to lightning, the relationship between the lightning stroke and the damage is often unclear. The purpose of their study was to complete experimental investigations on lightning surges that flow into residences. SPDs were not installed in these residences.

- Lightning surge waveform detectors were installed in 49 residences and monitored for four years (2003 to 2006). During the four-year observation period, lightning surge waveforms were obtained for a total of 18 lightning stroke events.

- Damage occurred to appliances in 4 of the 18 events. The most severe damage occurred when lightning appeared to have hit an antenna. In this case, currents of 1 kA or greater were recorded at all the measurement points, and many appliances were damaged.

- The home appliances, typically having built-in lightning protective devices with a peak current of 1 kA or higher, broke down at a current peak value of approximately 1 kA or higher, according to the observations.

- The analysis of observation data found that in some cases a ground potential rise causes a lightning surge to flow from the ground of another residence or the ground of a distribution system into the distribution system and, in turn, to flow into another residence.

Notice that the above effort took four years of monitoring at 49 residences to produce recordings of 18 surge events, of which four were severe enough to cause damage to appliances. This illustrates the difficulty of acquiring actual surge data.

4.3 Who Has Data on Surges, Surge Effects, and SPDs

4.3.1 *Surge Data – Lightning Surges*

Vaisala[13] owns and operates the National Lightning Detection Network (NLDN) that provides accurate lightning data information across the USA. And, Vaisala can provide lightning location reports that provide individual cloud-to-ground lightning strikes and the intensity of strike at a specific location on the date of loss. This capability represents the largest and most complete source of lightning surge location and intensity.

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[12] Teru Miyazaki, et al, *A Field Study of Lightning Surges Propagating Into Residences*, IEEE Transactions on Electromagnetic Compatibility, Vol. 52, No. 4, November 2010.

[13] http://www.vaisala.com/en/services/dataservicesandsolutions/lightningdata/Pages/default.aspx

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Data for lightning surges that extend to the inside of facilities is not readily available. Published papers and IEEE C62.41.1 provide information regarding the expected surge levels within a facility or residence, but extensive data is not available.

4.3.2 *Surge Data – Switching Surges*

Switching-related surge data, either internally or externally generated, is sparse. The added difficulty with this data is that these surges often do not cause immediate failure of electrical and electronic equipment; the damage occurs as a cumulative effect.

4.3.3 *Surge Effects – Manufacturers*

Although manufacturers produce SPDs and do a great job of educating consumers regarding their products, very little failure data associated with surges appears to be available from them. NEMA maintains the Surge Protection Institute[14] and they have completed surveys in 2013 and 2014 regarding failures of electrical and electronic equipment caused by surges. Although the sample size is relatively small, the survey results are helpful with respect to historical failures of life safety equipment. Refer to Section 2.2.1 for more information.

4.3.4 *Surge Effects – Consulting Firms*

Many engineering consulting firms assist with evaluations of surge damage in support of insurance claims. However, this data is not compiled in a readily usable manner nor is the data accessible in many cases. Surge data is not typically available.

4.3.5 *Surge Effects – Insurance Claims*

The largest documented source of surge effects is contained within the insurance claim documents for damage caused by surges. The Insurance Information Institute in collaboration with State Farm® produces annual reports of insurance claims associated with lightning-induced damage (refer to Section 2.2.2 for more information). The information contained in these claim reports likely provides additional detail regarding surge effects and the types of damage caused.

4.4 Data Acquisition Plan

There are challenges in obtaining usable data applicable to residential applications, such as:

- Confirming that equipment failures were a direct result of a surge event.
- Establishing any median and upper bounds to actual surge levels since this is not recorded inside facilities.
- Defining the protection improvement realized by applying SPDs.

Given the scarcity of real data relating to surges and the effects of surges, the approach described below is recommended.

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[14] *Refer to http://www.nemasurge.org.*

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4.4.1 *Purpose of Data to Be Obtained*

The purpose of the recommended data acquisition approach is to produce real data regarding damage and injuries caused by surges. This information is intended to assist the NFPA 70 code-making committees with additional technical data to support a decision to require or not require SPDs for the variety of electrical applications proposed in past NFPA 70 update cycles (refer to Section 1.2).

4.4.2 *Lightning Stroke Data*

The starting point for this project is to acquire the nationwide lightning stroke data for the continental USA for 2013 (or 2014 if the project starts in 2015). This information can tie back to insurance claim data and possibly provide surge current values for the locations of interest.

4.4.3 *Insurance Information Institute Claim Data*

The Insurance Information Institute is proposed to manage the insurance industry claim data. Their involvement assures that the insurance industry claim reports can remain confidential while allowing access to additional data that might be contained in the claim reports.

The Insurance Information Institute already publishes annual summaries of the number of lightning-related insurance claims and the claim amount. Additional information of interest that might be available in the claim data includes:

- Date and location of surge event (to establish geographical correlations).
- Electronic equipment and appliances damaged.
- Life safety equipment damaged – smoke detectors, CO or CO_2 detectors, or other equipment.
- Fires caused by surge effects.
- Personal injuries associated with the surge event.
- Presence of or lack of installed SPDs.

Life safety equipment damage, fires caused by surge events, and personal injuries are of particular interest for code-making efforts.

Although the annual Insurance Information Institute survey has historically focused on residential claims, the survey for this project should include commercial and industrial claims also. NEMA assistance and direction with this effort will be helpful.

4.4.4 *NEMA Participation*

NEMA Low Voltage Surge Protective Devices Section (5-VS) participation is recommended for the following:

- Assisting with project scope, including commercial and industrial users.

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- Reviewing the project checklist for the type of information to be obtained from the insurance industry.

- Reviewing failure data report summaries.

- Considering recommended SPD design principles, including the specification of surge protection in low-lightning flash density areas versus high-lightning flash density areas. Should NFPA elect to require SPDs in dwelling units or other applications, then minimum surge protection current limits should also be addressed, similar to the method provided in NFPA 780. As SPD surge current rating increases (and the degree of protection), the SPD cost also increases.

4.4.5 *Why Not Another Test Program?*

The IEEE paper, *A Field Study of Lightning Surges Propagating Into Residences*, illustrates the difficulty with obtaining real data during surge events. Although this study produced very useful results, it took a 4-year period at 49 homes to obtain data for 18 surge events, of which four surge events caused damage to appliances and electronic equipment. This is considered a typical outcome to be expected. A test program sponsored by the Fire Protection Research Foundation is not recommended.

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A

REFERENCES

Appendix A provides a list of references used in the development of this report.

A.1 Industry Standards

IEEE 1100, *Powering and Grounding Electronic Equipment.*

IEEE 1692, *IEEE Guide for the Protection of Communication Installations from Lightning Effects.*

IEEE C62.41.1, *Guide On The Surge Environment In Low-Voltage (1000V And Less) AC Power Circuits.*

IEEE C62.41.2, *Recommended Practice On Characterization Of Surges In Low-Voltage (1000V And Less) AC Power Circuits.*

IEEE C62.45, *Recommended Practice On Surge Testing For Equipment Connected To Low-Voltage (1000V And Less) AC Power Circuits.*

IEEE C62.50, *IEEE Standard for Performance Criteria and Test Methods for Plug-in (Portable) Multiservice (Multiport) Surge-Protective Devices for Equipment Connected to a 120 V/240 V Single Phase Power Service and Metallic Conductive Communication Line(s).*

NFPA 70, *National Electrical Code®*, 2014 Edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2014 Edition .

UL 497 series, *Protectors for Fire Alarm Signaling Circuits.*

UL 1283, *Electromagnetic Interference Filters.*

UL 1449, Third Edition, *Surge Protective Devices*, September 29, 2006.

A.2 NFPA Documents

1. *National Electrical Code® Committee Report on Proposals – 2013 Annual Revision Cycle*, National Fire Protection Association, 2012.

2. Marty Ahrens, *Lightning Fires and Lightning Strikes*, National Fire Protection Association, Fire Analysis and Research Division, June 2013.

http://www.floridabuilding.org/Upload/Modifications/Rendered/Mod_7208_Rationale_RFDataAssessmentforElectricalSurgeProtectionDevices_43.png

A.3 IEEE Documents

1. *How to Protect Your House and Its Contents from Lightning, IEEE Guide for Surge Protection of Equipment Connected to AC Power and Communication Circuits*, by Richard L. Cohen and others, ISBN 0-7381-4634-X, 2005.

2. Lightning and Insulator Subcommittee of the T&D Committee, *Parameters of Lightning Strokes: A Review*, IEEE Transactions on Power Delivery, Vol. 20, No. 1, January 2005.

3. Teru Miyazaki, et al, *A Field Study of Lightning Surges Propagating Into Residences*, IEEE Transactions on Electromagnetic Compatibility, Vol. 52, No. 4, November 2010.

4. Jinliang He, et al, *Evaluation of the Effective Protection Distance of Low-Voltage SPD to Equipment*, IEEE Transactions on Power Delivery, Vol. 20, No. 1, January 2005.

5. Shozo Sekioka, et al, *Simulation Model for Lightning Overvoltages in Residences Caused by Lightning Strike to the Ground*, IEEE Transactions on Power Delivery, Vol. 25, No. 2, January 2010.

6. Joseph Randolph, *Lightning Surge Damage to Ethernet and POTS Ports Connected to Inside Wiring*, IEEE, 2014.

7. Vladimir A. Rakov, *Direct Lightning Strikes to the Lightning Protective System of a Residential Building: Triggered-Lightning Experiments*, IEEE Transactions on Power Delivery, Vol. 17, No. 2, January 2002.

Note: The IEEE Power & Energy Society sponsors the Surge Protective Devices Committee, which provides information associated with their standards. Refer to http://pes-spdc.org.

A.4 NIST Documents

1. NIST Special Publication 960-6, *Surges Happen! How to Protect the Appliances in Your Home*, 2001.

Note: The NIST website provides many historical documents available in the public domain related to surge protection. Although this information is over 10 years old, it is still useful as a reference source. Refer to http://www.nist.gov/pml/div684/spd.cfm.

A.5 NEMA Documents

1. NEMA 2013 *U.S. Surge Protection Damage Survey.*

2. NEMA *Surge Damage Survey Results – Wave 2*, March 2014.

Note: The NEMA Surge Protection Institute maintains a website devoted to low voltage SPDs. Refer to http://www.nemasurge.org.

A.6 Insurance Industry Documents

1. *Lightning Sparks Concern For Insurance Industry; Homeowners Claims Rise Sharply Over Last Five Years*, Insurance Information Institute, March 2010.

2. *Thunderstruck! Average Lightning Claim Costs Up by 25 Percent, But Number of Claims Continues to Fall*, Insurance Information Institute, June 2013.

3. *Number, Cost of Homeowners Insurance Claims From Lightning Fell In 2013; Dry Conditions, Fewer Powerful Thunderstorms A Contributing Factor*, Insurance Information Institute, June 2014.

4. *Lightning,* Insurance Information Institute, August 2014.

5. *Protect Your Property From Power Surges*, State Farm website.

6. *Guidelines for Providing Surge Protection at Commercial Institutional and Industrial Facilities*, The Hartford Steam Boiler Inspection and Insurance Company.

7. *Approval Standard for Transient Voltage Surge Suppression Devices*, FM Approvals.

A.7 Manufacturer's Documents

1. Emerson Network Power Report SL-30119, *Surge Protection Reference Guide*, November 2011.

A.8 Miscellaneous Documents

1. A. Ametani,, et al, *Surge Voltages and Currents into a Customer due to Nearby Lightning*, International Conference on Power Systems Transients (IPST"07) June 2007.

2. Schneider Electric Data Bulletin DB03A, *Surge Protection: Measured Lightning Stroke Data*.

3. Al Martin, *Lightning Induced GPR, Why it's a problem, characteristics and simulation*, In Compliance, June 2012.

4. Thomas Key, et al, *Update on a Consumer-Oriented Guide for Surge Protection*, Proceedings, PQA'99 Conference, May 1999.

5. François D. Martzloff, et al, *The Role and Stress of Surge-Protective Devices in Sharing Lightning Current*, EMC Europe 2002, September 2002.

6. Arshad Mansoor, et al, *The Dilemma of Surge Protection vs. Overvoltage Scenarios: Implications for Low-Voltage Surge-Protective Devices*, Proceedings, 8th Annual Conference on Harmonics and Quality of Power, October 1998.

7. Air Force Manual 32-1181, *Design Standards for Interior Electrical Systems*.

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B

ACRONYMS

Appendix B provides a list of the abbreviations and acronyms used in this report.

EMI – Electromagnetic interference.

FPRF – Fire Protection Research Foundation.

GDT – Gas discharge tube.

GPR – Ground potential rise.

Hz – Hertz.

III – Insurance Information Institute.

kA – Thousands of amperes.

khz – Kilo-hertz.

L–G – Line-to-ground.

L–L – Line-to-line.

MCOV – Maximum continuous operating voltage.

MOV – Metal oxide varistor.

N–G – Neutral-to-ground.

NEMA – National Electrical Manufacturers Association.

NLDN – National Lightning Detection Network.

NFPA – National Fire Protection Association.

NIST – National Institute of Standards and Technology.

pu – Per unit.

SAD – Silicon avalanche diode.

SCCR – Short circuit current rating.

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SPD – Surge protective device.

TOV – Temporary overvoltage.

TVSS – Transient voltage surge suppressor (no longer used – replaced by SPD).

UL – Underwriter's Laboratories.

µsec – Micro-second.

VPR – Voltage protection rating.

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E7205

9

Date Submitted	11/6/2018	**Section**	405.6.3	**Proponent**	Bryan Holland
Chapter	4	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation No Affirmative Recommendation
Commission Action Pending Review

Comments

General Comments Yes **Alternate Language** No

Related Modifications

Summary of Modification

This proposed modification revises the voltage drop requirement to include "customer-owned service conductors" in addition to feeder conductors and branch circuit conductors.

Rationale

The current requirement for voltage drop does not include customer-owned service conductors which in long runs can result in significant voltage drop. The term “conductors” has been added to feeder and branch circuit to add clarity. A definition of "voltage drop&" is being added to harmonize the Florida Energy Code with the IECC and ASHRAE 90.1 Standard.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will have no impact to the local entity relative to code enforcement.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will ensure customer-owned service conductors are included in the voltage drop calculation to prevent unnecessary losses in the complete premises wiring systems.

Impact to industry relative to the cost of compliance with code

This proposed modification could result in an increased cost of compliance if the designer chooses to increase the customer-owner service conductors in response to excess voltage drop.

Impact to small business relative to the cost of compliance with code

This proposed modification should not have an impact on small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected with the health, safety, and welfare of the general public.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves the code by adding a needed definition and revising the prescriptive language of the section to include all conductors on the premises-wiring side of the electrical installation.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code.

2nd Comment Period

Proponent Bryan Holland **Submitted** 5/21/2019 **Attachments** No

E7205-G2

Comment:

Please reconsider this proposed modification for approval. The revised language simply adds "customer-owned service conductors" to the voltage drop requirement as previously required in earlier editions of the FBC Energy Conservation Code. Excluding these premises wiring conductors from the calculation can results in excess energy losses on the system before a single load is being supplied. Please be advised the ICC Commercial Energy Code Development Committee unanimously voted 15-0 to approve Proposal CE214-19 during the ICC Group B Committee Action Hearings. This will keep the Florida Energy Code aligned with the IECC-C.

2nd Comment Period

E7205-G3

Proponent	Jennifer Privateer	Submitted	5/22/2019	Attachments	No

Comment:
agreed as modified

2nd Comment Period

E7205-G4

Proponent	Jennifer Privateer	Submitted	5/22/2019	Attachments	No

Comment:
I agree

2nd Comment Period

E7205-G5

Proponent	Harold Barrineau	Submitted	5/25/2019	Attachments	No

Comment:
I agree this is a good modification

2nd Comment Period

E7205-G6

Proponent	Harold Barrineau	Submitted	5/25/2019	Attachments	No

Comment:
I agree with this modification

1st Comment Period History

E7205-G1

Proponent	Vincent Della Croce	Submitted	1/8/2019	Attachments	No

Comment:
I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

C405.6.3 Voltage drop. ~~The conductors for feeders and branch circuits combined shall be sized for a maximum of 5 percent voltage drop total.~~ The total voltage drop across the combination of customer-owned service conductors, feeder conductors, and branch circuit conductors shall not exceed 5 percent.

Add to Section C202 Definition:

VOLTAGE DROP. A decrease in voltage caused by losses in the wiring systems that connect the power source to the load.

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E7206

Date Submitted	11/6/2018	**Section**	405.6.1	**Proponent**	Bryan Holland
Chapter	4	**Affects HVHZ**	No	**Attachments**	No

TAC Recommendation No Affirmative Recommendation
Commission Action Pending Review

Comments

General Comments Yes **Alternate Language** No

Related Modifications

Summary of Modification

This proposed modification revises the section to clarify that compliance with Section 8 Power of the ASHRAE Standard 90.1 is required by Section 405.6.1

Rationale

The purpose of this proposed modification is to align the code with DS 2016-033 and further clarify that Section 8 Power of the ASHRAE Standard 90.1 is the part being referenced by C405.6 Electric power. The revised language will assist those designing, installing, or enforcing the requirements of the Florida Energy Code.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will assist the local entity when enforcing the requirement of the Florida Energy Code by clarifying exactly what requirements in the ASHRAE Standard 90.1 are applicable to C405.6.1 compliance.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will ensure building and property owners have electric distribution systems installed in compliance with both C405.6 of the FBC-EC and Section 8 of ASHRAE Standard 90.1.

Impact to industry relative to the cost of compliance with code

This proposed modification will not change the cost of compliance with the code.

Impact to small business relative to the cost of compliance with code

This proposed modification will have no impact to small business.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification is directly connected to the health, safety, and welfare of the general public by ensuring electrical power distribution in buildings meet the requirements of the code.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification improves the code by clarifying the section and giving a pointer to the specific section of ASHARE Standard 90.1 that is applicable.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code by clarifying the rule.

2nd Comment Period

E7206-G2

Proponent Bryan Holland **Submitted** 5/21/2019 **Attachments** No

Comment:

Please reconsider this proposed modification for approval. The current language is vague, confusing, and not well understood in the field. The revised language adds a pointer to the specific requirements in the ASHRAE standard that are applicable as clearly indicated in Declaratory Statement DS2016-033. It should be noted the Electrical TAC has recommended this modification for approval unanimously 9-0. The electrical industry is the most impacted by the rule and with this vote has shown the need for the code change.

1st Comment Period History

E7206-G1

Proponent Vincent Della Croce **Submitted** 1/8/2019 **Attachments** No

Comment:

I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

C405.6 Electrical power (Mandatory).

C405.6.1 Applicability.

This section applies to all building power distribution systems. The provisions for electrical distribution for all sections of this code are subject to ~~the design conditions~~ the requirements of Section 8 Power in ASHRAE Standard 90.1.

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Sub Code: Residential

E7207

11

Date Submitted	11/7/2018	**Section**	328	**Proponent**	Bryan Holland
Chapter	3	**Affects HVHZ**	No	**Attachments**	Yes

TAC Recommendation No Affirmative Recommendation

Commission Action Pending Review

Comments

General Comments **No**

Alternate Language **Yes**

Related Modifications

7208

Summary of Modification

This proposed modification will add mandatory surge protection requirements to buildings under the scope of the FBC-R.

Rationale

This revision is intended to address the recognized need for surge protection to protect the sensitive electronics and systems found in most modern appliances, safety devices (such as AFCI, GFCI and smoke alarms) and equipment used in dwellings. Additionally, the expanding use of distributed energy resources (DER) within electrical systems often results in more opportunity or greater exposure for the introduction of surges into the system.

Electronic life-saving equipment such as fire alarm systems, IDCI's, GFCI's, AFCI's and smoke alarms, may be damaged when a surge occurs due to lighting, internal local switching as well as external utility switching. Other equipment is also damaged when subjected to surge. In many cases, electronic devices and equipment can be damaged and rendered inoperable by a surge and yet this damage is undetected by the owner. It is practical to require a SPD to provide a general level of protection. In almost all new service installations, as well as service upgrades, no consideration is given to providing a general level of protection to the "whole structure" which would include those devices that cannot be afforded a cord connected Type 3 SPD protection. R328.4 is included to require that when a service is upgraded, an SPD is to be installed.

Studies by recognized authorities including NEMA, IEEE, and UL, all substantiate the fact that surges can and do cause significant damage. Nationwide Insurance organizations recognize the need for effective surge protection as well and have published recommendations that include point-of-use surge protectors and installation of surge protection at service equipment.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This proposed modification will require additional enforcement requirements related to electrical services. The impact will be minor.

Impact to building and property owners relative to cost of compliance with code

This proposed modification will increase the cost of compliance to building and property owners where the cost of providing a mandatory SPD is passed-on to the consumer.

Impact to industry relative to the cost of compliance with code

SPDs are available with a large variety of ratings, configurations, and options. The cost can be as low as $25 per device to several hundred-dollars where higher levels of protection or other performance features are selected.

Impact to small business relative to the cost of compliance with code

This proposed modification will increase the cost to small business owners where the cost of providing a mandatory SPD is passed-on to the consumer.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This proposed modification will enhance the health, safety, and welfare of the general public by reducing the negative impacts of transient surges to a building's premises wiring system and equipment.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This proposed modification strengthens and improves the code by closing an essential life and property saving protection gap in the current code.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This proposed modification does not discriminate against any material, product, method, or system of construction.

Does not degrade the effectiveness of the code

This proposed modification enhances the effectiveness of the code by adding life and property saving surge protection.

2nd Comment Period

E7207-A1

Proponent Bryan Holland **Submitted** 5/21/2019 **Attachments** Yes

Rationale

This alternative language comment addresses the concerns made by the public and the TAC by adding an exception to the rule where the NFPA 780 Risk Assessment indicates surge protection would not be needed based on the low risk of exposure to the hazard of lightning. Please see the rationale submitted with the original modification and the guide attached to this comment on how to specify surge protection.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This alternative language comment will have little to no impact on the local entity.

Impact to building and property owners relative to cost of compliance with code

This alternative language comment will increase the cost of code compliance for those buildings that would benefit from surge protection as determined by risk assessment. The most expensive SPD on the market today costs less than the average lightning damage insurance claim in the state of Florida.

Impact to industry relative to the cost of compliance with code

This alternative language comment will have no impact on industry.

Impact to Small Business relative to the cost of compliance with code

This proposed modification will increase the cost to small business owners where the cost of providing a mandatory SPD is passed-on to the consumer.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This alternative language comment improves the health, safety, and welfare of the general public by providing surge protection where it will be most beneficial in reducing damages and losses to transient energies.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This alternative language comment strengthens the code by adding additional protective measures against a real and serious hazard to electrical systems.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This alternative language comment does not discriminate against any materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This alternative language comment enhances the effectiveness of the code.

1st Comment Period History

E7207-G1

Proponent Vincent Della Croce **Submitted** 1/8/2019 **Attachments** No

Comment:

I support the proposed modification as it will ensure the Code includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

Section R328
Surge Protection

R328.1 Surge Protective Device.
All services supplying buildings under the scope of this code shall be provided with a surge protective device (SPD).

R328.2 Location.
The surge protective device shall be an integral part of the service equipment or shall be located immediately adjacent thereto.

Exception: The surge protective device shall not be required to be located in the service equipment if located at each next level distribution equipment downstream toward the load.

R328.3 Type.
The surge protective device shall be a Type 1 or Type 2 SPD.

R328.4 Replacement.
Where service equipment is replaced, all of the requirements of this section shall apply.

Exception:

Surge protection shall not be required where determined to be unnecessary by evaluation using the Risk Assessment Guide in NFPA 780, Standard for the Installation of Lightning Protection Systems or an alternative method approved by the authority having jurisdiction.

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Section R328
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Exception: The surge protective device shall not be required to be located in the service equipment if located at each next level distribution equipment downstream toward the load.

R328.3 Type.
The surge protective device shall be a Type 1 or Type 2 SPD.

R328.4 Replacement.
Where service equipment is replaced, all of the requirements of this section shall apply.

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NEMA SPD 1.1-2019

Part 1—Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems

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Rosslyn, Virginia 22209

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Foreword

This foreword is not part of NEMA SPD1.1—*Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems—Part 1*.

A properly derived and professionally presented product specification enhances the credibility of a manufacturer as it clarifies and verifies the characteristics and capabilities of their product. A manufacturer should completely describe the product by using an accurate product specification sheet.

This guide represents the consensus of NEMA's Low Voltage Surge Protective Device (SPD) Section 5VS. It is intended to serve primarily as a guide for those who use or specify SPDs and others affiliated with the Low Voltage SPD marketplace so that uniformity of specifications, in terms of valid, understandable parameters, will improve the comprehension, application, and utilization of SPDs. The parameters will be defined in adequate detail to allow the user to make a proper interpretation of the relevant specifications and evaluation of aspects necessary for the application. The methods associated with their measure or derivation will be referenced, though most are extensively addressed, since adequate procedural definition and discussion is already available in NEMA, ANSI, IEEE, UL and IEC technical publications.

Historically, SPDs have been known as a Transient Voltage Surge Suppressors (TVSS) or Secondary Surge Arresters (SSA). To harmonize with modern technical literature and international nomenclature, the term "Surge Protective Device" or "SPD" has been adopted to refer to the same product.

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Technical Director, Operations
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

The information detailed in this guide is intended to identify the system compatibility and performance ratings of a surge protective device (SPD) that should be addressed by the manufacturer of the SPD. As such, the ratings detailed herein may not apply to every SPD and/or SPD application. In other applications, the complete list of ratings detailed herein, plus others, may be required to meet the protection needs of the end-use equipment or power distribution system.

For safety requirements of the SPD (i.e., electric shock, overcurrent protection and protection against fire hazard) this document references testing and evaluation to the appropriate safety standards. In the US, the primary standard is ANSI/UL 1449. In Canada, the primary standard is CSA C22.2, No. 269 series. In some countries, the primary standard is IEC 61643-11. The requirements of the above standards do not evaluate the effect of SPDs on connected loads, the effect of SPDs on harmonic distortion of the supply voltage, the degree of attenuation provided by SPDs, nor the adequacy of the Voltage Protection Rating of SPDs to protect specific connected equipment from upset or damage.

This Specification Guide supersedes the rescinded LS1-1992 Standard.

References to the *National Electrical Code*® (NEC) are from the 2017 Edition unless otherwise indicated. NFPA 70®, *National Electrical Code*® and NEC are registered trademarks of the National Fire Protection Association, Quincy, MA.

This document consists of: a) Specifications Introduction—Terms, definitions and acronyms, b) Specification documentation, c) SPD ratings, and d) Specification Format—a standard format is

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presented for specifying, defining requirements and reporting SPD specifications and applications. This Specification Guide was developed by NEMA Low Voltage Surge Protective Devices Section (5VS). The section approval of the guide does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the section was composed of the following members:

ABB Industrial Solutions	Plano, TX
ABB Power Protection, LLC.	Richmond, VA
ASCO Power Technologies	Clearwater, FL
CITEL Inc.	Miramar, FL
Eaton Corporation	Pittsburgh, PA
Emerson Automation Solutions	Rosemont, IL
Hubbell Inc.	Shelton, CT
Legrand/Pass & Seymour	Syracuse, NY
Leviton Manufacturing	Chula Vista, CA
Littelfuse, Inc.	Chicago, IL
Mersen USA	Newburyport, MA
MVC-Maxivolt	Amarillo, TX
Pentair Engineered Electrical & Fastening Solutions	Solon, OH
Phoenix Contact	Middletown, PA
Raycap, Inc.	Post Falls, ID
Schneider Electric USA	Salt Lake City, UT
Siemens Industry, Inc.	Norcross, GA
Southwire Company	Clearwater, FL
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Surge Suppression, LLC	Brooksville, FL

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Section 1
General

1.1 Scope

This specification guide is Part 1 of a series of such guides that is intended to provide guidance on the evaluation, specification and/or use of surge protective devices (SPDs) deployed in low voltage power distribution system applications. This specification guide describes a uniform specification methodology for SPDs, containing at least one non-linear component, that are connected to or within a 50/60 Hz power distribution equipment that is rated up to 1000 Vac. Such SPDs are specifically intended to mitigate the transient overvoltage effects to end-use equipment.

This guide is not intended to introduce new standards, derive tests, create an evaluation methodology, or define extensive vocabulary. It is intended to guide those who are evaluating and/or comparing the essential parameters of SPDs. The parameters being compared are measurable using available commercial test equipment and/or established standards and measurements as referenced in Section 1.2.

1.1.1 Purpose

The purpose of this specification guide is to complete the Specification Checklist included in Section 4. Sections 1-3 and the included annexes are to provide guidance and definition for the compilation of the data required to complete the Specification Checklist.

> Note: Locating the checklist at the end of the guide encourages the user to consider the guidance provided ahead of the checklist.

1.2 References

The following publications are adopted in part, by reference in this publication, and are available from the organizations below.

1.2.1 Normative References

The following normative documents contain provisions, which through reference in this text, constitute provisions of this standards publication. By reference herein, these publications are adopted, in whole or in part as indicated, in this standards publication.

The Institute of Electrical and Electronics Engineers
Three Park Avenue
New York, NY 10016-5997 USA

ANSI/IEEE Std. C62.41.2	*IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits*
ANSI/IEEE Std. C62.45	*IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits*
ANSI/IEEE Std. C62.62	*IEEE Standard Test Specifications for Surge-Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low Voltage (1000 V and less) AC Power Circuits*
ANSI/IEEE Std. C62.72	Guide for the Application of Surge-Protective Devices for Use on the Load Side of the Service Equipment in Low-Voltage (1000 V or Less, 50 or 60 Hz) AC Power Circuits

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ANSI C84.1	*Electrical Power Systems and Equipment—Voltage Ratings (60Hz).*
NEMA 250	*Enclosures for Electrical Equipment (1000 Volts Maximum)*

Underwriters Laboratories
333 Pfingsten Road
Northbrook, IL 60062-2096 U.S.A.

ANSI/UL 1449	*Standard for Safety - Surge Protective Devices*

1.3 Definitions

Category A, B, or C: Categories (as defined by ANSI/IEEE Std. C62.41.2) used to classify the expected electrical surge environment at which the SPD might be installed. Category A refers to power outlets and long branch circuits. Category B refers to short branch circuits near the branch distribution panel, and those feeders approaching the service entrance panel. Category C refers to the area where external power services or the primary service entrance panel to the facility to those feeders approaching the distribution panel.

Combination Wave: A surge delivered by a generator which has the inherent capability of applying a 1.2/50 µs voltage wave across an open circuit, and delivering an 8/20 µs current wave into a short-circuit. The exact wave that is delivered is determined by the generator and instantaneous impedance to which the combination surge is applied.

Degradation: Change of original performance parameters as a result of exposure of the SPD to surge, service, or unfavorable environment. (ANSI/IEEE C62.62-2010)

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In-Line SPD: A two-port surge-protective device (SPD) connected in series between the power supply and a load where the load current passes through the conductive terminals of the SPD such that the removal of the SPD opens the circuit but has no intended impedance. (ANSI/IEEE C62.62-2010).

Note: 1—In-line SPDs were formerly referred to as “Kelvin-Connected SPDs.”
Note: 2—ANSI/IEEE C62.62-2010. Reprinted with permission from IEEE. Copyright IEEE 2010 - All Rights Reserved.

Leakage Current: Current flowing from the live parts of the installation to earth, in the absence of an insulation fault.

Listed (certified): Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production listed equipment or materials or periodic evaluation of services, and whose listing states that the equipment, material, or services either meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Maximum Continuous Operating Voltage (MCOV): The maximum rms voltage that may be continuously applied to the SPD for each connected mode.

Note: MCOV is evaluated by the certifier and is published as part of the product certification. The symbol, U_C, is used in some international standards to represent MCOV.

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Measured Limiting Voltage (MLV): The maximum magnitude of voltage that is measured across the leads, terminals, receptacle contacts, or similar locations of the SPD during the application of impulses of a specified wave shape and amplitude.

Mode of Protection: An SPD's protective component(s) might be connected wherever defense is desired against transient over voltages. These can include Line to Neutral (L-N), Line to Ground (L-G), Line to Line (L-L) and Neutral to Ground (N-G).

Nominal Discharge Current (i_n) Rating: Peak value of the surge current through the SPD, selected by the manufacturer from a list of predetermined values, having a short-circuit current wave shape of 8/20 µs where the SPD remains functional after 15 surges

Note: Nominal Discharge Current Rating is evaluated by the certifier and is published as part of the product certification.

Nominal System Voltage (V_O): A value assigned to designate a system of a given voltage class in accordance with ANSI C84.1, Table 1.

Open-Type SPD: A Type 1, 2 or 3 SPD, with an incomplete or partial enclosure and with field wiring terminals and/or leads, suitable for field installation, in accordance with the ANSI/NFPA 70 - National Electrical Code®, within a suitable enclosure. (ANSI/UL 1449)

Note: References to the National Electrical Code® (NEC®) are from the 2017 Edition unless otherwise indicated. NFPA 70®, *National Electrical Code®,* and *NEC®* are registered trademarks of the National Fire Protection Association, Quincy, MA.

One-Port SPD: A surge protective device (SPD) connected in shunt with the circuit to be protected. (ANSI/IEEE Std C62.62)

Rated Load Current (I_L): Maximum continuous rated rms current that can be supplied to a load connected to the output of a two-port or in-line SPD.

Secondary Surge Arrester (SSA): An SPD intended for connection on the line side of the service equipment that has not been listed/certified to ANSI/UL 1449.

Note: The term secondary surge arrester is a legacy term (often used by utilities). The term Type 1 SPD is intended to replace this term.

Service Equipment: The necessary equipment, consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the utility electric system and intended to constitute the main control and disconnect of the utility electric system. (NFPA 70®-2017, National Electrical Code®)

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Short-Circuit Current Rating (SCCR): The suitability of an SPD for use on an AC power circuit that is capable of delivering not more than a declared rms symmetrical current at a declared voltage during a short-circuit condition. (ANSI/UL 1449)

Note: Often short-circuit current ratings are confused with surge current ratings. The two ratings are not the same.

SPD Enclosure Protection Rating: Describes the degree of environmental protection provided by the enclosure per NEMA 250 of the SPD final assembly as it leaves the manufacturing facility and is installed per manufacturers' recommendation.

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SPD Location: The intended placement of the SPD, either external or internal to power distribution or end-use equipment.

Note: See also IEEE Category Locations A, B, C.

SPD Types: A term originating from ANSI/UL 1449 to describe the intended application location of the SPD, either upstream or downstream of the main overcurrent protective device of the facility. Refer to the definitions for Type 1, Type 2, and Type 3 SPDs, Type 4 Component Assembly, and Type 5 Components.

Status Indicator: A device that indicates the operational condition of an SPD, or a part of an SPD.

Surge Protective Device (SPD): A device that contains at least one nonlinear component and is intended to limit surge voltages and divert surge currents.

Type 1 SPD: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and Molded Case SPDs intended to be installed without an external overcurrent protective device. (ANSI/UL 1449)

Type 1 Component Assembly: Consists of a Type 4 Component Assembly with internal short-circuit protection or [safety] disconnector that is intended for use as a Type 1 SPD. (ANSI/UL 1449)

Note: Type 1 Component Assemblies are recognized components rather than listed/certified. These components assemblies have conditions of acceptability that are usually related to having exposed terminals or the requirement to be installed within another enclosure.

Type 2 SPD: A permanently connected SPD intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel and Molded Case SPDs. (ANSI/UL 1449)

Type 2 Component Assembly: Consists of a Type 4 Component Assembly with internal or external short-circuit protection or [safety] disconnector that is intended for use as a Type 2 SPD. (ANSI/UL 1449)

Note: Type 2 Component Assemblies are recognized components rather than listed/certified. These components assemblies have conditions of acceptability that are usually related to having exposed terminals, the requirement to be installed within another enclosure or a requirement for external/supplemental overcurrent protection.

Type 3 SPD: Point of utilization SPDs, installed at a minimum conductor length of 10 m (30 ft) from the electrical service panel (service equipment) to the point of utilization - for example, cord-connected, direct plug-in, receptacle type, and SPDs installed at the utilization equipment being protected. (ANSI/UL 1449)

Note: The distance (10 m) is exclusive of conductors provided with or used to attach SPDs. If the Nominal Discharge Current test is performed on a Type 3 SPD, the minimum distance from the service equipment does not apply.

Type 3 Component Assembly: Consists of a Type 4 Component Assembly with internal or external short-circuit protection or [safety] disconnector that is intended for use as a Type 3 SPD. (ANSI/UL 1449)

Note: Type 3 Component Assemblies are recognized components rather than listed/certified. These components assemblies have conditions of acceptability that are usually related to having exposed terminals, the requirement to be installed within another enclosure or a requirement for external/supplemental overcurrent protection.

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Type 4 Component Assembly: Component assembly consisting of one or more Type 5 components together with a [safety] disconnector (integral or external) or a means of complying with the limited current abnormal overvoltage tests. (ANSI/UL 1449)

Type 5 Component: Discrete component surge protective components, (such as MOVs, gas [discharge] tubes, ABDs, etc.) that may be mounted on a printed wiring board, connected by its leads or provided within an enclosure with mounting means and wiring terminations. (ANSI/UL 1449)

Two-port SPD: SPD with two sets of terminals, input, and output. A specific series impedance is inserted between these terminals. (ANSI/IEEE C62.62-2010)

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Voltage Protection Rating (VPR): A rating per ANSI/UL 1449, signifying the average Measured Limiting Voltages of a mode of protection within an SPD when the SPD is subjected to the surge produced by a 6 kV, 3 kA Combination Waveform generator.

Note: The VPR is determined by averaging the Measured Limiting Voltages of a particular mode and selecting the next highest rating from a list of preferred values. The VPR is evaluated by the certifier and is published as part of the product certification.

Voltage Regulation (V_L): A variation in the output voltage of a two-port or in-line SPD when subjected to maximum rated load condition, measured in percent of the source voltage applied to the input terminals of the SPD.

1.4 Acronyms

ABD	Avalanche Breakdown Diode
AC	Alternating Current
ANSI	American National Standards Institute
GDT	Gas Discharge Tube
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
MCOV	Maximum Continuous Operating Voltage
MLV	Measured Limiting Voltage
MOV	Metal Oxide Varistor
NEC®	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
OSHA	Occupational Safety and Health Administration
PDS	Power Distribution System
RMS	Root Mean Square
SCCR	Short-Circuit Current Rating
SP	Standards Publication
SPC	Surge Protective Component
SPD	Surge Protective Device
SSA	Secondary Surge Arrester
TVSS	Transient Voltage Surge Suppressor
UL	Underwriters Laboratories
VPR	Voltage Protection Rating

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Section 2
SPD Specification Documentation

For each SPD specified, documentation of the product's performance and safety are to be provided. The system compatibility and product performance characteristics of an SPD are:

a. Nominal system voltage (V_O)
b. Power distribution system configuration of the SPD
c. SPD Type
d. SPD Location
e. Rated load current (I_L) (two-port and In-line SPDs only)
f. Voltage regulation (V_L) (two-port and In-line SPDs only)
g. Maximum Continuous Operating Voltage (MCOV)
h. Short Circuit Current Rating (SCCR)
i. Voltage Protection Rating (VPR)
j. Measured Limiting Voltage(s) and the description of the test(s) used
k. Modes of protection
l. SPD enclosure rating
m. SPD Safety Agency Certifications
n. Nominal Discharge Current (I_N)
o. Description of external SPD safety disconnector (if required)
p. Surge Current Rating
q. Leakage Current
r. Status Indicator

For each SPD performance characteristic specified, the following information should be included if requested:

a. The test procedures used
b. A checklist detailing the features of the SPD that were installed during the testing of the device, e.g., fuses, circuit breakers, capacitors, status circuitry, etc.
c. The test results that show compliance to the published specifications
d. Agency Approvals

Note: Although this NEMA Guide does not require independent third-party testing, a list of nationally recognized testing laboratories (NRTL's) are identified by OSHA at http://www.osha.gov/dts/otpca/nrtl/

Documentation that provides evidence of the SPD performance characteristics should include relevant test procedures, atmospheric conditions, test equipment, measurement methods, calibration data, performance data, summary results, and any additional support information required to analyze the performance of the SPD under specific conditions.

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Section 3
SPD Ratings

3.1 Introduction

There are two sets of ratings for an SPD. Some ratings relate to the operating system (Section 3.2) in which the SPD is to be installed and are used to coordinate the SPD with the power distribution system at the point of application. Others relate to SPD performance (Section 3.3). These characteristics include features of the SPD and its ability to limit specific transients. It is highly recommended that the grounding and bonding system be verified.

3.2 SPD Ratings Related to the Operating System

System-related operating ratings are required to ensure that the SPD specified or chosen is appropriate for the installation location in the power distribution system within a facility. The system related operating ratings for the SPD include:

a. Power distribution system configuration of the SPD and Nominal system voltage (V_O)
b. SPD Location and Type
c. Maximum Continuous Operating Voltage (MCOV)
d. Short Circuit Current Rating (SCCR)
e. Rated load current (I_L), (two port and in-line SPDs only)
f. Voltage regulation (V_L), (two port and in-line SPDs only)

It is important to note that the correct selection of the ratings for the SPD depends on the configuration of the power distribution system to which it is connected.

3.2.1 Power Distribution System Configuration and Nominal System Voltage

The power system configuration of the SPD dictates what type of power distribution system to which it can be applied. This configuration is commonly part of the nomenclature or description of the SPD itself. When specifying an SPD, the configuration of the SPD should match the configuration of the power distribution system. Further, in some cases such as the ungrounded delta system, the SPD must be specifically listed for this power system configuration as noted in NFPA 70 Article 285.3(2). Examples of power distribution system and SPD configurations are given below. Often these are referred to more generically as a “single phase,” “wye” or “delta” connected SPD.

Nominal System Voltage (V_O) is a value assigned to designate a system of a given voltage class in accordance with ANSI C84.1, Table 1.

A non-exhaustive list of example power distribution system configurations and nominal system voltages is provided in Table 3-1.

Table 3-1
Common Power Distribution System Voltages

Nominal System Voltage	Power Distribution System Configuration	Number of Conductors
120	Single phase	2W+G
120D	3-phase ungrounded delta	3W+G
127	Single phase	2W+G
120/240	Single (split) phase	3W+G
208Y/120	3-phase wye	4W+G
208D	3-phase ungrounded delta	3W+G
220Y/127	3-phase wye	4W+G
220	Single phase	2W+G

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Nominal System Voltage	Power Distribution System Configuration	Number of Conductors
230	Single phase	2W+G
240	Single phase	2W+G
240D/120	3-phase high-leg delta	4W+G
240D	3-phase ungrounded delta	3W+G
240D	3-phase corner grounded delta	3W+G
380Y/220	3-phase wye	3W+G
400Y/230	3-phase wye	4W+G
480Y/277	3-phase wye	4W+G
480D	3-phase ungrounded delta	3W+G
480D	3-phase corner grounded delta	3W+G
600Y/347	3-phase wye	4W+G
600D	3-phase ungrounded delta	3W+G

All points within the power distribution system, including the SPD, are to be installed and maintained in accordance with the local code and/or appropriate national electrical code.

3.2.2 SPD Locations and Types

SPDs (including Open-Type SPDs) can be located throughout the power distribution system. They can be connected upstream (on the line or utility side) of the service equipment or downstream (on the load side) of the service equipment for the facility. In either case, the local code and/or appropriate national electrical code govern the applications of SPDs in these locations.

SPD installation locations are referred to by SPD Type in ANSI/UL 1449. SPDs permitted to be installed on the line side of the service equipment are denoted as Type 1 SPDs and Open-Type 1 SPDs. Type 1 SPDs are also permitted to be installed on the load side of the service equipment. Type 2 SPDs and Open-Type 2 SPDs are only permitted to be installed on the load side of service equipment and might require an external safety disconnector. Type 3 SPDs and Open-Type 3 SPDs are installed on the load side of the service equipment. Type 1, 2 and 3 SPDs, Open-Type 1, 2, and 3 SPDs, and Component Assemblies are marked with Voltage Protection Ratings (VPRs) when listed/certified to ANSI/UL 1449.

> Note: The terms “service equipment” and “service disconnect” are used interchangeably in Clause 285 of the NEC (2017 revision). Therefore, references in this standard to the “service equipment” are to be understood to include what is referred to as the “service disconnect.”

Another recent addition to the UL SPD types are the Open-Type SPDs. For example, an Open-Type 1 SPD is similar to a Type 1 SPD except that it does not have a complete enclosure. The SPD must meet the full requirements like that of a complete SPD, but it is intended to be installed into an existing enclosure. The Open-Type 1 SPD must have suitable field or factory wiring terminations included on the device.

> Note: Although outside the scope of this standard, Type 4 Component Assemblies and Type 5 Components are defined as partial assemblies or surge protective components that require additional packaging and testing in order to be installed on the electrical distribution system. Type 4 and 5 SPDs have Measured Limiting Voltage (MLV) ratings determined at various surge levels only and not VPRs when listed/certified to ANSI/UL 1449. These ratings might be determined at different levels than those reported in Section 5.

SPDs can be installed either internal or external to switchgear, panelboards, end-use equipment, etc. Some SPDs (component assemblies and recognized components) have conditions of acceptability that must be met to permit their use in particular applications. Consult the SPD manufacturer regarding how to address conditions of acceptability for SPD component assemblies. Further, consult with the manufacturer when installing SPDs internal to end-use equipment. See Section 2 for the definitions of SPD Types.

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Note: Procuring SPDs and SPD installation may be simplified by appreciating that the term “single phase” may have colloquial meanings of ‘true single phase’ or ‘split phase.’ Also, be aware that many SPDs are voltage specific and may have specific wiring instructions for Corner Grounded Delta’s (Phase B is normally grounded) and Hi-Leg Delta’s (Phase B is normally the Hi-Leg).

3.2.3 Maximum Continuous Operating Voltage (MCOV)

The SPD has a characteristic of being able to withstand a continuous voltage that is greater than the nominal system voltage of the power distribution system. It is recommended that the Maximum Continuous Operating Voltage be greater than or equal to 115 percent of the nominal system voltage to accommodate normal fluctuations within a power system.

The Maximum Continuous Operating Voltage is required to be on the product data label of the SPD and in the installation instructions and/or operation manual.

Maximum Continuous Operating Voltage is a parameter declared by the manufacturer on the basis of several considerations, e.g., ambient temperature, exposure to surges, actual system voltage, definition of an end of life criteria, SPD topology.

For SPDs listed/certified to ANSI/UL 1449 (and/or tested in accordance with ANSI/IEEE Std. C62.62), the MCOV is a required marking, and the declared value is verified during the Nominal Discharge Current Test.

3.2.4 Short Circuit Current Rating (SCCR)

The SPD is required to be marked with a Short Circuit Current Rating (SCCR). As per NFPA 70, Article 285, the SCCR of the SPD shall be equal to or greater than the available short-circuit current of the system at the point of installation. The Short Circuit Current Ratings detailed in ANSI/UL 1449 for SPDs (in thousands of amperes, kA) include:

5, 10, 14, 18, 22, 25, 30, 42, 50, 65, 85, 100, 125, 150, 200

The testing methodology is specified in ANSI/UL 1449, Standard for Safety for Surge Protective Devices.

3.2.5 Rated Load Current (Two-Port and In-Line SPDs Only)

The rated load current of the SPD applies to two-port SPDs (which have an intended series impedance) and In-line SPDs (which have separate input and output terminals but no intended series impedance). The rated load current is the amount of steady-state current that the SPD can conduct through to the load without causing damage to the SPD due to excess heat buildup or mechanical stress. It is important to ensure that for a two-port or in-line SPD operating at rated load current, that the series voltage drop or voltage regulation is acceptable to the load. Common rated load currents, in amps, of two-port or in-line SPDs include:

5, 10, 15, 20, 30, 50, 75, 100, 200, 225, 250, 400, 600, 800, 1,000, 1,200, 1,600, 2,000, 3,000, 4,000

3.2.6 Voltage Regulation (Two-Port and In-Line SPDs Only)

Voltage regulation (V_L) is calculated by the equation:

$$\%V_L = \left[\frac{|V_{IN} - V_{OUT}|}{V_{IN}}\right] * 100$$

Where V_{IN} is the voltage across the input terminals, and V_{OUT} is the voltage across the output terminals.

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Common voltage regulation values of two-port and in-line SPDs includes: 1%, 3%, and 5%

3.3 SPD RATINGS RELATED TO PERFORMANCE

These ratings and characteristics provide data to help quantify an SPD's ability to divert or attenuate and mitigate the effects of transients under parameters given by specific industry standards or items that are relevant to the SPD's application and for comparison purposes. The electrical industry has used these specific parameters for many years. The common parameters include:

a. Measured Limiting Voltage(s) (MLVs)
b. Voltage Protection Rating (VPR)
c. Nominal Discharge Current (I_N)
d. Modes of protection
e. Enclosure rating
f. Safety agency certifications
g. Safety disconnector description
h. Surge current rating

3.3.1 Measured Limiting Voltage(s)

Measured Limiting Voltage (MLV) is defined as the maximum magnitude of voltage that is measured across the terminals of the surge-protective device (SPD) during the application of a series of impulses of specified wave shape and amplitude. MLVs are peak voltages, not rms voltages. The Measured Limiting Voltages can be used to analyze the capability of an SPD to limit transients (test wave shapes and amplitudes) defined in ANSI/IEEE Std. C62.41.2 and ANSI/IEEE Std. C62.62. The standard test waveforms are the:

a. Category A 100 kHz Ring Wave
b. Category B 100 kHz Ring Wave
c. Category A Combination Wave
d. Category B Combination Wave
e. Category C Low Combination Wave
f. Category C High Current Driven Test

Further, the tests listed above are the "standard" tests from ANSI/IEEE Std. C62.41.2 and ANSI/IEEE Std. C62.62. These standards also contain "additional" and "optional" tests that might be selected by mutual agreement. In these cases, these tests can be added to the specification checklist (Section 5) as needed. The additional waveforms identified are the:

a. EFT Burst
b. Unidirectional 10/1000 µs Long Wave

Testing of the SPD is conducted using all overcurrent components, over-temperature components, EMI capacitors, status indication, disconnects, SPD safety disconnectors, etc.

The testing methodology used is defined in ANSI/IEEE Std. C62.45 (testing of equipment) and ANSI/IEEE Std. C62.62 (testing of SPDs). The point of application of the surge voltage and the resultant Measured Limiting Voltages are defined in UL 1449 and ANSI/IEEE Std. C62.62. In particular, the Measured Limiting Voltages for a parallel (one-port) connected SPD are measured at a point of 150 mm (6 inches) from where the conductors exit the enclosure of the SPD. The Measured Limiting Voltages of a series (two-port) connected SPD are measured at the output terminals of the SPD. See ANSI/IEEE Std. C62.62 for specific details, illustrations, and examples. Further, ANSI/IEEE Std. C62.62 provides specific requirements on the measurement equipment, measurement methods, and methods of reporting the results of surge testing SPDs.

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By mutual agreement between end-user and manufacturer, the appropriate wave shapes and amplitudes for the specific application are to be selected from ANSI/IEEE Std. C62.41.2 and/or ANSI/IEEE Std. 62.62. Not all the test waveforms are appropriate for every application. For example, a Type 3 SPD might not need to be tested to the Category C Current Driven Test.

3.3.2 Voltage Protection Rating (VPR)

The VPR utilizes MLVs from a sampling of SPDs when subjected to a specific set of transient wave shapes and (e.g., voltage and current). Once the MLVs are obtained, then the VPR can be determined from a list of values and assigned by an NRTL.

The VPR is to be determined using the procedure in ANSI/UL 1449. A brief outline of the procedure is listed here. The same samples used to determine the VPR are used for the Nominal Discharge Current Test as described in ANSI/UL 1449 and in Section 3.3.3 of this Guide.

Testing, using a 6 kV, 3 kA Combination Wave generator, is conducted on three SPD samples for each mode of protection (see Section 3.3.4) declared by the manufacturer. The MLVs of the tests are recorded and averaged. The averaged value of the MLVs for a particular mode of protection is then utilized to determine the VPR for that mode of protection—which is equal to or lower than a selected value from a list of values in ANSI/UL 1449. VPRs are marked on the product. The VPR indicated in volts (V) are as shown in Table 3-2. For example, if the average MLV of three impulses is 598 V, the NRTL would assign a VPR of 600. If the average MLV of three impulses is 602 V, the NRTL would assign a VPR of 700 (because it is over 600 V).

Table 3-2
VOLTAGE PROTECTION RATINGS

330	400	500	600	700	800	900	1000	1200
1500	1800	2000	2500	3000	4000	5000	6000	–

3.3.3 Nominal Discharge Current (I_n)

The following is an excerpt from ANSI/IEEE Std. C62.62 describing the purpose and rationale for the Nominal Discharge Current Test:

> *The Nominal Discharge Current Test exercises an SPD's ability to be subjected to repetitive current surges of a selected value without degradation in performance by comparing a pre-test and post-test baseline averaged Measured Limiting Voltages per mode of a mode of protection (e.g., A-N pre-test versus A-N post-test).*
>
> *The purpose of these tests is to demonstrate the performance (repetitive surges, energy handling capability, and absence of undesirable side effects) of an SPD in response to surges that can be expected at the service equipment and/or within a building.*
>
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The manufacturer declared Nominal Discharge Current is verified by a listing agency using the procedure in ANSI/UL 1449 in conjunction with the determination of the VPR. (The same test is included in ANSI/IEEE Std. C62.62.) The test amplitudes from ANSI/UL 1449 are listed below. Other standards may have additional values. The test short-circuit current wave shape is 8/20 µs.

10 kA or 20 kA for Type 1 SPDs, and
3 kA, 5 kA, 10 kA or 20 kA for Type 2 SPDs
3 kA for Type 3 SPDs (optional)

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Some Type 3 SPDs are tested to the 3 kA test value for Nominal Discharge Current. This is an optional test from ANSI/UL 1449. Other Type 3 SPDs listed/certified to ANSI/UL 1449 are subjected to the Duty Cycle Test as defined in ANSI/UL 1449 which uses a 6 kV, 3 kA Combination Wave test rather than a 3 kA Current Driven Test.

3.3.4 Modes of Protection

The modes of protection for the SPD shall be appropriate for the installation. In most North American grounded power systems, the line-to-neutral (L-N), line-to-line (L-L), and line-to-ground (L-G) modes of protection are all that are available for an SPD applied at the service equipment. The neutral-to-ground (N-G) bond in grounded wye systems (208Y/120, 3Φ, 4w) ensures that the neutral (grounded) conductor and the grounding conductor are at the same potential (bonded) at this point in the power system. Therefore, the existence of the N-G mode at the service equipment is not required but does not need to be specifically excluded.

When the distance of the SPD from the neutral-ground bond exceeds two meters, additional modes of protection should be considered. This includes common modes of protection, e.g., line-to-ground (L-G), and neutral-to-ground (N-G).

There are also cases where the power system is ungrounded. In these cases, line-to-line (L-L) protection and line-to-ground (L-G) protection are the available modes of protection.

Further, it is important to understand how test results are reported with regard to the modes of protection. For additional detail on this topic, see Appendix A.2 and A.3.

The modes of protection are declared by the manufacturer. The existence or effectiveness of the modes of protection can be verified through Measured Limiting Voltages and the Nominal Discharge Current Test results.

3.3.5 SPD Enclosure Protection Rating

The SPD enclosure protection rating is very similar to the NEMA 250 enclosure ratings used for electrical enclosures and determines if it is appropriate to apply the SPD at specific locations within the power distribution system. The SPD enclosure protection rating is not the same as the NEMA enclosure rating but differs only because the rating is obtained after the SPD manufacturer has installed all components and status features that make up the entire SPD package. Some common SPD enclosure ratings are shown in Table 3-3.

Table 3-3
Common SPD Enclosure Protection Ratings

SPD Enclosure Protection Rating (NEMA)	Location for Use
1	General Purpose - Indoor
3R	Rainproof, Sleet Resistant - Outdoor
4	Watertight, Dust-tight, Sleet Resistant - Indoor & Outdoor
4X	Watertight, Dust-tight, Sleet Resistant, Corrosion Resistant – Indoor & Outdoor
12, 13	Industrial Use, Dust-tight & Drip-tight - Indoor

There is no direct equivalency between NEMA and IEC IP ratings. See Table A-1 of https://www.nema.org/Products/Documents/nema-enclosure-types.pdf.

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The SPD enclosure protection rating should be detailed on the product and documentation provided with all submittal packages. To determine the actual details of the appropriate NEMA ratings, consult NEMA 250.

3.3.6 SPD Safety Agency Certifications

SPDs undergo safety agency certifications for application and installation in various locations. The applicable national safety standards, unlike this guide, dictate requirements for the safety of the SPD including acceptable end-of-service or failure conditions. The certifications carried by a product are to be provided.

> Note: In the US, the United States Department of Labor through the Occupational Safety and Health Administration (OSHA) oversees safety agency certifications through its Nationally Recognized Testing Laboratory (NRTL) program. An NRTL is by its definition a third party, independent organization as defined below by OSHA:

A Nationally Recognized Testing Laboratory (NRTL) is a private-sector organization that OSHA has recognized as meeting the legal requirements in 29 CFR 1910.7 to perform testing and certification of products using consensus-based test standards. These requirements are:

a. The capability to test and evaluate equipment for conformance with appropriate test standards;
b. Adequate controls for the identification of certified products, conducting follow-up inspections of actual production;
c. Complete independence from users (e.g., employers subject to the tested equipment requirements) and from any manufacturers or vendors of the certified products; and
d. Effective procedures for producing its findings and for handling complaints and disputes.

An organization must have the necessary capability both as a product safety testing laboratory and as a product certification body to receive OSHA recognition as an NRTL.

See https://www.osha.gov/dts/otpca/nrtl/nrtl_faq.html for additional details.

3.3.7 SPD Safety Disconnector Description

Some SPDs require an external safety disconnector (usually an external circuit breaker or fuse). This requirement is part of the SPDs certification, and the safety disconnector is required to maintain the listing of the SPD in end use applications. If applicable, the external safety disconnector is to be specified or supplied by the SPD manufacturer.

3.3.8 Surge Current Ratings

The following is an excerpt from ANSI/IEEE Std. C62.72-2016 (Clause 13.2):

When an SPD operates to limit a transient overvoltage, the SPD mitigates the impact of the overvoltage surge by conducting current. It is important for specifiers and users of SPDs to understand the term surge current. Surge current ratings, or the surge current capability of an SPD is one of the most common specification parameters of an SPD. At the release date of this publication, there is no standardized test for determining maximum or peak surge current ratings of SPDs within IEEE standards that apply to SPDs within the scope of this guide. However, the Nominal Discharge Current Rating is well defined (see ANSI/IEEE Std. C62.62™). Users and specifiers should consult the SPD manufacturer to determine how this rating [surge current rating] is determined for a particular SPD. The surge current rating of an SPD can refer to the amount of current that the SPD can divert resulting in the following conditions or based upon:

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- *No damage or degradation to the SPD without the operation of an internal or external SPD [safety] disconnector*
- *No damage or degradation to the surge protective components within an SPD but with the operation of an internal or external SPD [safety] disconnector not resulting in an undesirable end of service condition*
- *Damage or degradation of the SPD, surge protective components within the SPD, and/or internal or external SPD [safety] disconnector not resulting in an undesirable end of service condition*
- *The sum of the component manufacturer's surge current ratings of the individual surge protective components within the SPD with or without consideration of an internal or external SPD [safety] disconnector surge current rating*

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For additional information on per mode and per phase surge current ratings, see Annex A Section A.2.

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Section 4
Specification Checklist

SPD Manufacturer _____

SPD Model Number _____

NOTE: The corresponding section numbers for each item in Table 4-1 are listed to the left of each heading.

Table 4-1
Specification Checklist

4.1 SPD Ratings Related To The Operating System	
3.2.1 Power Distribution System Configuration	

3.2.1 Nominal system voltage	

3.2.2 SPD Location/Type	

3.2.3 SPD Maximum Continuous Operating Voltage (MCOV)							
L-N		L-G		N-G		L-L	

3.2.4 SPD Short Circuit Current Rating (SCCR) - see 3.3.7 in this Table	

3.2.5 SPD Rated Load Current (I_L) (Two-Port and In-Line SPDs only)	

3.2.6 SPD Voltage Regulation (V_R) (Two-Port and In-Line SPDs only)	

4.2 SPD Ratings Related To Performance							
Measured Limiting Voltages (MLV) (add lines as necessary):							
3.3.1 IEEE Category A 100 kHz Ring Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Phase Angle			
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category B 100 kHz Ring Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Phase Angle			
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category A Combination Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Short Circuit Current			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category B Combination Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Short Circuit Current			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category C Low Combination Wave Measured Limiting Voltages (if applicable)							
Open Circuit Voltage				Short Circuit Current			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 IEEE Category C High Current Drive Test Measured Limiting Voltages (if applicable)

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Voltage				Current Through SPD			
Phase Angle							
L-N		L-G		N-G		L-L	

3.3.1 Additional and Optional IEEE Tests - Measured Limiting Voltages (if applicable)							
Test Waveform/Description							
Voltage Amplitude				Short Circuit Current			
Phase Angle							
Notes:							
L-N		L-G		N-G		L-L	

3.3.2 Voltage Protection Rating (VPR) – ANSI/UL 1449							
L-N		L-G		N-G		L-L	

3.3.3 Nominal Discharge Current Rating (I_n)	

3.3.4 Modes of Protection (Check those that apply)							
L-N		L-G		N-G		L-L	

3.3.5 SPD Enclosure Rating	

3.3.6 SPD Safety Agency Listings/Certifications (list all standards the SPD is listed/certified to, file numbers, links to certification pages, etc.)	Check all that apply: ☐ NEMA 1 ☐ NEMA 3R ☐ NEMA 4 ☐ NEMA 4X ☐ NEMA 12,13 ☐ Other:_____

3.3.7 SPD Safety Disconnector/Overcurrent Protection Device Requirements (if applicable), i.e., fuse or circuit breaker	Select/provide as applicable: ☐ No Additional Safety Disconnector Required ☐ External Fuse Required Type and Size: _____ Manufacturer Part Number: _____ ☐ External Circuit Breaker Required Type and Size: _____ Manufacturer Part Number: _____
4.2.8 SPD Surge Current Rating	Select/provide as applicable: ☐ Per Phase: _____kA ☐ L-N Mode: _____kA ☐ L-G Mode: _____kA ☐ N-G Mode: _____kA ☐ L-L Mode: _____kA

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Annex A
Additional Information
(Informative Only)

The following annex is provided as additional information only and is not a normative part of NEMA SPD1.1, *Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems–Part 1*.

A.1 Surge Current Ratings

SPD surge current ratings are subjective based on multiple factors such as surge amplitude, level of redundancy, projected life expectancy, anticipation of degradation, value of protected load, value of avoided downtime losses, etc.

Within structures, ANSI/IEEE standards defining the expected surge environment state that system inductance and impedance limit the expected surge current to levels around 10 kA. ANSI/UL 1449 includes repetitive surge current testing up to 20 kA. Surge current levels in outdoor equipment environments from direct lightning strikes are not well documented but may exceed these values. Similarly, a direct lightning stroke to earth can create momentary, localized increases in ground potential (Ground Potential Rise), which may also exceed these values.

SPDs are purposely placed in harm's way. It is generally good engineering practice to specify sufficient surge current capacity, plus margin for error and/or redundancy. Additional and/or multiple internal suppression components will share surge current, thus reducing stresses on individual components leading to longer SPD life. For similar reasons, lower measured limiting voltages are sometimes achievable. There are instances where additional and/or larger surge protective components provide safety benefit, and/or reduce degradation effects from usage.

Geographic considerations may apply. For example, the southeastern United States is prone to numerically-higher rates of lightning strokes, although most regions can expect to receive equally large lightning in terms of kA amplitude. The physical proximity of SPD and load to outdoors is also a consideration based on the likelihood of additional stresses.

The user or specifier should consult the SPD manufacturer for application guidance.

A.2 Per Mode And Per Phase Ratings

A 'Per Mode' surge current rating is the summed rating of suppression elements connected directly from one power system terminus to a second. Modes may be line-to-neutral (L-N), line-to-ground (L-G), neutral-to-ground (N-G) or line-to-line (L-L). (It is to be understood that "line" and "phase" are often used interchangeably to indicate the connection to a particular phase of the system.) For example, L-N may be specified as 100 kA, suggesting ten 10 kA MOVs, or two 50 kA MOVs, etc. connected in parallel to the specified mode.

a. 'Per Mode' ratings are not intended to include indirectly connected suppression elements. For example, the L-G per mode rating is not intended to include compound-connected suppression elements configured as L-N-G for L-G. Similarly, the L-L per mode rating is not intended to include compound-connected suppression elements such as L1-N-L2 and/or L1-G-L2 for the L-L mode.
b. In a given manufacturer declaration, no individual suppression element may be double counted to obtain 'Per Mode' ratings.
c. Determination of any L-L 'Per Mode' rating is the number of suppression elements connected directly from one energized power system terminus to a second energized power system terminus. The L-L 'Per Mode' rating is not intended to include L1-N-L2 and/or L1-G-L2, etc.

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A 'Per Phase' surge current rating is the summed rating of suppression elements connected directly from one energized power system terminus to another terminus, which may or may not be energized. For example, Phase A might have five 10 kA MOVs connected Phase A-Neutral, and five 10 kA MOVs connected Phase A-Ground for a per phase rating of 100kA.

a. N-G suppression elements are not to be included in 'Per Phase' surge current ratings.
b. For 'Per Phase' surge current rating calculation purposes, any contribution of L-L suppression elements should be limited to one phase to a second phase, and not one phase to multiple other phases.

Calculations of surge current ratings for SPDs including derived neutral connections and/or compound-connected should clearly indicate such and identify any suppression elements that are counted more than once.

A.3 SPD Modes Of Protection

A mode of protection is defined as how an SPD's protective components might be connected line to line, line to ground (earth), line to neutral, or neutral to ground (earth), and any combination thereof. A mode of protection can be established using directly connected surge protective components in a particular mode or through a combination of surge protective components connected between other modes that when used in a series combination also covers other modes. This is different than a "per mode" or "per phase" surge current rating. A mode of protection offers defense against surges propagating in that mode.

For example, an SPD with SPCs directly connected in ten modes provides protection for all ten modes of the wye configured PDS. Similarly, an SPD with SPCs directly connected in seven modes (i.e., each phase to neutral, each phase to ground and neutral to ground) provides protection for all ten modes for the wye configured PDS; however, the phase to phase mode of protection is accomplished through the series combination of the phase to neutral (or ground) SPCs. For example, the phase A to phase B mode of protection is completed by the series connection of the SPCs connected phase A to neutral to phase B (or via the phase to ground SPCs in a similar fashion). In this case, the phase to phase MCOV would be the MCOV of phase A to neutral (or ground) plus phase B to neutral (or ground).

Likewise, an SPD with SPCs directly connected in four modes (i.e., each phase to neutral and neutral to ground for a Wye configured SPD) also provides protection for all ten modes of the wye configured PDS. In this case, the phase to phase mode of protection is completed in the same way as the SPD with SPCs directly connected in seven modes; however, the phase to ground mode of protection is completed by the series combination of the phase to neutral and neutral to ground SPCs. The phase to ground MCOV would be the MCOV from phase to neutral plus neutral to ground. This compounding of MCOVs may increase Measured Limiting Voltages, which may or may not be desirable in some circumstances.

All three of these designs offer defense in all the modes of protection available for the PDS; however, they accomplish this through different means. The specifier or user of SPDs should understand how a particular SPD provides protection (what modes of protection exist and how they are accomplished) for the equipment connected to the PDS. There are differing philosophies as to which approach is preferred. The user or specifier should consult the SPD manufacturer to understand the design philosophy of a particular SPD.

For additional information regarding MLVs and VPRs, see Table 4-1.

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Annex B
General Earthing (Grounding) Practices (Informative Only)

The following annex is provided as additional information only and is not a normative part of NEMA SPD1.1 *Surge Protective Device Specification Guide for Low Voltage Power Distribution Systems—Part 1*.

B.1 Description

Network systems are classified by the International Electrotechnical Commission (IEC) in IEC 60364-1 (Low-voltage electrical installations—Part 1: Fundamental principles, assessment of general characteristics, definitions) according to the type of grounding, or *earthing*, practices used in the PDS and the methods used for protection against electrical shock in the installation. Although all IEC network systems are not currently used within the United States, some classifications can be applied.

An important note is the difference in language, between IEC countries and that of North America, for terms having the same meaning. In this annex, the terms *earthed* and *unearthed* have the same meaning as *grounded* and *ungrounded*. For clarity to the readers, this guide will substitute the IEC term, *earthed*, for the common North American term, *grounded*, and the IEC term, *unearthed*, for the common North American term, *ungrounded*.

PDSs are divided into grounded and ungrounded systems. IEC 60364-1 classifies network systems according to the configuration of live conductors (including the neutral) and the type of grounding system used. As part of the classification, the following nomenclature is used. The first letter, I or T, shows the relationship between the current carrying conductors and the grounding system. The second letter, T or N, shows the relationship of the accessible conductive parts, including a metallic frame, of the component or equipment in the installation with respect to the grounding system.

> Note: “Grounded” or “ungrounded” refers to the power system’s reference to ground. This is different than an incorrect colloquial understanding where there is, or is not, a ground conductor. All equipment requires a ground conductor. Reference to ground refers to the connection of the secondary side of a transformer to ground. Among other things, this provides system voltage stability particularly for L-G and N-G modes.

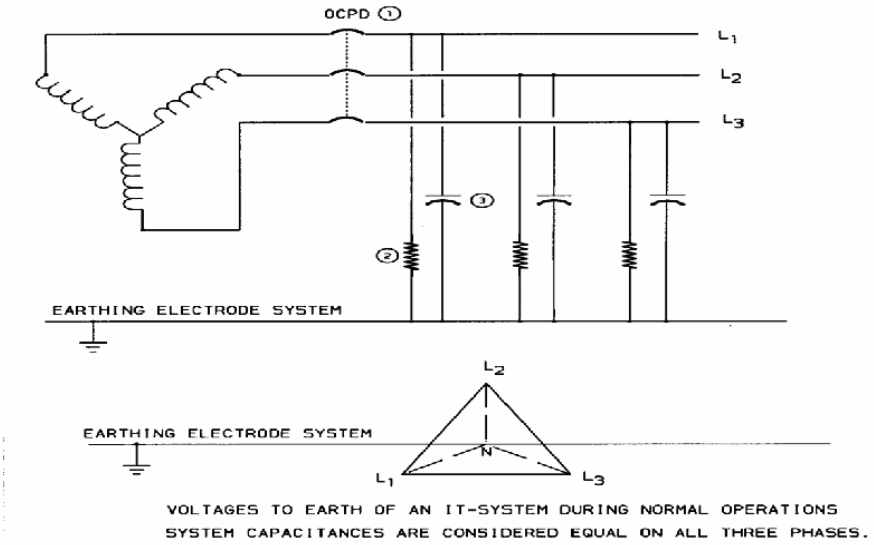
For the purposes of this discussion, a “bolted” fault is a short-circuit condition. Per ANSI/NEMA FU 1-86, the definition for a bolted fault refers to a zero impedance fault considered at locations in a power system where the maximum value of available fault current is calculated.

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First letter (I or T)

The first letter “I” represents *isolation*. The letter “I” signifies that all live parts are isolated from ground or earth, or that points of the network are connected to earth through some impedance as a surge arrester or air gap. The first letter “T” represents the Latin word, *terra*, meaning earth. The “T” signifies a direct connection of at least one point in the network to earth. Special grounding requirements or practices may be necessary depending on the type of network system used. See Figure B.1 through Figure B.3.

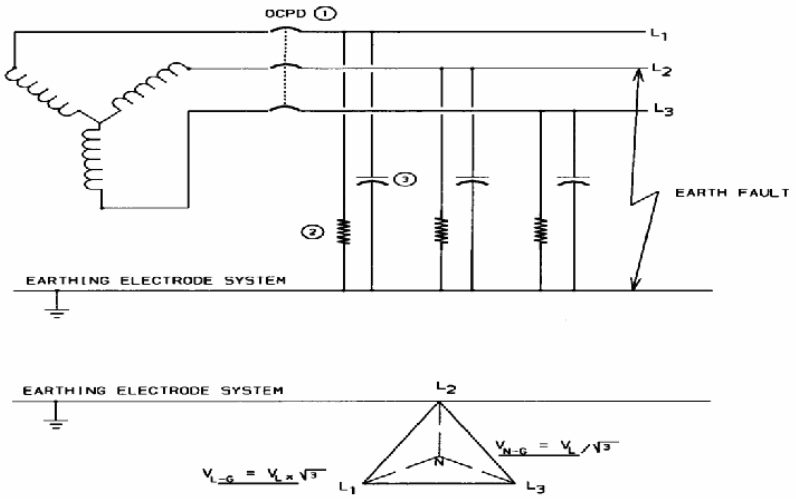


NOTE.
1. OVER CURRENT PROTECTIVE DEVICE
2. INSULATION RESISTANCE OF CONDUCTOR WITH RESPECT TO EARTH (TYPICAL FOR ALL PHASES)
3. CAPACITIVE REACTANCE IN SYSTEM (TYPICAL FOR ALL PHASES)

Figure B.1 - Typical IT System During Operation

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VOLTAGES TO EARTH OF AN IT-SYSTEM DURING A BOLTED FAULT TO EARTH CONDITION. WHEN A SOLID BOLTED FAULT OCCURS ON ONE PHASE THE PSEUDO NEUTRAL POINT IS DISPLACED AND THE VOLTAGE ON THE UNGROUNDED PHASES IS ELEVATED.

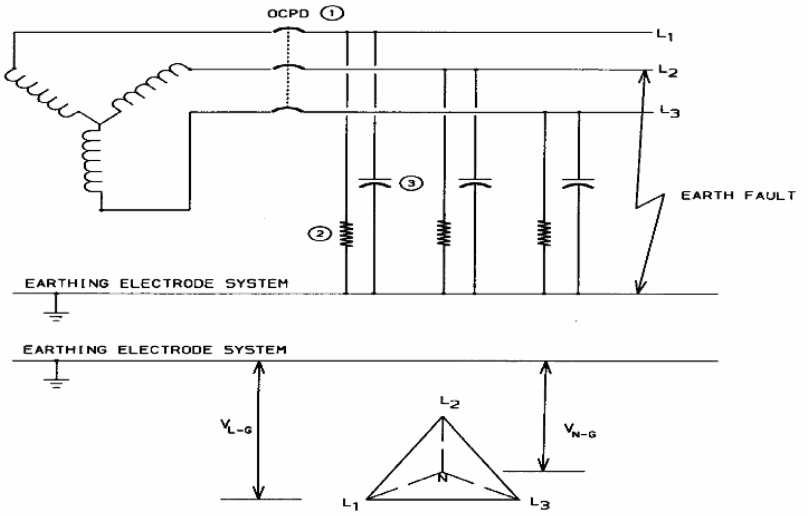
NOTE.

1. OVER CURRENT PROTECTIVE DEVICE
2. INSULATION RESISTANCE OF CONDUCTOR WITH RESPECT TO EARTH (TYPICAL FOR ALL PHASES)
3. CAPACITIVE REACTANCE IN SYSTEM (TYPICAL FOR ALL PHASES)

Figure B.2- IT System with a Bolted Fault

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VOLTAGES TO EARTH OF AN IT-SYSTEM DURING AN ARCING FAULT TO EARTH CONDITION. AN ARCING FAULT TO EARTH IS POTENTIALLY MORE DESTRUCTIVE BECAUSE THE PSEUDO NEUTRAL POINT CAN BE OFFSET SIGNIFICANTLY FARTHER FROM THE GROUND PLAIN EACH TIME THE ARC RESTRIKES.

NOTE:

1. OVER CURRENT PROTECTIVE DEVICE
2. INSULATION RESISTANCE OF CONDUCTOR WITH RESPECT TO EARTH (TYPICAL FOR ALL PHASES)
3. CAPACITIVE REACTANCE IN SYSTEM (TYPICAL FOR ALL PHASES)

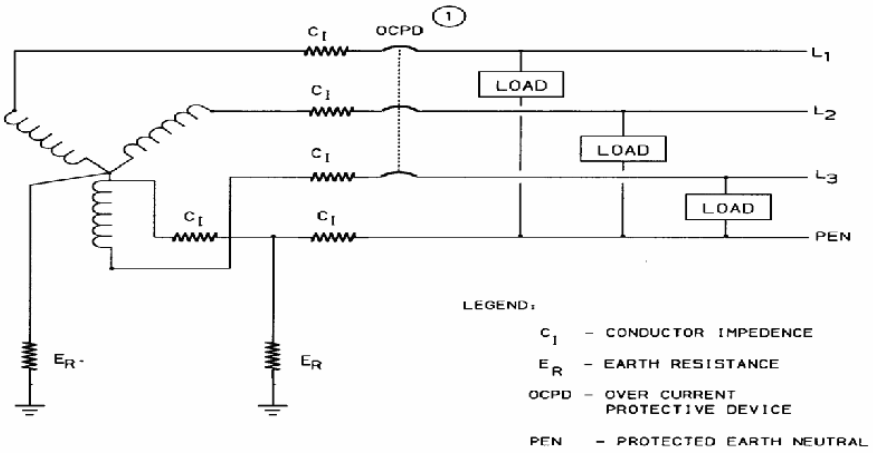
Figure B.3 - IT System with an Arcing Fault

Second Letter (T or N)

The second letter designates the type of connection between the protective equipment—grounding conductor used in the installation and earth. The second letter “T” signifies a direct connection between accessible conductive parts of connected equipment and ground (terra), which is independent of the grounding system that may or may not exist on current carrying conductors of the system. The second letter “N” signifies a direct connection of accessible conductive parts to the ground points of the PDS by means of a PEN (protected earth neutral) or PE (protected earth) conductor. The PDS is then connected to ground. See Figure B.4 through Figure B.7.

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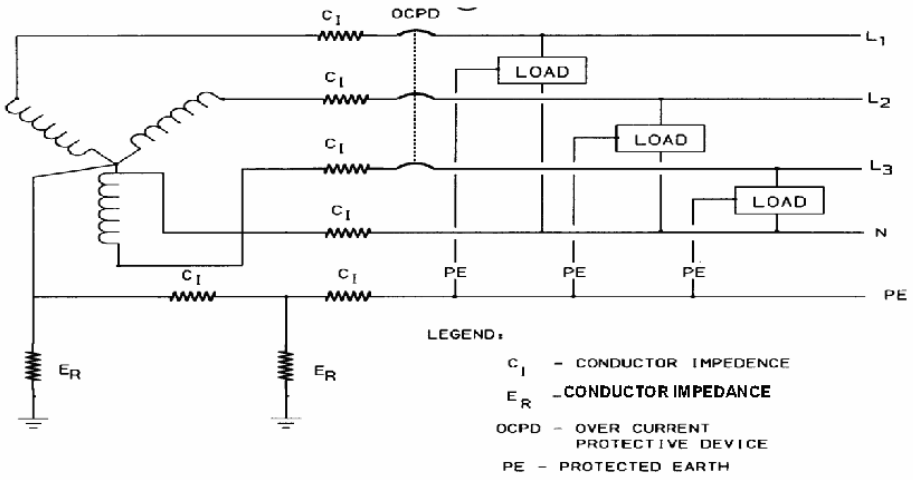


TYPICAL EXAMPLE OF A TN-C SYSTEM

NOTE:

1. MAIN OVERCURRENT PROTECTIVE DEVICE SHOULD NOT HAVE GROUND FAULT PROTECTION

Figure B.4 - Typical TN-C System



TYPICAL EXAMPLE OF A TN-S SYSTEM

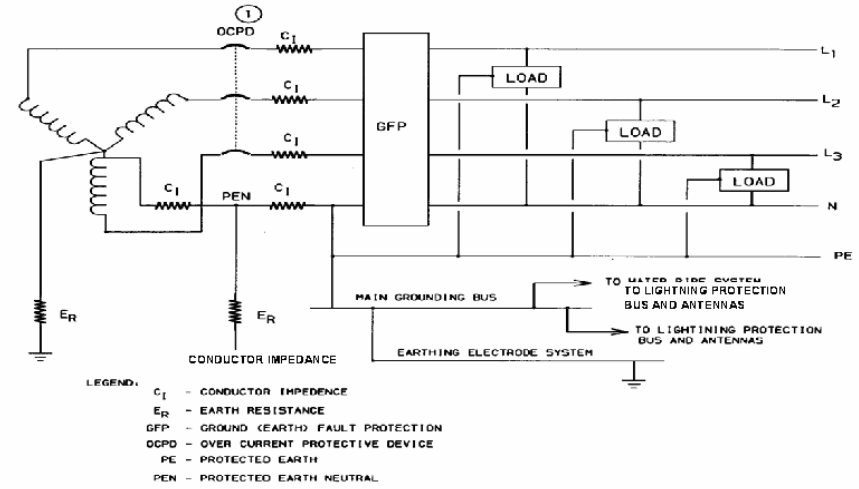
NOTE:

1. OCPD CAN INCLUDE, OR NOT INCLUDE, GROUND FAULT PROTECTION

Figure B.5 - Typical TN-S system

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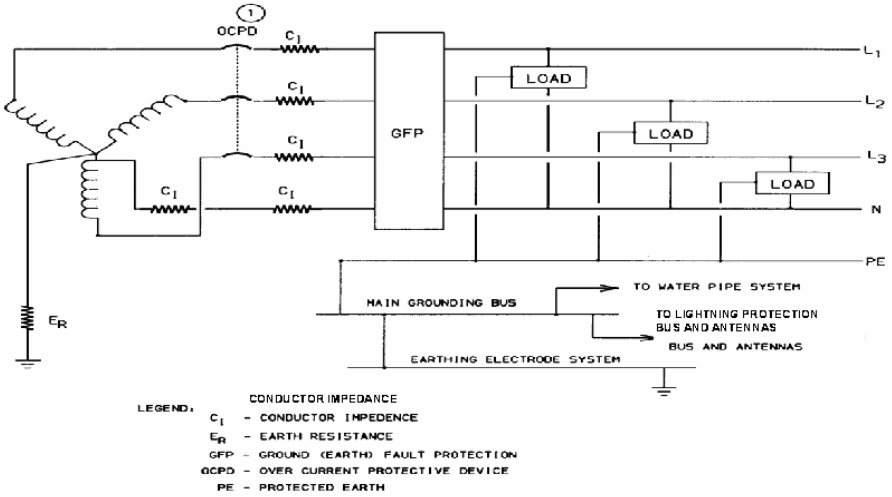
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TYPICAL EXAMPLE OF A TN-C-S SYSTEM

NOTE:
1. OCPD CAN INCLUDE, OR NOT INCLUDE, GROUND FAULT PROTECTION

Figure B.6 - Typical TN-C-S system



TYPICAL EXAMPLE OF A T-T SYSTEM

NOTE:
1. OCPD CAN INCLUDE, OR NOT INCLUDE, GROUND FAULT PROTECTION

Figure B.7 - Typical T-T system

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In IEC network systems, the grounding of the PDS and the means of protection against electric shock are independent considerations. Distribution systems are grounded to limit the voltage rise that can develop from lightning, transient over voltages, contact with higher voltage(s), or ground faults that may occur in a PDS. The PDS can be intentionally ungrounded to avoid service interruption when a single ground fault occurs. See Table B.1.

Table B.1

IEC Systems And Equipment Grounding

System designation	System grounding	Equipment grounding
IT	No direct system grounding. Can be connected to earth through impedance or gap.	Independently and directly connected to earth
TT	Connected to earth at one or more points in the PDS outside of the premises wiring.	Independently and directly connected to earth.
TN	Connected to earth at one or more points in the PDS and at one or more points in the premises wiring.	Connected to the PDS via a PEN or PE conductor.

Third Letter (C or S)

In TN systems, a third letter designates the possible configuration of, as well as the relationship between, the neutral conductor, the PE-conductor, and the PEN-conductor.

In a “TN-C”-type PDS, the suffix “C” represents a common function. The PEN-conductor is used to serve the common function of a grounding or protective earthing conductor as well as the neutral conductor for the PDS. In a “TN-C”-type PDS, ground-fault current and neutral current use the same return path. In such installations, the neutral conductor would be bonded to the frame of the equipment or apparatus at each utilization point. In a “TN-C”-type PDS, the application and installation of ground-fault protective devices are not indicated or recommended because such devices would never reliably function as intended. (In North America, older low-voltage appliances with metallic frames represent a single-phase circuit in a “TN-C” system and residential two-prong receptacle circuits where a separate grounding conductor is not used.)

In a “TN-S”-type PDS, the suffix “S” represents a separate grounding or protective earthing conductor. There is no PEN-conductor. The PE-conductor is only bonded once to the neutral conductor and only at the neutral terminal of the supply transformer for the PDS. In a “TN-S”-type PDS, ground-fault current and neutral current use separate conductive paths. In such installations, a separate grounding conductor would be bonded to the frame of the equipment or apparatus at each utilization point for the conduction of ground-fault current. In a “TN-S”-type PDS, the separation of the PE-conductor and the neutral conductor allows for the successful application and utilization of a ground-fault protection system.

TN-C-S Systems

A “TN-C-S”-type PDS is a combination of a “TN-C”- and a “TN-S”-type system. The “TN-C-S”-type PDS is the most commonly used earthing system. In a “TN-C-S”-type PDS, there is a PEN-conductor, a separate PE-conductor, and a separate neutral conductor. The PEN-conductor is used only between the supply transformer and the service equipment. The actual connections to earth of the PEN-conductor are commonly made at the neutral terminal of the supply transformer and on the neutral conductor in the service equipment. Beyond the service equipment, only separate neutral conductors and PE-conductors

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are used. In a “TN-C-S”-type PDS, the separation of the PE-conductor and the neutral conductor allows for the successful application and utilization of a ground-fault protection system as those used in a “TN-S” type system. However, a ground-fault protection system can only be used downstream or on the load side of the PEN-conductor. In addition, any electrical connections between, or bonding of, a PE-conductor and a neutral conductor downstream of the PEN-conductor could cause dysfunction in a ground-fault protection system installed in the “TN-C-S” system.

Differences Highlighted

The following illustrations serve to show the differences between some of the common systems.

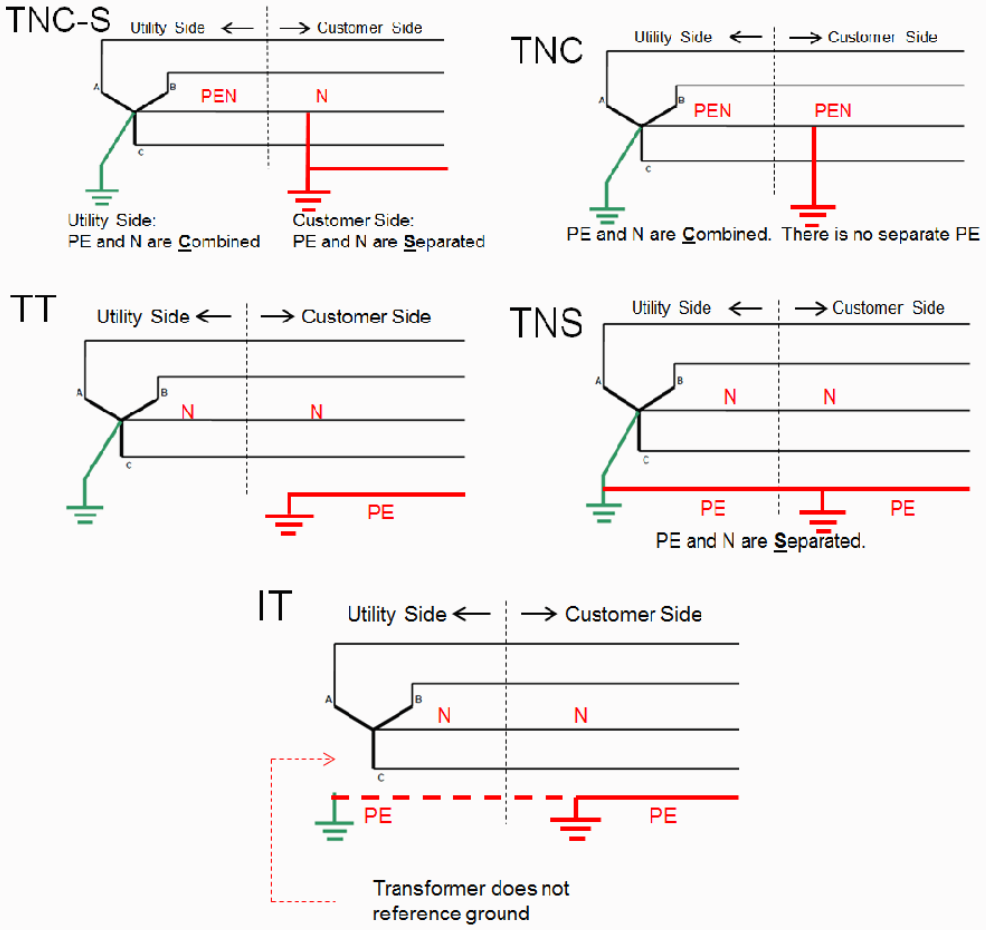


Figure B.8 - Differences in Common Systems

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National Electrical Manufacturers Association

A NEMA Low Voltage Surge Protective Devices Section White Paper
VSP 1-2017

Susceptibility of Electrical and Electronic Components to Surge Damage

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Foreword

This is a new NEMA white paper based on member-supported testing. To ensure that a meaningful publication was developed, draft copies were distributed to groups within NEMA that have an interest in this topic. Their comments and suggestions provided vital input prior to final NEMA approval and resulted in a number of substantive changes in this publication. To remain up to date with advancing technology, this publication will be periodically reviewed by the Low Voltage Surge Protective Devices Group of the NEMA Commercial Products Division.

Proposed or recommended revisions should be submitted to:

Senior Technical Director, Operations
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

This white paper was developed by the Low Voltage Surge Protective Devices Group of the NEMA Commercial Products Division. Approval of this white paper does not necessarily imply that all members of the Product Group voted for its approval or participated in its development.

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Littelfuse, Inc.	Chicago, IL
Mersen USA	Newburyport, MA
MVC-Maxivolt	Amarillo, TX
Pentair Engineered Electrical & Fastening Solutions	Solon, OH
Phoenix Contact	Middletown, PA
Raycap, Inc.	Post Falls, ID
Schneider Electric USA	Salt Lake City, UT
Siemens Industry, Inc.	Norcross, GA
Southwire Company	Clearwater, FL
Space Age Electronics	Sterling, MA
Surge Suppression, LLC	Brooksville, FL
Thomas & Betts, a member of the ABB Group	Richmond, VA

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The National Electrical Manufacturers Association (NEMA) provides information to assist with answering various questions related to the application and use of surge protective devices.

Executive Summary

The NEMA Low Voltage Surge Protection Devices, 05VS, has been asked to provide an overview of electrical and electronic equipment surge susceptibility. This overview will help the electrical community, engineers, consumers, and technicians understand the various transient conditions to which electrical and electronic equipment may be subjected. The intent is not to evaluate individual companies' equipment as to safety or product performance, but to create awareness and offer guidance based on real-world testing on protection. This will be helpful in preventing problems with products. While there are many documents, papers, standards, web sites, and other media that talk about the harmful effects of transient impulses practical and empirical data is not readily available. Some of the explanations for this lack of data are the variable conditions electrical equipment is subjected to events such as electrical equipment failure, electronic equipment process interruption, insulation breakdown in electric conductors and electronic circuits, electronic component breakdown, premature aging of electrical and electronic components, etc. The standards community has many test procedures and evaluation practices for a prescribed environment. The challenge is that these environments are normally under standard test conditions, for example, 25°C. There are two are issues that are not covered under these standard test conditions.

a. What is the upset capability of the equipment?
b. What level of voltage or current would cause damage to equipment?

Quantitative data on how big or how many transient impulses are required to significantly reduce the life of or cause failure of an electrical or electronic device is almost nonexistent. Reasons for this lack of available information are the variable conditions under which an electrical device is subjected, i.e., at one location normal operating voltage might have a range of 110 to 135 Vac. Other locations may have more consistent supply voltage, but how many times does it fluctuate? When it does change, how long was the unstable condition? How large was the transient condition? When a system is influenced by another device or system, how large is the impact on the rest of the equipment?

The 05VS section understands that every possible combination of events and test equipment cannot be tested. The burden placed upon manufactures and consumers would be impractical. For instance, what happens when a transient impulse occurs to an electrical device when it is at its maximum operating temperatures, upper and lower boundaries? As every electrical device has its own unique set of environmental conditions, a frequent request is, "How many surges does it take to damage my equipment" or "How much longer will my equipment last with and without surge protection?"

Another missing piece of information is data on the cumulative effect of transient impulses. The average person, unless taught otherwise, often believes that surge damage is a one-time event. When lightning strikes and a piece of equipment is damaged, the damage may be attributed to a transient impulse. But when a piece of equipment fails due to the accumulation of numerous smaller magnitude surges, the failure is attributed to the age of equipment, poor quality of the equipment, or a hundred other unexplained conditions.

For this paper, the term "surge" and "transient" are used interchangeably.

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Scope

The purpose of this paper is to present the test results of actual devices in a real-world surge environment. This white paper will generate some information on the surge susceptibility for various electrical components. This white paper is not meant to be an exhaustive study, nor a complete test spectrum. It is merely a means to provide useful information to the electrical community, both for those who design electronic and electrical equipment and for those who install and use electronic and electrical equipment. The tests were performed in certified testing laboratories. The tests were completed using standardized test sequences and parameters. The test specimens used were off-the-shelf devices; they were not modified or altered in any way. The electrical products used were selected to represent a broad spectrum of common electrical components familiar to all users of electrical appliances.

The results obtained by this testing can be used as a guide to the reaction of electrical devices under various conditions. Some devices might show malfunctions, and some may experience upset events caused by surge events in actual installations. Upset conditions will be a concern if any other electronics are controlling a critical safety component. For example, a control transformer with an upset output could cause process failure for equipment being run by the transformer.

Test Methodology

A variety of waveforms were selected to represent surge conditions. These waveforms are based on the standard waveforms found in the current edition of IEEE C62.41.2 with the addition of some intermediate waveforms from an earlier version of this standard. They are a representation of impulse events created by interruptions in the electrical system. Most equipment is designed to handle minor variations in nominal operating voltages. However, surges can range in impact and adversity and may affect nearly all equipment under certain conditions. Here are some of the standard waveforms for equipment surge susceptibility. While most equipment has a nominal level of intrinsic resistibility, based on environment, application, and installation, additional or redundant levels of surge protection may be recommended.

The following standard waveforms were used in the testing protocol:

a) Category C Low / Category B Combination Wave (6,000 V / 3,000 A)
b) Category C Low / Category B Combination Wave (4,000 V / 2,000 A)
c) Category B Combination Wave (2,000 V / 1,000 A)
d) Category B Ring Wave (6,000 V / 500 A)
e) Category B Ring Wave (4,000 V / 333 A)
f) Category B Ring Wave (2,000 V / 167 A)
g) Category A Ring Wave (6,000 V / 200 A)
h) Category A Ring Wave (4,000 V / 133 A)
i) Category A Ring Wave (2,000 V / 67 A)

Note: See IEEE Std. C62.41.2 TM-2002 especially Clause 6.2; Tables 2, 3 and 4; and the notes associated with those tables for further explanation of the surge test levels selected.

The 6,000 V combination wave was developed to represent a variety of surge events. These events may be externally or internally generated electrical surges, such as when a utility capacitor bank is switched into or out of an electrical system. Internal events can come from inductive load switching. This surge is not meant to be a replication of lightning impulses, but rather a representation of the energy produced from an impulse during normal electrical operating conditions. For additional information on lightning impulses, please see NFPA 780 *Standard for the Installation of Lightning Protection Systems*.

These tests were designed to determine the number and magnitude of surges some common electrical devices used in residential, commercial and industrial applications could withstand before failure. Each

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sample was tested starting with the highest magnitude IEEE C62.41.2 waveform from the list above, the 6,000 V / 3,000 A Category C Low Combination Wave. If the sample could withstand 300 surges, the test was stopped.

If the sample failed before 300 surges in this category were applied, then the surge generator was re-calibrated to output the next lower surge waveform. This continued until the sample withstood 300 surges.

The following common electrical and electronic devices were tested:

a) Incandescent Bulb
   - Common 120 V, 60 W screw-base bulb
b) Compact Fluorescent Bulb
   - Common 120 V, 60 W (equivalent) screw-base bulb
c) Electronic Ballast & Fluorescent Bulb
   - Common 120 V electronic ballast with two 25 W, 36 inch fluorescent tubes
d) LED Bulb
   - Common 120 V, 60 W (equivalent) screw-base bulb
e) Control Transformer
   - Industrial 50 VA, 120 V to 24 V transformer
f) Variable Frequency Drive (VFD)
   - Industrial 120 V single-phase, 0.33 HP VFD
g) Uninterruptable Power Supply (UPS)
   - Common 120 V, 500 VA, off-line UPS

The test procedure was designed to subject the test samples to a range of surges of different types and magnitudes representing real-world applications. The testing started with IEEE Category C and then proceeded to Categories B and A (decreasing in severity). If the sample failed during the first series of test surges, a new sample was tested with surges of the next lower level until the test sample passed 300 surges without issue.

Note: that the test samples were not directly connected to the surge generator. The samples were connected through a 10 meters (30 feet) length of cable. This is a better representation of a practical and actual electrical installation.

The following steps were taken to conduct the test on each device:

a) The open circuit voltage waveform and short circuit current waveform were measured to verify the test waveform.
b) The sample to be tested was attached to the output of the generator using a 10 meters cable (12-2 non-metallic sheathed cable).
c) Apply the highest combination surges from Table 1 to the first test sample. Perform up to 300 strikes unless the sample fails. The impulses are injected at 60 second intervals and are applied at the peak of the AC sine wave (90 degrees of the power frequency).
d) If the sample fails, apply the surge waveform in the next column to the right in Table 1 in 60 second intervals at 90 degrees of the power frequency for up to 300 strikes or until the device fails and record results.
e) Continue testing with the test waveform in the next column to the right in Table 1 until one sample passes the test of 300 surges.

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Test Results

Table 1 contains the compiled results of the surge susceptibility testing. The first column describes the device being tested. The devices tested were all commercially available products manufactured by a variety of companies. The second column lists the number of the sample being tested. This is followed by the nine different surge waveforms used in the testing, starting with the highest voltage and current waveforms on the left and working to the lowest magnitude waveforms on the right.

The number in the columns under the different test waveforms are the number of surges of that surge type when the sample failed. None of the samples survived more than one of Category C Low Combination Wave (6,000 V / 3,000 A) waveform. When a number “1” appears in a column, then the test sample failed on the first surge in that category. When there is a “300” in a column under one of the test waveforms, then the test sample survived 300 of those waveforms without damage. At that point, the testing was stopped, as the sample would have passed all the surge waveforms to the next lowest value (to the right in Table 1).

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Table 1: Test Results

Sample	Sample Number	Category C Low / Category B Combination Wave			Category B Ring Wave			Category A Ring Wave		
		6 kV 3,000 A	4 kV 2,000 A	2 kV 1,000 A	6 kV 500 A	4 kV 333 A	2 kV 167 A	6 kV 200 A	4 kV 133 A	2 kV 67 A
Incandescent Bulb	1	1								
	2		1							
	3			1						
	4				1					
	5					1				
	6						1			
	7							44		
	8								300	
Compact Fluorescent Bulb	1	1								
	2		1							
	3			1						
	4				300					
Electronic Ballast & Fluorescent Bulb	1	1								
	2		1							
	3			1						
	4				300					
LED Bulb	1	1								
	2		1							
	3			1						
	4				300					
50 VA Control Transformer	1				53					
VFD 0.33 HP	1	1								
	2				300					
	3*				20, L-G					
500 VA UPS	1				300					

Note: All VFD surges were performed Line to Neutral in positive polarity except for VFD sample number 3 which was tested Line to Ground.

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Conclusions

Table 1 in this document shows the surge test results for some common products. They cover a range of products from an incandescent light bulb to an uninterruptible power supply. These are common devices that are connected to an electrical supply and are exposed to everyday electrical surges that can be damaged by these events. The surges applied in this testing are at the same levels to be expected in common electrical installations.

As documented in the test results, the surge environment can produce a variety of effects. Surge damage can be experienced in a single event or as the result of an accumulation of surges. For example, in the case of an incandescent light bulb, the damage can be immediate or from repeated surges as shown by the quantity of the 44 surges in the Category A environment (i.e., test sample 7 in the table above). The application of a quality surge protective device can prevent damage to common electrical or electronic products. Surge protection is just as effective when used in commercial and industrial environments.

Electrical equipment is subject to surge damage, and these results show conclusively that everyday electrical devices are damaged by surges of the level expected in a normal electrical distribution system. The application of a surge protective device within a home or facility can alleviate the effects and save the cost or replacement for many electrical or electronic devices. For additional information on surge protection and its applications, visit www.NEMASurge.org.

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Data Assessment for Electrical Surge Protection Devices

Phase 1
Final Report

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FOREWORD

Every year there are widespread anecdotal reports of homeowners' property damage to electrical and electronic equipment resulting from electrical surges. The revision cycle of the 2011 edition of NFPA 70, *National Electrical Code®* (NEC®) included several proposals (e.g. NEC 4-53 and NEC 4-127) to add new requirements for a Surge Protective Device for all dwelling units. These proposals were rejected by the respective Code Making Panel (i.e., CMP-4) due to a lack of reliable data to support such requirements.

The goal of this project is to develop a data collection plan to assess loss related to electrical surge in homes, and address the potential impact electrical surge protection devices would have in mitigating these losses. The deliverables from this project represent a Phase I study in support of a potential second phase (not included in the scope of this effort).

The Research Foundation expresses gratitude to the report authors Eddie Davis, Nick Kooiman, and Kylash Viswanathan, all with Hughes Associates, Inc. Likewise, appreciation is expressed to the Project Technical Panelists and all others who contributed to this research effort for their on-going guidance. Special thanks are expressed to the project sponsors Eaton Corporation and the National Electrical Manufacturers Association for providing the funding for this phase 1 project.

The content, opinions and conclusions contained in this report are solely those of the authors.

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Data Assessment for Electrical Surge Protective Devices

Prepared for:

The Fire Protection Research Foundation
1 Batterymarch Park
Quincy, MA 02169-7471

Project Number: 1ELD62001.001
October 2014

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EXECUTIVE SUMMARY

Purpose

The Fire Protection Research Foundation sponsored this project to address electrical surge protection for residential dwelling units. The goal of the project is to develop a data collection plan to assess loss related to electrical surges in homes, and address the potential impact electrical surge protection devices (SPDs) would have in mitigating these losses. The deliverables from this project represent a Phase I study (this report) in support of a potential second phase (not included in the scope of this effort).

Report Content

This report provides information regarding:

- Surge phenomena and their sources.
- Surge protection methods.
- Surge protection strategies recommended by various sources.
- Industry standards and their recommendations.
- Available data associated with electrical surges and their impact.
- Recommended data collection in support of code-making efforts.

Surge Protection

Sources of Surges

A surge is a transient wave of voltage or current. The duration is not tightly specified but is usually less than a few milliseconds. The following are typical sources of surges:

- Lightning.
- Utility switching, including capacitor switching.
- Equipment switching and switching inductive loads within a facility.

Protection against surges is referred to as *surge protection*, and includes protection against both surge voltages and currents. The devices used to protect against surges are referred to as *surge*

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protective devices, or SPDs. A surge of duration longer than a few milliseconds is referred to as a swell or temporary overvoltage (TOV) and requires a different type of protection design; SPDs can fail if exposed to long duration TOVs.

Surge Effects

Surges can cause equipment damage. Large surges damage equipment and other components in the electrical distribution system. Smaller surges can cumulatively damage equipment and can cause nuisance equipment tripping. Both surge voltage and current can be damaging. In the case of lightning strokes, the surge can be carried into a facility via all of the connected conductive paths.

There is a limit on how high of a voltage can be transmitted into a facility or residence. Above a certain level, a high voltage will result in flashover in the insulation system of electrical equipment and conductors. A flashover can cause insulation damage, electric shock, and fire.

NEMA surveys of facility managers confirmed catastrophic failure or damage of electrical or electronic equipment due to a lightning event or voltage surge and premature failure of electrical or electronic equipment, including failure of life safety equipment.

The Insurance Information Institute report for 2013 identified 114,740 insurer-paid lightning claims for residential locations. The average lightning paid-claim amount was $5,869.

Residential Surge Protection

Residential surge protection has long been viewed as an important safety consideration and guidance has been issued by IEEE and NIST to help homeowners protect their house and its contents. This protection has often been described as being similar to an insurance policy, partly because there is not an NFPA code requirement for SPD installation in residences. Today's residences often contain electronic equipment throughout, including appliances, computers, security systems, life safety equipment, automation systems for internet-enabled applications, and home entertainment systems.

Industry Standards

SPDs are routinely used in facilities that are potentially exposed to voltage or current surges from nearby lightning, utility switching, or other sources; and there are many manufacturers of SPDs and these manufacturers often offer guidance regarding SPD installation ratings and recommended applications. However, industry codes and standards provide limited guidance regarding selection, rating, and application.

One limitation with surge protection design is that there is no industry standard that describes what is an acceptable level of surge protection for standard facilities or residential locations. Although industry codes and standards are available that establish standardized surge criteria and assist with the application of specific surge protector types, these standards do not provide adequate design guidance that ensures a facility is properly protected against surges. There is no existing industry guidance for surge protection of residential facilities.

Refer to Section 3 for an overview of the available industry standards.

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Data Acquisition Plan

Surge Data and Its Effects

Lightning strokes, either direct, nearby, or some distance away can cause voltage and current surges into a facility. Information is available regarding lightning strokes and their intensity. But, less information is available regarding the extent to which these surges are transmitted into commercial facilities, industrial facilities, or residences. Section 4.2 describes the difficulty associated with obtaining this data.

Available Data

Vaisala owns and operates the National Lightning Detection Network (NLDN) that provides accurate lightning data information across the USA. And, Vaisala can provide lightning location reports that provide individual cloud-to-ground lightning strikes and the intensity of strike at a specific location on the date of loss. This capability represents the largest and most complete source of lightning surge location and intensity.

Data for lightning surges that extend to the inside of facilities is not readily available. Published papers and IEEE C62.41.1 provide information regarding the expected surge levels within a facility or residence, but extensive data is not available.

Switching-related surge data, either internally or externally generated, is sparse. The added difficulty with this data is that these surges often do not cause immediate failure of electrical and electronic equipment; the damage occurs as a cumulative effect.

The largest documented source of surge effects is contained within the insurance claim documents for damage caused by surges. The Insurance Information Institute in collaboration with State Farm® produces annual reports of insurance claims associated with lightning-induced damage.

Data Acquisition Plan

There are challenges in obtaining usable data applicable to residential applications, such as:

- Confirming that equipment failures were a direct result of a surge event.
- Establishing any median and upper bounds to actual surge levels since this is not recorded inside facilities.
- Defining the protection improvement realized by applying SPDs.

Given the scarcity of real data relating to surges and the effects of surges, the approach described below is recommended.

The purpose of the recommended data acquisition approach is to produce real data regarding damage and injuries caused by surges. This information is intended to assist the NFPA 70 code-making committees with additional technical data to support a decision to require or not require SPDs for the variety of electrical applications proposed in past NFPA 70 update cycles (refer to Section 1.2).

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The starting point for this project is to acquire the nationwide lightning stroke data for the continental USA for 2013 (or 2014 if the project starts in 2015). This information can tie back to insurance claim data and possibly provide surge current values for the locations of interest.

The Insurance Information Institute is proposed to manage the insurance industry claim data. Their involvement assures that the insurance industry claim reports can remain confidential while allowing access to additional data that might be contained in the claim reports.

The Insurance Information Institute already publishes annual summaries of the number of lightning-related insurance claims and the claim amount. Additional information of interest that might be available in the claim data includes:

- Date and location of surge event (to establish geographical correlations).
- Electronic equipment and appliances damaged.
- Life safety equipment damaged – smoke detectors, CO or CO_2 detectors, or other equipment.
- Fires caused by surge effects.
- Personal injuries associated with the surge event.
- Presence of or lack of installed SPDs.

Life safety equipment damage, fires caused by surge events, and personal injuries are of particular interest for code-making efforts.

Although the annual Insurance Information Institute survey has historically focused on residential claims, the survey for this project should include commercial and industrial claims also. NEMA assistance and direction with this effort will be helpful.

NEMA Low Voltage Surge Protective Devices Section (5-VS) participation is recommended for the following:

- Assisting with project scope, including commercial and industrial users.
- Reviewing the project checklist for the type of information to be obtained from the insurance industry.
- Reviewing failure data report summaries.
- Considering recommended SPD design principles, including the specification of surge protection in low-lightning flash density areas versus high-lightning flash density areas. Should NFPA elect to require SPDs in dwelling units or other applications, then minimum surge protection current limits should also be addressed, similar to the method provided in NFPA 780. As SPD surge current rating increases (and the degree of protection), the SPD cost also increases.

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1

INTRODUCTION

1.1 Project Overview

The Fire Protection Research Foundation sponsored this project to address electrical surge protection for residential dwelling units. The goal of the project is to develop a data collection plan to assess loss related to electrical surges in homes, and address the potential impact electrical surge protection devices (SPDs) would have in mitigating these losses. The deliverables from this project represent a Phase I study (this report) in support of a potential second phase (not included in the scope of this effort).

The project includes the following activities that are documented in this report:

- Literature review – review of literature to include fundamental factors contributing to electrical surges, existing data associated with losses, case studies of SPD effectiveness, and overview of SPD designs.
- Preliminary data collection plan – develop a preliminary data collection plan that will address the identified data gaps. When implemented, the data collection plan should provide a comprehensive review of electrical surge related losses in homes in the United States and address the potential impact of electrical surge protection devices in mitigating these losses.
- Final report – to be issued after review of the draft report.

1.2 NFPA 70 Committee Report on Proposals – 2013

Each update cycle for NFPA 70, *National Electrical Code®*, includes numerous proposals for changes throughout the document. In particular, the installation of SPDs has been proposed for virtually all low-voltage (600 volts or less) electrical distribution equipment. Because of the breadth of these recommendations, the proposals and their reasons for rejection are summarized here. Although this Fire Protection Research Foundation report is focused on SPDs for residential dwelling units, the proposals for SPDs cover a much broader set of electrical distribution equipment.

The *National Electrical Code® Committee Report on Proposals – 2013 Annual Revision Cycle*[1] provides a summary of all proposals and their disposition in support of the 2014 edition of NFPA 70. With respect to the application of SPDs, the following proposals were submitted:

[1] The *National Electrical Code® Committee Report on Proposals – 2013 Annual Revision Cycle*. The 2010 version provided similar recommendations.

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- Proposal 4-65 Log #3318 NEC-P04 – New Article 225.41 Surge Protection. A Type 1 or Type 2 listed SPD shall be installed on all outside branch circuits and feeders and shall be located at the point where the outside branch circuits and feeders receive their supply.

- Proposal 4-143 Log #3319 NEC-P04 – Article 230.67 Surge Protection. A Type 1 or Type 2 listed SPD shall be installed on all services.

- Proposal 4-143a Log #3504 NEC-P04 – Article 230.67 Dwelling Unit Surge Protection.
  (A) Surge Protective Device. All dwelling units shall be provided with a surge protective device (SPD) installed in accordance with Article 285.
  (B) Location. The surge protective device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto.
  (C) Type. The surge protective device shall be a Type 1 or Type 2 SPD.
  (D) Replacement. Where service equipment is upgraded, all of the requirements of this section shall apply.

- Proposal 5-244 Log #3320 NEC-P05 – New Article 285.2 Required uses. A listed SPD shall be installed in or on the following equipment that is rated at 1000 volts or less.
  (1) Switchboards and panelboards
  (2) Motor control centers
  (3) Industrial control panels
  (4) Control Panels for elevators, dumbwaiters, escalators, moving walks, platform & stairway chairlifts
  (5) Power distribution units supplying information technology equipment in information technology rooms
  (6) Solar photovoltaic (PV) combiner boxes, recombiner boxes, and inverters
  (7) Roof-top air conditioning and refrigerating equipment
  (8) Adjustable-speed drive systems
  (9) Burglar alarm panels
  (10) Fire alarm panels
  (11) Critical Operations Power Systems
  (12) Small Wind Electric Systems

- Proposal 9-117 Log #3321 NEC-P09 – Article 408.6 Surge Protection. A listed SPD shall be installed in or on all switchboards and panelboards.

- Proposal 11-14 Log #3322 NEC-P11 – Article 409.70 Surge Protection. A listed SPD shall be installed in or on all industrial control panels.

- Proposal 11-42 Log #3323 NEC-P11 – New Article 430.92 Surge Protection. A listed SPD shall be installed in or on all motor control centers.

- Proposal 11-55 Log #3324 NEC-P11 – New Article 430.121 Surge Protection. A listed SPD shall be installed in or on all adjustable-speed drive systems.

- Proposal 11-84 Log #3325 NEC-P11 – New Article 440.9 Surge Protection. A listed SPD shall be installed in or on all roof-top air-conditioning and refrigerating equipment.

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- Proposal 12-49 Log #3326 NEC-P12 – New Article 620.56 Surge Protection. A listed SPD shall be installed in or on control panels for elevators, dumbwaiters, escalators, moving walks, platform and stairway chairlifts.

- Proposal 12-140 Log #3327 NEC-P12 – New Article 645.18 Surge Protection. A listed SPD shall be installed in or on all switchboards, panelboards, and power distribution units supplying information technology equipment in information technology rooms.

- Proposal 12-169 Log #3328 NEC-P12 – New Article 670.6 Surge Protection. A listed SPD shall be installed in or on all industrial machinery.

- Proposal 4-254 Log #3329 NEC-P04 – New Article 690.12 Surge Protection. A listed SPD shall be installed in or on all solar photovoltaic (PV) combiner boxes, recombiner boxes, and inverters.

- Proposal 13-98 Log #3330 NEC-P13 – New Article 700.8 Surge Protection. A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.

  Note: Although the *Committee Report on Proposals* lists the Final Action as Reject, the 2014 edition of NFPA 70 does include a new Article 700.8 that states:

  700.8 Surge Protection
  A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.

- Proposal 4-405 Log #3331 NEC-P04 – New Article 705.13 Surge Protection. A Type 1 listed SPD shall be installed at the point of connection of all interconnected electric power production sources.

- Proposal 3-131 Log #3332 NEC-P03 – New Article 725.36 Surge Protection. A listed SPD shall be installed in or on all burglar alarm control panels.

- Proposal 3-179 Log #3333 NEC-P03 – New Article 760.36 Surge Protection. A listed SPD shall be installed in or on all fire alarm control panels.

The NFPA 70 Panel rejected the above proposals on various bases, including:

- *Surge protection is permitted to be installed and should not be required, as surge probabilities vary by locality, and different types of electrical loads have differing surge protection requirements. Surge protection must also be periodically maintained or replaced. The user should make the decision to install this protection.*

- *While the use of SPD's is appropriate in many instances, it is not always needed in every installation. System designers should apply SPD's where needed. Equipment manufacturers frequently provide integrated surge protection when it is deemed appropriate. The substantiation provided does not warrant the imposition of this new requirement.*

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- *Surge protective devices have proven to provide benefits for components and systems against the damages of voltage surges, but the substantiation for this proposal does not document that such protection would specifically benefit HVAC equipment installed on a roof. In addition this may not work with high resistance, impedance or ungrounded systems. The NFPA FPRF is working on a project in this area which may provide information in the future.*

- *CMP-13 acknowledges that surges may result in failures. However, the proposal does not state what type or level of protection should be required. Further substantiation through a formal research report that presents evidence of the type of SPD and the level of protection required would present the opportunity for the panel to reconsider the proposal.*

Miscellaneous changes were made to the 2014 edition of NFPA 70 Article 285, *Surge-Protective Devices (SPDs), 1000 Volts or Less*, but these changes do not affect the locations where surge protection has been required.

1.3 Report Content

This report provides information regarding:

- Surge phenomena and their sources.
- Surge protection methods.
- Surge protection strategies recommended by various sources.
- Industry standards and their recommendations.
- Available data associated with electrical surges and their impact.
- Recommended data collection in support of code-making efforts.

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2

SURGE PROTECTION FUNDAMENTALS

Section 2 provides an overview of electrical surges and protection against the effects of these destructive surges.

2.1 Sources of Surges

A surge is a transient wave of voltage or current. The duration is not tightly specified but is usually less than a few milliseconds. The following are typical sources of surges:

- Lightning.
- Utility switching, including capacitor switching.
- Equipment switching and switching inductive loads within a facility.

The following summarizes the effects of these various surge sources.

Table 2-1
Sources of Surges

Source of Surge	Peak Voltage Magnitude	Frequency of Occurrence	Comments
Lightning	<1,000 volts to >40,000 volts with average of about 20,000 volts	Weekly to rarely, depending on location	Magnitude depends on proximity of stroke to facility and coupling of stroke to facility electrical system. Voltages within a facility above 6,000 volts are unlikely due to flashover.
Utility Capacitor and System Switching	Up to 1,300 volts on a 480 volt system	Never to several times a day, depending on utility	Capacitors might or might not be installed nearby.
Facility Equipment Switching	Up to 2,000 volts on a 480 volt system	Many times a day	Magnitude is small compared to lightning-induced transients, but switching can occur frequently.

Protection against surges is referred to as *surge protection*, and includes protection against both surge voltages and currents. The devices used to protect against surges are referred to as *surge protective devices*, or SPDs. A surge of duration longer than a few milliseconds is referred to as a swell or temporary overvoltage (TOV) and requires a different type of protection design; SPDs can fail if exposed to long duration TOVs.

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2.1.1 *Lightning Surges*

Lightning-induced surges into an electrical system are caused by lightning strokes to the ground, towers, or structures. A lightning stroke can produce peak discharge currents ranging from a few thousand amperes to 200,000 amperes, or higher. This lightning discharge current is developed within a few microseconds and typically discharges most of its energy within a millisecond. The location where a lightning stroke will occur is not completely predictable; cloud-to-ground strokes have been recorded almost 20 miles from the base of the source cloud.

The frequency of lightning strokes varies with geographical location. Figure 2-1 shows the Vaisala lightning flash density map for the United States. Lightning strokes are a rare occurrence in Portland Oregon while they can be a routine event in Orlando Florida.

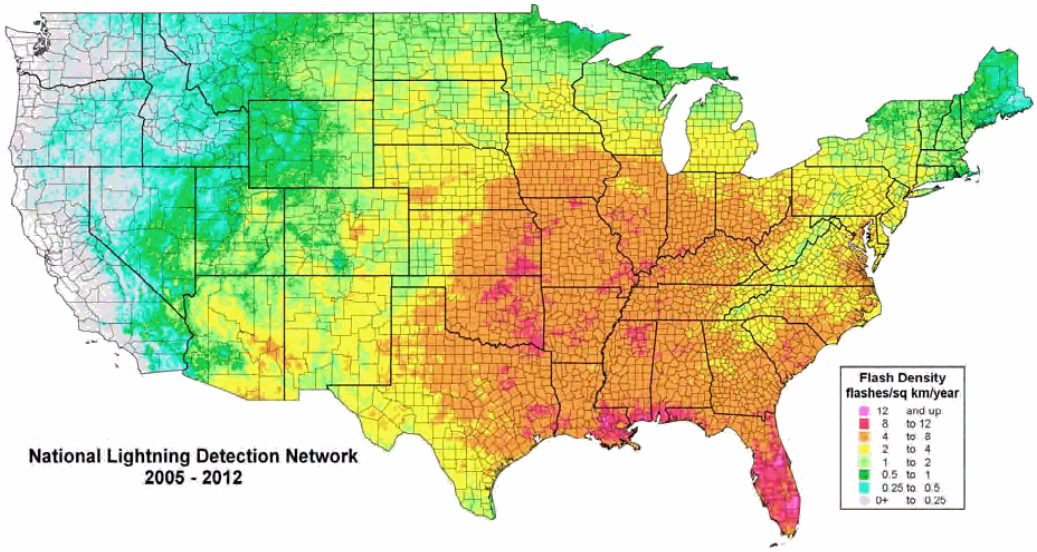


Figure 2-1
Lightning Flash Density Map
Courtesy Vaisala

A single intense storm can produce thousands of lightning strokes. Schneider Electric Data Bulletin DB03A, *Surge Protection: Measured Lightning Stroke Data*, describes a July 2000 storm in Tampa Florida that recorded 33,863 lightning strokes during a 14 hour period. Both positive and negative polarity strokes were detected,[2] with the following recorded surge currents:

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[2] A lightning stroke is a lightning discharge between a thundercloud and the ground and commonly referred to as cloud-to-ground lightning. The most common type of lightning stroke is referred to as a negative lightning stroke and usually originates near the bottom of the cloud with a large concentration of negative charge in the cloud base. The term *negative lightning* means that there is a net transfer of negative charge from the cloud to the ground. Positive lightning strokes represent only about 5% of the lightning strokes and tend to originate in the more positively charged top of the cloud.

Positive Lightning Stroke Surge Currents

- 95% – less than 30 kA
- 98% – less than 60 kA

Negative Lightning Stroke Currents

- 82% – less than 30 kA
- 98% – less than 60 kA

For this Tampa Florida storm, notice that the above results show that 2% of the lightning strokes produced surge currents greater than 60 kA. A few lightning strokes approached 200 kA. But, over 80% of the lightning strokes produced surge currents less than 60 kA.

This data correlates reasonably well with a report from the IEEE Lightning and Insulator Subcommittee of the T&D Committee that showed a 50% probability of less than about 20 kA, a 95% probability of less than about 60 kA, and a 99% probability of less than about 100 kA.[3]

A lightning-induced surge is a high magnitude impulsive transient of very short duration, typically measured in microseconds or milliseconds. But, during this short period, significant system damage can occur. Figure 2-2 shows an example.

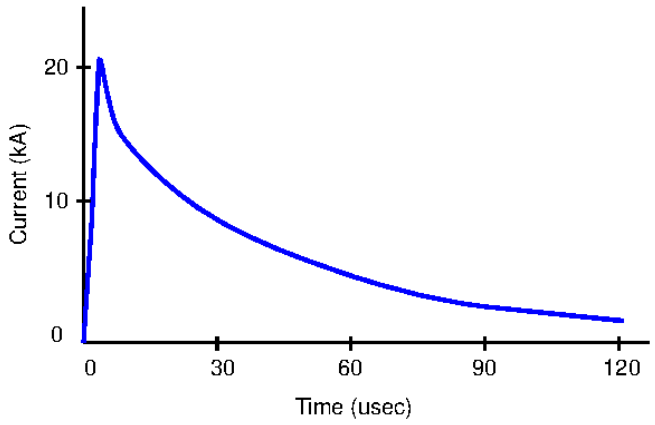


Figure 2-2
Typical Lightning Surge Current

Lightning-induced surges can be introduced into the electrical distribution system by any of the following methods, either alone or in combination:[4]

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[3] Refer to Lightning and Insulator Subcommittee of the T&D Committee, *Parameters of Lightning Strokes: A Review*, IEEE Transactions on Power Delivery, Vol. 20, No. 1, January 2005, for the actual range of values.

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- Direct lightning strokes to the service entrance, either at low voltage lines or on the high voltage windings of service entrance transformers.
- Nearby strokes that induce voltages in distribution transformer secondary circuits.
- Strokes near the service entrance that induce surges onto the electrical system.
- Strokes to a building that induce surges in the system ground with respect to power supplies.
- Surges that cause surge protector operation, thereby placing a surge on the ground and neutral wire common to the low voltage system.

The greatest number of lightning-caused surges that will be seen originate on the high voltage side of the distribution transformer. Far less often, the surges will be caused by a local stroke impinging on the facility, service entrance transformer, or nearby equipment. Most surges, regardless of whether they originate on the primary or secondary side of the transformer are not from a direct stroke; usually, the surge is caused by a stroke to the pole, tower, ground wire, or nearby object with the surge electromagnetically coupled into the distribution or service conductors. Once into the electrical system wiring, surges on the high side of the transformer are coupled into the secondary and transmitted throughout a facility.

2.1.2 *Utility Switching*

Utility switching is a broad term that applies to how utility configurations are occasionally changed. Each switching operation can produce a transient that can momentarily exceed equipment voltage ratings. Although the transients are not as large in magnitude as a nearby lightning stroke, switching transients can cause cumulative damage to electrical equipment. And, if switching results in a temporary overvoltage (TOV), it can also cause SPD failure.

Capacitor switching is a special case of utility switching. Capacitors might also be switched periodically by large industrial power customers. Capacitor switching can be a common every-day event, occurring several times each day in some locations, as a utility adjusts system voltage and compensates for inductive loads.

Capacitor switching causes a surge voltage by the following process. The voltage across a capacitor is zero before it is switched into the circuit. As a capacitor is switched, there is a momentary short circuit across the capacitor as the system voltage is applied to the zero voltage of the capacitor. At the capacitor location, the bus voltage momentarily experiences a step change to zero volts. After the initial step change, the voltage recovers and then overshoots as the system eventually return to its steady state value. Thereafter, the system oscillates until damping returns the voltage to its steady-state value. During the initial oscillation period, the peak transient voltage can approach 200 percent of the normal peak system voltage (common peak surge voltages can range from 150 percent to 180 percent of normal). Another factor contributing to the transient is the inrush current as the capacitor energizes; this inrush current

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[4] IEEE C62.41.1, *Guide On The Surge Environment In Low-Voltage (1000V And Less) AC Power Circuits*, uses the terms “direct flash”, “near flash”, and “far flash” to distinguish between lightning strokes and how they induce a surge on a facility.

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can have a resonant frequency anywhere from 300 hz to 1,000 hz depending on the installed inductance and capacitance, which adds to the system oscillations. Figure 2-3 shows an example of a capacitor switching transient.

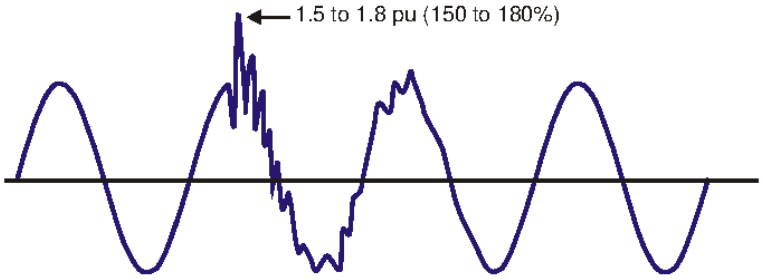


Figure 2-3
Voltage Waveform for Capacitor Switching Transient

Capacitors inside a facility can resonate with the switching-induced oscillations, thereby magnifying the peak voltage and extending the period until the voltage returns to normal. Magnification of the switching transient can occur if the utility switched capacitor bank is much larger than the facility capacitor bank and there is little resistive load (mostly motor load) to provide a damping mechanism.

2.1.3 *Facility Internal Switching*

Switched equipment in a facility electrical system or residence results in the inductive release of energy that creates a momentary voltage surge. Even minor switching, such as deenergizing lighting loads, can cause a significant inductive surge in the system. This type of switching accounts for the overwhelming majority of switching transients. However, the magnitude of this type of surge is much smaller than for lightning-induced surges.

2.2 Surge Effects

Surges can cause equipment damage.[5] Large surges damage equipment and other components in the electrical distribution system. Smaller surges can cumulatively damage equipment and can cause nuisance equipment tripping. Both surge voltage and current can be damaging. In the case of lightning strokes, the surge can be carried into a facility via all of the connected conductive paths. The following figures show examples of damage caused by surges.

[5] Refer to IEEE 1100, *Powering and Grounding Electronic Equipment*, for additional information regarding the effects of surges.

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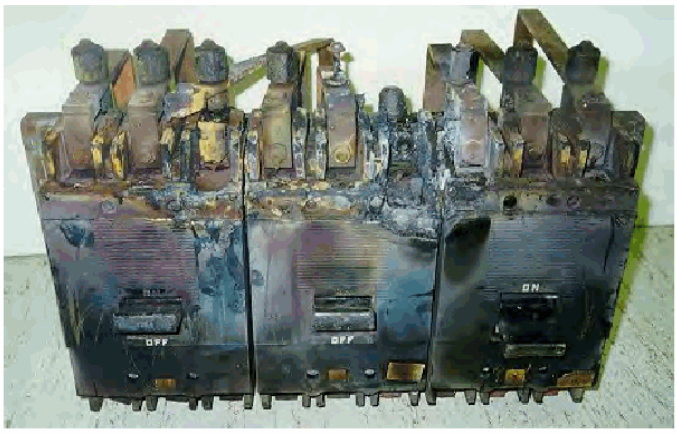


Figure 2-4
Circuit Breaker Failure Caused by Surge Voltage



Figure 2-5
Copper Busbar Melted by Surge Current

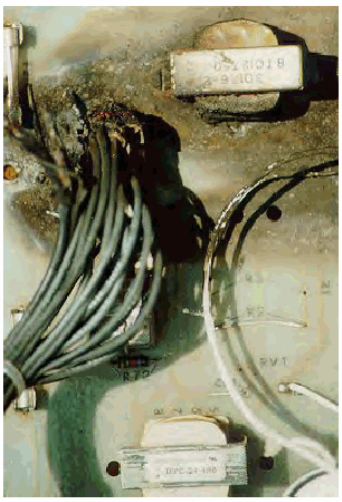


Figure 2-6
Circuit Board Damage Caused by Surge Voltage

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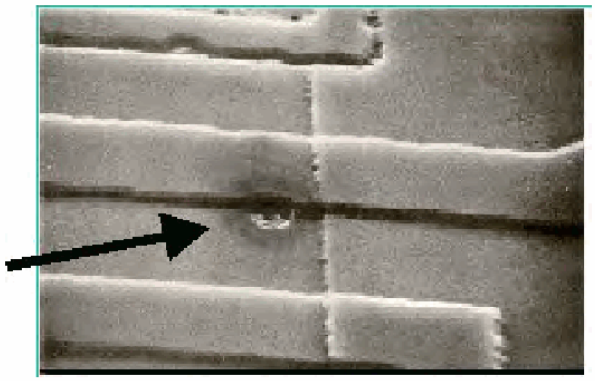


Figure 2-7
Micro Circuit Damage Caused by Surge Voltage

Electronic equipment is susceptible to surge transients. Computers and internet-enabled devices are not only at risk in the power supply but can also be damaged by surges that propagate into the equipment via the communications link.

There is a limit on how high of a voltage can be transmitted into a facility or residence. Above a certain level, a high voltage will result in flashover in the insulation system of electrical equipment and conductors. A flashover can cause insulation damage, electric shock, and fire.

2.2.1 *NEMA Surveys*

The NEMA Low Voltage Surge Protective Devices Section (5-VS) sponsored surveys of surge damage in 2013 and 2014.[6] The surveys were targeted towards facility managers and attempted to accomplish the following:

- Determine if SPDs are installed.
- Obtain failure data for electrical or electronic equipment due to a lightning event or voltage surge.
- Determine the frequency of damage incidents.
- Address the type of equipment damaged.
- Summarize the cost of damage.

The following summarizes the 2014 survey results:

- 100 respondents completed the survey.

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[6] NEMA 2013 *U.S. Surge Protection Damage Survey* and NEMA *Surge Damage Survey Results – Wave 2*. Refer to http://www.nemasurge.org for reports.

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- A plurality (48%) of respondents noted that their facility had experienced unexplained process interruptions. Catastrophic failure or damage of electrical or electronic equipment due to a lightning event or voltage surge and premature failure of electrical or electronic equipment were both frequently reported (41%) events. More than a third (38%) noted the occurrence of lockup of computer or industrial process systems.

- For most respondents (61%), it cost less than $10,000 to repair the damage resulting from voltage surges, but a sizable number (16%) reported damage costing in excess of $50,000 to fix.

- Nearly 95% of those who reported having experienced a surge event resulting in equipment damage indicated that they subsequently purchased surge protection. Virtually all of those who did so, purchased immediately or within three months of the event.

- Over 65% reported downtimes associated with voltage surges of 6 hours or more.

- Respondents reported damage or loss of function of the following types of life safety equipment because of voltage surges:

  - Smoke detector (34.7%)
  - CO2 detector (18.7%).
  - Fire alarm system (41.3%).
  - Security system (49.3%).
  - Ground fault circuit interrupters (22.7%).
  - Emergency lighting (32.0%)
  - Emergency generators or backup power (33.3%).
  - Fire pumps (12.0%).
  - Elevators or escalators (24.0%).
  - Safety interlocking systems on machines (26.7%)

  Of the respondents, only 14.7% stated that no life safety equipment was damaged or lost function.

- When asked if anyone had been injured, either directly or indirectly, as a result of a voltage surge, 10.7% replied yes.

The NEMA survey is significant in that it shows the effect of surges on life safety equipment and the potential impact to personnel in a facility.

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2.2.2 *Insurance Information Institute Surveys*

The Insurance Information Institute[7] provides periodic reports of homeowner insurance claims associated with lightning-induced damage. Their report for 2013, produced in collaboration with State Farm®, included the following:

- There were 114,740 insurer-paid lightning claims in 2013, down 24% from 2012.
- The average lightning paid-claim amount was also down in 2013, slipping by 8.3% to $5,869 from $6,400 in 2012.
- The decline in lightning damage last year is consistent with data from the National Weather Service, which recorded 137 days in 2013 with lightning causing property damage, while 160 such days were recorded in 2012—a 14 percent decrease.
- Despite the drop in the number of paid claims in 2013, the average cost per claim rose nearly 122% from 2004-2013. The average cost per claim has generally continued to rise, in part because of the huge increase in the number and value of consumer electronics in homes.

2.3 Surge Protective Devices (SPDs)

2.3.1 *Typical Configuration*

Most SPDs in use for the applications covered by this report use metal oxide varistors (MOVs) to accomplish surge suppression in the electrical power system. MOVs exhibit nonlinear resistance characteristics as a function of voltage. Within the MOV voltage rating, the resistance usually exceeds 10,000,000Ω, but the resistance drops to less than 0.1Ω when the MOV is exposed to an overvoltage, such as a transient voltage spike due to a nearby lightning stroke. It is this characteristic that makes MOVs an effective protection element.

The MOV is essentially a matrix of zinc oxide grain boundaries that have a nonlinear resistance characteristic. The series combination of the boundaries defines the MOV voltage rating, the parallel combination defines the total current that can be passed, and the bulk volume determines how much energy that it can absorb. When an MOV is energized with an AC voltage, resistive and reactive current flows through the highly capacitive disc.

Most SPDs are connected in parallel with the circuit and operate when a transient voltage exceeds the voltage protection rating. Parallel surge protectors have little interaction with the circuit under normal conditions.

A different technology is commonly used for communications lines, referred to as a gas discharge tube (GDT), which is a spark gap type of surge suppression device. When subjected to a surge voltage, the gas discharge tube sparks over, thereby causing an arc to ground. The hermetically sealed tubes used today can have a precise and repeatable turn-on voltage. Gas discharge tubes consist of a spark gap in series with a resistance or varistance to limit the discharge current to safe levels.

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[7] Their reports are accessible at http://www.iii.org/.

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2.3.2 *SPD Classification*

UL 1449 classifies SPDs by type depending, in part, on their location in the system and their level of internal protection:

- Type 1 – Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device. They must have overcurrent protective devices either installed internally on the SPD or included with it. While these are primarily intended for installation before the main service disconnect, Type 1 SPDs can be installed in Type 2 and Type 4 locations such as distribution panels, end-use equipment. Residential installations are often Type 1, installed near the incoming meter.

- Type 2 – Permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device; including SPDs located at the branch panel. While some will have internal overcurrent protective components, Type 2 SPDs can rely on the service entrance overcurrent disconnect device for over current protection. These SPDs can be installed in service equipment, distribution panels, and end-use equipment.

- Type 3 – Point of utilization SPDs, installed at a minimum conductor length of 10 meters (30 feet) from the electrical service panel to the point of utilization, for example cord connected, direct plug-in, receptacle type and SPDs installed at the utilization equipment being protected.

- Type 4 – Component SPDs, including discrete components as well as component assemblies.

Permanently installed self-contained SPDs are usually Type 1 or Type 2.

2.3.3 *SPD Ratings*

SPDs are tested and rated in accordance with UL 1449. The following ratings are normally provided for each model and size of SPD:

- Nominal voltage and frequency.

- Maximum continuous overvoltage (MCOV) – defines the voltage at which the SPD will start conducting to ground. Continuous operation above the MCOV will lead to SPD failure.

- Voltage protection rating (VPR) – a UL 1449 rating of the limiting voltage measured during the transient-voltage surge suppression test using the combination wave generator at a setting of 6kV, 3kA. A lower VPR is better.

- Surge current rating – the maximum surge current that an SPD is rated to carry without excessive overheating and consequent premature breakdown or combustion risk. The surge current rating is expressed in thousands of amps (kA) and is an indicator of how many MOVs are installed in parallel inside the device. SPDs are readily available rated for as low as ≤20 kA up to ≥600 kA. SPD price tends to increase as surge current rating increases.

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- Protection modes – line-to-line, line-to-ground, line-to-neutral, neutral-to-ground.
- Short circuit current rating (SCCR).
- Surge life – expected number of surges that the SPD can withstand.

Other important attributes include monitoring and design for the environment at the installation location.

2.4 Residential Surge Protection

Residential surge protection has long been viewed as an important safety consideration and guidance has been issued in the past to help homeowners protect their house and its contents[8]. This protection has often been described as being similar to an insurance policy, partly because there is not an NFPA code requirement for SPD installation in residences. Today's residences often contain electronic equipment throughout, including appliances, computers, security systems, life safety equipment, automation systems for internet-enabled applications, and home entertainment systems.

2.4.1 *Design*

SPDs used in residential applications are typically designed for 240/120 volts with the electrical power neutral bonded to ground at the service entrance. A permanently-installed SPD can be installed at the incoming meter (Type 1) or at the service entrance (Type 2). Type 3 SPDs can still be installed at the point of use for electronic equipment also.

The IEEE document, *How to Protect Your House and Its Contents from Lightning, IEEE Guide for Surge Protection of Equipment Connected to AC Power and Communication Circuits*, provides an excellent overview of the design and installation considerations for SPDs. A permanently-installed SPD should be installed by a qualified electrician and should consider quality of the grounding system, lead length for connections, overcurrent protection, and disconnect capability. Installation in accordance with NFPA 70 is a requirement.

2.4.2 *General Cost*

Prices vary widely for SPDs. An SPD intended for residential use (240/120 volts) and rated for 50 kA surge current can cost as little as $125 and as much as $500. Integrated protection to protect the incoming power lines as well as the phone/internet communication lines can cost an additional $100. A reasonable level of protection can typically be realized for about $500.

One consideration is how high of a surge current rating to specify. Cost tends to increase as the surge current rating increases because of the additional MOV modules that are required. The cost can be considerably higher for three-phase circuits, partly because there are more protection

[8] Key documents include *How to Protect Your House and Its Contents from Lightning, IEEE Guide for Surge Protection of Equipment Connected to AC Power and Communication Circuits*, by Richard L. Cohen and others, ISBN 0-7381-4634-X, 2005 and NIST Special Publication 960-6, *Surges Happen! How to Protect the Appliances in Your Home*, 2001. Some insurance companies also provide guidance on their websites.

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modes to consider compared to a single-phase application and partly because the surge current rating might be higher. For residential applications, a surge current rating above 30 kA likely is adequate for 80% to 90% of lightning strokes.[9] A surge current rating above 60 kA likely is adequate for virtually all lightning strokes. In lightning-prone areas (refer to Figure 2-1), a higher surge current rating can also provide a longer SPD life if it is exposed to repeated surges.

[9] Lightning strokes produce the largest surges.

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3

INDUSTRY STANDARDS

Section 3 provides an overview of industry codes and standards that apply to SPDs.

SPDs are routinely used in facilities that are potentially exposed to voltage or current surges from nearby lightning, utility switching, or other sources; and there are many manufacturers of SPDs and these manufacturers often offer guidance regarding SPD installation ratings and recommended applications. However, industry codes and standards provide limited guidance regarding selection, rating, and application.

One limitation with surge protection design is that there is no industry standard that describes what is an acceptable level of surge protection for standard facilities or residential locations. Although industry codes and standards are available that establish standardized surge criteria and assist with the application of specific surge protector types, these standards do not provide adequate design guidance that ensures a facility is properly protected against surges. There is no existing industry guidance for surge protection of residential facilities.

3.1 NFPA Codes and Standards

3.1.1 *NFPA 70*

NFPA 70 distinguishes between surge arresters for applications over 1,000 volts (Article 280) and SPDs for applications 1,000 volts or less (Article 285). Each Article provides installation requirements.

NFPA 70[10] requires SPDs for the following applications:

- Article 501.35, Surge Protection – required Class I Division 1 and 2 locations.
- Article 694, Wind Electric Systems. Article 694.7(D) requires, "*A surge protective device shall be installed between a small wind electric system and any loads served by the premises electrical system. The surge protective device shall be permitted to be a Type 3 SPD on a dedicated branch circuit serving a small wind electric system or a Type 2 SPD located anywhere on the load side of the service disconnect.*"
- Article 700, Emergency Systems. New Article 700.8, Surge Protection, was added in 2014 and requires, "*A listed SPD shall be installed in or on all emergency systems switchboards and panelboards.*"

[10] The *National Electrical Code® Handbook* provides additional discussion of surge protection requirements.

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- Article 708, Critical Operations Power Systems (COPS). Article 708.20(D) requires, "*Surge protection devices shall be provided at all facility distribution voltage levels*".

- If surge protection is provided, Article 646, Modular Data Centers, requires that SPDS are listed, labeled, and installed in accordance with Article 285.

Article 285 provides requirements regarding the installation of SPDs, but it provides limited guidance for when a SPD is required or recommended ratings. The NFPA 70 Handbook also avoids discussion regarding the application of SPDs. In other words, NFPA 70 provides guidance regarding SPD installation, but provides no information regarding SPD selection and rating.

3.1.2 *NFPA 780*

NFPA 780[11], *Standard for the Installation of Lightning Protection Systems*, is more specific regarding the application of SPDs for lightning protection systems. This standard provides detailed requirements for the application of SPDs in support of a lightning protection system, including SPD rating information. Key requirements include:

- SPDs shall be installed at all power service entrances.

- The SPD shall protect against surges produced by a 1.2/50 µs and 8/20 µs combination waveform generator.

- SPDs at the service entrance shall have a nominal discharge current (I_n) rating of at least 20 kA 8/20 µs per phase.

- Signal, data, and communications SPDs shall have a maximum discharge current (I_{max}) rating of at least 10 kA 8/20 µs when installed at the entrance.

- The published voltage protection rating (VPR) for each mode of protection shall be selected to be no greater than those given in Table 4.20.4 for the different power distribution systems to which they can be connected. The maximum allowed VPR per mode of protection varies from 600 to 1,800 volts, depending on the service voltage and connection type.

- The maximum continuous operating voltage (MCOV) of the SPD shall be selected to ensure that it is greater than the upper tolerance of the utility power system to which it is connected.

- SPDs at grounded service entrances shall be wired in a line-to-ground (L–G) or line-to-neutral (L–N) configuration. Additional modes, line-to-line (L–L), or neutral-to-ground (N–G) shall be permitted at the service entrance. For services without a neutral, SPD elements shall be connected line-to-ground (L–G). Additional line-to-line (L–L) connections shall also be permitted.

[11] NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2014 Edition.

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- Installation of surge suppression hardware shall conform to the requirements of NFPA 70, *National Electrical Code*. SPDs shall be located and installed so as to minimize lead length. Interconnecting leads shall be routed so as to avoid sharp bends or kinks.

Although NFPA 780 only applies to lightning protection systems, it provides clear SPD design, rating, and installation guidance for these systems.

3.2 IEEE Standards

IEEE has historically taken the lead with respect to characterizing the surge environment. The following sections discuss key IEEE documents that apply to SPDs.

3.2.1 *IEEE C62.41.1*

IEEE C62.41.1, *Guide On The Surge Environment In Low-Voltage (1000V And Less) AC Power Circuits*, provides comprehensive information about surges and the environment in which they occur. This guide form the basis for IEEE surge testing criteria and is recommended for any review of surge characteristics. IEEE C62.41.1 is also valuable as a source of recorded data of surge events. Temporary over-voltages are also discussed, including their potential impact on SPDs.

3.2.2 *IEEE C62.41.2*

IEEE C62.41.2, *Recommended Practice On Characterization Of Surges In Low-Voltage (1000V And Less) AC Power Circuits*, presents recommendations for selecting surge waveforms, and the amplitudes of surge voltages and currents used to evaluate equipment immunity and performance of SPDs. The following figures show the surges recommended by IEEE C62.41.2 for consideration.

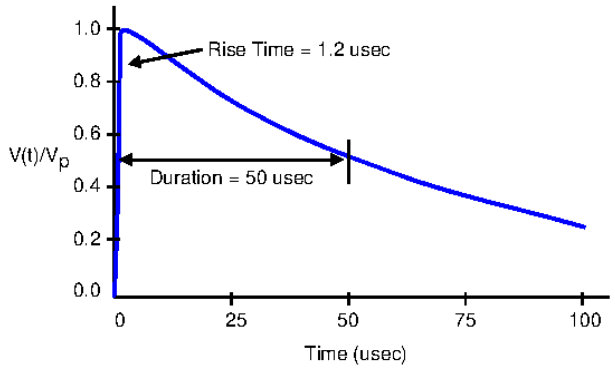


Figure 3-1
Combination Wave—1.2 x 50 µsec, Open Circuit Voltage

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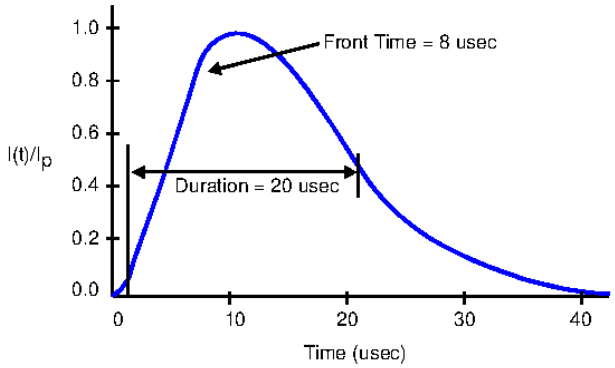


Figure 3-2
Combination Wave—8 x 20 µsec, Short Circuit Current

The second type of IEEE C62.41.2 surge voltage is called a 100 khz ring wave with a waveform below.

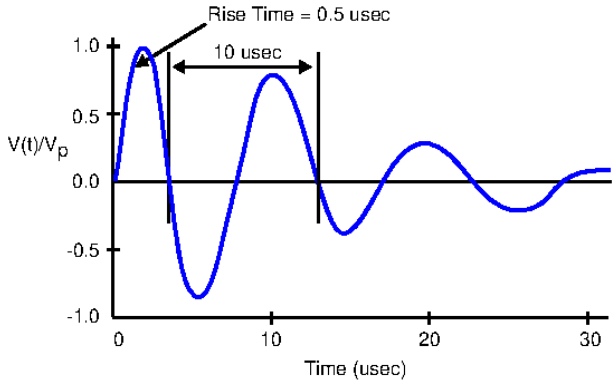


Figure 3-3
100 khz Ring Wave—Open Circuit Voltage

The combination and ring waves are intentionally generic in shape, in that peak magnitudes are not provided. Voltage and current values are assigned according to distance into the distribution system.

3.2.3 *IEEE C62.45*

IEEE C62.45, *Recommended Practice On Surge Testing For Equipment Connected To Low-Voltage (1000V And Less) AC Power Circuits*, describes surge testing procedures using simplified waveform representations (described in IEEE C62.41.2) to obtain reliable measurements and enhance operator safety.

3.2.4 *IEEE 1100*

IEEE 1100, *Powering and Grounding Electronic Equipment*, provides guidance regarding SPDs. Unfortunately, the information provided in IEEE 1100 is dated and does not reflect the current SPD products that arevavailable; much of the information provided is over 15 years old. But,

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IEEE 1100 provides a good discussion of surge effects and protecting against surges.

3.2.5 *IEEE 1692*

IEEE 1692, *IEEE Guide for the Protection of Communication Installations from Lightning Effects*, provides design guidelines to help prevent lightning damage to communications equipment within structures.

3.3 UL Documents

3.3.1 *UL 1449*

In the USA, SPDs are manufactured and specified in accordance with UL 1449, Third Edition, *Surge Protective Devices*, which was issued on September 29, 2006 with an effective date of September 29, 2009. This revision to UL 1449 changed how surge protective devices (SPDs) are named, tested, and rated. UL 1449 listing is specifically required by NFPA 780 and SPD listing (presumably to UL 1449) is required by NFPA 70. UL 1449 defines the performance requirements for an SPD; however, it does not address the engineering application of SPDs. UL also addresses additional related product performance criteria in UL 1283, *Electromagnetic Interference Filters*, and the UL 497 series, *Protectors for Fire Alarm Signaling Circuits*.

UL 1449, Third Edition, improved the harmonization of methods with IEC 61643 series, *Low Voltage Surge Protective Devices*, but there still remain some differences in approach between the UL and IEC test methods.

UL 1449, Third Edition, changed testing and rating requirements such that an SPD listed to UL 1449, Second Edition, cannot be compared to an SPD listed to UL 1449, Third Edition; the differences are too significant. Some of the key changes include:

- New performance tests use more surge current, resulting in higher let-through voltages. The older tests were performed at 500 amperes and 6,000 volts. The new tests are performed at 3,000 amperes and 6,000 volts.
- Test results for the new performance tests in the Third Edition are higher than the equivalent tests in the Second Edition, which has resulted in manufacturers changing their product literature. With a surge current of 6 times the Second Edition level, the Third Edition results for let-through voltage must be higher (the let-through voltage or clamping voltage was referred to as suppressed voltage rating in the Second Edition and is referred to as voltage protection rating in the Third Edition).
- Terminology has changed.
- UL 1449 is now ANSI-approved.

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3.3.2 *UL 497*

The UL 497 series, *Protectors for Fire Alarm Signaling Circuits*, provides performance standards and testing procedures for enclosures, corrosion protection, field wiring connections, and components of SPDs, as well as product labeling and installation instructions.

3.3.3 *UL 1283*

UL 1283, *Electromagnetic Interference Filters*, provides requirements for electromagnetic interference (EMI) filters. It addresses filters installed on, or connected to, 600 V or lower voltage circuits and 50-60 Hz frequency. These filters are used to attenuate unwanted radio frequency (RF) signals, such as noise or interference generated from electromagnetic sources. They consist of capacitors and inductors used alone or in combination with each other and may be provided with resistors.

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4

DATA ACQUISITION PLAN

Section 4 provides an overview of the recommended data acquisition plan for SPDs.

4.1 Type of Desired Data

In order to address fully the potential application of SPDs as a code requirement, the following types of data would be especially helpful:

Installations With SPDs Installed

- Characterization of surge events that were successfully diverted without damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that occurred with subsequent damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that resulted in damage or loss of function to life safety equipment.

Installations Without SPDs Installed

- Characterization of surge events that did not cause damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that occurred with subsequent damage to electronic equipment, electrical equipment, or the structure.
- Characterization of surge events that resulted in damage or loss of function to life safety equipment.

Surge Characterization

- Real data recording of lightning-induced surges.
- Real data recording of switching-induced surges, either internally generated (appliances or motors turning on or off) or externally generated (such as capacitor switching).

The problem lies in acquiring the above data, which is the goal of this project. The above information does not really exist, except in a few limited scope studies and in insurance claim documents. Refer to the following sections for more information.

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4.2 Data to Characterize the Nature of Surges

Lightning strokes, either direct, nearby, or some distance away can cause voltage and current surges into a facility. Information is available regarding lightning strokes and their intensity. But, less information is available regarding the extent to which these surges are transmitted into commercial facilities, industrial facilities, or residences. The IEEE paper, *A Field Study of Lightning Surges Propagating Into Residences*[12], provides an outstanding view into the effort needed to acquire even limited amounts of real-world data. This paper provides the following insights:

- When a home appliance malfunctions due to lightning, the relationship between the lightning stroke and the damage is often unclear. The purpose of their study was to complete experimental investigations on lightning surges that flow into residences. SPDs were not installed in these residences.

- Lightning surge waveform detectors were installed in 49 residences and monitored for four years (2003 to 2006). During the four-year observation period, lightning surge waveforms were obtained for a total of 18 lightning stroke events.

- Damage occurred to appliances in 4 of the 18 events. The most severe damage occurred when lightning appeared to have hit an antenna. In this case, currents of 1 kA or greater were recorded at all the measurement points, and many appliances were damaged.

- The home appliances, typically having built-in lightning protective devices with a peak current of 1 kA or higher, broke down at a current peak value of approximately 1 kA or higher, according to the observations.

- The analysis of observation data found that in some cases a ground potential rise causes a lightning surge to flow from the ground of another residence or the ground of a distribution system into the distribution system and, in turn, to flow into another residence.

Notice that the above effort took four years of monitoring at 49 residences to produce recordings of 18 surge events, of which four were severe enough to cause damage to appliances. This illustrates the difficulty of acquiring actual surge data.

4.3 Who Has Data on Surges, Surge Effects, and SPDs

4.3.1 *Surge Data – Lightning Surges*

Vaisala[13] owns and operates the National Lightning Detection Network (NLDN) that provides accurate lightning data information across the USA. And, Vaisala can provide lightning location reports that provide individual cloud-to-ground lightning strikes and the intensity of strike at a specific location on the date of loss. This capability represents the largest and most complete source of lightning surge location and intensity.

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[12] Teru Miyazaki, et al, *A Field Study of Lightning Surges Propagating Into Residences*, IEEE Transactions on Electromagnetic Compatibility, Vol. 52, No. 4, November 2010.

[13] http://www.vaisala.com/en/services/dataservicesandsolutions/lightningdata/Pages/default.aspx

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Data for lightning surges that extend to the inside of facilities is not readily available. Published papers and IEEE C62.41.1 provide information regarding the expected surge levels within a facility or residence, but extensive data is not available.

4.3.2 *Surge Data – Switching Surges*

Switching-related surge data, either internally or externally generated, is sparse. The added difficulty with this data is that these surges often do not cause immediate failure of electrical and electronic equipment; the damage occurs as a cumulative effect.

4.3.3 *Surge Effects – Manufacturers*

Although manufacturers produce SPDs and do a great job of educating consumers regarding their products, very little failure data associated with surges appears to be available from them. NEMA maintains the Surge Protection Institute[14] and they have completed surveys in 2013 and 2014 regarding failures of electrical and electronic equipment caused by surges. Although the sample size is relatively small, the survey results are helpful with respect to historical failures of life safety equipment. Refer to Section 2.2.1 for more information.

4.3.4 *Surge Effects – Consulting Firms*

Many engineering consulting firms assist with evaluations of surge damage in support of insurance claims. However, this data is not compiled in a readily usable manner nor is the data accessible in many cases. Surge data is not typically available.

4.3.5 *Surge Effects – Insurance Claims*

The largest documented source of surge effects is contained within the insurance claim documents for damage caused by surges. The Insurance Information Institute in collaboration with State Farm® produces annual reports of insurance claims associated with lightning-induced damage (refer to Section 2.2.2 for more information). The information contained in these claim reports likely provides additional detail regarding surge effects and the types of damage caused.

4.4 Data Acquisition Plan

There are challenges in obtaining usable data applicable to residential applications, such as:

- Confirming that equipment failures were a direct result of a surge event.
- Establishing any median and upper bounds to actual surge levels since this is not recorded inside facilities.
- Defining the protection improvement realized by applying SPDs.

Given the scarcity of real data relating to surges and the effects of surges, the approach described below is recommended.

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[14] *Refer to http://www.nemasurge.org.*

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4.4.1 *Purpose of Data to Be Obtained*

The purpose of the recommended data acquisition approach is to produce real data regarding damage and injuries caused by surges. This information is intended to assist the NFPA 70 code-making committees with additional technical data to support a decision to require or not require SPDs for the variety of electrical applications proposed in past NFPA 70 update cycles (refer to Section 1.2).

4.4.2 *Lightning Stroke Data*

The starting point for this project is to acquire the nationwide lightning stroke data for the continental USA for 2013 (or 2014 if the project starts in 2015). This information can tie back to insurance claim data and possibly provide surge current values for the locations of interest.

4.4.3 *Insurance Information Institute Claim Data*

The Insurance Information Institute is proposed to manage the insurance industry claim data. Their involvement assures that the insurance industry claim reports can remain confidential while allowing access to additional data that might be contained in the claim reports.

The Insurance Information Institute already publishes annual summaries of the number of lightning-related insurance claims and the claim amount. Additional information of interest that might be available in the claim data includes:

- Date and location of surge event (to establish geographical correlations).
- Electronic equipment and appliances damaged.
- Life safety equipment damaged – smoke detectors, CO or CO_2 detectors, or other equipment.
- Fires caused by surge effects.
- Personal injuries associated with the surge event.
- Presence of or lack of installed SPDs.

Life safety equipment damage, fires caused by surge events, and personal injuries are of particular interest for code-making efforts.

Although the annual Insurance Information Institute survey has historically focused on residential claims, the survey for this project should include commercial and industrial claims also. NEMA assistance and direction with this effort will be helpful.

4.4.4 *NEMA Participation*

NEMA Low Voltage Surge Protective Devices Section (5-VS) participation is recommended for the following:

- Assisting with project scope, including commercial and industrial users.

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- Reviewing the project checklist for the type of information to be obtained from the insurance industry.

- Reviewing failure data report summaries.

- Considering recommended SPD design principles, including the specification of surge protection in low-lightning flash density areas versus high-lightning flash density areas. Should NFPA elect to require SPDs in dwelling units or other applications, then minimum surge protection current limits should also be addressed, similar to the method provided in NFPA 780. As SPD surge current rating increases (and the degree of protection), the SPD cost also increases.

4.4.5 *Why Not Another Test Program?*

The IEEE paper, *A Field Study of Lightning Surges Propagating Into Residences*, illustrates the difficulty with obtaining real data during surge events. Although this study produced very useful results, it took a 4-year period at 49 homes to obtain data for 18 surge events, of which four surge events caused damage to appliances and electronic equipment. This is considered a typical outcome to be expected. A test program sponsored by the Fire Protection Research Foundation is not recommended.

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A

REFERENCES

Appendix A provides a list of references used in the development of this report.

A.1 Industry Standards

IEEE 1100, *Powering and Grounding Electronic Equipment.*

IEEE 1692, *IEEE Guide for the Protection of Communication Installations from Lightning Effects.*

IEEE C62.41.1, *Guide On The Surge Environment In Low-Voltage (1000V And Less) AC Power Circuits.*

IEEE C62.41.2, *Recommended Practice On Characterization Of Surges In Low-Voltage (1000V And Less) AC Power Circuits.*

IEEE C62.45, *Recommended Practice On Surge Testing For Equipment Connected To Low-Voltage (1000V And Less) AC Power Circuits.*

IEEE C62.50, *IEEE Standard for Performance Criteria and Test Methods for Plug-in (Portable) Multiservice (Multiport) Surge-Protective Devices for Equipment Connected to a 120 V/240 V Single Phase Power Service and Metallic Conductive Communication Line(s).*

NFPA 70, *National Electrical Code®*, 2014 Edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2014 Edition .

UL 497 series, *Protectors for Fire Alarm Signaling Circuits.*

UL 1283, *Electromagnetic Interference Filters.*

UL 1449, Third Edition, *Surge Protective Devices*, September 29, 2006.

A.2 NFPA Documents

1. *National Electrical Code® Committee Report on Proposals – 2013 Annual Revision Cycle*, National Fire Protection Association, 2012.

2. Marty Ahrens, *Lightning Fires and Lightning Strikes*, National Fire Protection Association, Fire Analysis and Research Division, June 2013.

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A.3 IEEE Documents

1. *How to Protect Your House and Its Contents from Lightning, IEEE Guide for Surge Protection of Equipment Connected to AC Power and Communication Circuits*, by Richard L. Cohen and others, ISBN 0-7381-4634-X, 2005.

2. Lightning and Insulator Subcommittee of the T&D Committee, *Parameters of Lightning Strokes: A Review*, IEEE Transactions on Power Delivery, Vol. 20, No. 1, January 2005.

3. Teru Miyazaki, et al, *A Field Study of Lightning Surges Propagating Into Residences*, IEEE Transactions on Electromagnetic Compatibility, Vol. 52, No. 4, November 2010.

4. Jinliang He, et al, *Evaluation of the Effective Protection Distance of Low-Voltage SPD to Equipment*, IEEE Transactions on Power Delivery, Vol. 20, No. 1, January 2005.

5. Shozo Sekioka, et al, *Simulation Model for Lightning Overvoltages in Residences Caused by Lightning Strike to the Ground*, IEEE Transactions on Power Delivery, Vol. 25, No. 2, January 2010.

6. Joseph Randolph, *Lightning Surge Damage to Ethernet and POTS Ports Connected to Inside Wiring*, IEEE, 2014.

7. Vladimir A. Rakov, *Direct Lightning Strikes to the Lightning Protective System of a Residential Building: Triggered-Lightning Experiments*, IEEE Transactions on Power Delivery, Vol. 17, No. 2, January 2002.

Note: The IEEE Power & Energy Society sponsors the Surge Protective Devices Committee, which provides information associated with their standards. Refer to http://pes-spdc.org.

A.4 NIST Documents

1. NIST Special Publication 960-6, *Surges Happen! How to Protect the Appliances in Your Home*, 2001.

Note: The NIST website provides many historical documents available in the public domain related to surge protection. Although this information is over 10 years old, it is still useful as a reference source. Refer to http://www.nist.gov/pml/div684/spd.cfm.

A.5 NEMA Documents

1. NEMA 2013 *U.S. Surge Protection Damage Survey.*

2. NEMA *Surge Damage Survey Results – Wave 2*, March 2014.

Note: The NEMA Surge Protection Institute maintains a website devoted to low voltage SPDs. Refer to http://www.nemasurge.org.

A.6 Insurance Industry Documents

1. *Lightning Sparks Concern For Insurance Industry; Homeowners Claims Rise Sharply Over Last Five Years*, Insurance Information Institute, March 2010.

2. *Thunderstruck! Average Lightning Claim Costs Up by 25 Percent, But Number of Claims Continues to Fall*, Insurance Information Institute, June 2013.

3. *Number, Cost of Homeowners Insurance Claims From Lightning Fell In 2013; Dry Conditions, Fewer Powerful Thunderstorms A Contributing Factor*, Insurance Information Institute, June 2014.

4. *Lightning,* Insurance Information Institute, August 2014.

5. *Protect Your Property From Power Surges*, State Farm website.

6. *Guidelines for Providing Surge Protection at Commercial Institutional and Industrial Facilities*, The Hartford Steam Boiler Inspection and Insurance Company.

7. *Approval Standard for Transient Voltage Surge Suppression Devices*, FM Approvals.

A.7 Manufacturer's Documents

1. Emerson Network Power Report SL-30119, *Surge Protection Reference Guide*, November 2011.

A.8 Miscellaneous Documents

1. A. Ametani,, et al, *Surge Voltages and Currents into a Customer due to Nearby Lightning*, International Conference on Power Systems Transients (IPST"07) June 2007.

2. Schneider Electric Data Bulletin DB03A, *Surge Protection: Measured Lightning Stroke Data*.

3. Al Martin, *Lightning Induced GPR, Why it's a problem, characteristics and simulation*, In Compliance, June 2012.

4. Thomas Key, et al, *Update on a Consumer-Oriented Guide for Surge Protection*, Proceedings, PQA'99 Conference, May 1999.

5. François D. Martzloff, et al, *The Role and Stress of Surge-Protective Devices in Sharing Lightning Current*, EMC Europe 2002, September 2002.

6. Arshad Mansoor, et al, *The Dilemma of Surge Protection vs. Overvoltage Scenarios: Implications for Low-Voltage Surge-Protective Devices*, Proceedings, 8th Annual Conference on Harmonics and Quality of Power, October 1998.

7. Air Force Manual 32-1181, *Design Standards for Interior Electrical Systems*.

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B

ACRONYMS

Appendix B provides a list of the abbreviations and acronyms used in this report.

EMI – Electromagnetic interference.

FPRF – Fire Protection Research Foundation.

GDT – Gas discharge tube.

GPR – Ground potential rise.

Hz – Hertz.

III – Insurance Information Institute.

kA – Thousands of amperes.

khz – Kilo-hertz.

L–G – Line-to-ground.

L–L – Line-to-line.

MCOV – Maximum continuous operating voltage.

MOV – Metal oxide varistor.

N–G – Neutral-to-ground.

NEMA – National Electrical Manufacturers Association.

NLDN – National Lightning Detection Network.

NFPA – National Fire Protection Association.

NIST – National Institute of Standards and Technology.

pu – Per unit.

SAD – Silicon avalanche diode.

SCCR – Short circuit current rating.

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SPD – Surge protective device.

TOV – Temporary overvoltage.

TVSS – Transient voltage surge suppressor (no longer used – replaced by SPD).

UL – Underwriter's Laboratories.

µsec – Micro-second.

VPR – Voltage protection rating.

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E7215

Date Submitted	11/8/2018	**Section**	3702.13	**Proponent**	John Hall
Chapter	37	**Affects HVHZ**	No	**Attachments**	Yes

TAC Recommendation No Affirmative Recommendation
Commission Action Pending Review

Comments

General Comments No

Alternate Language Yes

Related Modifications

No related modifications have been identified.

Summary of Modification

The modification provides for infrastructure to accomodate future electric vehicle charging equipment in one- and two-family dwellings and townhouses with garages.

Rationale

Florida consistently ranks in the top three states for electric vehicle sales. The Florida legislature cited the importance and benefit of electric vehicles in FS 718.113(8). The ability for property owners to install EV charging equipment without destructive measures will faciltate the adoption of this technology, protecting the environment and providing an economic benefit to the state.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

There will be no cost impact relative to enforcement of the code due to this proposed modification. The inspection activity will be performed during already required inspections that are regularly scheduled.

Impact to building and property owners relative to cost of compliance with code

The cost impact to building and property owners for compliance with the proposed modification will be negligible. The modification seeks only the provision of a raceway and space in the electrical panel to facilitate the installation of EV charging equipment at a future date.

Impact to industry relative to the cost of compliance with code

The cost impact to industry will likewise be negligible due to the limited scope of the proposed modification. No installation of equipment, wiring, or outlet is required by the modification. Only an empty raceway and space in the electrical panel for the future circuit breaker is envisioned.

Impact to small business relative to the cost of compliance with code

There will be no cost impact to small business. The scope of the proposed modification is limited to one- and two-family dwellings and townhouses.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

The proposed modification has connection with the health, safety, and welfare of the general public through reduction of emissions from the use of fossil fuels and the economic savings of operating an electric vehicle versus the cost of operating fossil fuel powered vehicles.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

The proposed modification improves the code by making provision for the implementation of better products and methods of powering transportation. Electrical vehicle use is increasing annually and these systems are crucial to further adoption of the technology.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

The proposed modification does not discriminate against any materials, products, methods, or systems of construction as none are specified. The modification simply provides for the easier implementation of the technology with no destructive effect to the structure.

Does not degrade the effectiveness of the code

The proposed modification does not degrade the effectiveness of the code. The implementation of the code is enhanced through the provision of simplified means of compliance for property owners desiring to operate electric vehicles.

Alternate Language

2nd Comment Period

7215-A1

Proponent Bryan Holland **Submitted** 5/21/2019 **Attachments** Yes

Rationale

This alternative language comment addresses the concerns made during public comment and shared by the members of the TAC by offering an alternative code location due to the recommended approval of Proposed Modification E7199. Please see the attached support file for additional substantiation of this code change.

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

This alternative language comment would have little to no impact on the local entity.

Impact to building and property owners relative to cost of compliance with code

This alternative language comment would increase the cost of construction for building owners with large parking areas.

Impact to industry relative to the cost of compliance with code

This alternative language comment will not have an impact on industry.

Impact to Small Business relative to the cost of compliance with code

There will be no cost impact to small business. The scope of the proposed modification is limited to one- and two-family dwellings and townhouses.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

This alternative language comment improves the health, safety, and welfare of the general public by providing needed EVSE at parking spaces at commercial buildings.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

This alternative language comment improves the code.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

This alternative language comment does not discriminate against any materials, products, methods, or systems of construction.

Does not degrade the effectiveness of the code

This alternative language comment enhances the effectiveness code.

1st Comment Period History

E7215-G1

Proponent Vincent Della Croce **Submitted** 1/8/2019 **Attachments** No

Comment:

I support the proposed modification as it will ensure the FBC includes the most current requirements for electrical installations that provide for the health, safety and general welfare of the public.

E7215 -A1 Text Modification

Add the following definitions to C202 General Definitions of the FBC, Energy Conservation:

ELECTRIC VEHICLE (EV). An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, electric motorcycles, and the like, primarily powered by an electric motor that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current. Plug-in hybrid electric vehicles (PHEV) are electric vehicles having a second source of motive power. Off-road, self-propelled electric mobile equipment, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, boats, and the like are not considered electric vehicles.

ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors, and the *Electric Vehicle* connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the *Electric Vehicle*.

EV CAPABLE SPACE. Electrical panel capacity and space to support a minimum 50-ampere, 208/240-volt branch circuit for each EV parking space, and the installation of raceways, both underground and surface mounted, to support the *EVSE*.

EV READY SPACE. A designated parking space which is provided with one 50-ampere, 208/240-volt dedicated branch circuit for a future dedicated Level 2 *EVSE* servicing *Electric Vehicles*. The circuit shall terminate in a NEMA 6-50 or NEMA 14-50 receptacle or a suitable electrical connector rated for 208/240 or greater service. The circuit shall have no other outlets. The service panel shall include an over-current protective device and provide sufficient capacity and space to accommodate the circuit and over-current protective device and be located in close proximity to the proposed location

Add new text and table following (

C405.10. *Electric Vehicle (EV)* charg ›nstruction shall facilitate future installation and use of *Electric Vehicle Supply Equipment (EVSE)* in accordance with the NFPA 70.

C405.10.1. New buildings. *EV Ready Spaces* and *EV Capable Spaces* shall be provided in accordance with Table C405.10.1. Where the calculation of percent served results in a fractional parking space, it shall be shall rounded up to the next whole number. The service panel or sub panel circuit directory shall identify the spaces reserved to support EV charging as “EV Capable” or “EV Ready”. The raceway location shall be permanently and visibly marked as “EV Capable”.

TABLE C405.10.1.
EV READY SPACE AND EV CAPABLE SPACE REQUIREMENTS

Total Number of Parking Spaces	Minimum number of *EV Ready Spaces*	Minimum number of *EV Capable Spaces*
1	1	-
2 – 10	2	-
11 – 15	2	3
16 – 19	2	4
21 - 25	2	5
26+	2	20% of total parking spaces

C405.10.2. Identification. Construction documents shall indicate the raceway termination point and proposed location of future EV spaces and *EVSE*. Construction documents shall also provide information on amperage of future *EVSE*, raceway methods, wiring schematics and electrical load calculations to verify that the electrical panel service capacity and electrical system, including any on-site distribution transformers, have sufficient capacity to simultaneously charge all EVs at all required EV spaces at the full rated amperage of the EVSE.

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E7215 Text Modification

CHAPTER 37
BRANCH CIRCUIT AND FEEDER REQUIREMENTS

SECTION E3702
BRANCH CIRCUIT RATINGS

E3702.1 Branch-circuit voltage limitations.

The voltage ratings of branch circuits that supply luminaires or receptacles for cord-and-plug-connected loads of up to 1,400 volt-amperes or of less than 1/4 horsepower (0.186 kW) shall be limited to a maximum rating of 120 volts, nominal, between conductors.

Branch circuits that supply cord-and-plug-connected or permanently connected utilization equipment and appliances rated at over 1,440 volt-amperes or 1/4 horsepower (0.186 kW) and greater shall be rated at 120 volts or 240 volts, nominal. [210.6(A), (B), and (C)]

E3702.2 Branch-circuit ampere rating.

Branch circuits shall be rated in accordance with the maximum allowable ampere rating or setting of the overcurrent protection device. The rating for other than individual branch circuits shall be 15, 20, 30, 40 and 50 amperes. Where conductors of higher ampacity are used, the ampere rating or setting of the specified over-current device shall determine the circuit rating. (210.3)

E3702.3 Fifteen- and 20-ampere branch circuits.

A 15- or 20-ampere branch circuit shall be permitted to supply lighting units, or other utilization equipment, or a combination of both. The rating of any one cord-and-plug-connected utilization equipment not fastened in place shall not exceed 80 percent of the branch-circuit ampere rating. The total rating of utilization equipment fastened in place, other than luminaires, shall not exceed 50 percent of the branch-circuit ampere rating where lighting units, cord-and-plug-connected utilization equipment not fastened in place, or both, are also supplied. [210.23(A)(1) and (2)]

E3702.4 Thirty-ampere branch circuits.

A 30-ampere branch circuit shall be permitted to supply fixed utilization equipment. A rating of any one cord-and-plug-connected utilization equipment shall not exceed 80 percent of the branch circuit ampere rating. [210.23(B)]

E3702.5 Branch circuits serving multiple loads or outlets.

General-purpose branch circuits shall supply lighting outlets, appliances, equipment or receptacle outlets, and combinations of such. Multioutlet branch circuits serving lighting or receptacles shall be limited to a maximum branch-circuit rating of 20 amperes. [210.23(A), (B), and (C)]

E3702.6 Branch circuits serving a single motor.

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Branch-circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating. [430.22(A)]

E3702.7 Branch circuits serving motor-operated and combination loads.

For circuits supplying loads consisting of motor-operated utilization equipment that is fastened in place and that has a motor larger than 1/8 horsepower (0.093 kW) in combination with other loads, the total calculated load shall be based on 125 percent of the largest motor load plus the sum of the other loads. [220.18(A)]

E3702.8 Branch-circuit inductive and LED lighting loads.

For circuits supplying luminaires having ballasts or LED drivers, the calculated load shall be based on the total ampere ratings of such units and not on the total watts of the lamps. [220.18(B)]

E3702.9 Branch-circuit load for ranges and cooking appliances.

It shall be permissible to calculate the branch-circuit load for one range in accordance with Table E3704.2(2). The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance. The branch-circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens all supplied from a single branch circuit and located in the same room shall be calculated by adding the nameplate ratings of the individual appliances and treating the total as equivalent to one range. (220.55 Note 4)

E3702.9.1 Minimum branch circuit for ranges.

Ranges with a rating of 8.75 kVA or more shall be supplied by a branch circuit having a minimum rating of 40 amperes. [210.19(A)(3)]

E3702.10 Branch circuits serving heating loads.

Electric space-heating and water-heating appliances shall be considered to be continuous loads. Branch circuits supplying two or more outlets for fixed electric space-heating equipment shall be rated 15, 20, 25 or 30 amperes. [424.3(A)]

E3702.11 Branch circuits for air-conditioning and heat pump equipment.

The ampacity of the conductors supplying multimotor and combination load equipment shall be not less than the minimum circuit ampacity marked on the equipment. The branch-circuit overcurrent device rating shall be the size and type marked on the appliance. [440.4(B), 440.35, 440.62(A)]

E3702.12 Branch circuits serving room air conditioners.

A room air conditioner shall be considered as a single motor unit in determining its branch-circuit requirements where all the following conditions are met:

1. It is cord- and attachment plug-connected.
2. The rating is not more than 40 amperes and 250 volts; single phase.
3. Total rated-load current is shown on the room air-conditioner nameplate rather than individual motor currents.
4. The rating of the branch-circuit short-circuit and ground-fault protective device does not exceed the ampacity of the branch-circuit conductors, or the rating of the branch-circuit conductors, or the rating of the receptacle, whichever is less. [440.62(A)]

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E3702.12.1 Where no other loads are supplied.
The total marked rating of a cord- and attachment plug-connected room air conditioner shall not exceed 80 percent of the rating of a branch circuit where no other appliances are also supplied. [440.62(B)]

E3702.12.2 Where lighting units or other appliances are also supplied.
The total marked rating of a cord- and attachment plug-connected room air conditioner shall not exceed 50 percent of the rating of a branch circuit where lighting or other appliances are also supplied. Where the circuitry is interlocked to prevent simultaneous operation of the room air conditioner and energization of other outlets on the same branch circuit, a cord- and attachment-plug-connected room air conditioner shall not exceed 80 percent of the branch-circuit rating. [440.62(C)]

E3702.13 Electric vehicle branch circuit.

Outlets installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit. Each circuit shall not supply other outlets. (625.40)

E3702.13.1 Electric vehicle (EV) charging for new construction.
New construction shall comply with this Section to facilitate future installation of *electric vehicle supply equipment.*

E3702.13.2 New one- and two-family dwellings and *townhouses* with attached or detached private garages.

For each dwelling unit with an attached or detached garage shall be designed with provision for future installation of *electric vehicle supply equipment* in accordance with Section E3702.13 through E3702.13.3.2.

E3702.13.3 Raceway.

A listed raceway of minimum trade size 1 shall be installed to accommodate a branch circuit for *electric vehicle supply equipment.*

The raceway shall originate at the main electrical panel or a properly rated sub-panel, and terminate in a listed box or enclosure in close proximity to the proposed location of the *electric vehicle supply equipment.*

The raceway shall be continuous from the point of origin to the termination at the proposed location of the *electric vehicle supply equipment.*

The enclosure provided for future *electric vehicle supply equipment* shall be labeled "EV CAPABLE". The label shall comply with NFPA 70 Section 110.21(B).

E3702.13.3.4 Service Capacity.

The electrical service shall be sized to accommodate a 40-ampere 240-volt branch circuit for *electric vehicle supply equipment.*

E3702.13.3.5 Electrical panel capacity.

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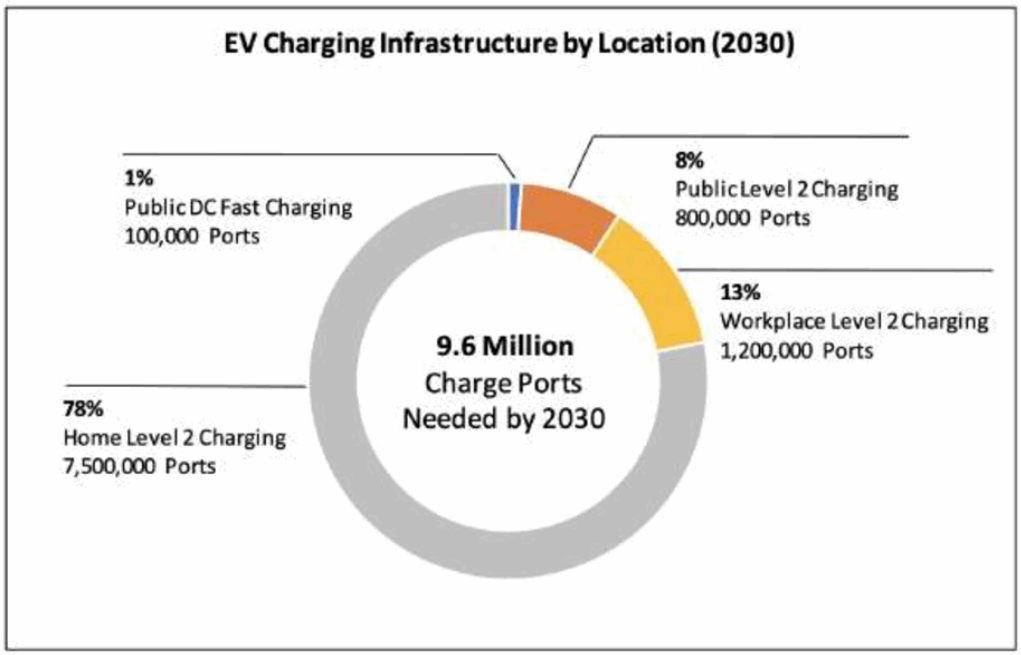
The electrical panel from which the electric vehicle supply equipment branch circuit originates shall be rated for, and be provided with open space for installation of a two-pole 40-ampere overcurrent protective device. The provided overcurrent device space(s) shall be identified in the panel circuit directory as "EV CAPABLE".

E3702.14 Branch-circuit requirement—summary.

The requirements for circuits having two or more outlets, or receptacles, other than the receptacle circuits of Sections E3703.2, E3703.3 and E3703.4, are summarized in Table E3702.14. Branch circuits in dwelling units shall supply only loads within that dwelling unit or loads associated only with that dwelling unit. Branch circuits installed for the purpose of lighting, central alarm, signal, communications or other purposes for public or common areas of a two-family dwelling shall not be supplied from equipment that supplies an individual dwelling unit. (210.24 and 210.25)

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In the US, electric vehicle (EV) sales increased by 80 percent from 2017 to 2018. According to a November 2018 forecast from the Edison Electric Institute, the number of EVs on U.S. roads is projected to grow from 1 million vehicles at the end of 2018, to 18.7 million by 2030. To recharge these new EVs, the U.S. will need 9.6 million charge ports.



EVs provide significant economic benefits for consumers through fuel and maintenance cost savings, and have been identified as a key climate strategy to reduce GHG emissions from the US transportation sector. The interest in EVs has grown alongside greater EV model availability and increased vehicle range. Every major auto manufacturer in the world has announced a plan to electrify a significant portion of their vehicle fleets over the next 3-5 years. Ford recently announced an $11 billion investment to reach their goal of 40 EV models by 2022 (3). The goal for GM: 20 EV models by 2023 (4); for VW: 27 EV models by 2022 (5); for Toyota: 10 BEVs by the early 2020's (6); and similar goals for Volvo, Daimler, Nissan, BMW, and Fiat-Chrysler.

However, the lack of access to EV charging stations continues to be a critical barrier to EV adoption. In particular, there are significant logistical barriers for building owners to upgrade existing electrical infrastructure and install new EV charging stations.

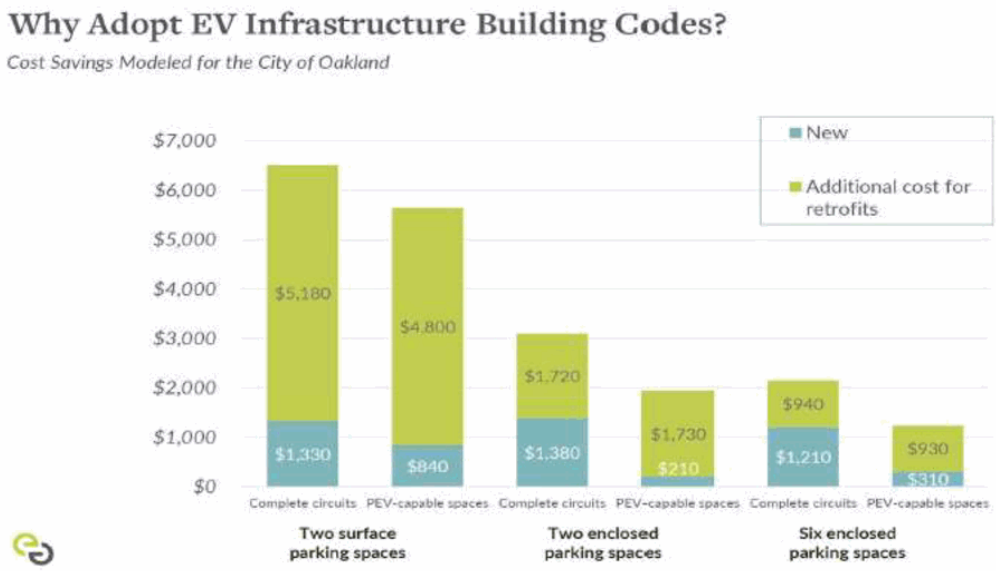
A lack of pre-existing EV charging infrastructure, such as electrical panel capacity, raceways, and pre-wiring, can make the installation of a new charging station cost-prohibitive for a potential EV-owner. The installation of an EV charging station is made three to four times less expensive

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when the infrastructure is installed during the initial construction phase as opposed to retrofitting existing buildings to accommodate the new electrical equipment.

New buildings are constructed to last for decades, and so it is critical that EV charging infrastructure is incorporated at the pre-construction stage to ensure that new buildings can accommodate the charging needs of future EV-owners.

Significant retrofit costs can be avoided by installing EV charging infrastructure in new construction. CARB staff reviewed multiple sources to obtain average retrofit costs of installing infrastructure to support Level 2 charging stations in existing buildings. An estimated $7,000 per parking space can be avoided with multiple installations of Level 2 charging stations. An estimated $8,000 per parking space can be avoided when an individual Level 2 charging station is installed. These retrofit costs do not include the cost of the electrical vehicle supply equipment (EVSE). Retrofit costs are focused on parking lot trenching, adding electrical service and/or panel upgrades. The 10 percent requirement would result in the installation of an additional 38,000 to 47,000 parking spaces with EV charging infrastructure beyond the current 3 percent requirement. If the proposed 10% requirement is not adopted, CARB staff assumed that every one of these parking spaces would need the basic EV charging infrastructure (raceway and panel capacity) to become EV Capable and support future installation of Level 2 charging stations. CARB staff estimates that the avoided retrofit costs range from $272 million to $386 million between 2020 and 2025.



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Plug In America

We drive electric. You can too.

Electric Vehicles in Florida

Plug-in electric vehicles (PEVs) are fun to drive and provide significant benefits to the American economy not just through the domestic manufacturing of the vehicles, but also through additional jobs in the electric power industry for the energy to operate them.[1,2] The increased use of domestic electricity in the transportation sector promotes national security by reducing our dependence on imported oil. These vehicles keep the U.S. competitive with China and the Europe Union, which are both movingly aggressively towards full deployment of the vehicles and nationwide charging systems.

There are currently over 23,376 PEVs on Florida roads today, with the market ready to expand as new vehicle makes and models become available in Florida.[3] As these vehicles are a win-win for Florida, it's no surprise that consumers want more of these vehicles today.

Policies in Florida for PEVs

Policy support at the federal, state and local levels is needed as the PEV market continues to develop and grow. Below is the most current list of PEV policies in Florida:

Vehicle Purchase Incentive: Jacksonville Electric Authority (JEA) offers a rebate up to $1,000 for the purchase or lease of a qualified PEV.[4]

Charging Station Incentive: The Orlando Utilities Commission (OUC) offers a rebate of $200 per station for businesses to install workplace charging stations. Local governments may also offer funding to property owners within their jurisdiction to help with EVSE financing.[5]



West Palm Beach, Florida National Drive Electric Week 2016

HOV Lane Access Policy: PHEVs are eligible for the HOV lane after applying for the Florida HOV decal. [6]

Parking Policy for PEVs: Some commercial and public buildings may offer parking for PEV customers only.

Other: FL Insurance companies may offer discounts on PEVs.

Fun Facts for PEVs in Florida

- Florida is second to California in number of EVs registered in the state. Florida even beats out New York, Texas, Washington and Georgia, all large car markets.
- With a cleaner electricity grid and improved efficiency of electric vehicles, greenhouse gas emissions and air quality from charging an electric vehicle on the grid improved in 76% of the regions sampled from 2012 to 2015.[7]

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[1] Currently, the U.S. manufactures PEVs and other advanced technology vehicles and components in at least 20 states, creating thousands of new, good jobs. Furthermore, the auto industry has distribution centers, sales offices and operational facilities in all 50 states; the PEV industry is a part of the same distribution, sales and operational network and is difficult to separate from the main auto industry. More at: http://sierraclub.typepad.com/compass/2012/06/fuel-economy-jobs.html

[2] PEVs include battery-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). The BEVs are charged by electricity from the local grid, while PHEVs drive on electricity from the local grid first, then on gasoline for longer trips

[3] https://autoalliance.org/in-your-state/FL/

[4] https://www.jea.com/Ways_to_Save/Go_Green/Plug-in_Electric_Vehicles/Electric_Vehicle_Incentives/

[55] http://www.ouc.com/business/business-rebates-programs/business-ev-charging-stations

[6] https://www.flhsmv.gov/motor-vehicles-tags-titles/high-occupancy-vehicle-decal/

[7] http://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf

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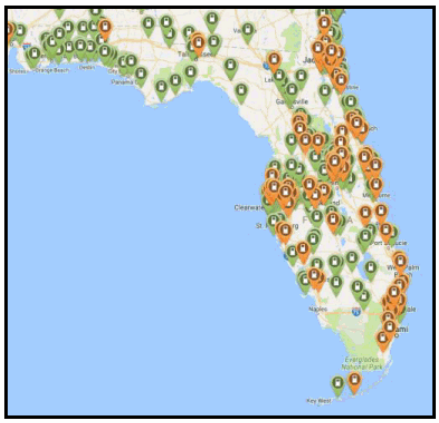
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- In 2016, the US sold over 159,000 EVs, which is a 38% increase over 2015.[8]
- In 2015, the Tesla Model S, Chevrolet Volt, and Nissan Leaf (all mass marketed EVs) ranked first, second and third for most satisfying commuter car.[9]

Benefits for Every Driver in Florida

The benefits of PEVs accrue to all residents in Florida, regardless if the driver is in an urban or metro area. Top benefits include:

1. **PEVs put money back in the pockets of consumers.** On average, fueling a car with electricity is roughly the same as gas at $1 per gallon, thanks to a PEV's performance efficiency and the lower cost of electricity.[10] Maintenance costs are also significantly reduced.
2. **All drivers in Florida have the ability to charge.** PEVs can be charged on a standard 120V wall outlet, also called Level 1 charging.[11] Faster charging can be achieved at the home or workplace with Level 2 charging.[12] The map at the right shows the public charging stations that are currently available to all Florida drivers.[13] The orange icons are DC Fast charging stations, and the green icons represent public Level 2 charging stations. It is possible to get nearly anywhere in the state with a PEV, proving that these vehicles can work for all Florida drivers.
3. **PEVs are significantly better for the local economy.** PEVs are fueled from electricity from the local grid, which is cheaper for all consumers. Money not spent on gas or on maintenance can be invested back into the local economy.
4. **PEVs improve air quality and reduce health care costs.** Poor air quality is still a problem for many U.S. states.[14] PEVs produce far fewer tailpipe emissions than a standard gasoline-powered vehicle, therefore significantly reducing dangerous air pollution. With more PEVs on the roads, public and private health care costs can be greatly reduced.



Current public charging stations available to all Florida drivers.

About Plug In America

Plug In America is the nation's leading independent consumer voice for accelerating the use of plug-in electric vehicles in the United States to consumers, policymakers, auto manufacturers and others. Formed as a non-profit in 2008, Plug In America provides practical, objective information collected from our coalition of plug-in vehicle drivers, through public outreach and education, policy work and a range of technical advisory services. Our expertise represents the world's deepest pool of experience of driving and living with plug-in vehicles. The organization conceived National Drive Electric Week and has advanced workplace charging by pioneering ride-and-drive events at such leading corporations as Google, Mattel and Paramount Pictures. We drive electric. You can too. www.pluginamerica.org

[8] http://www.fleetcarma.com/ev-sales-usa-2016-final/
[9] http://www.consumerreports.org/cars-the-most-satisfying-cars-for-commuting/
[10] http://energy.gov/eere/eveverywhere/ev-everywhere-saving-fuel-and-vehicle-costs
[11] Level 1 is AC charging at 120V, the level of power that is supplied by a normal household outlet. This will supply up to 40 miles of range for an 8-hour connection during a typical work day. That's enough to replenish the charge for the majority of Florida drivers.
[12] Level 2 is AC charging at a power level similar to what is supplied by an outlet for an electric dryer, typically 240V.
[13] Zooming in further shows even more charging stations available. PlugShare is one platform that tracks charging station locations, prices and types of charging at each location. Drivers can download the PlugShare app to a mobile phone for free.
[14] http://www.lung.org/our-initiatives/healthy-air/sota/key-findings/



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E8149

Date Submitted	12/14/2018	**Section**	3902.16	**Proponent**	STEVE ROOD
Chapter	39	**Affects HVHZ**	No	**Attachments**	Yes

TAC Recommendation No Affirmative Recommendation
Commission Action Pending Review

Comments

General Comments Yes

Alternate Language No

Related Modifications

Summary of Modification

This proposal recommends deletion of kitchens and laundry areas from the list of locations within dwelling units where AFCI protection is required.

Rationale

Please see two uploaded support files:

• One summarizes lack of substantiation of fires specifically located in kitchens or laundry areas from the fire data used to justify expansion to those areas, along with information on the nuisance tripping problem that is increasing along with expanded use of AFCI.

• The second is a two-page summary of an NFPA-funded Fire Protection Research Foundation report that advised “the most significant problem with residential electrical fire data is that nearly all of the currently available public data is lacking in quality and accuracy, and is relatively unusable for data analytics in its current state.” As such,” the existing residential electrical data is generally unrefined and provides limited value to the analysis of determining the effectiveness of electrical branch circuit protection devices.”

Fiscal Impact Statement

Impact to local entity relative to enforcement of code

No known impact; no known or obvious incremental added enforcement expense to the deletion of these requirements, as the enforcement activity is ongoing and required as is currently the case (a "roll back" vs. an added requirement is proposed).

Impact to building and property owners relative to cost of compliance with code

FISCAL IMPACT: Estimated electrical installer savings: $180 - $192 per home. Please see attached support file for fiscal input assumptions.

Impact to industry relative to the cost of compliance with code

No known impact; no known or obvious incremental cost of compliance to industry, as the recommendation is for a "roll back" as opposed to an added requirement.

Impact to small business relative to the cost of compliance with code

FISCAL IMPACT: Estimated electrical installer savings: $180 - $192 per home. Please see attached support file for fiscal input assumptions.

Requirements

Has a reasonable and substantial connection with the health, safety, and welfare of the general public

Mandated AFCI protection in kitchen and laundry areas can compromise electrical safety for home dwellers. Please see uploaded support file that reviews these points.

Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction

Strengthens the code with respect to incrementally reducing AFCI requirements where increased safety that is purported to be provided by its implementation in the kitchen and laundry areas cannot be quantified or confirmed due to the lack of verifiable data as the FPRF report points out.

Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities

No known discrimination of this sort; assists with reductions of installer call backs due to nuisance tripping, which enhances productivity of builders, contractors and similar installer firms.

Does not degrade the effectiveness of the code

No known degradation to the effectiveness of the code; many other states and municipalities have approved and implemented amendments and exceptions to AFCI protection for the same reasons as detailed in this proposal. Please see uploaded support file of 15 states and 3 municipalities.

2nd Comment Period

Proponent Michael Carlson **Submitted** 5/1/2019 **Attachments** Yes

Comment:

PIFF urges the Electrical TAC to reject Mod E8149. Please see the attached letter.

E8149-G8

1st Comment Period History

E8149-G1

Proponent Vincent Della Croce **Submitted** 1/8/2019 **Attachments** No

Comment:

I strongly oppose this proposal as it reduces the effectiveness and safety of the code requirements related to life and property safety.

1st Comment Period History

E8149-G2

Proponent Si Farvardin **Submitted** 2/5/2019 **Attachments** Yes

Comment:

Dear TAC members,

The Insurance Institute for Business & Home Safety (IBHS) is a nonprofit organization supported by the property insurance industry. Our mission is to identify and promote effective ways to strengthen homes and businesses against natural hazards and other causes of loss. We do this by conducting research and testing, and advocating adoption of building and safety codes, and improved construction, maintenance and preparedness practices.

Among IBHS's highest priorities are the adoption and enforcement of building and safety codes without any weakening amendments. Accordingly, IBHS respectfully requests the Florida Electrical TAC to reject Modification E8149, which proposes to eliminate the arc fault circuit interrupters (AFCIs) in kitchen and laundry circuits of residential dwellings. The AFCIs required by the National Electrical Code® (NEC) are proven to be quite effective in residential wiring systems by detecting and isolating problems that could lead to electrical fires. Elimination of this important code requirement and life-saving technology—from kitchen and laundry circuits—will seriously reduce the electrical safety of new residential dwelling construction throughout the state of Florida.

IBHS urges the TAC members to continue to protect the safety and welfare of the state residents and retain the recommended requirement for arc fault circuit interrupters in kitchen and laundry circuits to be adopted as part of the 2017 NEC.
We thank you for the opportunity to comment.

Sincerely,

Si Farvardin
Manager of Codes and Standards
Insurance Institute for Business & Home Safety

1st Comment Period History

E8149-G3

Proponent Bryan Holland **Submitted** 2/6/2019 **Attachments** Yes

Comment:

NEMA strongly opposes this proposed modification that would reduce electrical safety by increasing the risk of fire in a home.
Please see the attached support files.

1st Comment Period History

E8149-G4

Proponent Jeff Terrey **Submitted** 2/15/2019 **Attachments** Yes

Comment:

Please see attached.

1st Comment Period History

E8149-G5

Proponent Jeff Terrey **Submitted** 2/15/2019 **Attachments** Yes

Comment:

Please see attached.

1st Comment Period History

E8149-G6

Proponent Johnson Steve **Submitted** 2/15/2019 **Attachments** No

Comment:

Dear Committee members,

My name is Steve Johnson and I'm a professional firefighter in Marion County. My wife is a burn survivor from an electrical fire started by an arc in a circuit. Together, we offer unique perspectives on why you should not approve a proposal that would prevent our state from having the strongest electrical building codes at 2017 levels. This proposal would scale back arc fault circuit interrupter requirements to 2011 levels – exposing all new residential construction to potential electrical fires in kitchens and laundry areas. Why would you do that?

As a career firefighter, I respond to numerous house fires, most of which are determined to be caused by an electrical malfunction and many of which originate in these areas of the home. These areas need this additional protection with the use of added electrical devices, power cords, and appliances. Do we need these devices to detect the dangerous arcing that can prevent these fires from ever starting? Of course, we do. We need them as badly as we need smoke detectors, sprinklers, fire ladders, carbon monoxide detectors, and fire resistant construction materials that also help prevent the spread of fires. Everything working together helps prevent and warn us of house fires that risk not only the occupant's lives, but mine as a firefighter as well.

I've seen firsthand how devastating electrical fires can be to buildings and families. Estimates are in the millions of dollars when it comes to structural damage, and more importantly, consider the emotional toll deaths and injuries bring to people nationwide.

You are the experts on this issue on the front end, but from someone who is out in the trenches, I beg of you – please protect the safety of every man, woman and child and those protecting our communities in the fire services. Approve of technologies like AFCIs that save lives and prevent electrical fires. Please oppose this bad idea to scale back those requirements.

Steve Johnson

1st Comment Period History

E8149-G7

Proponent David Hewitt **Submitted** 2/18/2019 **Attachments** Yes

Comment:

Siemens strongly opposes this proposed modification in that it would reduce electrical safety by increasing the risk of fire in a home. Removing AFCI protection raises concerns with respect to the protection of life and property.

Branch circuits that supply 120-volt, single-phase, 15- and 20-ampere outlets installed in ~~kitchens~~, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreations rooms, closets, hallways, ~~laundry areas~~ and similar rooms or areas shall be protected by any of the following: [210.12(A)]

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Insurance Institute for Business & Home Safety®

February 4, 2019

Florida Electrical TAC

Re: —Opposition to Modification E8149

Dear TAC members,

The Insurance Institute for Business & Home Safety (IBHS) is a nonprofit organization supported by the property insurance industry. Our mission is to identify and promote effective ways to strengthen homes and businesses against natural hazards and other causes of loss. We do this by conducting research and testing, and advocating adoption of building and safety codes, and improved construction, maintenance and preparedness practices.

Among IBHS's highest priorities are the adoption and enforcement of building and safety codes without any weakening amendments. Accordingly, IBHS respectfully requests the Florida Electrical TAC to reject Modification E8149, which proposes to eliminate the arc fault circuit interrupters (AFCIs) in kitchen and laundry circuits of residential dwellings. The AFCIs required by the *National Electrical Code*® (NEC) are proven to be quite effective in residential wiring systems by detecting and isolating problems that could lead to electrical fires. Elimination of this important code requirement and life-saving technology—from kitchen and laundry circuits—will seriously reduce the electrical safety of new residential dwelling construction throughout the state of Florida.

IBHS urges the TAC members to continue to protect the safety and welfare of the state residents and retain the recommended requirement for arc fault circuit interrupters in kitchen and laundry circuits to be adopted as part of the 2017 NEC.
We thank you for the opportunity to comment.

Sincerely,

Si Farvardin
Manager of Codes and Standards
Insurance Institute for Business & Home Safety

Where building safety research leads to real-world solutions.

4775 E. Fowler Ave., Tampa FL 33617 | (813) 286-3400 | DisasterSafety.org

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Circuit Breaker AFCIs | Advanced Technology for the Modern Home

Applying technology to improve the electrical safety of the modern home is a wise investment for both the homeowner and the community at large. Circuit breaker arc-fault circuit interrupters, or AFCIs, can provide enhanced protection from fires resulting from damaged or unsafe home wiring conditions. Typical household fuses and standard circuit breakers do not respond to early arcing and sparking conditions in home wiring. By the time a fuse or standard circuit breaker opens a circuit to defuse these conditions, a fire may already have begun.

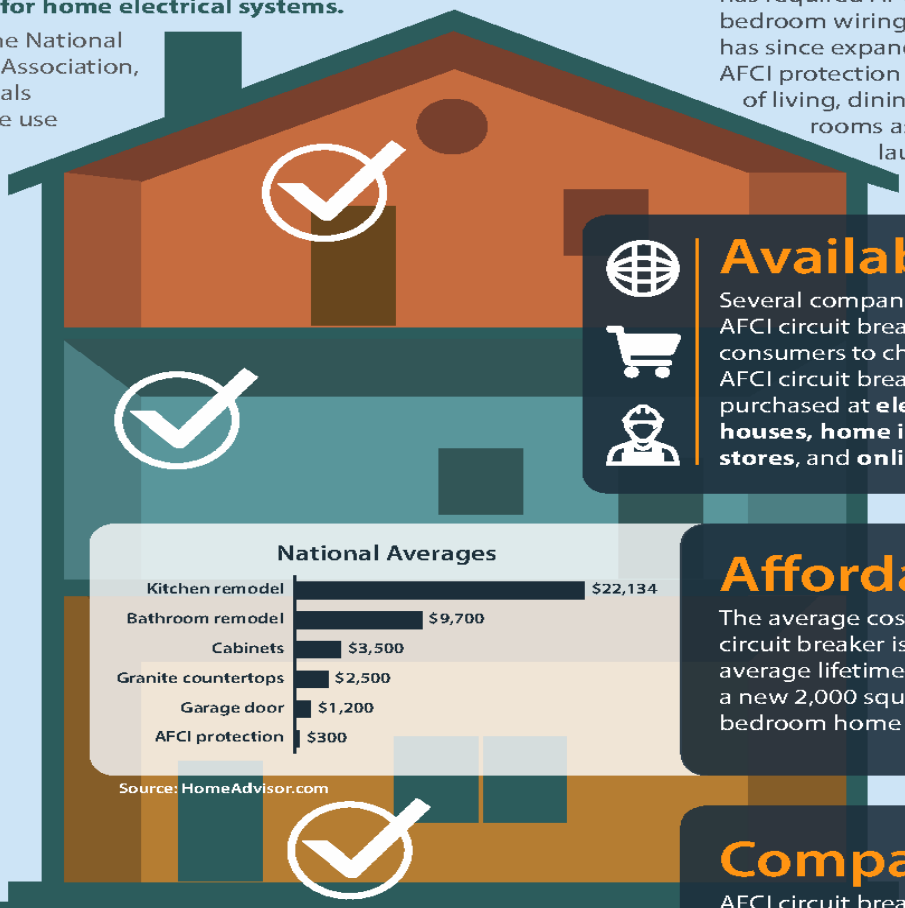
AFCI circuit breakers represent the latest technological advancement for home electrical systems.

According to the National Fire Protection Association, fire safety officials recommend the use of AFCIs in all dwellings.

Effective

AFCI circuit breakers are **intelligent devices** containing advanced technology that will detect an arc fault in home wiring and automatically shut down the electricity when it senses a hazard.

The National Fire Prevention Association publishes the National Electrical Code® (NEC) to protect people and property from electrical hazards. The NEC has required AFCI protection for bedroom wiring since 2002 and has since expanded to require AFCI protection for the wiring of living, dining, and family rooms as well as kitchens, laundry, hallways, and closets.



Available

Several companies manufacture AFCI circuit breakers for consumers to choose from. AFCI circuit breakers can be purchased at **electrical supply houses, home improvement stores**, and **online**.

Affordable

The average cost for an AFCI circuit breaker is **$38***, and the average lifetime cost to protect a new 2,000 square-foot, four-bedroom home is **$300**.

AFCI circuit breakers should be installed by a person trained and qualified in electrical wiring methods.

Compatible

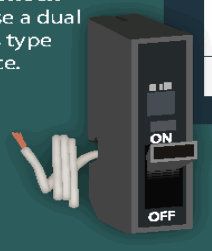
AFCI circuit breakers work extremely well with **new appliances** that meet U.S. product safety standards.



AFCI vs GFCI

AFCIs and GFCIs provide different but **critically important protection**. AFCI circuit breakers address fire hazards whereas GFCIs address **electric shock hazards**. A common way to provide both types of protection is to use a dual function breaker that combines Class A 5mA GFCI and combinations type AFCI protection against both arc faults and ground fault in one device.

According to the Consumer Product Safety Commission, both AFCI and GFCI circuit breakers are important safety devices.



For more information go to **www.afcisafety.org**

**NEMA blind survey for 2017 HUD Manufactured Housing Construction Standards.*

NEMA
National Electrical Manufacturers Association

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National Electrical Manufacturers Association

The association of electrical equipment and medical imaging manufacturers
www.nema.org

Circuit Breaker Arc-Fault Circuit Interrupters (AFCIs) – Myth vs. Fact

Cost

Myth: AFCI circuit breakers required in new home construction can cost $3,000+ per home, making them unaffordable.

Fact: The average cost for an AFCI circuit breaker is $38 (according to a NEMA blind survey for 2017 HUD Manufactured Housing Construction Safety Standards), or approx. $300 to protect a new 2,000-square-foot, four-bedroom home from electrical fires caused by electrical arcing. That's about 83 cents per month to protect a family from electrical fires over a 30-year mortgage. In contrast, material and hefty labor costs associated with installing a home builder upgrade like granite countertops averages around $4,500, or $12.50 per month over the same period. The National League of Cities recently indicated home builder "labor and land costs are by far the biggest construction expenses nationwide," resulting in rapidly rising home prices.

Appliance Compatibility

Myth: AFCI circuit breakers are not compatible with common household appliances.

Fact: AFCI circuit breakers work extremely well with new appliances that meet U.S. product safety standards. Some older appliances may incorporate components that predate current product safety standards or have operational characteristics that are not compatible with AFCI protection. Counterfeit appliances or those not certified by a Nationally Recognized Testing Laboratory (NRTL) may also be incompatible with AFCI circuit breakers.

AFCI/GFCI Compatibility

Myth: AFCI circuit breaker and Ground Fault Circuit Interrupters (GFCIs) won't work together.

Fact: AFCI circuit breakers and GFCIs complement and function well together in providing electrical safety and fire protection throughout a home. Both devices are required by the 2017 National Electrical Code® because they provide different, but critically important, protection. AFCI circuit breakers detect dangerous arcing in a home's wiring and stop electrical fires before they can start. GFCIs are required in rooms like kitchens, bathrooms and laundry rooms where water is present and help prevent possible shock and electrocution. There are dual function AFCI/GFCI circuit breakers on the market today that provide both types of protection in one device.

Product Availability

Myth: AFCI circuit breakers are hard to find.

Fact: Several companies manufacture AFCI circuit breakers for consumers to choose from. AFCI circuit breakers can be purchased at electrical supply houses, home improvement stores, and online.

AFCI Lifespan

Myth: AFCI circuit breakers only last one year or need frequent replacement.

Fact: AFCI circuit breakers are tested and certified to extremely rigorous U.S. product safety standards. When installed correctly, AFCI circuit breakers are expected to last the life of a standard circuit breaker under normal operating conditions. AFCI circuit breakers also carry a manufacturer's warranty.

1300 17th St N, Suite 900 – Arlington, VA 22209 – 703.841.3200

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NEMA

ISSUE BRIEF

The Association of Electrical Equipment and Medical Imaging Manufacturers | nema.org/policy-briefs

Circuit Breaker Arc-Fault Circuit Interrupters (AFCI)

Smoke alarms, fire extinguishers and escape ladders are all examples of emergency equipment used in homes to take action when a fire occurs. A circuit breaker arc-fault circuit interrupter (AFCI) is a product designed to detect a wide range of arcing electrical faults to help reduce the electrical system from being an ignition source of a fire. Unlike a standard circuit breaker detecting overloads and short circuits, an AFCI utilizes advanced electronic technology to "sense" the different arcing conditions that may be occur on a circuit. While there are different techniques employed to detect arcs by the various AFCI circuit breaker manufacturers, the end result is the same: detection of arcing conditions on the branch-circuit wiring, plugged-in electrical cords, and within appliances and other utilization equipment.

Importance

AFCI circuit breakers were created as a direct response to a U.S. Consumer Product Safety Commission report conducted by Underwriters Laboratories (UL) that identified an electrical problem in residential wiring systems causing numerous residential fires. In 1999, AFCI protection became a requirement in the National Electrical Code®. According to a 2017 National Fire Protection Association report, between 2010 and 2014, U.S. municipal fire departments responded to an estimated annual average of 45,210 home structure fires involving electrical failure or malfunction. These fires caused annual averages of 420 civilian deaths, 1,370 civilian injuries, and $1.4 billion in direct property damage.

Affordability

The average cost for an AFCI circuit breaker is $38, according to a NEMA blind survey for 2017 HUD Manufactured Housing Construction Safety Standards, or $300 to protect a new 2,000-square-foot, four-bedroom home from electrical fires caused by electrical arcing. That equates to 83 cents per month to protect a family from electrical fires over a 30-year mortgage. When installed correctly, AFCI circuit breakers are expected to last the life of a standard circuit breaker under normal operating conditions. AFCI circuit breakers can be purchased at electrical supply houses, home improvement stores, and online. Several companies manufacture AFCI circuit breakers for consumers to choose from.

Compatibility

AFCI circuit breakers work extremely well with appliances and devices that meet U.S. product safety standards. AFCI circuit breakers also compliment ground-fault circuit interrupters (GFCIs) and function well together to provide electrical safety and fire protection throughout a home. Both devices are required by the National Electrical Code® because they provide different but critically important protection. AFCIs detect dangerous arcing in a home's wiring and stop electrical fires before they can start whereas GFCIs help to prevent possible shock and electrocution where these hazards to a person are present.

NEMA Position

The National Electrical Manufacturers Association actively supports and promotes the installation and use of AFCI technology in residential and commercial buildings as an important electrical safety device to protect persons and property.

The National Electrical Manufacturers Association (NEMA) represents nearly 350 electrical equipment and medical imaging manufacturers that make safe, reliable, and efficient products and systems. Our combined industries account for 360,000 American jobs in more than 7,000 facilities covering every state. Our industry produces $106 billion shipments of electrical equipment and medical imaging technologies per year with $36 billion exports.

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arc fault circuit interrupters

using advanced technology to reduce electrical fires



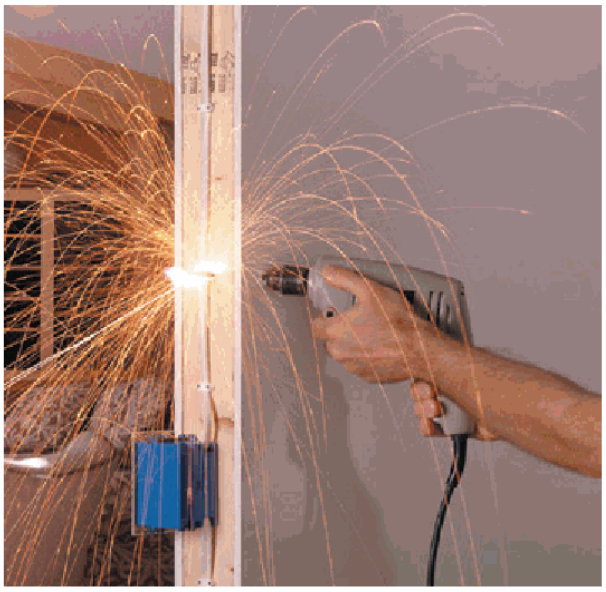
NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

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INTRODUCTION

Arc fault circuit interrupters (AFCIs) are required by the National Electrical Code® (NEC) for certain electrical circuits in the home. Questions have been raised regarding their application and even the need for them. Various technical "opinions," organizational "marketing pitches," and misinformation are being distributed about AFCIs that further mislead the public about the purpose of the device as a part of overall electrical safety for the public.



This brochure is intended to address the various aspects of AFCIs and dispell the misinformation circulating in the industry.

WHY DO WE REALLY NEED AFCIs?

Smoke alarms, fire extinguishers and escape ladders are all examples of emergency equipment used in homes to take action when a fire occurs. An AFCI is a product that is designed to detect a wide range of arcing electrical faults to help prevent the electrical system from being an ignition source of a fire. Conventional overcurrent protective devices do not detect low level hazardous arcing currents that have the potential to initiate electrical fires. It is well known that electrical fires do exist and take many lives and damage or destroy significant amounts of property. Electrical fires can be a silent killer occurring in areas of the home that are hidden from view and early detection. The objective is to protect the circuit in a manner that will reduce its chances of being a source of an electrical fire.

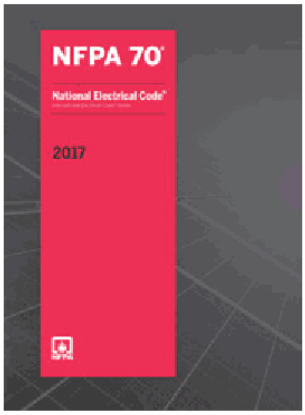
THE JOURNEY TO DEVELOP DETECTION TECHNOLOGY

Research in the arc fault area began in the late 1980s and early 1990s when the U.S. Consumer Product Safety Commission (CPSC) identified a concern with the residential fires of electrical origin. A large number of these fires were estimated to be in branch circuit wiring systems.

The concept of AFCIs gained more momentum when code proposals were made to the 1993 NEC to change the instantaneous trip levels of 15A and 20A circuit breakers. The Electronic Industries Association (EIA) had studied the issue of electrical fires and determined that additional protection against arcing faults were an area that needed to be addressed by electrical protection. This proposal first attempted to do this by requiring that instantaneous trip levels of a circuit breaker be reduced from a range of 120 to 150 amperes down to 85 amperes. However, it became clear that the lowering of those levels below some of the minimums already available on the market would result in significant unwanted tripping due to normal inrush currents.

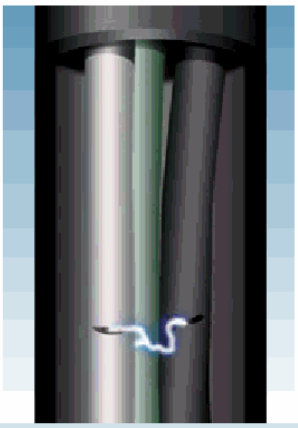
It was these early studies and code efforts that led to the first proposals requiring AFCIs, which were made during the development of the 1999 NEC. NEC Code-Making Panel 2 (CMP2) reviewed many proposals ranging from protecting the entire residence to the protection of living and sleeping areas. In addition, the panel heard numerous presentations on both sides of the issue. After much data analysis and discussion, the CMP2 concluded that AFCI protection should be required for branch circuits that supply receptacle outlets in bedrooms.

Subsequent editions of the NEC further upgraded the requirements to include all 120-volt, single-phase, 15- and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, and similar rooms or areas, along with other enhancements.

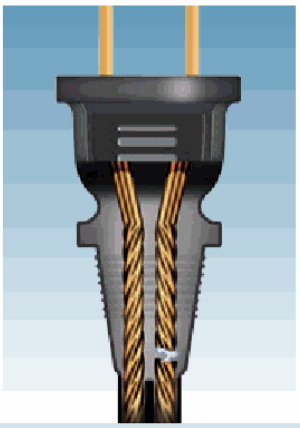


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Parallel Arc



Series Arc

WHAT ARE ARC FAULTS?

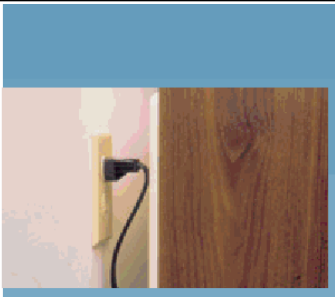
The UL Standard for AFCIs (UL 1699) defines an arc fault as an unintentional arcing condition in a circuit. Arcing creates high intensity heating at the point of the arc, resulting in burning particles that may over time ignite surrounding material, such as wood framing or insulation.

The temperatures of these arcs can exceed 10,000 degrees Fahrenheit. Repeated arcing can create carbon paths that are the foundation for continued arcing, generating even higher temperatures.

typical causes of arc faults

Example conditions where arc faults may start include:

- Damaged wires
- Worn electrical insulation
- Wires or cords in contact with vibrating metal
- Overheated or stressed electrical cords and wires
- Misapplied or damaged electrical appliances



Furniture pushed against or resting on electrical cords can damage the wire insulation. Damaged cords can become a potential condition for arcing.



Extension or appliance cords that are damaged or have worn or cracked insulation can contribute to electrical arcing.



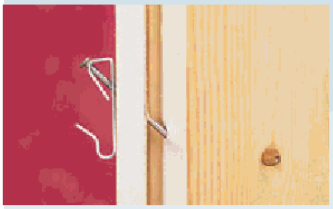
Cord insulation can be deteriorated by heat generated by hot air ducts or sunlight.



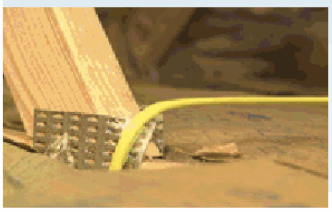
Cables that are improperly nailed or stapled too tightly against a wall stud can sever insulation and cause arcing.



Wires located behind walls can be accidentally punctured by a screw or drill bit damaging the insulation of the wiring.

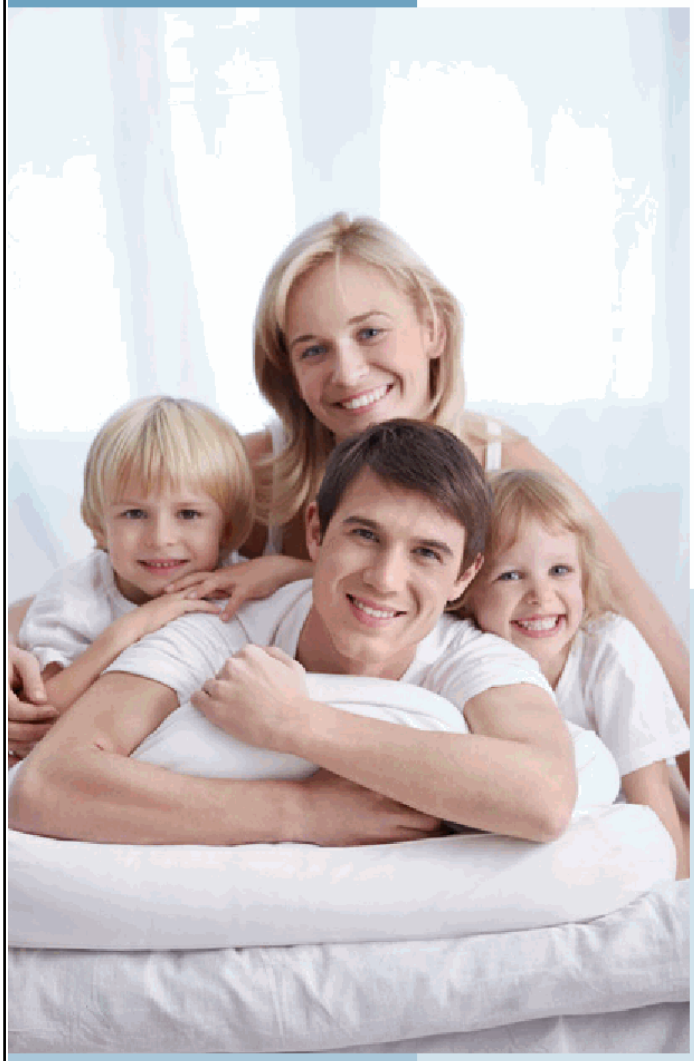


Nails carelessly driven into walls can break wire insulation and cause arcing.



Non-metallic sheathed cable damaged by gusset plate while being pulled through attic.

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FIRE DATA ANALYSIS

The Federal Government, the National Fire Protection Association, and US fire departments track the incidence of electrical fires across the United States and categorize those fires based on their causes. In reviewing statistics from 2003 to 2014, fires in home electrical systems averaged 25,366 annually and resulted in 378 civilian deaths, 1,290 civilian injuries and $1.4 billion in direct property damage.* The NFPA Home Electrical Fires Fact Sheet indicates that wiring and related equipment were involved in 63% of these fires and half of the associated deaths in 2007-2011.

The U.S. Department of Housing and Urban Development (HUD) recommendation is to promote AFCIs as one of the many devices that can be used to prevent burns and fire related injuries. In addition, it cites a 1999 CPSC Report recommending the use of AFCIs to "prohibit or reduce potential electrical fires from happening."**

As you can see from the data above, fires of electrical origin are a significant issue that must be addressed. Frequently, it is argued that fires only occur in older homes. However, it should be recognized that new homes become older homes. It is critical to install the AFCIs in the beginning so that they can perform their protection function from the start. Seldom are devices such as AFCIs added to homes after they are constructed and occupied.

*Home Electrical Fires Fact Sheet, National Fire Protection Association

**Healthy Homes Issues: Injury Hazards, U.S. Department of Housing and Urban Development, Version 3, March 2006

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HOW IS AN ARC FAULT DETECTED?

An AFCI device uses advanced electronic technology to "sense" the different arcing conditions. While there are different technologies employed to measure arcs by the various AFCI manufacturers, the end result is the same, detecting parallel arcs (line to line, line to neutral and line to ground) and/or series arcs (arcing in series with one of the conductors).

How does arc fault detection work? In essence, the detection is accomplished by the use of advanced electronic technology to monitor the circuit for the presence of "normal" and "dangerous" arcing conditions. Some equipment in the home, such as a motor driven vacuum cleaner or furnace motor, naturally create arcs. This is considered to be a normal arcing condition. Another normal arcing condition that can sometimes be seen is when a light switch is turned off and the opening of the contacts creates an arc.

A dangerous arc, as mentioned earlier, occurs for many reasons, including damage of the electrical conductor insulation. When arcing occurs, the AFCI analyzes the characteristics of the event and determines if it is a hazardous event. AFCI manufacturers test for the hundreds of possible operating conditions and then program their devices to monitor constantly for the normal and dangerous arcing conditions.

THE NEC AND UL STANDARD

National Electrical Code

The National Electrical Code specifically defines and mandates the installation of AFCIs. The areas in homes where AFCI protection is required have gradually expanded, and as of the 2014 edition include kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, and similar rooms or areas.

UL Standard

Product standards to cover AFCIs began to be developed in the mid-1990s. Underwriters Laboratories published UL 1699 Standard for Safety for AFCIs in 1999 to cover a wide variety of conditions to evaluate an AFCI. The standard includes requirements for the following conditions:

- Humidity conditioning
- Leakage current
- Voltage surge
- Environmental evaluation
- Dielectric voltage
- Arc-fault detection
- Unwanted tripping
- Operation inhibition
- Resistance to environmental noise
- Abnormal operation

One of the most frequent questions about AFCIs is related to resistance to unwanted tripping. There are four varieties of tests related to its ability to resist unwanted tripping:

- Inrush current: High-current-draw devices such as tungsten filament lamps and capacitor start motors.
- Normal arcing: Brush motors, thermostatic contacts, wall switch and appliance plugs.
- Non-sinusoidal waveforms: Examples of devices creating these electrical waveforms include electronic lamp dimmers, computer switching-mode power supplies and fluorescent lamps.
- Cross talk: This test measures trip avoidance for an AFCI when an arc is detected in an adjacent circuit. Only the circuit with the arc should cause the breaker to trip, not another circuit.

Through the use of the NEC requirement and extensive UL testing, manufacturers' AFCI products provide superior protection against arcing faults.

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CONTRASTING AFCIs AND GFCIs

There is a major difference between the functioning of an AFCI as compared to a GFCI (ground fault circuit interrupter). The function of the GFCI is to protect people from the deadly effects of electric shock that could occur if parts of an electrical appliance or tool become energized due to a ground fault. The function of the AFCI is to protect the branch circuit wiring and electrical cords connected to it from dangerous arcing faults that could initiate an electrical fire.

AFCI and GFCI technologies can co-exist with each other and are a great complement for the most complete protection that can be provided on a circuit.

WHAT ARE THE VARIOUS SAFETY AND GOVERNMENTAL AGENCIES SAYING ABOUT AFCI?

"The National Association of State Fire Marshals (NASFM) strongly supports the broad adoption of AFCI technology through national, state, and local building codes. AFCIs are the most welcome addition to fire prevention in decades. AFCIs promise to save hundreds of lives every year."

— John C. Bean, President, NASFM

"The National Association of Home Inspectors (NAHI) strongly encourages its members to educate all of their clients about the life and property saving benefits of AFCI technology, especially those clients considering the purchase of a home more than 20 years old."

— Mallory Anderson, Executive Director

"The National Electrical Contractors Association (NECA) submitted comments to legislative committees in Michigan and South Carolina, urging them to retain requirements for AFCI protection of bedroom receptacles in their state electrical codes. Cost-cutting pressure from homebuilders' associations in both states led to code proposals to delete AFCI protection required by the National Electrical Code, when constructing new homes."

— NECA Contractor Code Letter

"CPSC has identified arc fault circuit interrupter (AFCI) technology as an effective means of preventing fires caused by electrical wiring faults in homes."

— U.S. Fire Administration

"The Electrical Safety Foundation International (ESFI) urges that arc fault circuit interrupter (AFCI) technology be installed in all new and existing housing to protect homes and families from fires caused by electrical arcing."

— Brett Brenner, President, ESFI

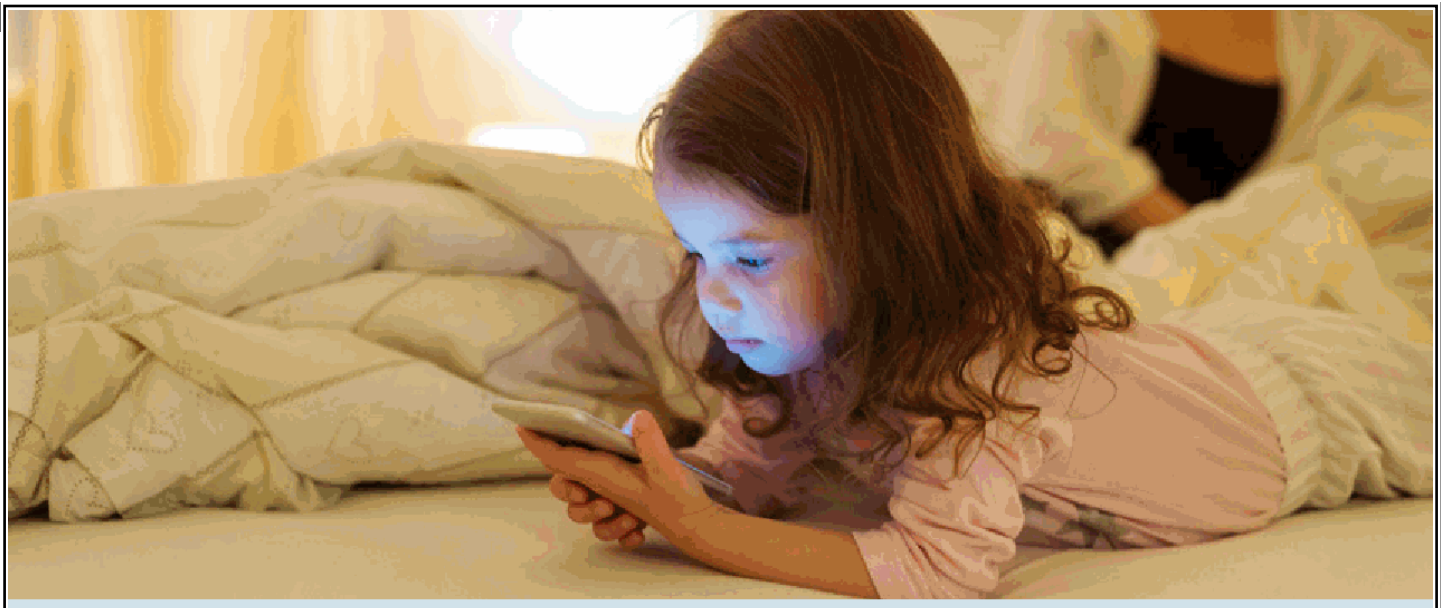
TYPES OF ARC FAULT CIRCUIT INTERRUPTERS

AFCI and GFCI Protection

An AFCI can be used in conjunction with GFCI protection to provide both arcing fault protection as well as 5mA ground fault (people) protection. A way to provide both types of protection is to use an AFCI circuit breaker and a GFCI receptacle. Another way is to install a dual function device that provides both AFCI and GFCI protection.



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defining the arc fault risk to people and property



WIRING AND INSTALLATION GUIDELINES

There are no special requirements for an AFCI circuit other than proper installation and wiring practices. There are various special considerations that must be given to certain circuits that vary from the norm, such as shared neutral applications, but in general the application of an AFCI is as simple as following the installation instructions that come from the manufacturer.

As with any change in the required protection for the electrical system, there have been many discussions and deliberations both for and against arc fault protection being a part of the NEC. Some have argued that the cost of installing AFCIs is higher than the cost of installing standard devices and, as such, it costs too much to provide the increased protection. Others have argued that since it is a relatively new type of protection, it does not have the history on which to base a decision as to whether to support or not.

These issues have been debated thoroughly and completely. It is important to keep a few critical facts in mind.

- The cost to install AFCI circuit breakers in the home is insignificant when compared to the number of lives and property the device helps protect.
- The additional cost to install AFCIs is insignificant compared to the total cost of a new home, typically less than 0.1%.
- The Consumer Product Safety Commission staff report on Estimated Residential Structure Fires on Selected Electrical Equipment (October 2006) from 1999-2003 reported that 142,300 electrical distribution fires occurred on all distribution components. Installed wiring fires were estimated to have occurred in 50,200 instances.
- Using the same report, the CPSC projected that there were 910 deaths attributed to electrical distribution equipment during that five-year period. Installed wiring led to approximately 210 deaths as a part of that total.

Applying technology to improve the electrical safety of the home is a wise investment for both the homeowner and the community at large. Reducing fires of electrical origin and saving lives is an important responsibility of the entire construction and regulatory community. Taking these CPSC statistics into account, one has to ask, if a portion of the 50,200 fires could have been prevented, would the increase in cost have been worth the added protection AFCIs provide the homeowner?

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what is the price of new safety technology worth?

When GFCIs were introduced in the 1970s, similar discussions took place regarding the cost/benefit to the consumer, homebuilder and others. GFCIs have been a standard requirement in homes for over 30 years with additional locations and circuits being added over time as well. GFCI also has a statistical track record over time as to the reduction of electrocutions. On an annual basis, in 1983, there were almost 900 electrocutions total per year with approximately 400 being consumer product related. Ten years later, the total was reduced to 650 annually and slightly over 200 consumer product electrocutions annually.

With over 20 years of history, statistically based analysis of GFCIs was built on a solid foundation of data. AFCIs are relatively new and have only been installed in a small fraction of the total number of circuits in U.S. homes. As with all products, given time, they too will be able to provide a solid statistical base of measure.

Some have argued that it should be shown how many times an AFCI has "prevented" a fire from occurring. Of course, this is not a feasible request. The AFCI disconnects the power when an arc fault occurs, therefore no incidence of fire or arc is reported to authorities. The same can be true when a smoke alarm siren alerts the homeowner and the small smoking event is extinguished without incident. Is that statistic reported to the federal government or local fire department? Of course not. Safety prevention is just that: prevention. The only statistics that are reported are those that have resulted in a fire or a response of a fire department. Many safety protection actions go unreported.

If we are to offer consumers a safer home, then the appropriate technology should be put into place.

Removing AFCI as a local or state code requirement is reducing safety requirements. These rules are established by a national body of experts that have heard testimony from many sources as well as reviewed a significant amount of data to make their recommendation. Shouldn't we trust the safety experts that develop our safety procedures?





NEMA AND ELECTRICAL SAFETY

For more than 80 years, manufacturers of low-voltage distribution equipment have been working to ensure public safety through standards writing efforts and the dissemination of important industry information through the National Electrical Manufacturers Association (NEMA), one of the most respected standards development organizations in the world. Headquartered in Rosslyn, Virginia, NEMA has approximately 350 electroindustry member companies, including large, medium and small businesses. To learn more about NEMA visit **www.nema.org**.

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

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NEMA Objections to Proposed Modification E8149:

1. NEC CMP-2 has rejected similar proposals that have attempted to reduce or remove AFCI requirements from the code. In fact, the proponent of this proposal submitted a similar public input to the 2020 NEC (PI-3813) which was overwhelmingly rejected. His second attempt to remove kitchens and laundry areas during the comment phase (PC-1432) was again soundly rejected by the committee. The Electrical TAC should not support a fire-safety "roll back" and should never approve a below-code amendment to a national consensus standard that provides the minimum provisions considered necessary for safety.

2. The substantiation being provided by the submitter is not accurate and not applicable to AFCI protection. The NFPA studies being cited have nothing to do with the effectiveness of AFCI devices. The findings of the reports do not focus on a specific reason home fires continue to be a problem. The total number of home fires in any given year is not a proper metric for determining the efficacy or merits of AFCI protection or any other electrical/fire safety product. Home fires that have not started as a result of AFCI protection are not reported or tracked. There is currently no way to document the reduction of fires as a result of AFCI protection. More importantly, nothing in the reports indicate that AFCIs are not preventing fires from occurring. In fact, there is currently no evidence in any published report that a fire has occurred in a home where AFCI protection has been installed. The removal or reduction of AFCI protection for kitchens and laundry areas is not supported by the findings of any NFPA report.

3. The wiring methods and materials supplying kitchens and laundry areas along with receptacle use in these rooms are identical to those in the other rooms and spaces of a dwelling. There is no technical basis for not including the branch circuits that supply these areas within a dwelling while supporting continued protection of the other branch circuits in the rooms and spaces named in the code.

4. Approval of this proposal would discriminate against 1&2 family dwelling owners as it would only apply to those buildings under the scope of the FBC-R. All other dwellings under the scope of the FBC-B have to comply with the 2017 NEC as published. The Florida codes should not discriminate against one class of citizen.

5. AFCI devices tested and certified to the UL 1699 Standard have been shown to effectively prevent the ignition of combustible materials where an arcing event occurs on the premises wiring system. AFCI devices undergo not less than (50) performance tests to ensure safe and proper operation. These findings have been reported to the US Consumer Product Safety Commission whom support and endorse AFCI protection as an effective means to prevent electric fires from occurring.

6. The UL 1699 Standard includes not less than six performance tests related to unwanted tripping. AFCI devices certified to UL 1699 will not trip due to inrush currents, normal operation arcing, non-sinusoidal waveforms, branch-circuit cross talk, multiple loads, and environmental noise (EM/RF). NEMA and the Association of Home Appliance Manufacturers (AHAM) have assembled a Task Force to address the remaining incompatibility issues that may exist between the UL 1699 Standard and the various appliance product Standards. Where unwanted AFCI tripping is encountered in the field, the NEMA Low Voltage Distribution Equipment section has developed an online unwanted tripping reporting tool at www.afcisafety.org. Additional guidance and support for Outlet Branch Circuit (OBC) AFCI Devices as an alternative solution to AFCI Circuit Breakers can be found at www.afcisafetyreceptacles.org.

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SCANDAGLIA RYAN LLP

February 15, 2019

Thomas Campbell
Executive Director
Florida Building Commission
2601 Blair Stone Road
Tallahassee FL 32399

James Schock
Vice Chairman
Florida Building Commission
2601 Blair Stone Road
Tallahassee FL 32399

Re: Legrand Proposal E8149

Dear Director Campbell and Vice Chairman Schock:

I represent the Arc Fault Circuit Interrupter Wiring Device Joint Research and Development Consortium ("the AFCI Consortium" or "the Consortium"). The AFCI Consortium is comprised of manufacturers of outlet branch circuit AFCI receptacles. Its members are: Hubbell Inc. (Delaware) Wiring Device Division ("Hubbell"), Legrand/Pass & Seymour ("LPS"), and Leviton Manufacturing Co. ("Leviton"). Please accept this letter as the AFCI Consortium's formal support of LPS's E8149 proposal to the Florida electrical code seeking deletion of kitchen and laundry areas from the list of locations within the dwelling unit where AFCI protection is required.

As an industry stakeholder, the AFCI Consortium supports E8149 because it seeks to pause further expansion of AFCI throughout the dwelling unit. The AFCI Consortium is concerned about a lack of technical substantiation and data to justify the proliferation of AFCI technology throughout the entire dwelling. As such, the Consortium questions whether continued AFCI expansion actually correlates with improved fire safety. On this front, the NFPA recently published a report saying that there was a lack of data to connect expanded AFCI with a decrease in fires. *See* V. Hutchison, "*Residential Electrical Fire Problem: The Data Landscape*," NFPA FIRE PROTECTION RESEARCH FOUNDATION pages 3-4 (Oct. 2018). This same report stated that since 2002, there has been an increase in residential fires despite the increase in AFCI technology during roughly the same time period. E8149 represents a much needed "pause" in the continued proliferation of AFCI technology throughout the dwelling unit pending the collection of technical data and substantiation that actually supports an increase in fire safety outcomes with expanded use of AFCI.

The AFCI Consortium supports E8149 for the additional and related reason that a "pause" in AFCI expansion is necessary until the problematic issue of "nuisance tripping" is better understood. A "nuisance trip" is an unwarranted or false trip of an AFCI or GFCI breaker or receptacle. For example, an AFCI breaker or receptacle may act as if there is an arc fault and "trip" (cut power to the circuit) when an arc fault does not exist. Concerns can arise from false trips due to home appliances. For example, unwarranted false trips can lead to increased safety risks within dwellings, driven significantly by homeowners seeking to correct a wide range of power outage situations on their own by "workarounds" that may cause inadvertent removal of *both* AFCI and GFCI protection. Reports of nuisance tripping involving refrigerators, dishwashers, and

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microwave ovens, among other appliances, are continuing to be accumulated. However, the data on nuisance tripping in AFCI and GFCI embodiments is incomplete. Still and all, nuisance tripping is the cited reason many States have exempted the AFCI requirements when determining the scope of local NEC adoptions. The AFCI Consortium believes that E8149 represents a necessary "pause" of continued AFCI expansion in the dwelling unit until a full and thorough accounting and consideration of relevant nuisance trip data is collected and analyzed.

Thank you for your consideration.

Counsel for the AFCI Consortium

By: _____

Eric J. Muñoz

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E8149 -G5 General Comment

SCANDAGLIA RYAN LLP

February 15, 2019

Thomas Campbell
Executive Director
Florida Building Commission
2601 Blair Stone Road
Tallahassee FL 32399

James Schock
Vice Chairman
Florida Building Commission
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Thank you for your consideration.

Counsel for the AFCI Consortium

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The US Consumer Product Safety Commission (CPSC), in Publication 5133 R042012, supports and endorses AFCI protection as an enhanced means of protection from electric fires resulting from unsafe home wiring conditions.

The NEC, in CMP2, has supported this position not only by requiring the use of AFCI protection since 1999 but had further expanded the requirements for their use throughout homes in each of the following code cycles. This proposed modification flies in the face of reason by reducing the required level of protection.

AFCIs are designed specifically to protect electrical circuits by detecting when an arcing event occurs, arcing events that cause fires, destroy homes and irrevocably change lives. Arcing can occur on any circuit including those removed though this proposal.

It has been rumored that installing AFCI protection is too costly for home owners. The truth is homeowners insurance premiums may increase due to lower ISO Building Code Effectiveness Grading Schedule rating. Additionally, lowering this score also decreases the amount of federal funding provided after natural disasters such as hurricane Wilma and Irma. Amending the code to remove AFCI protection weakens the mitigation intent of the code.

Do not support Proposed Code Modification E8149.

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Personal Insurance Federation OF FLORIDA

Members

Allstate Insurance Companies

Farmers Insurance

The Progressive Group of Insurance Companies

State Farm Insurance Companies

May 2, 2019

Florida Electrical TAC

Re: Opposition to Modification E8149

Dear TAC Members:

The Personal Insurance Federation of Florida, Inc., (PIFF) is a non-profit personal lines property & casualty trade association representing national insurers and their affiliates doing business in Florida. Our members collectively write $13B in premium in the auto and homeowners' insurance markets. We advocate for a healthy and competitive insurance marketplace for the benefit of Florida consumers.

One of our highest priorities is to protect Florida's building code from proposals that might weaken safety. Therefore, PIFF respectfully requests the Florida Electrical TAC to reject Modification E8149, which proposes to eliminate arc fault circuit interrupters (AFCIs) in kitchen and laundry circuits of residential dwellings. The AFCIs required by the National Electrical Code (NEC) are proven safety features in residential wiring systems that detect and isolate problems that could lead to electrical fires. Eliminating AFCIs would seriously reduce electrical safety in new residential home construction in Florida. We believe that the reduction in safety and the corresponding increase in fire risk are not in the interest of the consumers we serve.

PIFF urges TAC members to protect the safety and welfare of Floridians and preserve the recommended requirement for arc fault circuit interrupters in kitchen and laundry circuits to be adopted as part of the 2017 NEC. Thank you for your consideration of this comment.

Sincerely,

Michael Carlson
President/CEO

215 South Monroe Street
Suite 835
Tallahassee, FL 32301
Phone (850) 597-7425
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FISCAL IMPACT: Estimated electrical installer savings: $180 - $192 per home. Assumptions: Installation of 5 Kitchen plus 1 Laundry circuits = 6 total circuits to be installed. AFCI breaker per ACBMA = estimated unit cost of $35 each. Standard listed branch-circuit overcurrent protective device (i.e. – standard overcurrent circuit breaker) estimated unit cost of $3 to $5 each.

Range of added costs avoided = $180 to $192 per home based upon savings of $30 to $32 for each of the six breakers that would not need to be AFCI protected. No additional savings for labor expense associated with avoidance of AFCI breaker installation vs. standard breaker installation was calculated for this example, although there may be an associated labor expense savings.

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Residential Electrical Fire Problem: The Data Landscape

NFPA Research Foundation

October 2018

Summary

The Fire Protection Research Foundation (an affiliate of NFPA) was initially asked by leadership of NEC Code Making Panel (CMP) #2 to collect data to assist Panel members with determining the best methods of protecting branch circuit wiring in dwelling units against electric arcing. Upon closer consideration, the Foundation realized that there are inherent challenges and barriers to the effective identification and collection of applicable data, which must be resolved before recommendations or conclusions can be made towards degree of effectiveness of applied methods, such as AFCI.

The Foundation acknowledged that ***"data and data analytics is lacking to guide the optimum approaches to minimize residential electrical fires and related hazards."*** After identification and consideration of the numerous relevant (but unknown) factors, the goal of this project became an effort to summarize the landscape of residential electrical fire incident data to address the ***"problem and the impact of the NEC's regulatory changes regarding AFCIs from being precisely defined."*** The report summarizes the data landscape for residential electrical systems and related fires, identifies gaps in the available data, and makes recommendations to address the lack of data. It observes that "while proving the effectiveness of preventative measures (e.g. AFCI's) is a challenging task, the significant limitations associated with the existing traditional data sources presents serious concerns."

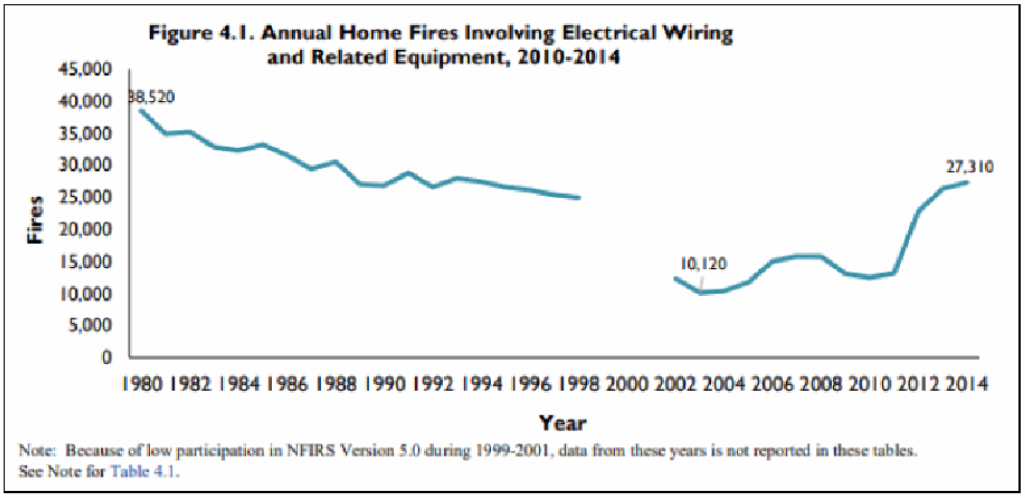


Figure 2 Annual Home Fires Involving Electrical Wiring (Image retrieved from Campbell, 2017)

The report highlights that, despite the general downward trend of electrical fires since 1980, "home fires involving electrical wiring and related equipment have generally been on the rise since 2002." In addition, a very significant increase in residential electrical fires was recorded from 2012 to 2014, of which 49% were said to be "related to some form of arcing in the electrical wiring." Accordingly, the report states that ***"there is uncertainty regarding the residential electrical fire problem and the effectiveness of branch circuit protection devices, such as AFCI's."***

Identification and Analysis of the Existing Data Sources

The report identified and analyzed existing data sources, along with the positive and negative characteristics of each in understanding electrical fires. Included in the analysis of identified current data sources was the following:

1) NFIRS: does not include the year a structure was built, the type of branch circuit protection or the type of wiring. This "lack of granular detail in an NFIRS report hinders a detailed analysis of residential fires due to

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electrical failures." Also, it is common to have misclassified cause of electrical fires, best evidenced by 51% of electrical fires from 2010 to 2014 being identified as "unclassified electrical failure or malfunction".

2) Fire Incident Data Organization (FIDO), an NFPA-owned database of fire incident data; this is a voluntary system (typically handwritten), "so the number of incidents in the database is somewhat sparse and is currently a relatively small sample of incidents." In addition, FIDO has extremely limited relevance towards solving the residential electrical fire problem, as "residential electrical fires have not been a targeted incident category".
3) Fire Investigation Reports: this is a small sample size, usually of large-loss fires. "The relatively small sample size of investigated residential electrical fires could be a limiting factor for this analysis." The reports are extremely detailed but are therefore very time consuming to develop and analyze. Most significantly, the data is not in a format that can lead to data analytics.

Summary Observations

The report finds that ***"the most significant problem with residential electrical fire data is that nearly all of the currently available public data is lacking in quality and accuracy, and is relatively unusable for data analytics in its current state."*** As such," the existing residential electrical data is generally unrefined and provides limited value to the analysis of determining the effectiveness of electrical branch circuit protection devices."

1) Good and accurate data is needed: "If the goal is to utilize data to evaluate the effectiveness of branch circuit protection devices, it is imperative that we collect better data. Without better data, we cannot prove the effectiveness of these devices or evaluate the optimal means of protecting branch circuits against electrical arcing."
2) A lot of good data is needed: "The primary issue with getting good data within the existing infrastructure is the frequent misclassification of electrical fire incidents, which limits the quantity of good, available data."
3) Data analytics is extremely challenging to perform on existing post-incident data: "The quality and quantity of currently available residential electrical fire incident data is inadequate."
4) The data needs to be compatible, unified and scalable.
5) The greatest challenge lies with the non-technical issues: there are political, social and economic issues that can impact data collection.
6) All data collected, despite the source, needs to be technically validated prior to use.

"Before conclusions can be drawn regarding the effectiveness of electrical protection devices, the summary observations listed above should be addressed with respect to residential electrical data."

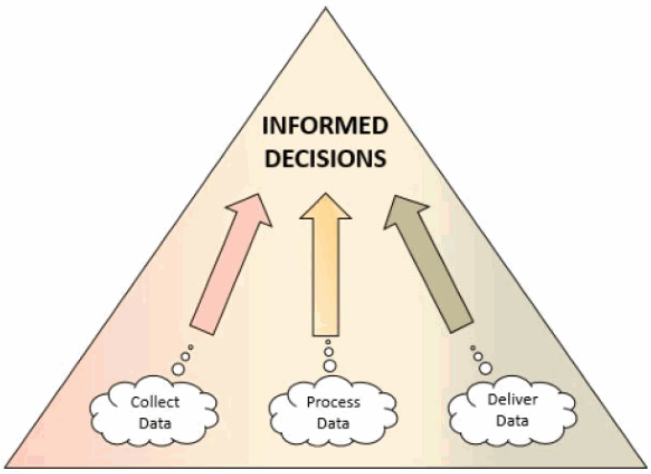


Figure 3 Core Principles of Data Collection and Analytics

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Review of the previous expansion proposals to add kitchens and laundry areas and their ballot comments noted that National Electrical Code Panel 2 did not have clear substantiation of fires specifically located in kitchens or laundry areas from the fire data used to justify that expansion. This lack of technical substantiation was noted in several comments for the 2014 NEC cycle, but was rejected by Panel 2.

Although we recognize the problem with residential fires due to electrical systems, there remains no independently verifiable measurement method to determine the performance of solutions. The data available presently does not serve to reflect the efficacy of any implemented solution. NEC Panel 2 has no independently verifiable tool to measure the veracity of AFCI protection.

In response to this lack of data, a project sponsored by NFPA was conducted by the Fire Protection Research Foundation. This project entitled "Residential Electrical Fire Problem: The Data Landscape" was initiated to "...summarize the landscape of residential electrical fire incident data and provide recommendations for future efforts to precisely define the residential electrical fire problem and the impact of the NECs regulatory changes (e.g. - AFCIs)." A link to the report on the NFPA site is provided here https://www.nfpa.org/News-and-Research/Data-research-and-tools/Electrical/Residential-Electrical-Fire-Problem-The-Data-Landscape, while a two-page summary is provided as an uploaded support file.

This completed NFPA-funded FPRF project concludes that, if the previous positions of NEC Panel 2 regarding the initial acceptance and subsequent expansions of AFCI requirements were and are justified based upon reductions in residential electrical fires delivered by increased AFCI protection, evidence-based substantiation data to support this claim does not exist and cannot be made.

Nuisance Tripping Problem Increased with Expanded AFCI Use: reports of nuisance trip incidents involving refrigerators, dishwashers and microwave ovens among other appliances are continuing to be accumulated. The impacts of the nuisance trips are multi-fold, including but not limited to:

- Removal of AFCI and GFCI protection by replacing a dual function AFCI/GFCI circuit breaker with a standard thermal-magnetic circuit breaker
- Unpaid call-backs for contractors
- Homeowner inconvenience
- Power loss resulting in property loss or injury
- Untested workarounds such EMI filters
- Unsafe workarounds such as extension cords

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Mandated AFCI protection in kitchen and laundry areas can compromise electrical safety for home dwellers. If GFCI protection is inadvertently removed and not replaced with a suitable GFCI device (which has been stated as happening in actual practice) to resolve an AFCI/GFCI nuisance trip, then the safety provided by the GFCI that has been historically present in these locations is lost. This is true because installers are not (and are not doing so) obligated to install GFCI protection at the point of use to comply with the code. All protection is being placed within the breaker panel in the form of a dual-function breaker; in these examples cited, the long-standing GFCI protection is now non-existent. Although the requirement is to ensure that GFCI protection remains in place, home dwellers often will come up with their own "work-arounds" to independently solve a dual-function breaker nuisance trip issue, compromising safety in the process due to no initial need for GFCI protection to be installed at the point of use.

AFCI expansion is resulting in fewer GFCIs located at the point of use. In view of the issues with nuisance tripping of AFCI or dual function AFCI/GFCI devices, accessibility for required monthly testing and to reset now becomes a very important safety factor to assure continued personnel protection. As such, this proposal respectfully requests for consideration and accounting for those with special needs (elderly, infirm, physically challenged and similar) to retain point of use capability to manage these requirements necessary to preserve safety in the home. Since the element of accessibility for all affected parties is not considered in the national minimal standard context of the NEC, the appeal here is to address it with this local amendment. The needs of dwelling occupants are addressed with this proposal to remove AFCI from kitchen and laundry areas; retention of AFCI in these areas can compromise the safety of those who are most affected by and due to their mobility challenges.

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State-by-State NEC Adoption – as of August 29, 2018

Overview of NEC adopted versions:

- 2017 NEC – 22 States
- 2014 NEC – 14 States
- 2011 NEC – 0 States
- 2008 NEC – 4 States
- Local Adoption – 5 States
  - Alabama, Arizona, Mississippi, Missouri and Nevada.
- AFCI Requirements Controlled by International Residential Code – 5 States

Overview of AFCI Requirements:

15 states and 3 major municipalities have made amendments to reduce the AFCI requirements. Below is summary of the changes that have been made:

- Arkansas (2017 NEC) – AFCI's are not required in kitchens and laundry areas.
- Delaware (2014 NEC) – Smoke alarms shall not be placed on branch circuits protected by AFCI's.
- Idaho (2017 NEC) – AFCI protection is only required in bedrooms.
- Iowa (2017 NEC) – AFCI requirements for branch circuit extensions or modifications in dwelling or dormitory units were deleted.
- Michigan (2018 IRC) – AFCI requirements were deleted.
- New Hampshire (2017 NEC) – AFCI requirements for dormitory unit devices and bathrooms, guest rooms and guest suites, and branch circuit extensions or modifications for dormitory units were deleted.
- New Jersey (2014 NEC) – AFCI requirements for kitchens and laundry areas, as well as for branch circuit extensions or modifications, were deleted.
- North Carolina (2017 NEC) – AFCI requirements for kitchens and laundry areas were deleted, as well as those for dormitory unit bathrooms guest room and guest suites, and extensions or modifications.
- Oregon (2017 NEC) – AFCI requirements deleted from branch circuits that supply hallways, kitchen or laundry areas, as well as GFCI protected receptacles installed in dining rooms. AFCI protection shall not be required for optional, dedicated outlets that supply equipment known to cause unwanted tripping of AFCI devices and for branch circuits that serve an appliance that is not easily moved or that is fastened in place.
- South Carolina (2018 IRC) – AFCIs will not be required in kitchens and laundry areas.*
- Tennessee (2008 NEC) – The 2017 NEC will become effective in the state on October 1, 2018 and states that AFCIs shall be optional for bathrooms, laundry areas, garages, unfinished basements, work or similar area, and for branch circuits dedicated to supplying refrigeration equipment.
- Utah (2015 IRC) – AFCI requirements were deleted.
- Vermont (2017 NEC) – AFCI requirements for branch circuit extensions or modifications were deleted where the extension of the existing conductors is used solely to hardwire single station smoke and or CO alarms in an existing dwelling or dormitory unit.
- Virginia (2014 NEC) – AFCI's only required in bedrooms.
- Wisconsin (2017 NEC) – AFCI requirements do not apply to kitchens.
- Mobile, AL (2014 NEC) – AFCI's requirements were deleted for family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets and hallways
- Kansas City and Springfield, MO (2011 NEC) – AFCI's only required in bedrooms.

*Adoption of 2018 IRC was approved by Building Codes Council and is pending legislative review.

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