



National Fire Protection Association

1 Batterymarch Park, Quincy, MA 02169-7471
Phone: 617-770-3000 • Fax: 617-770-0700 • www.nfpa.org

***Leona Attenasio Nisbet, Director
Codes and Standards Administration***

June 27, 2007

John Tobias
US Department of the Army
CELCMC, Attn: Amsel-SF-SI
2539 Laboratory Road
Forth Monmouth, NJ 07703-5000

Dear Mr. Tobias:

Enclosed is a copy of a letter from L. Josphe, representing the Heary Bros. Lightning Protection Co., requesting the Return of a portion of the Report in the form of an identifiable part(s) of a proposal and related comment(s) 780-38 (CAM)

The Council will consider this Appeal on **Tuesday, July 24, 2007 at 4:00 PM** at the **Treasure Island Hotel, 3300 Las Vegas Blvd., South, Las Vegas, NV 89109, (702) 894-7111.**

This is being considered an Appeal under 1-6 of the Regulations Governing Committee Projects. A copy of this appeal can be found on the NFPA Website: www.nfpa.org or by contacting Codes and Standards Administration.

Note: The website should be checked for the most up-to-date scheduling of appeals at the link posted below.

Under the Regulations Governing Committee Projects, interested parties are invited to appear before the Council or submit written information for the Council's consideration. If you or any member of the Committee have any comments that they would like to have before the Council when it considers this issue, please submit them by **July 9, 2007** (if via e-mail, please use mmaynard@nfpa.org). Please let me know at your early convenience if you can be in attendance to address the Council on this issue. In addition, if any member of the Committee wishes to be in attendance to address the Council on this issue, please let me know.

Thank you for your assistance.

Very truly yours,

Leona Attenasio Nisbet, Recording Secretary
NFPA Standards Council

c: P. DiNenno, M. Brodoff, C. Dubay, M. Puchovsky, C. Grant, M Earley, J. O'Connor, R. Roux
TC Lightning Protection

07-7-9-2

<http://www.nfpa.org/categoryList.asp?categoryID=834>



SCHRÖDER, JOSEPH & ASSOCIATES, LLP
A BOUTIQUE LITIGATION BASED PRACTICE

Linda H. Joseph, Esq.
(716) 881-4902
ljoseph@sjalegal.com

June 25, 2007

VIA FEDERAL EXPRESS

Standards Council
National Fire Protection Association
One1 Batterymarch Park
Quincy, Massachusetts

Re: Appeal of Action Taken At the June 6, 2007 Membership Meeting: NFPA 780

Dear Standards Council Members:

We are writing on behalf of Heary Bros. Lightning Protection Co. Inc. ("Heary Brothers") and William E. Heary, whose motion, to return Annex B to NFPA 780 to Committee, was rejected by the NFPA membership at the Technical Committee Report Session held on June 6, 2007. This letter shall constitute an appeal to the Standards Council of the action taken by the membership on Annex B. As discussed below, the inclusion of Annex B in NFPA 780 is misleading to the public and results in the NFPA actively and knowingly falsely claiming that NFPA 780 is based on scientifically proven theories on how lightning reacts with air terminals.

Proponents of NFPA 780 have now acknowledged, what Heary Brothers has been saying for years, namely, that NFPA 780 lacks a technical justification based on the physics of lightning and that the only justification for the standard is that systems which comply with NFPA 780 seem to work in practice.¹ The arguments presented by proponents of Annex B amount to nothing more than an outrageous claim that the NFPA is obligated to include a false and misleading claim that NFPA 780 is based on the "science of lightning" so long as there is a "consensus" among the members of the Technical Committee to mislead the public regarding the technical justification for the standard.

A. It Is Now Undisputed That NFPA Lacks A Scientific And Technical Justification for NFPA 780 and That The Only Justification for NFPA 780 Is Historical Performance

For more than a decade, questions have been raised regarding the scientific and technical justification for NFPA 780. In 1995 the National Institute of Science and

¹ Notably, as Heary Bros. has previously shown in prior submissions to the NFPA, ESE terminals likewise have been shown to work in practice during more than twenty years of successful performance. Thus, not only is Annex B falsely claiming a scientific basis for NFPA 780 traditional (Faraday) systems, but also its adoption would and does constitute yet another new example of disparate treatment of ESE lightning protections systems, given the NFPA's previously stated reasons for rejecting a standard for ESE systems.

766 Ellicott Street ☩ Buffalo, NY 14203 ☩ Tel: (716) 881-4900 ☩ Fax: (716) 881-4909

www.sjalegal.com

Linda H. Joseph, Esq.
(716) 881-4902
ljoseph@sjalegal.com

Technology concluded that more research was needed to develop statistically meaningful models on how lightning reacts with air terminals. In 1999, a panel chaired by Dr. John Bryan concluded that there was insufficient technical justification for NFPA 780 and recommended to the NFPA that the standard be downgraded to a recommended practice.

In 2000, the NFPA requested independent review to provide substantiation for the installation standard for NFPA 780. The primary justification submitted in support of retaining NFPA 780 as a standard was a report prepared by a committee of the American Geophysical Union (“AGU Report”) chaired by Dr. Rakov of the University of Florida authored by Dr. Rison of the New Mexico Institute for Technology and endorsed by Dr. Martin Uman. The AGU Report summarized various models and theories which, according to proponents of NFPA 780, provided the technical justification for retaining NFPA 780 as a standard. Based on the AGU Report, the NFPA concluded that there was sufficient technical justification to continue NFPA 780 as a standard.

However, despite the central role played by Dr. Rakov in the preparation of the AGU report—ONLY two years later—Dr. Rakov, and Dr. Martin Uman acknowledged in an article which appeared in December 2002 Edition of the *American Meteorological Society* that “[t]he theoretical justification of the conventional [Faraday] approach is fairly crude, in part due to our incomplete understanding of lightning’s attachment to ground-based objects.” Dr. Rakov and Dr. Uman went on to state that lightning protection systems installed in compliance with NFPA 780 and other international standards **“have a history of success in preventing or minimizing damage to structures [and that this historical performance, rather than the various theories and models cited in the AGU Report and Annex B] is the primary justification for their use.”** Dr. Rakov and Dr. Uman reiterated this conclusion in a recent book, stating that “the process of lightning attachment to the ground or to a grounded object is one of the least understood and poorly documented processes of the cloud to ground lightning discharge.” Dr. Rison, who is member of the NFPA 780 Technical Committee and the primary author of the AGU Report, citing to the works of Dr. Rakov and Dr. Uman, stated in voting to reject Annex B that the models and theories contained in Annex B, “is an **oversimplified explanation of a process which is not well understood.**” Thus, Dr. Rakov and Dr. Uman have both effectively admitted in these publications that the AGU Report did not and could not provide scientific justification for NFPA 780.

THERE CAN NOW BE NO QUESTION THAT THE SCIENTIFIC CONSENSUS IS THAT THERE IS A LACK OF UNDERSTANDING AS TO HOW LIGHTNING PROTECTION SYSTEMS WHICH COMPLY WITH NFPA 780 WORK. INSTEAD, THE ONLY JUSTIFICATION FOR THIS STANDARD IS THE HISTORICAL PERFORMANCE OF THESE SYSTEMS IN THE FIELD.

Linda H. Joseph, Esq.
(716) 881-4902
ljoseph@sialegal.com

ANY OTHER CLAIMS REGARDING THE TECHNICAL JUSTIFICATION FOR THIS STANDARD ARE FALSE AND MISLEADING. ²

B. Proponents of NFPA 780 Have Now Demonstrated A Willingness To Mislead Both the Public and The NFPA Membership

Heary Brothers believes that Dr. Rakov, Dr. Uman and Dr. Rison misled the NFPA in 2000 when they failed to disclose their conclusions that the primary justification for NFPA 780 was historical performance and not the models and theories presented in the AGU Report. The decision by the Technical Committee to include in proposed Annex B to the NFPA 780 a discussion of these very same theories and models discussed in AGU Report leaves no doubt that the so called "consensus" by the Technical Committee is nothing less than a knowing and intentional decision to continue to mislead the public regarding the primary justification for this standard.

This willingness of the Technical Committee members to mislead the public extends to a willingness to also mislead the NFPA general membership who voted on June 6, 2007. For example, Dr. Rakov, in his comment submitted on the Report on Proposals, stated that he supported the inclusion of Annex B in the standard but that the Annex simply required "some editing." Significantly, Dr. Rakov did NOT disclose to the membership the truth as both he and Dr. Uman had admitted it to be in the December 2002 Edition of the *American Meteorological Society* -- that the primary justification for the standard was not the models and theories discussed in Annex B, but simply that systems installed in compliance with NFPA 780 seem to work in practice. Apparently, Dr. Rakov believes it is acceptable for the NFPA to claim to the public that the technical justification for a standard is scientifically accepted models and theories, even though he himself has concluded that the models and theories are "crude" and do not provide the primary technical justification for the standard.

Likewise, other proponents of NFPA 780 affirmatively misled the membership at the June 6, 2007 Technical Report Session. Mark Morgan of East Coast Lightning Equipment voted against the inclusion of Annex B in the standard prior to the meeting. Specifically, prior to the June 6, 2007 meeting, Mr. Morgan gave the following written reasons for his negative vote which appears at page 780-19 of the Report on Comments:

² Again, as noted in Footnote 1 above, ESE systems are no different from NFPA 780 systems in that both are justified by their performance in the field. Thus, the only difference is that interested parties who are members of the Technical Committee for NFPA 780 have been successful in obtaining "consensus" for NFPA 780 while at the same time thwarting the consensus building process with respect to ESE systems. If this were not enough, these Technical Committee members now point to "consensus" as a justification for misleading the public by means of publishing a false Annex B which is intended to be used in the marketplace to persuade the public that there is a scientific basis for NFPA 780 when the very experts who prepared the AGU Report now have admitted that this is not true.

Linda H. Joseph, Esq.
(716) 881-4902
ljoseph@sjalegal.com

The lengthy narrative on lightning protection modeling theory is not needed in an installation standard. The proposed material is beyond the scope of the document. Certainly, the proposed discussion of models that have nothing to do with the design practices employed in NFPA 780 have no place in the standard and it is puzzling why they were presented for publication at all. M. Carie's explanation of Negative vote appears to suggest that a Task Force devoting significant time to a topic somehow obligates the Committee to endorse the Task Force's proposals. The Tasks Force is to be commended for working hard; however, the proposal's rejection should stand. J. J. Tobais' explanation of negative vote contains a lengthy new proposed addition to Annex B. It remains unclear what value if any this text adds to the standard. Some of the proposed text is editorializing and speculative in tone and does not seem appropriate for a standard of installation. The value of proposed B.3.2.3 is particularly questionable. The newly proposed text in its entirety has not been adequately scrutinized for inclusion in the standard.

Incredibly, Mr. Morgan stood before the NFPA general membership at the June 6, 2007 Technical Report Session and claimed that Mr. Heary in his motion to return Annex B "mischaracterized" his vote to reject including Annex B in NFPA 780. Mr. Morgan then represented to the NFPA general membership—in direct contradiction to his written statement—that he "fully supported Annex B" and that the only reason for his negative vote in the Report on Comments was that he believed the document "simply required additional editing." A copy of the Transcript of the June 6, 2007 Technical Reports Session, NFPA 780 is attached to this letter as Exhibit 1.

As the above-quoted written statement submitted by Mr. Morgan in support of his negative vote demonstrates, there can be no doubt that Mark Morgan was fully aware that the models and theories contained in Annex B do not and cannot provide the technical justification for NFPA 780 and that Annex B included—to use Mr. Morgan's own words—a "discussion of models that have nothing to do with the design practices employed in NFPA 780..." As the NFPA is aware, this is not the first time that East Coast has made misleading statements to the NFPA membership regarding a proposed standard. Apparently, it was only after Mr. Heary submitted his motion in writing to the NFPA that East Coast realized that—if Annex B is not adopted—East Coast could no longer make the claims made in its current literature to consumers that lightning protection systems which comply with NFPA 780 are somehow superior to other systems which—like NFPA 780 systems—also have a history of successful performance in the field. Realizing this, Mr. Morgan had no compunction about making a 180-degree turn in position so that he would be able to issue advertising claims that he knows full well would be misleading to the public at the NFPA's expense since the NFPA would now be participating in making such false and misleading advertising possible.

Linda H. Joseph, Esq.
(716) 881-4902
ljoseph@sjalegal.com

C. The Proponents of NFPA 780 Seek To Make The NFPA Knowingly Participate In False and Misleading Advertising to the Public Under the Guise of Consensus

During the debate at the June 6, 2007 Technical Report Session, the only justification offered in support of the inclusion of Annex B is that for 27 years proponents have claimed that NFPA 780, as well as certain other international standards, are based on the models and theories discussed in Annex B. See Exhibit 1, Transcript of June 6, 2007 Technical Reports Session, NFPA 780. Not a single speaker disputed the evidence submitted by Mr. Heary that the models and theories included in Annex B do not provide the technical justification for NFPA 780 or other international standards. In short, the only argument advanced by proponents of Annex B is that they should be permitted to continue misrepresenting to the public the technical justification for the standard because the NFPA had permitted them to do so in the past. Of course it is now clear that the NFPA can no longer rely on these models and theories given the published admissions of the authors of the AGU Report.

Moreover, even assuming that there ever was a scientific consensus that these models and theories provided a technical justification for NFPA 780 (a generous proposition for which there is no evidentiary support), it cannot be disputed that the most “up-to-date” scientific consensus is that there is simply a lack of understanding of how lightning interacts with air terminals and that these models and theories are “crude” and do not provide technical justification for NFPA 780. In response to this scientific consensus the Technical Committee not only did not seek to correct its prior false claims that NFPA 780 was based on scientifically accepted models and theories, but went one step further and now seeks to affirmatively represent to the public that NFPA 780 has a technical justification which the Committee knows to be false.

Until now the NFPA could hide behind the prior misrepresentations contained in the AGU Report. However, now that the authors of the previously-relied upon reports have acknowledged that the models and theories discussed in the AGU Report and now included in proposed Annex B do not provide the primary technical justification for the standard—and that the justification for NFPA 780 simply is the experience with the system in the field—the NFPA can no longer hide behind these misrepresentations. If the Standards Council does not take action by rejecting the inclusion of Annex B in NFPA 780, the NFPA will become a willing and knowing participant in providing false and misleading information to the public under the guise of “consensus.”


In closing, the Standards Council has one avenue it can reasonably adopt in response to these latest activities of the NFPA 780 Committee. Either the NFPA issues standards which honestly and fairly represent to the public as to the scientific and

Linda H. Joseph, Esq.
(716) 881-4902
ljoseph@sjalegal.com

technical justification for those standards or its standards are nothing more than promotional tools for industry which contain false and misleading information. We are confident of that the Standards Council will choose the high road.

Respectfully submitted,

SCHRODER, JOSEPH & ASSOCIATES, L.L.P.



Linda H. Joseph

Attorneys for William E. Heary and Heary Bros. Lightning
Protection Co., Inc.

Linda H. Joseph, Esq.
(716) 881-4902
ljoseph@sialegal.com

EXHIBIT 1

1 That concludes motions on NFPA 25.

2 Thank you, Mr. Lender.

3 MR. LENDER: Thank you, Mr. Chair.

4 NFPA 780 MR. PAULEY: The next report this

5 morning is that of the Committee on Lightning

6 Protection. Here is John Tobias of the U.S.

7 Department of the Army, Fort Monmouth, New Jersey.

8 This can be found in the blue 2007

9 annual ROP and ROC. The list of certified amending
10 motions is contained in the Motions Committee report.

11 We will proceed with the motions in that order.

12 Doctor Tobias.

13 DOCTOR TOBIAS: Thank you. Mr. Chair,

14 ladies and gentlemen, the report of the Technical

15 Committee on Lightning Protection can be found on

16 Pages 780-1 through 780-39 of the report on proposals

17 and on Pages 780-1 through 780-19 of the report on

18 comments for the 2007 annual revision cycle.

19 The committee proposed a partial

20 revision to NFPA 780, standard for the installation

21 of lightning protection systems. The committee

22 ballot results on each proposal and comment can be

23 found in the reports.

97

1 I would like to thank the committee for
2 the work that its done this cycle, and we are looking
3 forward to a productive year or a productive cycle
4 next time. Without any further comment, I will
5 return the podium to the presiding officer to proceed
6 with the certified amending motions on NFPA 780.

7 MR. PAULEY: Thank you. We have one
8 certified amending motion on 780. Microphone No. 6.

9 THE FLOOR: I think I will defer to
10 No. 5 for the author, I believe, of the NITMAM.

11 MR. PAULEY: Microphone No. 5, please.

12 MR. HEARY: William Heary, Heary
13 Brothers Lightning Protection. I move to return to
14 committee the proposed annex B of NFPA 780.

15 MR. PAULEY: The motion as we have it
16 stated would be to return a portion of the report in
17 a form of identifiable parts of the proposal and
18 related comments 780-38 and that identified part is
19 the entire annex B, is that correct?

20 MR. HEARY: Yes.

21 MR. PAULEY: That is the motion. Is
22 there a second? I see a second, please proceed.

23 MR. HEARY: Annex B to NFPA 780

98

1 purports to summarize the technical and scientific
2 basis for the placement of air terminals recommended
3 under NFPA 780. Annex B must be returned to
4 committee because its inclusion in NFPA 780 is
5 misleading to the public and falsely claims that NFPA
6 780 is based on scientifically proven theories on how
7 lightning reacts with air terminals.

8 Performance of NFPA (inaudible) have
9 now acknowledged what we at Heary Brothers have been
10 saying for years, that NFPA 780 lacks a technical
11 justification based on the physics of lightning and
12 the only justification for the standard is that
13 systems which comply with NFPA 780 seem to work in
14 practice.

15 For more than a decade there have been
16 questions raised regarding the scientific and
17 technical justification for NFPA 780. In 1995 the
18 National Institute of Science and Technology
19 concluded that more research was needed to develop
20 statistically meaningful models. In 1999 a panel
21 chaired by Doctor John Brian concluded that there was
22 insufficient technical justification for NFPA 780 and
23 recommended the standard be downgraded to a

1 recommended practice.

2 In 2000 the NFPA requested independent
3 review to provide substantiation for the installation
4 standard for NFPA 780. The primary -- in support of
5 the standard was a report prepared by committee of
6 American Geophysical Union chaired by Doctor Rakov of
7 the University of Florida and authored by Doctor
8 Rison of New Mexico Institute for Technology and
9 endorsed by Doctor Ulman.

10 The AGU report summarized various
11 models and theories which according to proponents of
12 NFPA provided that technical justification for
13 returning NFPA 780 as a standard. Based on ATU the
14 NFPA concluded that there was sufficient technical
15 justification to continue NFPA 780 as a standard.

16 Despite the central role played by
17 Doctor Rakov in the preparation of the AGU report,
18 two years later Doctor Rakov and Doctor Martin Ulman
19 acknowledged in an article which appeared in the
20 December 2002 edition of the American Meteorological
21 Society that the theoretical justification of the
22 conventional, that is, parity approach is fairly
23 crude in part due to our incomplete understanding of

100

1 lightning attachment to ground-based objects.

2 Because of this lack of understanding
3 of how lightning interacts with ground-based objects,
4 the conclusion of these scientists was that the prime
5 justification for NFPA 780 was that the configuration
6 of the air terminals have a history of success in
7 preventing or minimizing damage to structures in this
8 primary justification for their use.

9 Doctor Rakov and Doctor Ulman
10 reiterated this conclusion in a recent book stating
11 that the process of lightning attachment to the
12 ground or to a grounded object is one of the least
13 understood and poorly documented processes of the
14 cloud-to-ground lightning discharge.

15 Doctor Rison who is a member of the
16 NFPA 780 Technical Committee and contributor to the
17 AGU report stated in voting to reject annex B that
18 the models and theories contained in annex B is an
19 oversimplified explanation of a process not well
20 understood.

21 Other members of the committee who
22 voted against inclusion of annex B voted the models
23 discussed have little to do with design --

1 MR. PAULEY: You have about 20 seconds
2 remaining.

3 MR. HEARY: -- installation practices
4 of NFPA 780.

5 There can now be no question that the
6 scientific consensus is that there is a lack of
7 understanding as to how lightning protection systems
8 would comply with NFPA 780 work. Instead the only
9 basis for NFPA 780 is a historical performance of
10 these systems in the field.

11 MR. PAULEY: Your time has concluded.
12 Thank you. Doctor Tobias.

13 DOCTOR TOBIAS: Thank you,
14 Mr. Chairman. My rebuttal point to that is to point
15 out that the person making the NITMAM in the
16 organization represented has a seat and an alternate
17 on the committee, neither of whom returned ballots on
18 the balloting for the standard, and this motion for
19 the inclusion of the extra material into annex B
20 passed with over two-thirds at committee vote.

21 To rebut this technically, the basis
22 for which the presenter cites, and that is primarily
23 Doctor Husan's contention that this is an over-

102

1 simplification, I might add is that because the
2 explanatory material provided in the annex B is
3 exactly that. It provides the rationale using the
4 best available knowledge from the research community
5 for lightning protection as to how the model that has
6 been in our standard for 27 years now and has been
7 used in a European environment much longer than that
8 has been in the standard.

9 We commissioned this project in the
10 committee in response to inquiries from the field
11 that wanted more explanatory material in the annex
12 and realized that what the item in contention is in
13 fact annex material, explanatory material, and not a
14 code requirement.

15 We feel -- the committee feels again by
16 better than two-thirds of the vote, and I might add
17 also that the other person commenting on this, Doctor
18 Rakov, did not comment against the technical material
19 of annex B. He just said it could be more concise in
20 his voting, in his voting ballot.

21 So all that said, I think that the work
22 of the committee is sound. The work of the committee
23 passed by better than a two-thirds vote in balloting,

103

1 and it provides a useful edition to the next edition
2 of NFPA 780.

3 MR. PAULEY: Thank you. Microphone
4 No. 5, please.

5 MR. SANDERS: I'm Melvin Sanders. I
6 am an alternate on NFPA 780. I represent the
7 Institute of Electrical and Electronic Engineers, and
8 I speak in favor of the NITMAM.

9 There are some issues that I felt were
10 of concern, and they are found in the ROC at Page 18,
11 780-39. Basically part of it is a discussion of the
12 models again has little to do with design and
13 installation practices. The text proposed is
14 speculative and does not draw clear-cut conclusions
15 because of some lack of consensus within the
16 scientific community.

17 Again, the lightning attachment process
18 is one of the least understood aspects and, of
19 course, is undergoing continual study. There is some
20 disagreement on whether air terminals attract more
21 lightning or merely gather what is already there.
22 Again, that is lack of agreement on the current,
23 whether the air moves one way or the other.

104

1 With these conditions I felt there was
2 a need for more discussion time. This will allow the
3 materials to revert to the present text, and we can
4 have a little more full discussion on another
5 go-around. I believe it merits some inclusion, some
6 consideration; but I think this is premature.

7 I ask the chair's indulgence one more
8 time for permission to ask the members to see me in
9 the far corner. I would appreciate it.

10 MR. PAULEY: Thank you. Microphone
11 No. 2, please.

12 MR. MORGAN: Mark Morgan from East
13 Coast lighting Equipment. I'm opposed to the motion.
14 I am a member of committee.

15 I am one of the negative voters that
16 the motion submitter referenced. My negative vote
17 had nothing to do -- it was a little bit
18 mischaracterized by the submitter. It had nothing to
19 do with the technical validity of the modal we were
20 discussing. It was simply editorial in nature, and I
21 support the consensus the committee reached.

22 I think it was a good consensus and any
23 editorial changes I believe that may be necessary

105

1 going down the road can definitely be accomplished in
2 the next revision cycle. I am opposed to the motion
3 on the floor.

4 MR. PAULEY: Thank you. Microphone
5 No. 6, please.

6 MR. GUTHRIE: My name is Mitchell
7 Guthrie and I'm an independent consulting engineer
8 and I'm also a member of the committee as well as
9 technical advisor to the IAC TCA 1 committee on
10 lightning protection.

11 I speak in opposition to the NITMAM. I
12 think the changes we made to the annex were good and
13 they improved the annex. It's important to realize
14 that this annex is discussing the fundamentals of
15 lightning protection and is written to an audience --
16 it's not intended to be a textbook. If we included
17 too many of the scientific principles, then the point
18 we were trying to make would be lost.

19 These models we are using in this
20 standard are models that are accepted by the
21 international community and they are used by
22 scientists all over the world.

23 MR. PAULEY: Thank you. Microphone

1 No. 3, please.

2 MR. BLACK: Mr. Chair. Art Black,
3 Carmel Fire Protection, Carmel, California. I call
4 the question.

5 THE FLOOR: Second.

6 MR. PAULEY: A motion has been made to
7 move the previous question to end debate. I did hear
8 a second on that. All those in favor of the motion
9 to end debate, please raise your hand. Those
10 opposed. The motion passes.

11 We will proceed directly to the motion
12 that is on the floor. That motion is to return a
13 portion of the report in the form of identifiable
14 parts of a proposal and related comments. That
15 portion identifies the entire annex B. All those in
16 favor of that motion, please raise your hand. Thank
17 you. Those opposed. The motion fails. Thank you,
18 Doctor Tobias.

19 DOCTOR TOBIAS: Thank you, and I thank
20 the membership and the committee.

21 NFPA 58 MR. PAULEY: The next report this
22 morning is that of the Committee on Liquefied
23 Petroleum Gases. Here to present the committee

780-37 Log #12 Final Action: Accept
(A.8.5.2.1)

Submitter: Mitchell Guthrie, Blanch, NC

Comment on Proposal No: 780-97

Recommendation: Revise A.8.5.2.1 as follows:

A.8.5.2.1 In order to allow for main conductors to be routed externally to vulnerable areas; (as described in Section 8.4.1.6); but also to and reduce the risk of external side flashes from the lightning conductors, grounding electrodes should be located as close to the waterline as is practicable. Where an onboard fitting is below the waterline and close to the water, an additional supplemental grounding electrode is advisable in the vicinity of the fitting.

Substantiation: Editorial and clarification of intent.

Committee Meeting Action: Accept

Number Eligible to Vote: 30

Ballot Results: Affirmative: 25 Abstain: 1

Ballot Not Returned: 4 Dyl, D., Heary, W., Rapp, R., Reehl, D.

Explanation of Abstention:

KAISER, B.: See My Explanation of Abstention on 780-1 (Log #5).

780-38 Log #3 Final Action: Accept in Principle
(Annex B)

Submitter: Franco D'Alessandro, ERICO products Australia Pty Ltd

Comment on Proposal No: 780-110

Recommendation: Reconsider ROP 780-110.

Substantiation: The extended Annex B was rejected on the basis that the material was "outside the Scope of the NFPA document", that it "did not support the material in the main body of the standard" and the "volume of annex material was too large". However, there is a lot of annex material in the standard presently, some old and some new and approved at the ROP meeting, which also fits these criteria.

It is requested that this annex is revisited in an appropriate manner at the ROC meeting. If, as appears to be the case, the committee feels the above criteria are valid, then the following should take place:

1. The whole standard should be reviewed for any material that is not in the Scope or does not support the main body of the document. Any sections identified using these criteria should be deleted. [Reason: For consistency with the NFPA policy outlined in the February '06 ROP meeting and summarized above].

2. The information exchange and decision-making process between the main committee and task forces needs to be reviewed and improved. [Reason: During the revision cycle, the Modelling Task Force spent a considerable amount of time and energy discussing the extension of Annex B. This work was undertaken after general consensus was reached within the main committee that there was a need for additional explanatory material in this annex. However, in the February '06 ROP meeting, all of the additional explanatory material was rejected, literally in a matter of minutes, without consideration of how this material improved the standard. Clearly, this was a communication issue or some other problem].

Committee Meeting Action: Accept in Principle

Committee Statement: See Committee Action and Statement on 780-39 (Log #32).

Number Eligible to Vote: 30

Ballot Results: Affirmative: 22 Negative: 3 Abstain: 1

Ballot Not Returned: 4 Dyl, D., Heary, W., Rapp, R., Reehl, D.

Explanation of Negative:

MELTON, JR., R.: The following comment applies to each of the above since each refers directly to the original proposal, 780-110.

While the extended Annex B may(?) be "outside the scope of the NFPA document", I believe it is very important for those "users" of 780 to be able to read a technical summary of the rationale used in the preparation of the 780 standard. This would apply to both designers and installers of lightning protection systems. This serves to add both substantiation and credibility to the guidelines in 780 as opposed to stating "do it this way". Stating that there are various references that are already available as an alternative would not be a satisfactory response. I believe it is valuable to contain this information in Annex B, as proposed.

I, therefore, support the inclusion of the Annex B material as proposed in 780-110 by the Modeling Task Force and disagree with the committee's recommendation. This would also include any editorial, formatting and grammatical changes as necessary to make the document fit NFPA structure.

MORGAN, M.: I concur with Mr. W. Rison in his submission to the ROC. I don't believe that this section helps in the design of a lightning protection system or is necessary in an installation standard.

RISON, W.: Comment 780-38 should be rejected. See my Explanation of Negative Vote on Comment 780-39.

Explanation of Abstention:

KAISER, B.: See My Explanation of Abstention on 780-1 (Log #5).

780-39 Log #32 Final Action: Accept in Principle
(Annex B)

Submitter: John M. Tobias, US Army CELCMC

Comment on Proposal No: 780-110

Recommendation: Revise text to read as follows:

Annex B: Principles of Lightning Protection

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Fundamental Principles of Lightning Protection.

B.1.1 The fundamental principle in the protection of life and property against lightning is to provide a means by which a lightning discharge can enter or leave the earth without resulting damage or loss. A low impedance path that the discharge current will follow in preference to all alternative high impedance paths offered by building materials such as wood, brick, tile, stone, or concrete should be offered. When lightning follows the higher impedance paths, damage may be caused by the heat and mechanical forces generated during the passage of the discharge. Most metals, being good electrical conductors, are virtually unaffected by either the heat or the mechanical forces if they are of sufficient size to carry the current that can be expected. The metallic path must be continuous from the ground terminal to the strike termination device. Care should be exercised in the selection of metal conductors to ensure the integrity of the lightning conductor for an extended period. A nonferrous metal such as copper or aluminum will provide, in most atmospheres, a lasting conductor free of the effects of rust or corrosion.

B.1.2 Parts of structures most likely to be struck by lightning are those that project above surrounding parts such as chimneys, ventilators, flagpoles, towers, water tanks, spires, steeples, deck railings, shafthouses, gables, skylights, dormers, ridges, and parapets. The edges and corners of the roof are the parts most likely to be struck on flat or gently sloping roofed buildings.

B.2 Lightning Protection Systems.

B.2.1 Lightning protection systems consist of the following three basic parts that provide the low impedance metal path required:

(1) A system of strike termination devices on the roof and other elevated locations.

(2) A system of ground terminals.

(3) A conductor system connecting the strike termination devices to the ground terminals. Properly located and installed, these basic components improve the likelihood that the lightning discharge will be conducted harmlessly between the strike termination devices and the ground terminals.

B.2.2 While intercepting, conducting, and dissipating the main discharge, the three basic protection system components do not ensure safety from possible secondary effects of a lightning strike. Therefore, secondary conductors are provided to interconnect metal bodies to ensure that such metal bodies are maintained at the same electrical potential so as to prevent sideflashes or sparkover. Surge suppression devices are also provided to protect power lines and associated equipment from both direct discharges and induced currents.

B.2.3 The structure should be examined, and installation of air terminals should be planned for all areas or parts likely to receive a lightning discharge. The object is to intercept the discharge immediately above the parts liable to be struck and to provide a direct path to earth, rather than to attempt to divert the discharge in a direction it would not be likely to take. The air terminals should be placed high enough above the structure to obviate danger of fire from the arc.

ADD

B.3 Positioning of Air Terminals. Positioning of air terminals depends upon the physical lightning model used to describe the behavior of lightning. The development of these models has been ongoing for two hundred and fifty years and models have a basis in physical observations of lightning. While the models tend to be simplified compared to actual details of lightning development and propagation, empirical observations over hundreds of years have proven their effectiveness.

Air terminals are intended to intercept the lightning event by providing a preferred attachment point for lightning's electrical discharge. They operate by actually providing an upward propagating leader of ionized air to intercept a downward lightning leader. Since these leaders are ionized air of opposite charge, they attract and provide the electrical channel to earth for lightning when they connect. Air terminals placed upon a structure do not substantially increase the probability of the structure being struck by lightning. If the downward progressing lightning leader is close to the structure, it will probably attach to that structure anyway. Thus, air terminals are designed to provide a preferential attachment point on structures that already provide a likely lightning attachment point. Once lightning connects to the air terminal, it is easier to control the lightning current and direct it to earth as opposed to it taking a random, uncontrolled (and usually damaging) path through the structure otherwise.

This section is intended to educate the user of NFPA 780 by providing some background in the mechanics of the lightning models and their reduction into design rules for the placement of air terminals. To begin the discussion, we can start with the physics of lightning attachment.

B.3.1 Physics of Lightning Attachment. The first stroke of a ground flash is normally preceded by a downward-progressing, low-current leader discharge that commences in the negatively charged region of the cloud and progresses towards the earth, depositing negative charges in the air surrounding the leader

A.4.15.4.1 It is preferable that grounding electrodes be located no closer than 0.6 m (2 ft) from foundation walls to minimize the probability of damage to the foundation. Although this is not always practicable for all applications, it is preferable. For reference, IEC 62305, Part 3 requires that ring earth electrodes be buried at a depth of at least 0.5 m (18 in.) and a distance of approximately 1 m (3 ft) around external walls.

Add the following to N.2.1 IEC Publications
IEC 62305, Protection against lightning - Part 3: Physical damage to structures and life hazard, 2006.

Committee Statement: The Committee accepts the submitter's recommendation with the following revisions:

- Add * after 4.15.4.1 to reflect Annex text.
- Add 0.6 m to comply with Manual of Style requirements.
- The change satisfies the submitter's intent.

Number Eligible to Vote: 30
Ballot Results: Affirmative: 26
Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-104a Log #CP8 Final Action: Accept
(A.4.18.2.5)

Submitter: Technical Committee on Lightning Protection
Recommendation: Replace the 4th sentence in the first paragraph of A.4.18.2.5 as shown below:

Most services to facilities will require discrete surge suppression devices installed to protect against damaging surges. Occasionally, services will be located in an area or manner where the threat from lightning-induced surges and overvoltage transients may be negligible. For example, the requirements in 4.18.2.3 (also see A.4.18.6.1) exempt services less than 30 m (100 ft) in length that are run in grounded metal conduit between buildings requiring surge protection. These are examples of acceptable exceptions where SPDs may not be required on each service entrance. Other examples where surge protective devices may not be required to be installed at each service entrance are those applications where fiber optic transmission lines (with no conducting members) are used. The standard recognizes that there can be acceptable exceptions and consequently allows for such exceptions to the requirements for surge suppression on electrical utility, data, and other signal lines, provided a competent engineering authority has determined that the threat is negligible or that the system is protected in a manner equivalent to surge suppression.

Substantiation: This proposal is provided by the Task Group on Surge Protection in completion of Task Item 29. It identifies that the use of fiber optics transmission lines is an example where surge protection may be implemented without the installation of surge protective devices.

Committee Meeting Action: Accept
Number Eligible to Vote: 30
Ballot Results: Affirmative: 26
Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-105 Log #117 Final Action: Accept in Principle
(A.4.18.4)

Submitter: Mitchell A Guthrie, Independent Engineering Consultant
Recommendation: Add a new paragraph as follows after the existing text:
"Devices rated in accordance with UL 1449, Edition 3 will reflect a Voltage Protection Level (VPL) in place of the SVR. This is to reflect that the voltage rating test in the 3rd Edition will utilize a 3 kA peak current vice the 500 A current level used in the SVR test of UL 1449, Edition 2."
Substantiation: The proposed text will identify that SPDs rated in accordance with UL 1449, Edition 3 will utilize a VPL in place of the SVR.

Committee Meeting Action: Accept in Principle
Add a new paragraph as follows after the existing text:
Devices rated in accordance with UL 1449, Edition 3 will reflect a Voltage Protection Level (VPL) in place of the SVR. This is to reflect that the voltage rating test in the 3rd Edition will utilize a 3 kA peak current instead of the 500 A current level used in the SVR test of UL 1449, Edition 2.
Committee Statement: The Committee clarifies the text. The change satisfies the submitter's intent.

Number Eligible to Vote: 30
Ballot Results: Affirmative: 26
Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-106 Log #89 Final Action: Accept in Principle
(A.4.18.5(4))

Submitter: Mitchell A Guthrie, Independent Engineering Consultant
Recommendation: Revise A.4.18.5(4) as follows:
The Neutral-to-Ground (N-G) mode of protection places the an SPD between the grounded conductor (neutral) and the grounding conductor (ground) in a power system. This L-L-N and L-G modes protection are is not required at the service entrance (primary service panel board) if the, This is because a neutral-ground bond is implemented at this location or within some tens of meters from this point of installation. Thus, in general, an SPD with only L-L and L-N modes of protection are required at the service entrance.
Substantiation: Clarification of intent that the N-G mode of protection is not

required at the service entrance.

Committee Meeting Action: Accept in Principle

Revise A.4.18.5(4) to read as follows:

Neutral to ground (N-G) mode of protection places the an SPD between the grounded conductor (neutral) and the grounding conductor (ground) in a power system. This L-L-N and L-G mode of protection are is not required at the service entrance (primary service panel board) if the This is because a neutral-ground bond is implemented at this location or within some tens of meters from this point of installation. Thus, in general, an SPD with only L-L and L-N modes of protection may be required at the service entrance.

Committee Statement: The Committee clarifies the text. The change satisfies the submitter's intent.

Number Eligible to Vote: 30
Ballot Results: Affirmative: 26
Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-107 Log #112 Final Action: Accept
(A.4.18.6.3.1)

Submitter: Mitchell A Guthrie, Independent Engineering Consultant
Recommendation: Insert an asterisk after 4.18.6.3.1 and add new A.4.18.6.3.1 as follows:

A.4.18.6.3.1 The purpose of the SPD is to equalize L-L, L-N, L-G, and N-G potentials. While a good ground is important, a good bond is imperative to minimize damage due to lightning and/or power contact or induction.

Substantiation: The purpose of the proposed text is to stress the importance of a good bond in the installation of surge protective devices, regardless of the resistance to earth.

Committee Meeting Action: Accept
Number Eligible to Vote: 30
Ballot Results: Affirmative: 26
Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-108 Log #100 Final Action: Accept in Principle
(A.4.18.7.2)

Submitter: Mitchell A Guthrie, Independent Engineering Consultant
Recommendation: Revise text to read as follows:

A.4.18.7.2 Longer, or looped, SPD line and ground conductors increase the impedance of the SPD ground circuit. The ability of the SPD to discharge current to ground is affected by this impedance. Increasing the lead length serves to increase "let-through voltage" at the point where the SPD is wired into service equipment or a branch panelboard. Consequently, it is essential to minimize lead length impedance in this circuit.

Substantiation: Clarification of intent and stress that increased conductor length on both line and ground conductors increases "let-through" voltage.

Committee Meeting Action: Accept in Principle
Revise A.4.18.7.2 to read as follows:
A.4.18.7.2 Longer, or looped, SPD line and ground conductors increase the impedance of the SPD ground circuit. The ability of the SPD to discharge current to ground is affected by this impedance. Increasing the lead length serves to increase pass through voltage at the point where the SPD is wired into service equipment or a branch panelboard. Consequently, it is essential to minimize lead length impedance in this circuit.

Committee Statement: The Committee clarifies the text. The change satisfies the submitter's intent.
Number Eligible to Vote: 30
Ballot Results: Affirmative: 26
Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-109 Log #58 Final Action: Accept in Principle
(A.8.7.2)

Submitter: Dick Reehl, Quest Communications
Recommendation: Revise as follows:
"...of a thunderstorm, personnel occupants should head..."

Substantiation: Needs to apply to more than employees.
Committee Meeting Action: Accept in Principle

Revise A.8.7.2 to read as follows:
"...of a thunderstorm, personnel persons should head..."
Committee Statement: The Committee accepts the submitter's recommendation and changes the text for clarification. The change satisfies the submitter's intent.

Number Eligible to Vote: 30
Ballot Results: Affirmative: 26
Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-110 Log #107 Final Action: Reject
(Annex B)

Submitter: John M. Tobias, US Army CELCMC
Recommendation:
Proposed additions to Appendix B of NFPA 780
(additions are shown in within the region of the document annotated by *****)

Appendix B: Principles of Lightning Protection

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Fundamental Principles of Lightning Protection.

B.1.1 The fundamental principle in the protection of life and property against lightning is to provide a means by which a lightning discharge can enter or leave the earth without resulting damage or loss. A low impedance path that the discharge current will follow in preference to all alternative high impedance paths offered by building materials such as wood, brick, tile, stone, or concrete should be offered. When lightning follows the higher impedance paths, damage may be caused by the heat and mechanical forces generated during the passage of the discharge. Most metals, being good electrical conductors, are virtually unaffected by either the heat or the mechanical forces if they are of sufficient size to carry the current that can be expected. The metallic path must be continuous from the ground terminal to the strike termination device. Care should be exercised in the selection of metal conductors to ensure the integrity of the lightning conductor for an extended period. A nonferrous metal such as copper or aluminum will provide, in most atmospheres, a lasting conductor free of the effects of rust or corrosion.

B.1.2 Parts of structures most likely to be struck by lightning are those that project above surrounding parts such as chimneys, ventilators, flagpoles, towers, water tanks, spires, steeples, deck railings, shafthouses, gables, skylights, dormers, ridges, and parapets. The edges and corners of the roof are the parts most likely to be struck on flat or gently sloping roofed buildings.

B.2 Lightning Protection Systems.

B.2.1 Lightning protection systems consist of the following three basic parts that provide the low impedance metal path required:

- (1) A system of strike termination devices on the roof and other elevated locations.
- (2) A system of ground terminals.
- (3) A conductor system connecting the strike termination devices to the ground terminals.

Properly located and installed, these basic components improve the likelihood that the lightning discharge will be conducted harmlessly between the strike termination devices and the ground terminals.

B.2.2 While intercepting, conducting, and dissipating the main discharge, the three basic protection system components do not ensure safety from possible secondary effects of a lightning strike. Therefore, secondary conductors are provided to interconnect metal bodies to ensure that such metal bodies are maintained at the same electrical potential so as to prevent sideflashes or sparkover. Surge suppression devices are also provided to protect power lines and associated equipment from both direct discharges and induced currents.

B.2.3 The structure should be examined, and installation of air terminals should be planned for all areas or parts likely to receive a lightning discharge. The object is to intercept the discharge immediately above the parts liable to be struck and to provide a direct path to earth, rather than to attempt to divert the discharge in a direction it would not be likely to take. The air terminals should be placed high enough above the structure to obviate danger of fire from the arc.

*****ADD*****

B.3 Positioning of air terminals.

Positioning of air terminals depends upon the physical lightning model used to describe the behavior of lightning. The development of these models has been ongoing for two hundred and fifty years and models have a basis in physical observations of lightning. While the models tend to be simplified compared to actual details of lightning development and propagation, empirical observations over hundreds of years have proven their effectiveness.

Air terminals are intended to intercept the lightning event by providing a preferred attachment point for lightning's electrical discharge. They operate by actually providing an upward propagating leader of ionized air to intercept a downward lightning leader. Since these leaders are ionized of opposite charge, they attract and provide the electrical channel to earth for lightning when they connect. Air terminals placed upon a structure do not substantially increase the probability of the structure being struck by lightning. If the downward progressing lightning leader is close to the structure, it will probably attach to that structure anyway. Thus, air terminals are designed to provide a preferential attachment point on structures that already provide a likely lightning attachment point. Once lightning connects to the air terminal, it is easier to control the lightning current and direct it to earth as opposed to it taking a random, uncontrolled (and usually damaging) path through the structure otherwise.

This section is intended to educate the user of NFPA 780 by providing some background in the mechanics of the lightning models and their reduction into design rules for the placement of air terminals. Some of the methods presented here ARE NOT CURRENTLY PERMITTED by NFPA 780. Some of the air terminal placement methods are presented here to provide useful background information, or are in use internationally, or are in the preliminary stages of consideration for inclusion to NFPA 780. To begin the discussion, we can start with the physics of lightning attachment.

B.3.1 Physics of Lightning Attachment

The first stroke of a ground flash is normally preceded by a downward-progressing, low-current leader discharge that commences in the negatively

charged region of the cloud and progresses towards the earth, depositing negative charges in the air surrounding the leader discharge channel. (Occasionally, the downward leader can be positive in charge but this does not affect its behavior in terms of attachment.) When the lower end of the leader is 100 – 300 m from the earth or grounded objects, electrical discharges (streamers) are likely to be initiated from prominent points on grounded objects, and to propagate upwards towards the leader discharge channel. Several streamers may start, but usually only one is successful in reaching the downward leader.

The high current phase (return stroke) commences at the moment the upward moving streamer meets and connects with the downward leader. The position in space of the lower portion of the lightning discharge channel is therefore determined by the path of the successful streamer, i.e. the one that succeeded in reaching the downward leader. The primary task in protecting a structure is therefore to ensure a high probability that the successful streamer originates from the air terminals and not from a part of the structure that would be adversely affected by the lightning current that subsequently flows.

As the path of the successful streamer may have a large horizontal component as well as a vertical component, an elevated air terminal will provide protection for objects spread out below it. Within limits, it is therefore possible to provide protection for a large volume with a relatively small number of correctly positioned air terminals. This is the basis for the concept of a "zone of protection" and provides the basic principle underlying interception lightning protection.

Therefore, the function of an air terminal in an LPS is to divert to itself the lightning discharge that might otherwise strike a vulnerable part of the object to be protected. It is generally accepted that the range over which an air terminal can attract a lightning discharge is not constant, but increases with the severity of the discharge.

The path of a lightning discharge near a structure is determined by the path of the successful streamer (see Paragraph B.2.2) that will usually be initiated from a conducting part of the structure nearest to the downward leader. The initiation of streamers is also influenced by the local electric field. Conductive objects with a small radius of curvature will concentrate the electric field. Thus, air terminals, as well as the upper outer edges and corners of buildings or structures, and especially protruding parts, are likely to have higher local electric fields than elsewhere, and are therefore likely places for the initiation of upward streamers. When the downward leader is within about 200 m of the building, the electric field at these protruding parts and corners will exceed the breakdown field strength of air, resulting in corona currents that cause these parts to be surrounded by ionized air. At some point, this ionized air will begin to move in response to the elevated electric field provided by the downward leader. Upward streamers of ionized air will form and move toward the downward leader. Consequently, the most probable strike attachment point on a building is the edge, corner, or other protruding part in the vicinity of the downward leader. Hence, if air terminals are placed at all locations where high electric fields and streamer initiation are likely, there will be a high probability that the discharge will be intercepted successfully.

B.3.2 Overview of Methods

A "design method" is used to identify the most suitable locations placing for strike termination devices, based on the area of protection afforded by each one. These "placement methods" typically fall into one of four categories:

- (a) Purely geometrical constructions, such as the "Cone of Protection" or "Protection Angle" method;
- (b) "Faraday Cage" concepts, in which a "meshwork" of conductors or air terminations is placed at set intervals over a structure;
- (c) Electrogeometric models (EGM's), in which empirical relationships for striking distance and lightning peak current are invoked. The most common example is the "Rolling Sphere Method", which is also partly a geometric construction;
- (d) Physical models, where air breakdown mechanisms are applied to the lightning scale; these models have been derived from laboratory investigations of long sparks and, to a lesser extent, field studies of natural lightning.

The methods in categories (a), (b) and (c) are conceptually simple and relatively easy to apply. However, they do have inherent limitations that limit their applicability across a wide range of structures, particularly over a large range in height.

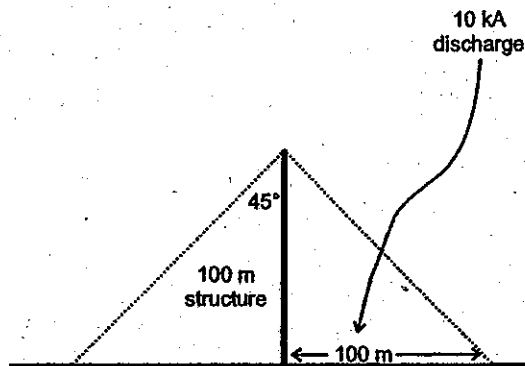


Figure B1: The "Cone of Protection" method.

B.3.2.1 Cone of Protection ("Protection Angle") Method

This method is based on the assumption that an air terminal or an elevated,

und object creates an adjacent, conical space that is essentially immune to lightning, as illustrated in Figure 1. The concept of a cone of sufficient angle to define the protected zone has its roots in the very beginning of lightning protection studies. Although Franklin recognized a limit as to the range of the air terminal in the late 1700's, the concept was first formally proposed by the French Academy of Science in 1823 and initially used a base of twice the height, i.e., an angle of 63°. By 1855, this angle was changed to 45° due to field reports that the method was failing. Generally, this angle was preserved in standards for more than one hundred years. In some standards today, a variable angle depending on the height of the structure is used.

It should be noted that the protected space is not totally immune to all lightning charges. Using the Electrogeometric Model (see section 3.5 for more details), a downward leader carrying a charge corresponding to a peak stroke current of 10 kA, if it approaches at a lateral distance greater than 45 meters it may pass the structure and enter the assumed zone of protection of 100 m.

3.2.2 Mesh Method

The "Faraday cage", in which a solid sheet of metal of sufficient thickness completely covers a structure, is an extremely good means of lightning protection. The concept is simple since no special "design method" is needed. Unfortunately, such a system is impractical, both aesthetically and in terms of cost. The practical Faraday cage or "mesh" is typically comprised of a series of horizontal air terminations (typically copper tape or conductor) which are attached to vertically descending, external downconductors. The horizontal strips are bonded at set intervals between 5 and 20 m. The structural steel, if bonded, may also be used to conduct the current. The overall scheme is illustrated in Figure 2.

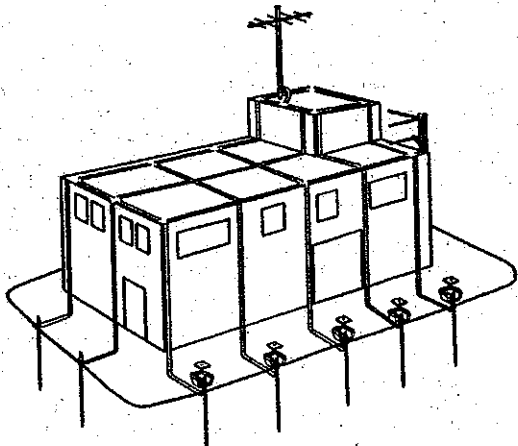


Figure B2: The "Faraday Cage" or "Mesh" method.

Users of this method need to be aware that, if it is applied with zero-height downconductors, there is no guarantee that the conductors will be struck by lightning in preference to some other nearby exposed point. Furthermore, protection of exposed items such as communication dishes is much more critical difficult and requires special bonding procedures. Note that this method is not used in NFPA 780 but is permitted in some international lightning protection standards.

3.2.3 Rolling Sphere Method

The Rolling Sphere method is the most common design method, superseding the cone of protection method in NFPA 780 in the 1980 edition. It originated in the electric power transmission industry, i.e., lightning strike attachment phase and shield wires of lines and is based on the simple Electrogeometric Model. To apply the method, an imaginary sphere, typically 45 m (150 ft) in diameter, is rolled over the structure. All surface contact points are deemed to require protection, whilst the unaffected surfaces and volumes are deemed to be protected, as shown in Figure 3.

The physical basis for the Rolling Sphere method is the Electrogeometric Model. Consider a particular peak lightning current I_p (kA) and the corresponding striking distance d_s (m), where $d_s = 10 I_p^{0.65}$ [as reported by Uman]. For a typical peak current of 10 kA, the striking distance is ~ 45 m, i.e., this is the distance at which a downward leader results in the initiation of an upward leader from the structure. A sphere of this radius is rolled over the structure in all directions. Each vertical line to the point the sphere contacts the structure represents a possible path for the lowest portion of the leader channel. The surface traced out by the center of the sphere defines all possible points in space from which a downward leader can attach to the structure. This is illustrated in Figure 4.

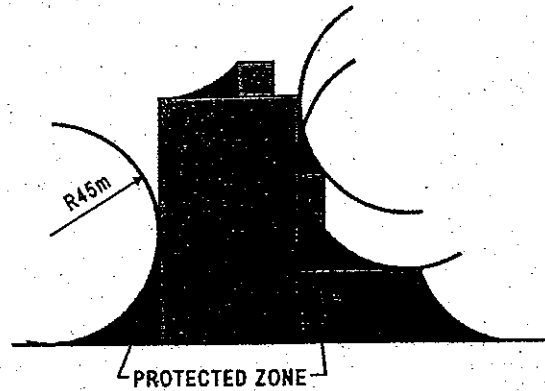


Figure B3: Lightning protection design using the Rolling Sphere Method.

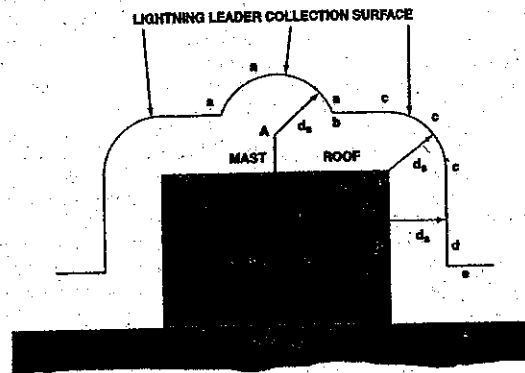


Figure B4: Illustration of the lightning leader "collection surface" (after Mackerras et al [5]).

Note that a smaller striking distance (implying a lower peak current of the lightning event) results in a smaller sphere that can intrude upon the standard 45 meter zone of protection. Thus, more conservative design is to size the sphere using a lower lightning peak current. Lightning peak currents below 5 kA - 7 kA are not realistic, however, and the 10 kA peak current represents 96% to 98% of all lightning events.

The advantage of the RSM is that it is relatively easy to apply, even to buildings with complicated shapes. However, since it is a simplification of the physical process of lightning attachment to a structure, it has some limitations. The main limitation is that it assigns an equal leader initiation ability to all contact points on the structure, i.e., no account is taken of the influence of electric fields in initiating return streamers, so it does not distinguish between likely and unlikely lightning strike attachment points. In other words, for a given prospective peak stroke current, the striking distance d_s is a constant value. This simplification stems from its origins in the electrical power transmission industry, where there is considerable uniformity in the parameters of transmission lines (diameters, heights, etc). These points are illustrated in Figure 4, where the implication is that the attractive range of the corner of the building (point C) is the same as the vertical flat surface half way down the side of the building (point D). The same claims apply to the flat roof of a structure, e.g., point B.

Some qualitative indication of the probability of strike attachment to any particular point can be obtained if the sphere is supposed to be rolled over the building in such a manner that its center moves at constant speed. Then the length of time that the sphere dwells on any point of the building gives a qualitative indication of the probability of that point being struck. Thus, for a simple rectangular building with a flat roof, the dwell time would be large at the corners and edges, and small at any point on the flat part of the roof, correctly indicating a high probability of the corners or edges being struck, and a low probability that a point on the flat part of the roof will be struck.

When the RSM is applied to a building of height greater than the selected sphere radius, then the sphere touches the vertical edges on the sides of the building at all points above a height equal to the sphere radius. This indicates the possibility of strikes to the sides of the building, and raises the question of the need for an air terminal network in these locations. Studies show that strikes to vertical edges on the sides of tall buildings do occur but are not very common. There are theoretical reasons for believing that only flashes with low I_p and consequently

low d values are likely to be able to penetrate below the level of the roof of the building and strike the sides. Hence, the consequences of a strike to the sides of a building may result in damage of a minor nature. Unless there are specific reasons for side protection, as would be the case of a structure containing explosives, it is considered that the cost of side protection would not normally be justified.

B.3.2.4 Collection Volume/Electric Field Intensification Method

After the development of the RSM, Eriksson presented an improved EGM which allowed for points of different electric field intensification. The improved model took a more physical approach than the simple EGM by utilizing the fact that the striking distance, d , is dependent on both the peak stroke current (or downleader charge) and the degree of electric field intensification, hereafter termed the "field intensification factor", K_f , of the prospective strike point.

For structures, the K_f is determined to a large extent by the height and width, but the shape and radius of curvature of the structure or structural features are also important. In the case of strike termination devices, the K_f depends on the height and tip radius of curvature as has been demonstrated in numerous papers by Moore *et al.* When air terminals are placed on buildings, the K_f 's are multiplied up by a factor which depends on the structure dimensions and their location on the structure.

Hence, a suggested improvement to lightning protection design is to assume all points on a structure are able to launch an intercepting upward leader, but to differentiate those points based on the local field intensification factor. The field intensification factor at any point in space, $K_f(x,y,z)$, is computed relatively easily using numerical techniques such as the finite element method. The CVM considers the approach of the lightning downward leader to a structure and, using the $K_f(x,y,z)$ of the air terminals and structural features, determines the point at which an upward leader will be launched. Eriksson's original model used the critical radius concept, but any other valid leader inception criteria can be used. Furthermore, the CVM stipulates that interception will occur only if an adjacent competing feature does not "win the race" to interception with the downward leader. This criterion introduces a "time" variable which is taken into account by the ratio of downward and upward leader velocity, K_v . From field observations of natural lightning, this ratio is typically of the order of unity.

The above analysis results in the definition of a parabolic-like volume above a point on a structure, e.g., edge, corner, parapet, mast, air terminal, etc. This volume represents the three dimensional "capture" or "collection volume" of that point. For a particular leader charge and velocity ratio, a downward leader will only terminate on a nominated point on the structure if the striking distance is attained and the leader path is contained within the boundary of the collection volume.

This information is often summarised in the form of an "attractive radius", R_a , which is simply the sectional radius of the collection volume, i.e., radius at the intersection point of the (upper) striking distance surface and velocity-limited (outer) boundary. The attractive radius is perhaps the most important output parameter of a collection volume analysis as it can then be used to compute the "attractive", "capture" or "protective area" of a given structure, structural feature or air terminal.

Eriksson's basic model has been extended to the protection of practical (3D) structures via:

- **3D Electric Field Modelling:** Modern desktop computers, along with modelling software that utilises the finite element or charge simulation methods, or a combination of both have made it possible to compute with relative ease the electric field distribution over and around a structure and its microgeometry. This can be done in either 2D XY plane, 2D RZ plane, or full 3D, depending on the particular geometry that is to be modelled. Hence, field intensification factors can be computed at any location in space, on or near prospective strike points, for input to the CVM design process.
- **Consideration of "competing features":** A collection volume is computed for each structural feature, including air terminals, masts, antennas etc. The attractive areas (plan view of the collection volumes) are then compared to ascertain the coverage of the protection system areas over the "competing feature" areas. A simple visual inspection can determine whether any parts of the structure are not protected and hence require additional strike termination devices.

Figure 5 shows a simple structure and the number of strike termination devices required to protect it according to a CVM analysis.

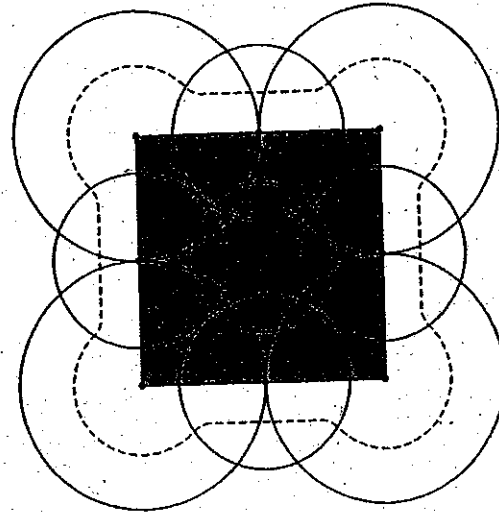


Figure B5: Example of the result of a Collection Volume design for a simple building. The dotted lines represent the competing features (i.e., the structure capture areas), and the solid lines show the corresponding air terminal capture areas, which vary depending on their location on the structure.

The CVM is much more computationally-intensive than the RSM and, ideally, is most easily applied using a computer program. This is the main trade-off with engineering models that are more complex than the simple EGM, as applied in the RSM. However, the advantage of being a very practical model that places greater design emphasis on protection of points on a structure with greatest field intensification and hence lightning attachment probability are significant points that make the additional computations worthwhile. The parameters of the model can also be updated as new research comes to hand.

While NOT CURRENTLY USED IN NFPA 780, CVM is currently under study and consideration for possible future inclusion as an alternative method to RSM.

B.3.2.5 Other Models and Design Methods

Other lightning models exist and are considered by a NFPA 780 subcommittee for development into design methods for inclusion into NFPA 780. One lightning model considered for development into a design method was Leader Progression Model (LPM). In this model, the incremental progression of a downward leader and an upward streamer through the air is calculated. At each increment of distance, the electric field between the streamer and the leader is computed and the direction of progression is determined by direction of the maximum electric field. The computation is repeated iteratively until the leader and streamer connect providing the electrical channel for the lightning event.

While potentially more physically accurate, several challenges prevented the development of the LPM into a useful design method for air terminal placement. The primary problem is that LPM is computationally intensive and cannot account for several structural features, air terminals, etc., without the use of sophisticated electromagnetic software models. In short, the gain in accuracy compared to existing models compared to the difficulty of practical application is not enough to merit its further development.

The sections below need to be renumbered.

B.3 Items to Consider When Planning Protection.

B.3.1 The best time to design a lightning protection system for a structure is during the structure's design phase, and the best time to install the system can be during construction. System components can be built in so as to be protected from mechanical displacement and environmental effects. In addition, aesthetic advantages may be gained by such concealment. Generally, it is less expensive to meet lightning protection requirements during construction.

- B3.2 moved up to section B.2

B.3.3 Conductors should be installed to offer the least impedance to the passage of stroke current between the strike termination devices and earth. The most direct path, without sharp bends or narrow loops, is best. The impedance of the conductor system is practically inversely proportional to the number of widely separated paths. Accordingly, there should be at least two paths to ground and more, if practicable, from each strike termination device. The number of paths is increased and the impedance decreased by connecting the conductors to form a cage enclosing the building.

B.3.4 Properly made ground connections are essential to the effective functioning of a lightning protection system, and every effort should be made to provide ample contact with the earth. This does not necessarily mean that the resistance

if the ground connection should be low, but rather that the distribution of metal on the earth or upon its surface in extreme cases should be such as to permit the dissipation of a stroke of lightning without damage.

B.3.5 Low resistance is desirable, but not essential, as may be shown by the extreme case on the one hand of a building resting on moist clay soil, and on the other by a building resting on bare solid rock. In the first case, if the soil is of normal resistivity or from 4,000 ohm-centimeters to 50,000 ohm-centimeters, the resistance of a ground connection made by extending the conductor 10 ft (3 m) into the ground will be from about 15 ohms to 200 ohms, and two such ground connections on a small rectangular building have been found by experience to be sufficient. Under these favorable conditions, providing adequate means for collecting and dissipating the energy of a flash without serious chance of damage is a simple and comparatively inexpensive matter.

B.3.6 In the second case, it would be impossible to make a ground connection in the ordinary sense of the term because most kinds of rocks are insulating, or at least of high resistivity, and in order to obtain effective grounding other more elaborate means are necessary. The most effective means would be an extensive wire network laid on the surface of the rock surrounding the building to which the down conductors could be connected. The resistance to earth at some distant point of such an arrangement would be high but at the same time the potential distribution about the building would be substantially the same, as though it were resting on conducting soil, and the resulting protective effect also would be substantially the same.

B.3.7 In general, the extent of the grounding arrangements will depend on the character of the soil, ranging from simple extension of the conductor into the ground where the soil is deep and of high conductivity to an elaborate buried network where the soil is very dry or of very poor conductivity. Where a network is required, it should be buried if there is soil enough to permit it, as this adds to its effectiveness. Its extent will be determined largely by the judgment of the person planning the installation with due regard to the following rule: The more extensive the underground metal available, the more effective the protection.

B.3.8 Where practicable, each ground terminal connection should extend or have a branch that extends below and at least 2 ft (0.6 m) away from the foundation walls of the building in order to minimize the likelihood of damage to foundation walls, footings, and stemwalls.

B.3.9 When a lightning conductor system is placed on a building, within or about which there are metal objects of considerable size within a few feet of a conductor, there will be a tendency for sparks or sideflashes to jump between the metal object and the conductor. To prevent damage, interconnecting conductors should be provided at all places where sideflashes are likely to occur.

B.3.10 Lightning currents entering protected buildings on overhead or underground power lines, or telephone conductors, or television or radio antennas are not necessarily restricted to associated wiring systems and appliances. Therefore, such systems should be equipped with appropriate protective devices and bonded to ensure a common potential.

B.3.11 Because a lightning protection system is expected to remain in working condition for long periods with minimum attention, the mechanical construction should be strong and the materials used should offer resistance to corrosion and mechanical injury.

B.4 Inspection and Maintenance of Lightning Protection Systems.

It has been shown that in cases where damage has occurred to a protected structure, the damage was due to additions or repairs to the building or to deterioration or mechanical damage that was allowed to go undetected and unrepaired, or both. Therefore, it is recommended that an annual visual inspection be made and that the system be thoroughly inspected every five years.

B.5 Indirect Losses. In addition to direct losses such as destruction of buildings by lightning, fire resulting from lightning, and the killing of livestock, indirect losses sometimes accompany the destruction or damage of buildings and their contents. An interruption to business or farming operations, especially at certain times of the year, may involve losses quite distinct from, and in addition to, the losses arising from the direct destruction of material property. There are cases where whole communities depend on the integrity of a single structure for their safety and comfort. For example, a community may depend on a water-pumping plant, a telephone relay station, a police station, or a fire station. A stroke of lightning to the unprotected chimney of a pumping plant might have serious consequences such as a lack of sanitary drinking water, irrigating water, or water for fire protection. Additional information on this topic is available in the documents identified in Appendix M.1.2.1.

Substantiation: The 780 committee contends that more information is desirable for inclusion to the appendix to better describe the theory and application of lightning protection methods.

Committee Meeting Action: Reject

Committee Statement: The proposal is beyond the scope of the document.

Number Eligible to Vote: 30

Ballot Results: Affirmative: 23 Negative: 3

Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

Explanation of Negative:

CAIE, M.: The extended Annex B was rejected on the basis that the material was "outside the Scope of the NFPA document", that it "did not support the material in the main body of the standard" and the "volume of annex material was too large". However, there is a lot of annex material in the standard presently, some old and some new and approved at the ROP meeting, that also fits these criteria.

It is requested that this annexe is revisited in an appropriate manner at the ROP meeting. If, as appears to be the case, the committee feels the above

criteria are valid, then the negative vote on this item could be reversed by the following two-fold action item:

1. For consistency, the whole standard should be reviewed for any material that is not in the Scope or does not support the main body of the document. Any sections identified using these criteria should be deleted.

2. During the revision cycle, the Modelling Task Force spent considerable time discussing Annex B and reported back to the committee that there was a need for additional explanatory material in this annex. There were no objections from the committee. However, in the ROP meeting, all of the additional explanatory material was rejected, literally in a matter of minutes, without consideration of how this material improved the standard. Hence, the annex should be revisited.

TOBIAS, J.: Much of the submitted Proposal 110 contains information within the scope of NFPA 780 and should be retained as explanatory material. It should have been accepted 'in part' or 'in part in principle.'

Please find below the suggested revised text with the sections considered out-of-scope removed. This section needs inclusion to the annex to provide useful design guidance and explanations for existing methods in use in the NFPA 780 document.

Proposed additions to Annex B of NFPA 780

(additions are shown in within the region of the document annotated by *****)

Annex B: Principles of Lightning Protection

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Fundamental Principles of Lightning Protection.

B.1.1 The fundamental principle in the protection of life and property against lightning is to provide a means by which a lightning discharge can enter or leave the earth without resulting damage or loss. A low impedance path that the discharge current will follow in preference to all alternative high impedance paths offered by building materials such as wood, brick, tile, stone, or concrete should be offered. When lightning follows the higher impedance paths, damage may be caused by the heat and mechanical forces generated during the passage of the discharge. Most metals, being good electrical conductors, are virtually unaffected by either the heat or the mechanical forces if they are of sufficient size to carry the current that can be expected. The metallic path must be continuous from the ground terminal to the strike termination device. Care should be exercised in the selection of metal conductors to ensure the integrity of the lightning conductor for an extended period. A nonferrous metal such as copper or aluminum will provide, in most atmospheres, a lasting conductor free of the effects of rust or corrosion.

B.1.2 Parts of structures most likely to be struck by lightning are those that project above surrounding parts such as chimneys, ventilators, flagpoles, towers, water tanks, spires, steeples, deck railings, shafthouses, gables, skylights, dormers, ridges, and parapets. The edges and corners of the roof are the parts most likely to be struck on flat or gently sloping roofed buildings.

B.2 Lightning Protection Systems.

B.2.1 Lightning protection systems consist of the following three basic parts that provide the low impedance metal path required:

(1) A system of strike termination devices on the roof and other elevated locations.

(2) A system of ground terminals.

(3) A conductor system connecting the strike termination devices to the ground terminals. Properly located and installed, these basic components improve the likelihood that the lightning discharge will be conducted harmlessly between the strike termination devices and the ground terminals.

B.2.2 While intercepting, conducting, and dissipating the main discharge, the three basic protection system components do not ensure safety from possible secondary effects of a lightning strike. Therefore, secondary conductors are provided to interconnect metal bodies to ensure that such metal bodies are maintained at the same electrical potential so as to prevent sideflashes or sparkover. Surge suppression devices are also provided to protect power lines and associated equipment from both direct discharges and induced currents.

B.2.3 The structure should be examined, and installation of air terminals should be planned for all areas or parts likely to receive a lightning discharge. The object is to intercept the discharge immediately above the parts liable to be struck and to provide a direct path to earth, rather than to attempt to divert the discharge in a direction it would not be likely to take. The air terminals should be placed high enough above the structure to obviate danger of fire from the arc.

*****ADD*****

B.3 Positioning of air terminals.

Positioning of air terminals depends upon the physical lightning model used to describe the behavior of lightning. The development of these models has been ongoing for two hundred and fifty years and models have a basis in physical observations of lightning. While the models tend to be simplified compared to actual details of lightning development and propagation, empirical observations over hundreds of years have proven their effectiveness.

Air terminals are intended to intercept the lightning event by providing a preferred attachment point for lightning's electrical discharge. They operate by actually providing an upward propagating leader of ionized air to intercept a downward lightning leader. Since these leaders are ionized air of opposite charge, they attract and provide the electrical channel to earth for lightning when they connect. Air terminals placed upon a structure do not substantially

increase the probability of the structure being struck by lightning. If the downward progressing lightning leader is close to the structure, it will probably attach to that structure anyway. Thus, air terminals are designed to provide a preferential attachment point on structures that already provide a likely lightning attachment point. Once lightning connects to the air terminal, it is easier to control the lightning current and direct it to earth as opposed to it taking a random, uncontrolled (and usually damaging) path through the structure otherwise.

This section is intended to educate the user of NFPA 780 by providing some background in the mechanics of the lightning models and their reduction into design rules for the placement of air terminals. To begin the discussion, we can start with the physics of lightning attachment.

B.3.1 Physics of Lightning Attachment

The first stroke of a ground flash is normally preceded by a downward-progressing, low-current leader discharge that commences in the negatively charged region of the cloud and progresses towards the earth, depositing negative charges in the air surrounding the leader discharge channel. (Occasionally, the downward leader can be positive in charge but this does not affect its behavior in terms of attachment.) When the lower end of the leader is 100 – 300 m from the earth or grounded objects, electrical discharges (streamers) are likely to be initiated from prominent points on grounded objects, and to propagate upwards towards the leader discharge channel. Several streamers may start, but usually only one is successful in reaching the downward leader.

The high current phase (return stroke) commences at the moment the upward moving streamer meets and connects with the downward leader. The position in space of the lower portion of the lightning discharge channel is therefore determined by the path of the successful streamer, i.e. the one that succeeded in reaching the downward leader. The primary task in protecting a structure is therefore to ensure a high probability that the successful streamer originates from the air terminals and not from a part of the structure that would be adversely affected by the lightning current that subsequently flows.

As the path of the successful streamer may have a large horizontal component as well as a vertical component, an elevated air terminal will provide protection for objects spread out below it. Within limits, it is therefore possible to provide protection for a large volume with a relatively small number of correctly positioned air terminals. This is the basis for the concept of a “zone of protection” and provides the basic principle underlying interception lightning protection.

Therefore, the function of an air terminal in an LPS is to divert to itself the lightning discharge that might otherwise strike a vulnerable part of the object to be protected. It is generally accepted that the range over which an air terminal can attract a lightning discharge is not constant, but increases with the severity of the discharge.

The path of a lightning discharge near a structure is determined by the path of the successful streamer (see Paragraph B2.2) that will usually be initiated from a conducting part of the structure nearest to the downward leader. The initiation of streamers is also influenced by the local electric field. Conductive objects with a small radius of curvature will concentrate the electric field.

Thus, air terminals, as well as the upper outer edges and corners of buildings or structures, and especially protruding parts, are likely to have higher local electric fields than elsewhere, and are therefore likely places for the initiation of upward streamers. When the downward leader is within about 200 m of the building, the electric field at these protruding parts and corners will exceed the breakdown field strength of air, resulting in corona currents that cause these parts to be surrounded by ionized air. At some point, this ionized air will begin to move in response to the elevated electric field provided by the downward leader. Upward streamers of ionized air will form and move toward the downward leader. Consequently, the most probable strike attachment point on a building is the edge, corner, or other protruding part in the vicinity of the downward leader. Hence, if air terminals are placed at all locations where high electric fields and streamer initiation are likely, there will be a high probability that the discharge will be intercepted successfully.

B.3.2 Overview of Methods

A “design method” is used to identify the most suitable locations placing for strike termination devices, based on the area of protection afforded by each one. There are generally two categories of “placement methods” as used in NFPA 780:

(a) Purely geometrical constructions, such as the “Cone of Protection” or “Protection Angle” method;

(b) Electrogeometric models (EGM’s), in which empirical relationships for striking distance and lightning peak current are invoked. The most common example is the “Rolling Sphere Method”, which is also partly a geometrical construction;

B.3.2.1 Cone of Protection (“Protection Angle”) Method

This method is based on the assumption that an air terminal or an elevated, grounded object creates an adjacent, conical space that is essentially immune to lightning, as illustrated in Figure 1. The concept of a cone of sufficient angle to define the protected zone has its roots in the very beginning of lightning protection studies. Although Franklin recognized a limit as to the range of the air terminal in the late 1700’s, the concept was first formally proposed by the French Academy of Science in 1823 and initially used a base of twice the height, i.e., an angle of 63°. By 1855, this angle was changed to 45° due to field reports that the method was failing. Generally, this angle was preserved in standards for more than one hundred years.

In some standards today, a variable angle depending on the height of the structure is used.

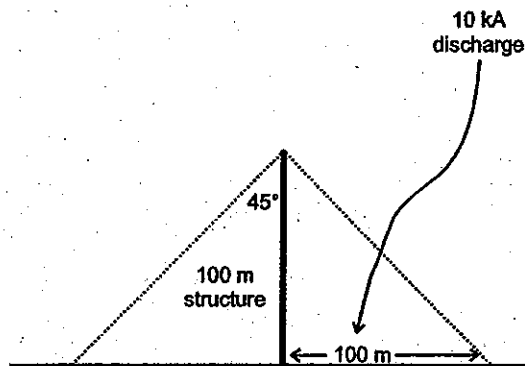


Figure B1: The “Cone of Protection” method.

It should be noted that the protected space is not totally immune to all lightning discharges. Using the Electrogeometric Model (see section 3.5 for more details), for a downward leader carrying a charge corresponding to a peak stroke current of 10 kA, if it approaches at a lateral distance greater than 45 meters it may bypass the structure and enter the assumed zone of protection of 100 m.

B.3.2.2 Rolling Sphere Method

The Rolling Sphere method is the most common design method, superseding the cone of protection method in NFPA 780 in the 1980 edition. It originated from the electric power transmission industry, i.e., lightning strike attachment to phase and shield wires of lines and is based on the simple Electrogeometric Model. To apply the method, an imaginary sphere, typically 45 m (150 ft) in radius, is rolled over the structure. All surface contact points are deemed to require protection, whilst the unaffected surfaces and volumes are deemed to be protected, as shown in Figure 3.

The physical basis for the Rolling Sphere method is the Electrogeometric Model. Consider a particular peak lightning current I_p (kA) and the corresponding “striking distance” d_s (m), where $d_s = 10 I_p^{0.65}$ [as reported by Uman]. For a typical peak current of 10 kA, the striking distance is ~45 m, i.e., this is the distance at which a downward leader results in the initiation of an upward leader from the structure.

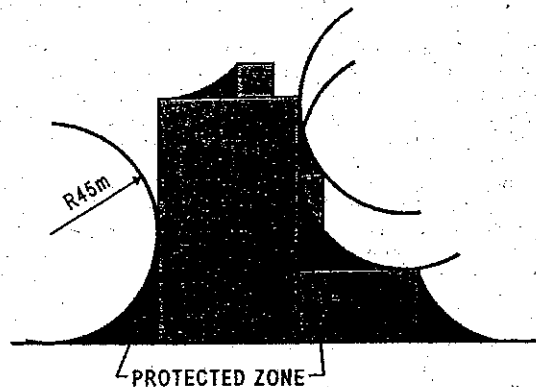


Figure B3: Lightning protection design using the Rolling Sphere Method

Note that a smaller striking distance (implying a lower peak current of the lightning event) results in a smaller sphere that can intrude upon the standard 45 meter zone of protection. Thus, more conservative design is to size the sphere using a lower lightning peak current. Lightning peak currents below 5 kA – 7 kA are not realistic, however, and the 10 kA peak current represents 96% to 98% of all lightning events.

The advantage of the RSM is that it is relatively easy to apply, even to buildings with complicated shapes. However, since it is a simplification of the physical process of lightning attachment to a structure, it has some limitations. The main limitation is that it assigns an equal leader initiation ability to all contact points on the structure, i.e., no account is taken of the influence of electric fields in initiating return streamers, so it does not distinguish between likely and unlikely lightning strike attachment points. In other words, for a given prospective peak stroke current, the striking distance d_s is a constant value. This simplification stems from its origins in the electrical power transmission industry, where there is considerable uniformity in the

meters of transmission lines (diameters, heights, etc). In reality, lightning preferentially strike the corner of the building rather than the vertical flat face half way down the side of the building. The same claims apply to the roof of a structure.

The qualitative indication of the probability of strike attachment to any particular point can be obtained if the sphere is supposed to be rolled over the building in such a manner that its center moves at constant speed. Then the length of time that the sphere dwells on any point of the building gives a qualitative indication of the probability of that point being struck. Thus, for a simple rectangular building with a flat roof, the dwell time would be large at the corners and edges, and small at any point on the flat part of the roof, correctly indicating a higher probability of the corners or edges being struck, and a low probability that a point on the flat part of the roof will be struck. When the RSM is applied to a building of height greater than the selected sphere radius, then the sphere touches the vertical edges on the sides of the building at all points above a height equal to the sphere radius. This indicates the possibility of strikes to the sides of the building, and raises the question of the need for an air terminal network in these locations. Studies show that strikes to vertical edges on the sides of tall buildings do occur but are not very common. There are theoretical reasons for believing that only flashes with low field strengths and consequently low field values are likely to be able to penetrate below the level of the roof of the building and strike the sides. Hence, the consequences of a strike to the sides of a building may result in damage of a minor nature. Unless there are specific reasons for side protection, as would be the case of a structure containing explosives, it is considered that the cost of side protection would not normally be justified.

3.2.3 Other Models and Design Methods

Other lightning models exist and are periodically considered by a NFPA 780 committee for development into design/air terminal placement methods for inclusion into NFPA 780. No further consideration of other models is given unless they do not fall within the scope of NFPA 780.

The sections below need to be renumbered.

3.3 Items to Consider When Planning Protection.

3.3.1 The best time to design a lightning protection system for a structure is during the structure's design phase, and the best time to install the system can be during construction. System components can be built in so as to be protected from mechanical displacement and environmental effects. In addition, aesthetic advantages may be gained by such concealment. Generally, it is less expensive to meet lightning protection requirements during construction.

3.3.2 moved up to section B.2

3.3.3 Conductors should be installed to offer the least impedance to the passage of stroke current between the strike termination devices and earth. The most direct path, without sharp bends or narrow loops, is best. The impedance of the conductor system is practically inversely proportional to the number of widely separated paths. Accordingly, there should be at least two paths to ground and more, if practicable, from each strike termination device. The number of paths is increased and the impedance decreased by connecting the conductors to form a cage enclosing the building.

3.3.4 Properly made ground connections are essential to the effective functioning of a lightning protection system, and every effort should be made to provide ample contact with the earth. This does not necessarily mean that the resistance of the ground connection should be low, but rather that the distribution of metal in the earth or upon its surface in extreme cases should be such as to permit the dissipation of a stroke of lightning without damage.

3.3.5 Low resistance is desirable, but not essential, as may be shown by the extreme case on the one hand of a building resting on moist clay soil, and on the other by a building resting on bare solid rock. In the first case, the soil is of normal resistivity or from 4,000 ohm-centimeters to 50,000 ohm-centimeters, the resistance of a ground connection made by extending a conductor 10 ft (3 m) into the ground will be from about 15 ohms to 200 ohms, and two such ground connections on a small rectangular building have been found by experience to be sufficient. Under these favorable conditions, providing adequate means for collecting and dissipating the energy of a flash without serious chance of damage is a simple and comparatively inexpensive matter.

3.3.6 In the second case, it would be impossible to make a ground connection in the ordinary sense of the term because most kinds of rocks are insulating, at least of high resistivity, and in order to obtain effective grounding other more elaborate means are necessary. The most effective means would be an extensive wire network laid on the surface of the rock surrounding the building, which the down conductors could be connected. The resistance to earth at some distant point of such an arrangement would be high but at the same time the potential distribution about the building would be substantially the same, though it were resting on conducting soil, and the resulting protective effect so would be substantially the same.

B.3.7 In general, the extent of the grounding arrangements will depend on the character of the soil, ranging from simple extension of the conductor into the ground where the soil is deep and of high conductivity to an elaborate buried network where the soil is very dry or of very poor conductivity. Where a network is required, it should be buried if there is soil enough to permit it, as this adds to its effectiveness. Its extent will be determined largely by the judgment of the person planning the installation with due regard to the following rule: The more extensive the underground metal available, the more effective the protection.

B.3.8 Where practicable, each ground terminal connection should extend or have a branch that extends below and at least 2 ft (0.6 m) away from the foundation walls of the building in order to minimize the likelihood of damage to foundation walls, footings, and stemwalls.

B.3.9 When a lightning conductor system is placed on a building, within or about which there are metal objects of considerable size within a few feet of a conductor, there will be a tendency for sparks or sideflashes to jump between the metal object and the conductor. To prevent damage, interconnecting conductors should be provided at all places where sideflashes are likely to occur.

B.3.10 Lightning currents entering protected buildings on overhead or underground power lines, or telephone conductors, or television or radio antennas are not necessarily restricted to associated wiring systems and appliances. Therefore, such systems should be equipped with appropriate protective devices and bonded to ensure a common potential.

B.3.11 Because a lightning protection system is expected to remain in working condition for long periods with minimum attention, the mechanical construction should be strong and the materials used should offer resistance to corrosion and mechanical injury.

B.4 Inspection and Maintenance of Lightning Protection Systems. It has been shown that in cases where damage has occurred to a protected structure, the damage was due to additions or repairs to the building or to deterioration or mechanical damage that was allowed to go undetected and unrepaired, or both. Therefore, it is recommended that an annual visual inspection be made and that the system be thoroughly inspected every five years.

B.5 Indirect Losses. In addition to direct losses such as destruction of buildings by lightning, fire resulting from lightning, and the killing of livestock, indirect losses sometimes accompany the destruction or damage of buildings and their contents. An interruption to business or farming operations, especially at certain times of the year, may involve losses quite distinct from, and in addition to, the losses arising from the direct destruction of material property. There are cases where whole communities depend on the integrity of a single structure for their safety and comfort. For example, a community may depend on a water-pumping plant, a telephone relay station, a police station, or a fire station. A stroke of lightning to the unprotected chimney of a pumping plant might have serious consequences such as a lack of sanitary drinking water, irrigating water, or water for fire protection. Additional information on this topic is available in the documents identified in Appendix M.1.2.1.

VANSICKLE, III, H.: The Committee rejected this proposal because it is "beyond the scope of the document". There is much good information included that is pertinent to the scope. The valid information should be included, and the non-compliant deleted. Generally the "Cone of Protection" and "Rolling Sphere" Methods information should be included, while the "Mesh", "Collection Volume/Electric Field Intensification", and "Leader Progression" Methods information should be deleted.

780-111 Log #59 Final Action: Accept in Principle (C.2.1)
 Submitted by: Dick Reehl, Quest Communications
 Recommendation: Revise as follows:
 "...to reduce this potential to zero; this standard..."
 Substantiation: Can't get to zero.
 Committee Meeting Action: Accept in Principle
 Revise C.2.1 to read as follows:
 "...to reduce this potential to essentially zero, this standard..."
 Committee Statement: The Committee accepts the submitter's recommendation and changes the text for clarification. The change satisfies the submitter's intent.
 Number Eligible to Vote: 30
 Ballot Results: Affirmative: 26
 Ballot Not Returned: 4 Dyl, D., Goldbach, W., Heary, W., Rapp, R.

780-112 Log #98 Final Action: Accept in Principle (Table C.2.3)
 Submitted by: Terrance K. Portfleet, Michigan Lightning Protection Inc.
 Recommendation: Revise Table C.2.3 Sample Calculations of Bonding Distances SI/English Unit Conversions as follows: