

UL 96A

Installation Requirements for Lightning Protection Systems

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Installation Requirements for Lightning Protection Systems, UL 96A

Twelfth Edition, Dated May 23, 2007

Summary of Topics

This new edition of UL 96A includes the following:

Changes to align with NFPA 780

Change to allow use of newer materials that are compatible with membrane roofing systems

Additional exception to replace a previous reference to a Practical Application Guideline (PAG)

New illustration showing zones of protection and applicable computations determined by using the rolling sphere concept

Rewording of the scope to clarify the requirements covering the application and inspection for the installation of lightning protection on all types of new and existing structures

Clarification of the requirements for Protection for Miscellaneous Structures

The terms “inductance and conductance”, when referring to metal bodies, was removed, and clarified with terms such as “strike termination devices” and “grounded metal bodies”. Also, the requirement for the use of the mega-ohm tester and continuity tester to determine whether a body is isolated was deleted

Requirement modifications to ground terminals located inside a structure, multiple ground rods, and ground ring electrodes

Revision to Common Ground requirement

Revision to zone of protection requirement

Addition of sprinkler lines and galvanized steel

Change in requirement to down conductor

Miscellaneous editorial revisions

The new requirements are substantially in accordance with UL's Proposal(s) on this subject dated March 27, 2006 and March 23, 2007.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfonet.ul.com/ulforeword.html>

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

UL's Standards for Safety are copyrighted by UL. Neither a printed copy of a Standard, nor the distribution diskette for a Standard-on-Diskette and the file for the Standard on the distribution diskette should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each

authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

Copyright © 2007 Underwriters Laboratories Inc.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-54.....	May 23, 2007
SA1-SA2	May 23, 2007

No Text on This Page

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

MAY 23, 2007

1

UL 96A

Standard for Installation Requirements for Lightning Protection Systems

Prior to the sixth edition, previous numbered and unnumbered editions covering Installation Requirements for Lightning Protection Systems have been published since 1916. The sixth edition was titled Installation Requirements for Master Labeled Lightning Protection Systems.

Sixth Edition – March, 1958
Seventh Edition – April, 1960
Eighth Edition – June, 1963
Ninth Edition – April, 1982
Tenth Edition – May, 1994
Eleventh Edition – July, 2001

Twelfth Edition

May 23, 2007

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com>.

COPYRIGHT © 2007 UNDERWRITERS LABORATORIES INC.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

No Text on This Page

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

CONTENTS

INTRODUCTION

1 Scope	5
2 Components	5
3 Units of Measurement	6
4 Undated References	6
5 Glossary	6

PROTECTION FOR ORDINARY BUILDINGS

6 General	10
7 Materials	11
8 Strike Termination Devices	12
8.1 General	12
8.2 Zone of protection	12
8.3 Dormers	14
8.4 Intermediate ridges	14
8.5 Irregular roof lines	14
8.6 Open areas	14
8.7 Domed or curved roofs	14
8.8 Chimneys, vents and roof top metal bodies	15
9 Conductors	26
9.1 General	26
9.2 Roof conductors	30
9.3 Down conductors	31
9.4 Interconnecting conductors	33
10 Grounding	33
10.1 General	33
10.2 Multiple ground rods	36
10.3 Shallow topsoil	38
10.4 Common grounds	39
10.5 Concrete-encased electrodes	39
10.6 Ground ring electrode	40
11 Metal Bodies Subject to Direct Strikes	40
12 Connectors and Fittings	44
13 Surge Protection	45
14 Concealed Installations	45
15 Structural Steel Framing	46

PROTECTION FOR MISCELLANEOUS STRUCTURES

16 General	48
------------------	----

PROTECTION FOR HEAVY-DUTY STACKS

17 Mechanical Execution of Work	49
18 Components	49
19 Corrosion Protection	49
20 Air Terminals	49
21 Conductors	51

*UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL*

22 Fasteners	51
23 Bonding	52
24 Splices	52
25 Metal Stacks	52
26 Metal Guy Wires and Cables	53

SUPPLEMENT SA - MATERIAL REQUIREMENTS

Document Was Downloaded By Keith Sterling For Use By STORM SHIELD LIGHTNING RODS

26045 : 12/10/2008 - 11:38 AM

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

INTRODUCTION

1 Scope

1.1 These requirements cover the installation of lightning protection systems on all types of structures other than structures used for the production, handling, or storage of ammunition, explosives, flammable liquids or gases, and other explosive ingredients including dust.

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

1.3 These requirements do not cover the installation of lightning protection systems for electrical generating, distribution, or transmission systems.

1.4 These requirements do not cover lightning protection components, which are covered by the Standard for Lightning Protection Components, UL 96.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

2.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.5 Components utilized in the installation of a lightning protection system covered by this standard shall comply with the Standard for Lightning Protection Components, UL 96.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

5.1 For the purpose of this standard, the following definitions apply.

5.2 AIR TERMINAL – A type of strike termination device intentionally installed for the purpose of intercepting lightning flashes. These items are sometimes referred to as lightning rods.

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

5.4 BUILDINGS:

- a) Ordinary Building – A building of common or conventional construction used for ordinary purposes, whether commercial, farm, industrial, institutional, or residential.
- b) Class I Ordinary Building – A building that is not more than 75 feet (22.9 m) high.
- c) Class II Ordinary Building – A building that is more than 75 feet (22.9 m) high or greater.
- d) Metal-Clad Building – A building with either sides or roof made of or covered with sheet metal.
- e) Metal-Framed Building – A building with electrically continuous framing of sufficient size and conductivity to be used as part of the lightning protection system.

5.5 CHIMNEY – A smoke or vent stack not meeting the requirements of a heavy-duty stack.

5.6 CONDUCTOR – The portion of a lightning protection system intended to transfer lightning discharge currents between strike termination devices and ground or to provide potential equalization between conductive bodies in/on the structure.

- a) Main Conductor – A conductor intended to conduct primary lightning currents that interconnects strike termination devices with grounding electrodes.
- b) Secondary Conductor – A conductor that connects metal bodies within the zone of protection to the lightning protection system to eliminate electrical potential that may create arcing.

5.7 EARTH – Finished grade level around a structure.

5.8 FASTENER – An attachment to secure a conductor to a structure.

5.9 GROUND GRID – A system of grounding electrodes consisting of interconnected bare cables buried in the earth to provide a common ground.

5.10 GROUNDING ELECTRODE – That portion of a lightning protection system extending into the earth, such as a ground rod, ground plate, or conductor, serving to bring the lightning protection system into electrical contact with the earth.

5.11 GROUNDED – Connected to earth, or to a conductive material that is connected to earth, so that electric charges are distributed freely to the earth.

5.12 LIGHTNING PROTECTION SYSTEM – A complete system of strike termination devices, conductors, grounding electrodes, interconnecting conductors, surge protective devices, connectors or fittings.

5.13 LOOP CONDUCTOR – A conductor:

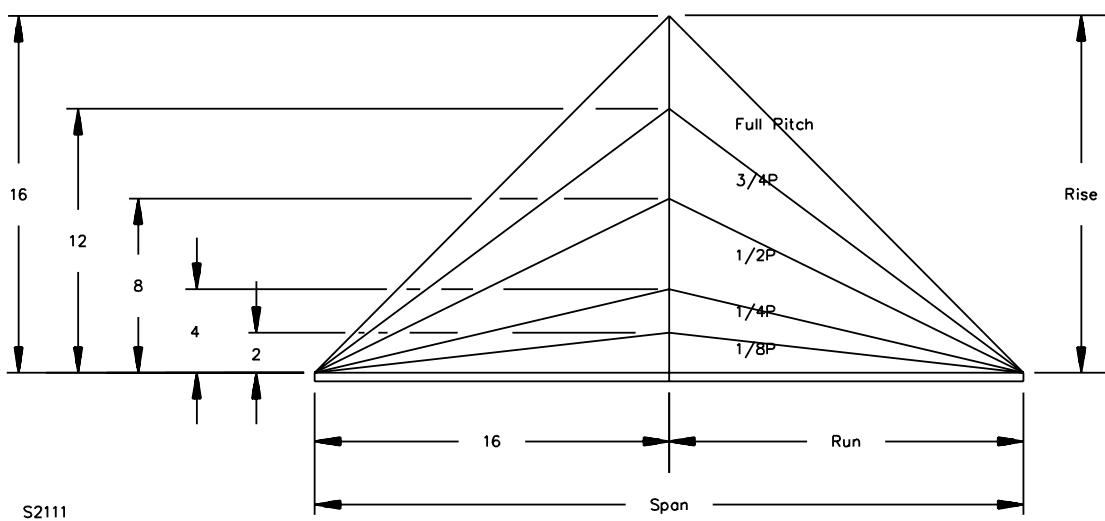
- a) That encircles a structure; and
- b) That is used to interconnect grounding electrodes, main conductors, or other grounded bodies.

5.14 METAL BODY:

- a) Grounded (Non-Isolated) Metal Body – A metal body having a ground path independent of the lightning protection system.
- b) Isolated (Ungrounded) Metal Body – A metal body having no ground path.

5.15 ROOF, FLAT OR GENTLY SLOPING – A roof having a span of 40 feet (12.2 m) or less and a pitch of less than 1/8, or a roof having a span exceeding 40 feet (12.2 m) and a pitch less than 1/4. Roof pitch is determined by the method illustrated in Figure 5.1.

Figure 5.1
Determination of roof pitch



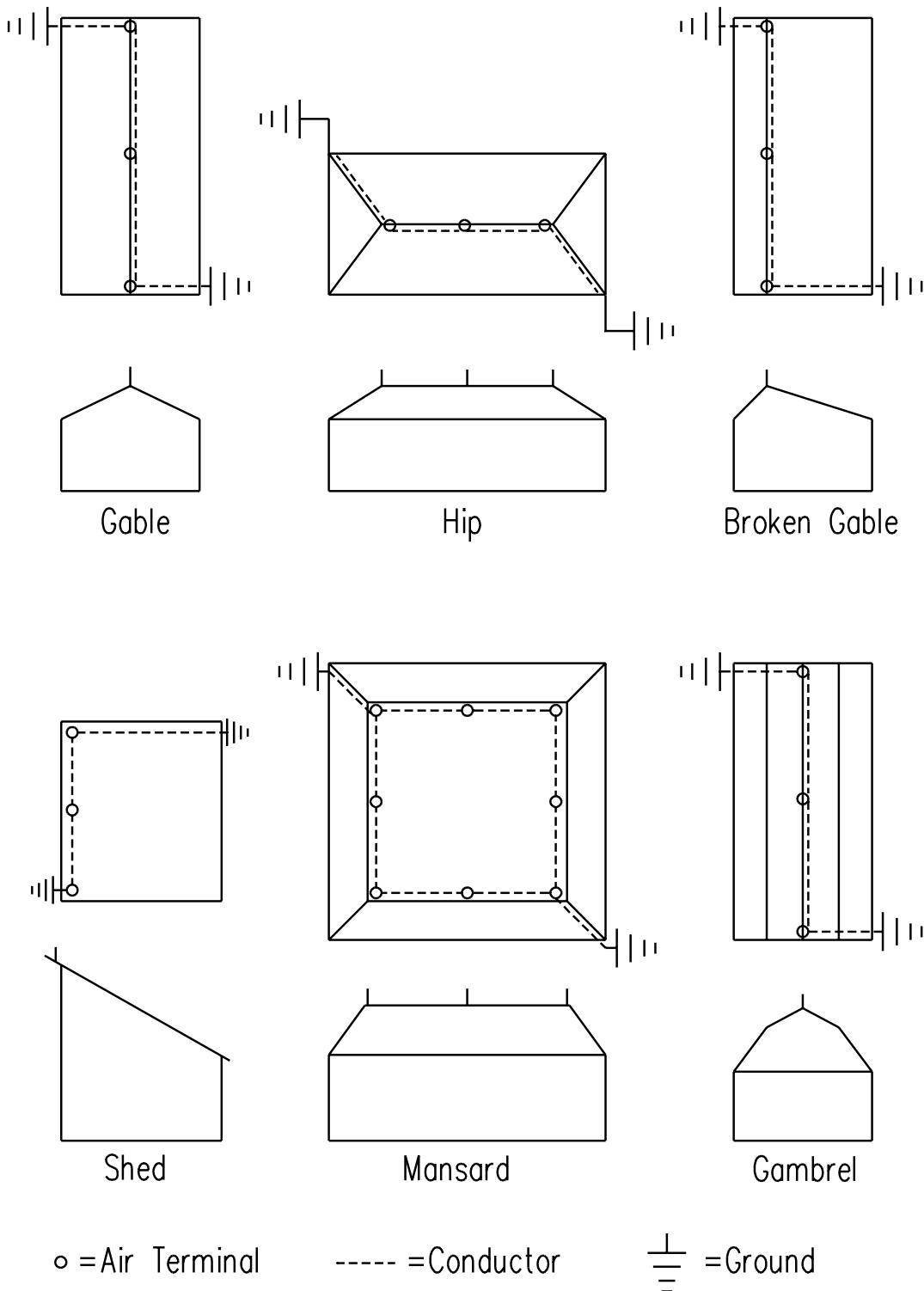
$$\text{Pitch (P)} = \text{Rise}/\text{Run}$$

Example: If Rise = 3 units, and Run = 12 units, Pitch = $3/12 = 1/4$

5.16 ROOF, TYPES – Typical roof types are shown in Figure 5.2.

Figure 5.2
Roof types

(Top and end views of each roof type are shown)



S2112B

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

5.17 SECONDARY ROOF AREA – A secondary roof is less than 10 percent of the total roof area of the protected building and lower than adjacent roofs.

5.18 STACK, HEAVY-DUTY – A smoke or vent stack more than 75 feet (22.9 m) high, and in which the cross-sectional area of the flue is more than 500 square inches (0.3 m^2).

5.19 STRIKE TERMINATION DEVICE – A metallic component of a lightning protection system that intercepts lightning flashes and connects them to a path to ground.

5.20 STRIKING DISTANCE – The distance over which final breakdown of the initial strike to ground or to a grounded object occurs.

5.21 SURGE PROTECTIVE DEVICE (SPD) – A device composed of at least one non-linear component and intended for limiting surge voltages on equipment by diverting or limiting surge current and is capable of repeating these functions as specified.

5.22 ZONE OF PROTECTION – The space adjacent to a grounded air terminal or mast or overhead ground wire that is substantially immune to direct strokes of lightning.

PROTECTION FOR ORDINARY BUILDINGS

6 General

6.1 A system on a Class II building shall be installed in accordance with the requirements for a Class I building and with the following requirements.

- a) Air terminals and conductors shall be Class II.
- b) Splices and cable connectors shall be metal and shall be secured with bolts or welds that are rated for use on Class II structures.
- c) When part of a structure is over 75 feet (22.9 m) high (such as a steeple), and the main portion is less than 75 feet (22.9 m) high, the requirements for Class II components shall apply only to that portion over 75 feet (22.9 m) high. Class II conductors from the higher portion shall be continuous to ground and shall be interconnected with the balance of the system.

6.2 Lightning protection systems shall be installed in a neat, professional manner.

7 Materials

7.1 A lightning protection system shall be made of materials that are resistant to corrosion or shall be acceptably protected against corrosion as specified in the Standard for Lightning Protection Components, UL 96.

7.2 Metals shall not be used in combinations that form electrolytic corrosion (metals that are not galvanically compatible) that accelerates their degradation (corrosion or oxidation) in the presence of moisture. This is in reference to the lightning protection system components only. For example, a combination of copper and aluminum shall not be used. See 7.5 – 7.8.

7.3 Components shall be protected or located to reduce the risk of deterioration because of local conditions. A part of a copper system that is exposed to direct action of chimney gases or other similar corrosive gases shall be protected by a continuous coating of lead or tin. All components located within 2 feet (610 mm) of the chimney top shall be so protected. Aluminum components are not required to have a coating of lead or tin.

7.4 Lightning conductors subject to mechanical damage or displacement shall be protected with molding or tubing. Metal pipe or tubing used around a conductor shall be bonded to the conductor at both ends of the pipe or tubing. A downspout shall not be used as a protector. See 9.3.5.

7.5 A copper lightning protection component shall not be installed directly on aluminum surfaces or external galvanized steel surfaces. See 7.2.

7.6 An aluminum lightning protection component shall not be installed directly on copper roofing material or other copper surface or below the run off from a copper surface. See 7.2.

7.7 Aluminum components shall not be used where they come into direct contact with earth. Bimetallic fittings shall be used for the connection of aluminum down conductors to copper or copper-clad conductors. Where so used, bimetallic fittings shall not be installed less than 18 inches (460 mm) above earth level. See 7.2.

7.8 Bimetallic fittings shall be used when joining metals that are not galvanically compatible. See 7.2.

7.9 Aluminum conductors and components shall not be:

- a) Embedded in concrete or masonry;
- b) In direct contact with a surface coated with an alkaline base paint; or
- c) Installed in wet locations, for example inside eave troughs or downspouts.

8 Strike Termination Devices

8.1 General

8.1.1 A metal body that is 3/16 inch (4.8 mm) thick or greater that is subject to a direct lightning strike may serve as a strike termination device and shall be connected to the lightning protection system. The connections shall be main-size and provide a two-way path to ground as is required for air terminals.

8.1.2 Strike termination devices shall be installed to provide a zone of protection in accordance with Section 8.2 for each part of a structure that is exposed to direct lightning strikes.

8.1.3 Air terminals are not required for parts of a structure located within a zone of protection.

8.1.4 Strike termination devices that are a permanent part of the structure and that are 3/16 inch (4.8 mm) thick or more shall be connected to the lightning protection system using main-size conductors and shall provide a two-way path to ground as is required for air terminals.

8.1.5 An air terminal shall be placed not more than 2 feet (610 mm) from the ends of each ridge, edge, or outside corner of roofs. See Figure 8.2.

8.1.6 Where air terminals are used, they shall be secured against overturning either by attachment to the object to be protected or by means of braces that are permanently and rigidly attached to the building. Each terminal that is more than 24 inches (610 mm) high shall be supported at a point not less than one-half its height. See Figure 8.3.

8.1.7 The wind-resistance area of an ornament or decoration on a freestanding, un-braced air terminal shall not exceed 20 square inches (130 cm^2) in any plane. A ball, 5 inches (127 mm) or less in diameter, complies with this requirement.

8.2 Zone of protection

8.2.1 General

8.2.1.1 The zone of protection is determined by one of the following: 8.2.2, 8.2.3, or 8.2.4.

8.2.2 Air terminal placement

8.2.2.1 When establishing a perimeter zone of protection, the tip of an air terminal shall be at least 10 inches (254 mm) above the object to be protected if the interval between air terminals is not more than 20 feet (6.1 m) and at least 24 inches (610 mm) above the object to be protected, or if the interval between air terminals is more than 20 feet (6.1 m) but not more than 25 feet (7.6 m). See Figure 8.3.

8.2.2.2 When establishing a zone of protection for flat or gently sloping roofs exceeding 50 feet (15.2 m) in width or length, air terminals shall be located at intervals not exceeding 50 feet (15.2 m) on the flat or gently sloping areas. See Figure 8.1. Also see 9.2.2.

8.2.2.3 Air terminals shall be placed as described in 8.1.5 on ridges of ridged roofs, or around the perimeter of a flat or gently sloping roof.

8.2.2.4 A pitched roof with eaves height of 50 ft (15.2 m) or less above grade with no projections shall require protection for the ridge only, where there is no horizontal portion of the building that extends beyond the eaves, other than a gutter. Pitched roofs with eaves height over 50 ft (15.2 m) shall have air terminals located in accordance with 8.1.5 and 8.2.2.

8.2.3 Rolling sphere

8.2.3.1 A zone of protection for a structure may be represented by the area under an imaginary rolling sphere having a radius of 150 feet (45.7 m), under all of the following conditions:

- a) The sphere never touches the building directly;
- b) The sphere is tangent to earth and in contact with properly spaced perimeter air terminals;
- c) The sphere rests on three or more air terminals properly spaced as determined by using the rolling sphere concept so that the sphere never touches the structure; and
- d) All possible placements (meaning three-dimensional) of the sphere shall be considered when determining the zone of protection using the rolling sphere model.

See Figures 8.4, 8.5, 8.6, and 8.7 for a graph and illustrations showing zones of protection and applicable computations determined by using the rolling sphere concept of 8.2.3.

8.2.3.2 A protected building protects lower building sections that lie within its zone of protection described in 8.2.3. An example is shown in Figure 8.7 where two higher protected sections of the building protect a lower section.

8.2.3.3 A protected building that is more than 150 feet (45.7 m) high provides protection for lower roof areas starting at 150 feet (45.7 m) and below when the lower area is located under an arc that has a 150 foot (45.7 m) radius and that is tangent to the side of the protected building and to the earth. See Figure 8.4.

8.2.4 Protective angle

8.2.4.1 A strike termination device that is not more than 25 feet (7.6 m) above earth protects lower areas in a one-to-two zone of protection.

8.2.4.2 A strike termination device that is more than 25 feet (7.6 m) but not more than 50 feet (15.2 m) above earth protects lower areas in a one-to-one zone of protection.

8.3 Dormers

8.3.1 Dormers that are as high or higher than the main roof shall be protected with air terminals, cable, down conductors, and grounds as normally specified in 8.2. Dormers and projections below the main ridge shall have air terminals on all areas extending outside a zone of protection as defined in 8.2. See Figure 9.2.

8.4 Intermediate ridges

8.4.1 A roof with a series of parallel ridges shall have air terminals along the end ridges at intervals not exceeding 20 feet (6 m) for air terminals 10 inches (254 mm) in height; or at intervals not exceeding 25 feet (7.6 m) for air terminals 24 inches (610 mm) in height. See 8.2.2.1. The intermediate area between ridges shall be protected according to the requirements for flat roofs in 8.2.2.2. Any intermediate ridge higher than an end ridge shall be protected in a manner similar to the end ridges. See Figure 8.8.

8.4.2 An air terminal shall be placed within 2 feet (610 mm) of the end of each intermediate ridge. See Figure 8.8.

8.5 Irregular roof lines

8.5.1 The edge of irregular roofs, which also applies to curved buildings, shall be a continuous line of air terminals that are located within 2 feet (610 mm) of the outermost projections of the roof edge at intervals in accordance with 8.2.2.1. See Figure 8.9.

8.6 Open areas

8.6.1 The perimeter of an open area (such as an open court yard) located within a large flat roofed structure shall be protected if the perimeter exceeds 300 feet (91.44 m) and both rectangular dimensions exceed 50 feet (15.24 m).

8.7 Domed or curved roofs

8.7.1 On curved or domed roofs, an air terminal shall be located at the center of the curve or dome with additional air terminals as required to provide a zone of protection determined in accordance with Zone of protection, 8.2.

8.8 Chimneys, vents and roof top metal bodies

8.8.1 Air terminals shall be placed on all chimneys, vents, and roof top metal bodies, including prefabricated metal chimneys, vents, and roof top metal bodies with metal thickness less than 3/16 inch (4.8 mm) – when such chimneys, vents, or roof top metal bodies are not within a zone of protection determined in accordance with zone of protection, 8.2.

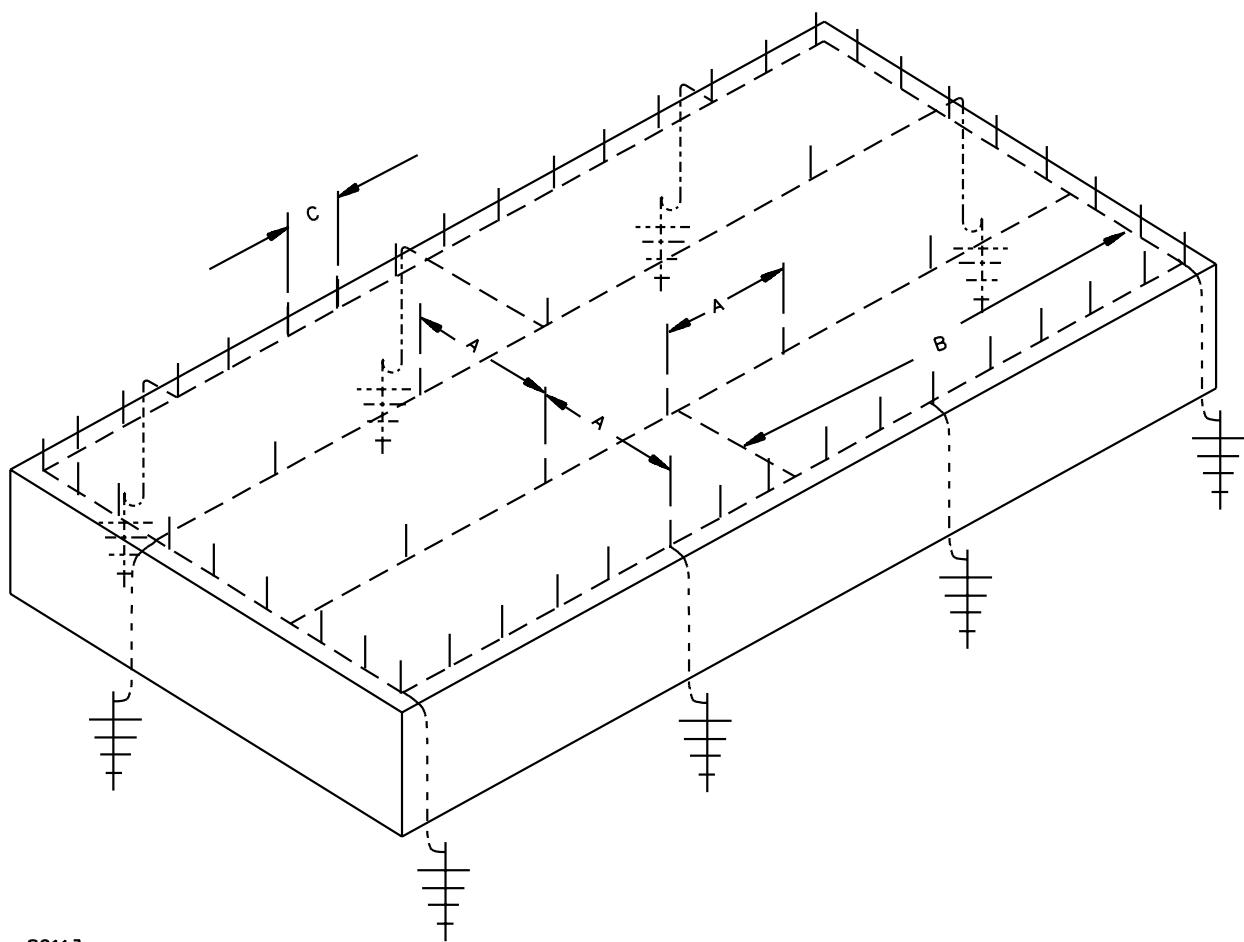
Exception: Metal handrails outside a zone of protection that are 1/8 in (3 mm) thick or more shall not require air terminals when the installation of the air terminals may result in a casualty risk. The handrail shall be bonded as specified in 8.1.1.

8.8.2 Chimneys, vents, or roof top metal bodies that have metal that is 3/16 inch (4.8 mm) thick or more shall only require bonding to the lightning protection system with two paths as required and defined in 8.1.1 and 8.8.3.

8.8.3 With regard to 8.8.1, connections shall be made using a main-size lightning conductor and a main-size bonding plate. See 12.10. The connection shall provide a two-way path to ground as required for air terminals.

8.8.4 Chimneys, vents, and enclosures shall be provided with air terminals so that no outside corner is more than 2 feet (610 mm) from an air terminal. See Figure 8.10.

Figure 8.1
Flat or gently sloping roof



S2113

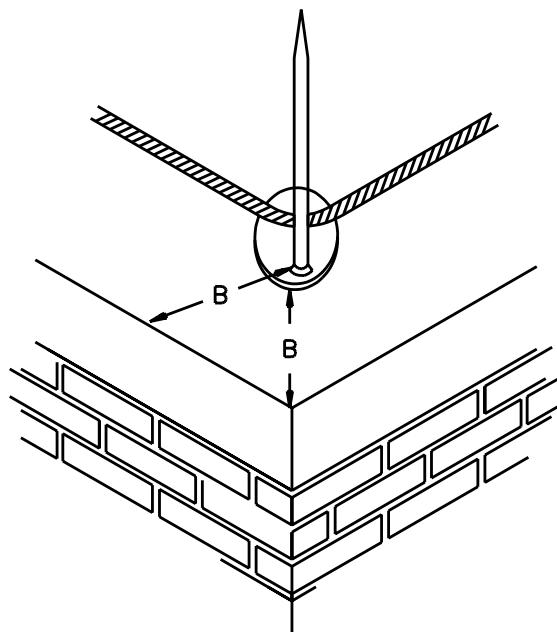
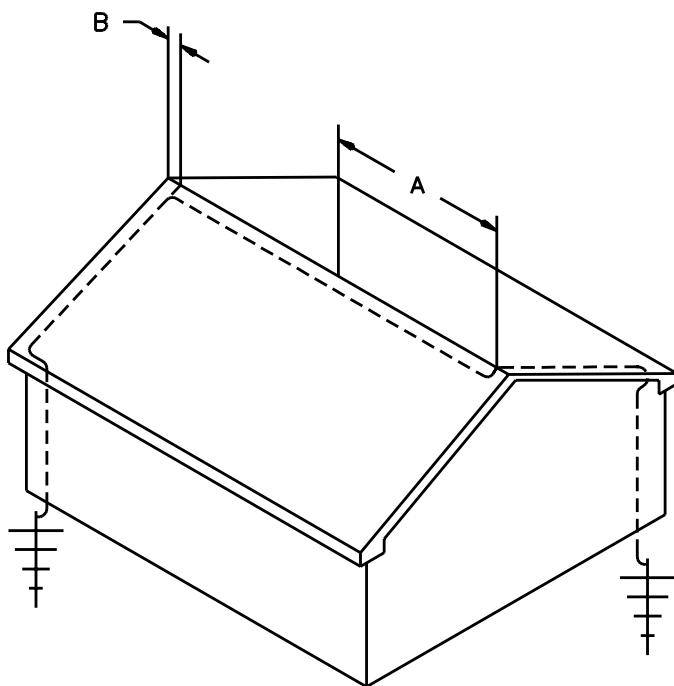
A = 50 feet (15.2 m) maximum spacing between air terminals. See 8.2.2.2.

B = 150 feet (45.7 m) maximum length of cross run conductor permitted without a connection to the main perimeter or down lead conductor. See 9.2.2.

C = Maximum spacing between air terminals along edge. See 8.2.2.1.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

Figure 8.2
Air terminal locations

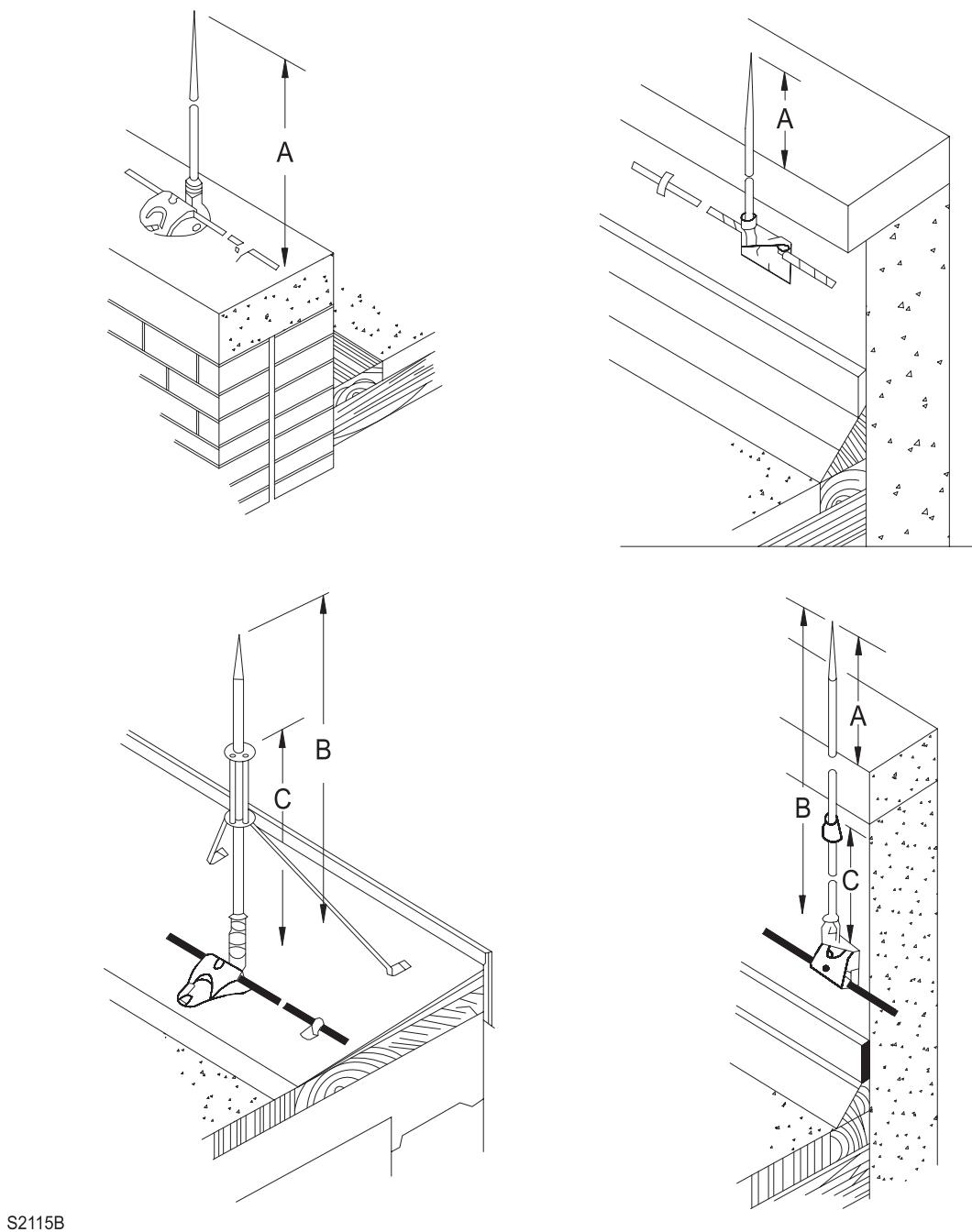


S2114

A = 20 feet (6.1 m) maximum spacing for 10 inch (254 mm) air terminal height or 25 feet (7.6 m) maximum spacing for 24 inch (610 mm) air terminal height.

B = 2 feet (610 mm) maximum spacing from the outside corner, roof edge or ridge end.

Figure 8.3
Air terminals



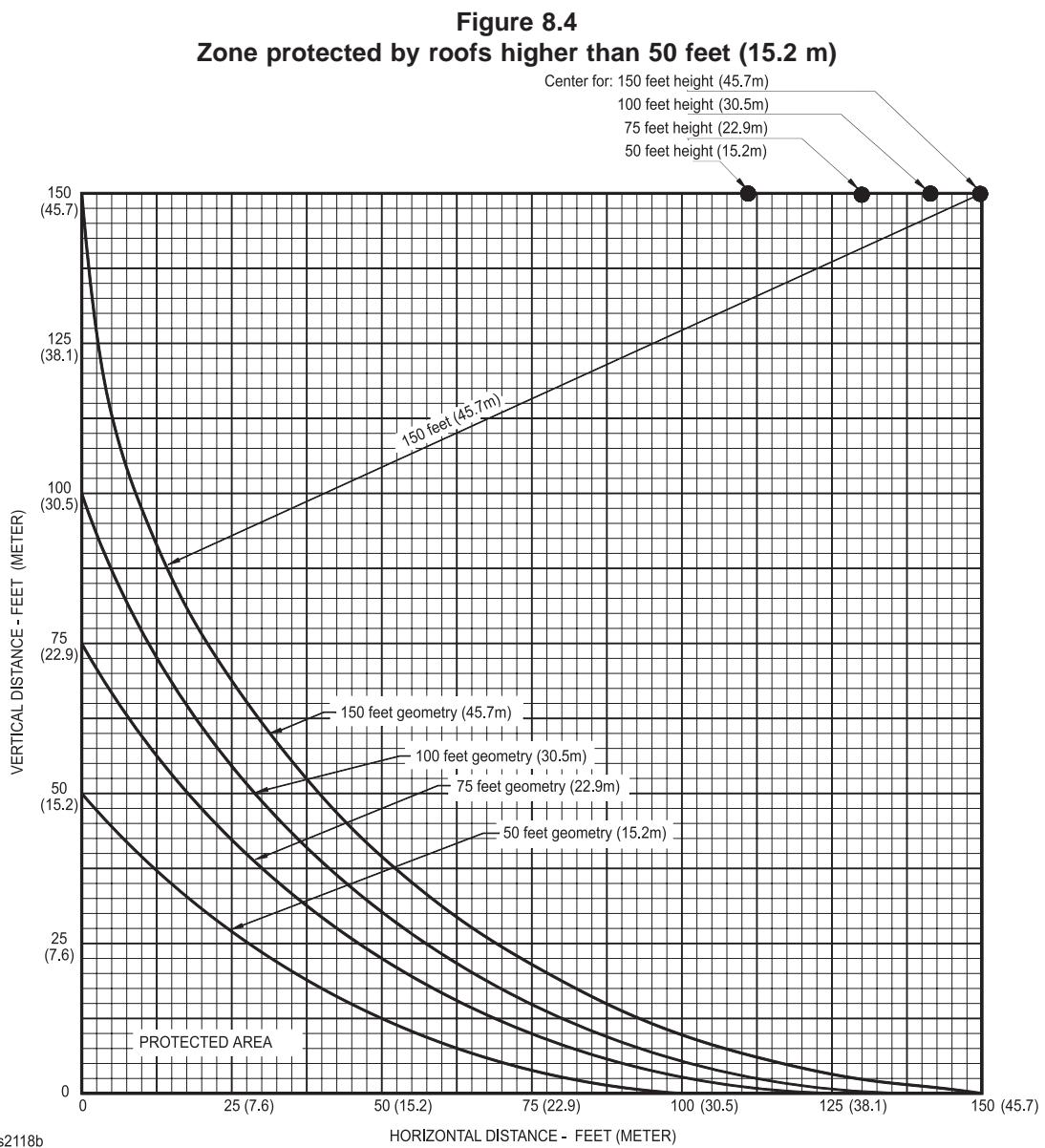
S2115B

A = Air terminal minimum height. See 8.2.2.1.

B = Air terminal total height. See 8.1.6.

C = Air terminal support height. See 8.1.6.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**



- SI values for units in this figure are:

Feet	(m)
25	(7.6)
50	(15.2)
75	(22.9)
100	(30.5)
125	(38.1)
150	(45.7)

- The distance may be determined analytically with the following equation:

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

In which:

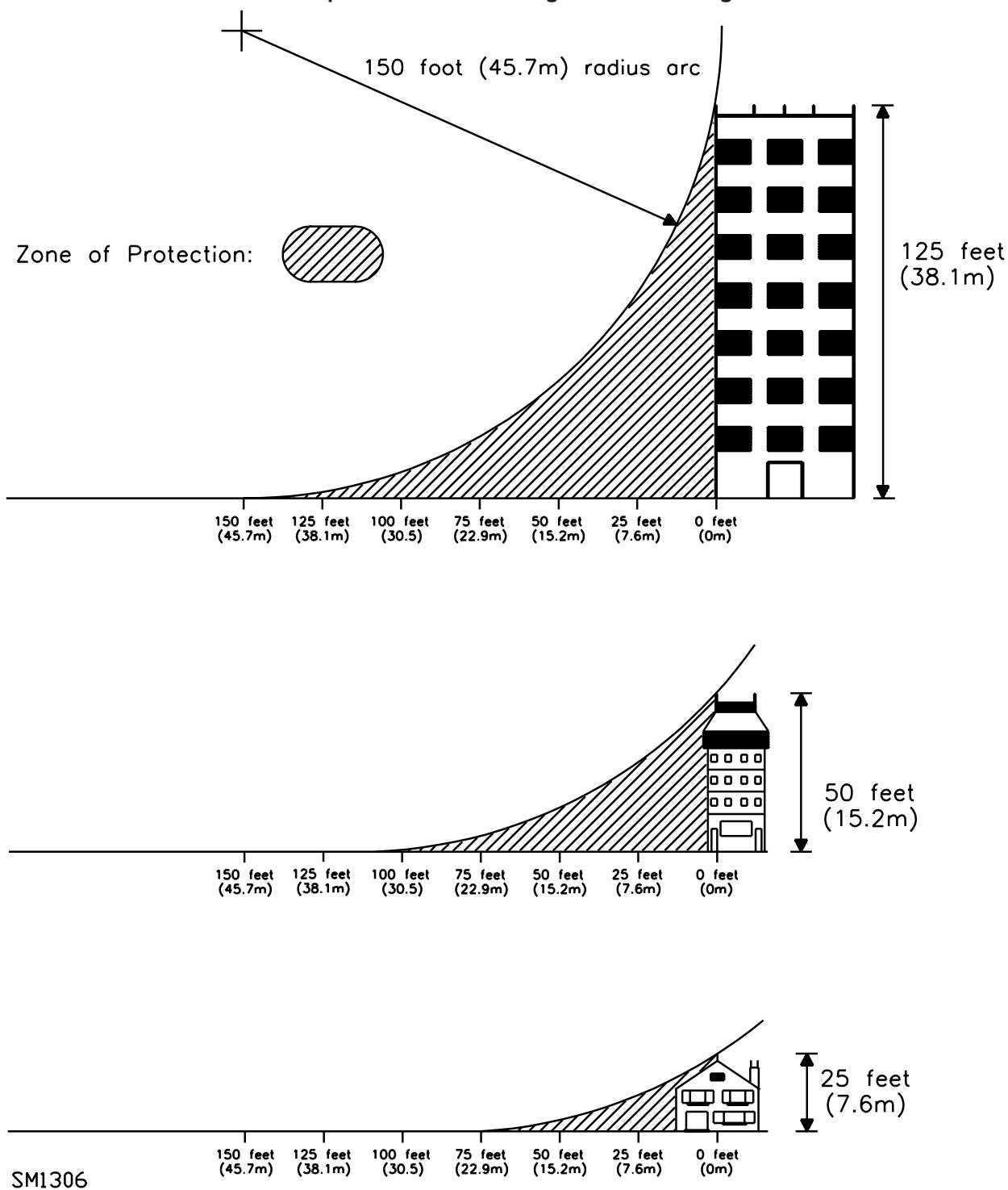
d is the horizontal distance

h₁ is the height of higher roof

h₂ is the height of lower roof

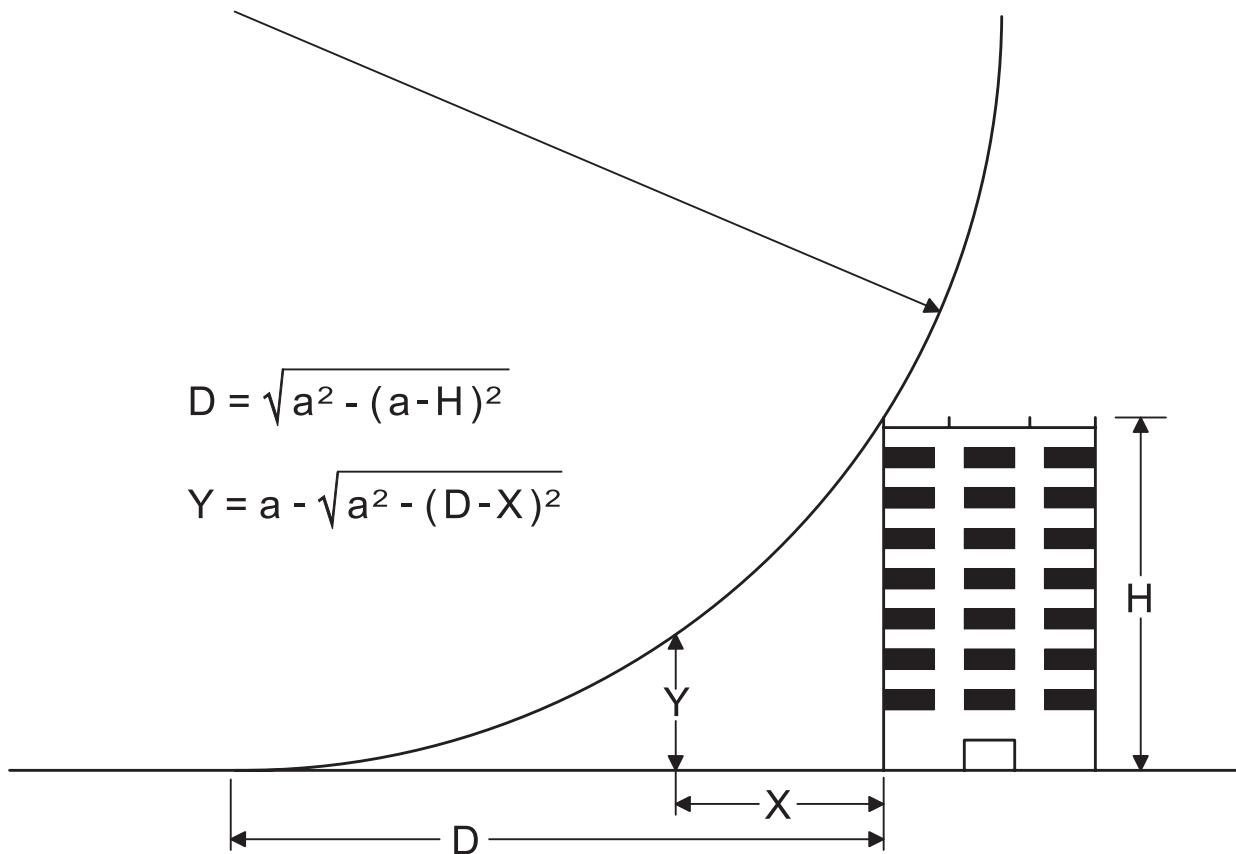
D is the rolling sphere diameter (300 ft (91.5 m))

Figure 8.5
Zone of protection for buildings of various heights



**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

Figure 8.6
Design equations for zone of protection
150 foot (45.7m) radius arc



SM1307b

For the equations in Figure 8.6:

D is the distance measured from the protected building to the intersection of the 150-foot (45.7 m) radius arc and earth.

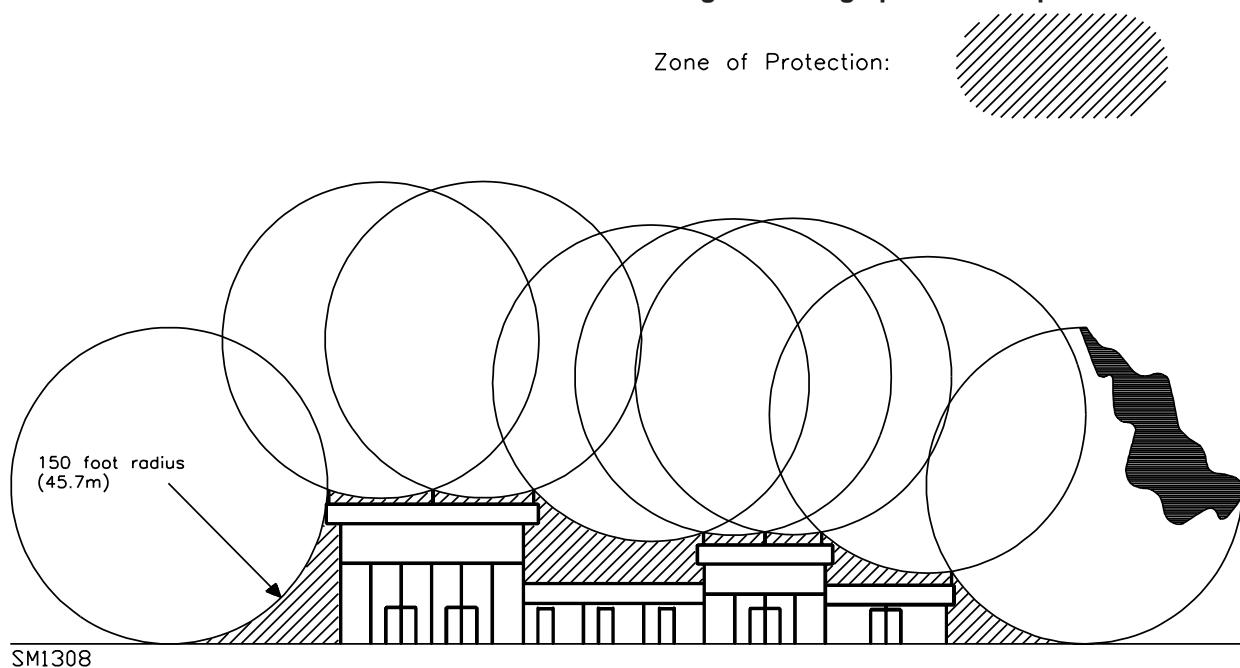
H is the height of the protected building which is required to be less than or equal to 150 feet (45.7 m).

Y is the vertical distance measured from earth to the 150-foot (45.7 m) radius arc with respect to a given distance X.

X is any given distance to determine Y.

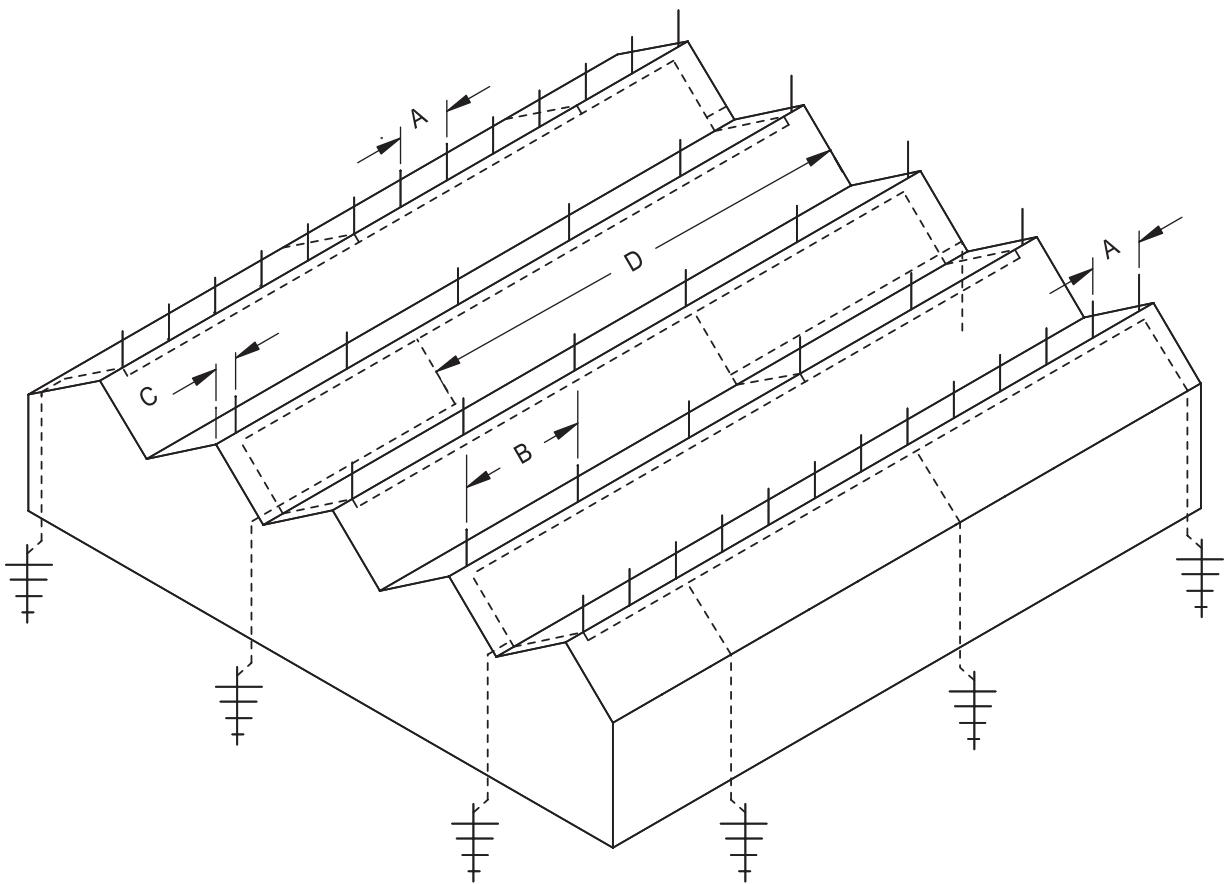
$a = 150$ feet (45.7 m)

Figure 8.7
Protection of lower roof sections utilizing the rolling sphere concept



**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

Figure 8.8
Air terminals and conductors on intermediate ridges



s2119b

Maximum spacing are:

A = 20 feet (6.1 m) or 25 feet (7.6 m). See 8.2.2.1.

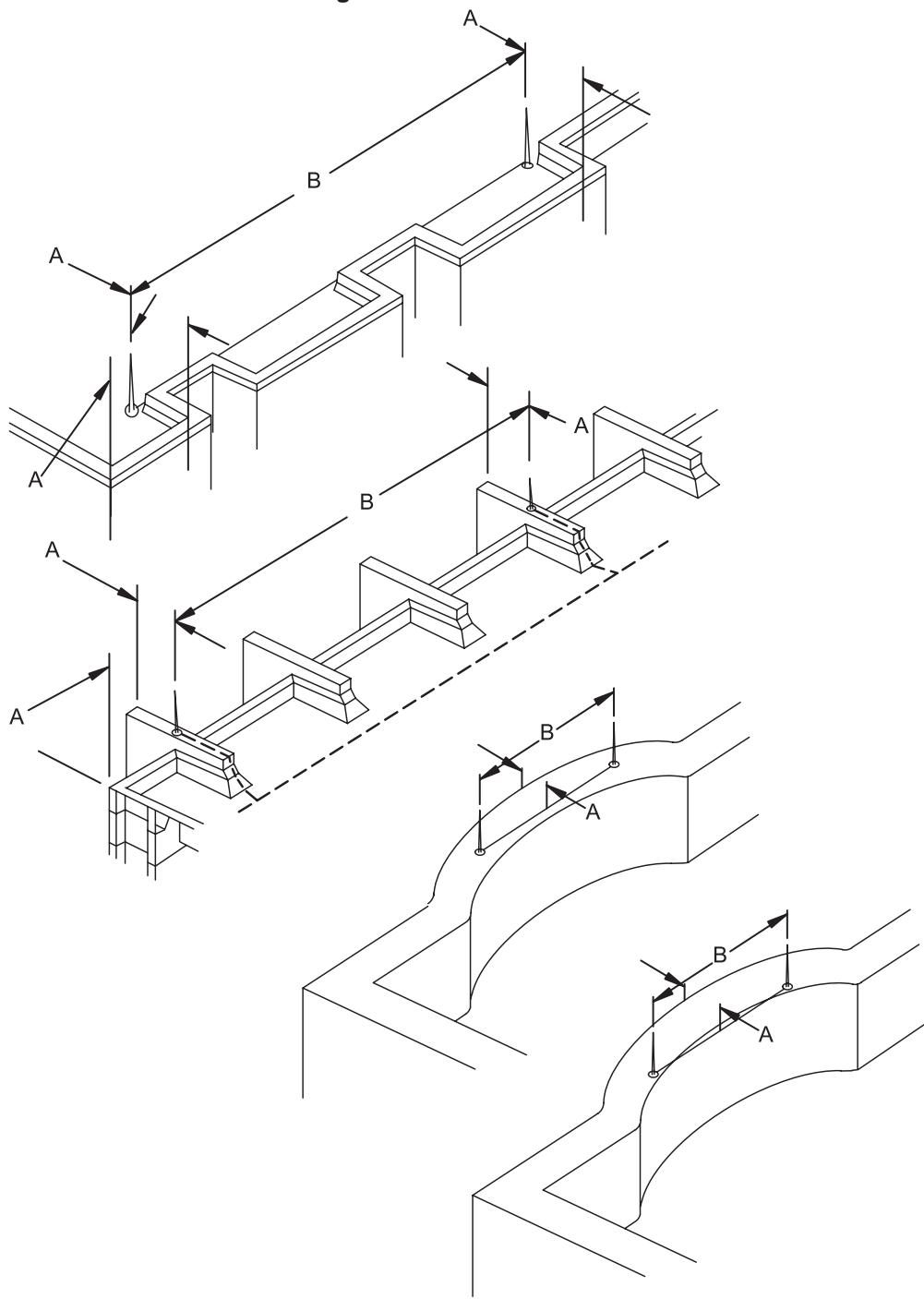
B = 50 feet (15.2 m). See 8.2.2.2.

C = 2 feet (610 mm). See 8.1.5.

D = 150 feet (45.7 m). See 9.2.2.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

**Figure 8.9
Irregular roof lines**

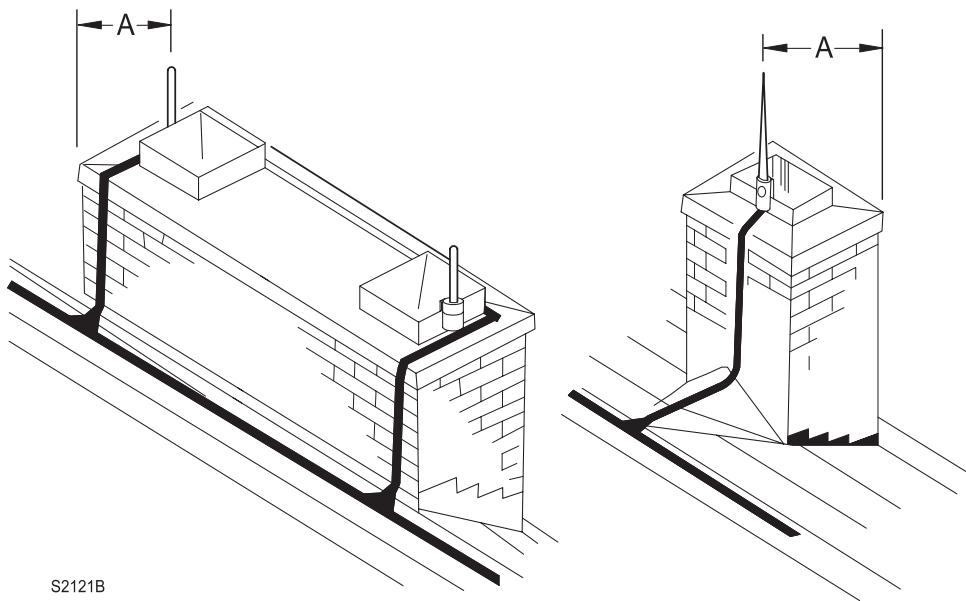


A = 2 feet (610 mm) maximum. See 8.1.5.

B = Maximum spacing between air terminals along edge. See 8.2.2.1.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

**Figure 8.10
Chimneys and vents**



A = 2 feet (610 mm) maximum.

9 Conductors

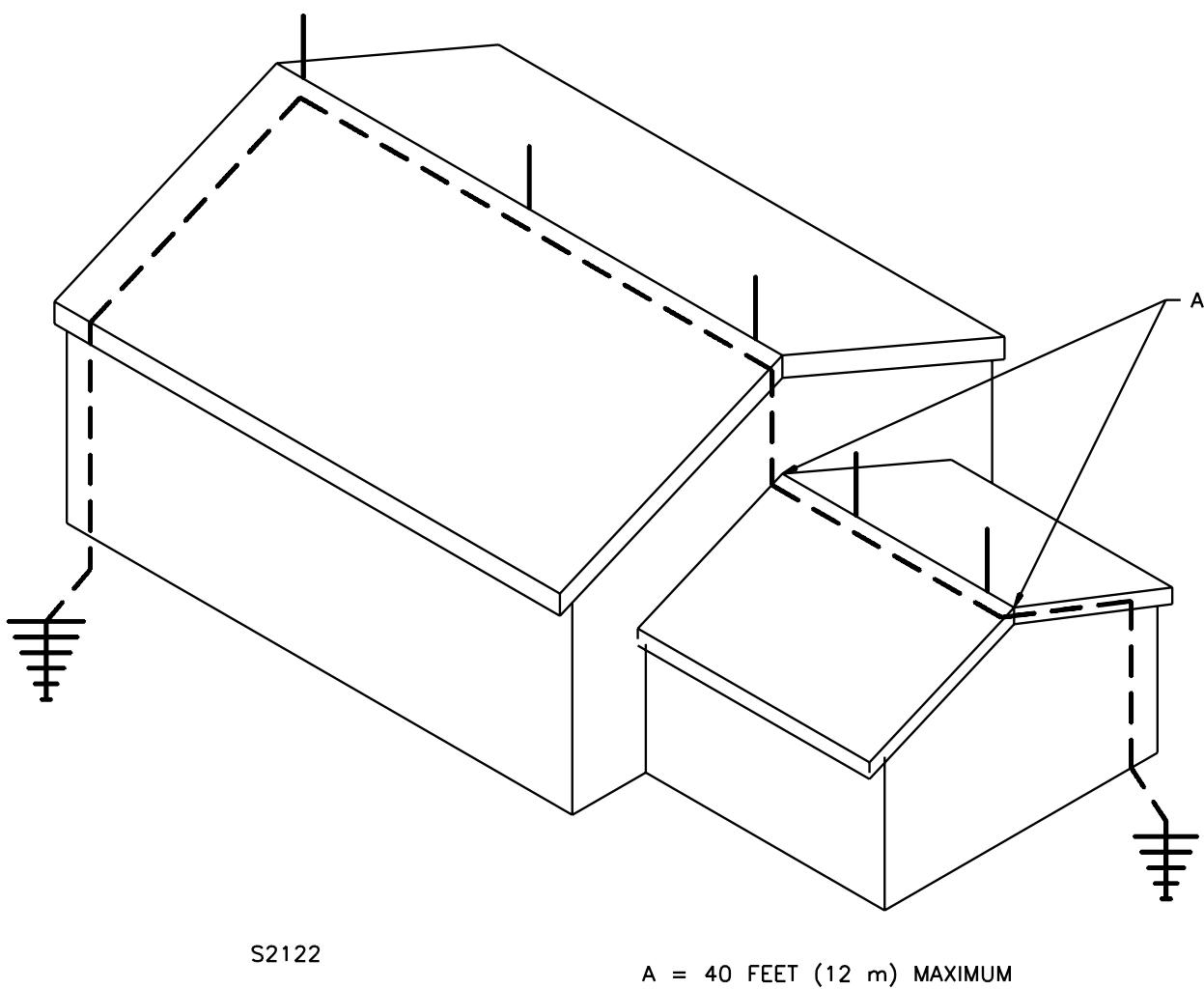
9.1 General

9.1.1 Main-sized conductors shall interconnect all air terminals and shall form a two-way path from each air terminal horizontally or downward to connections with grounding electrode.

Exception No. 1: Conductor drops from a higher to a lower roof level without an extra down conductor comply with this requirement when the lower roof conductor horizontal run does not exceed 40 feet (12.2 m). See Figure 9.1.

Exception No. 2: Air terminals that are dead ended with only one path to a main conductor on the main protected level comply with this requirement when the total length of the conductor run from the air terminal to a main conductor is not more than 8 feet (2.4 m) and the conductor maintains a horizontal or downward coursing path. On a secondary lower roof this length shall not be more than 16 feet (4.9 m). See Figure 9.2.

Figure 9.1
Ridge conductor drops from higher to lower roof levels

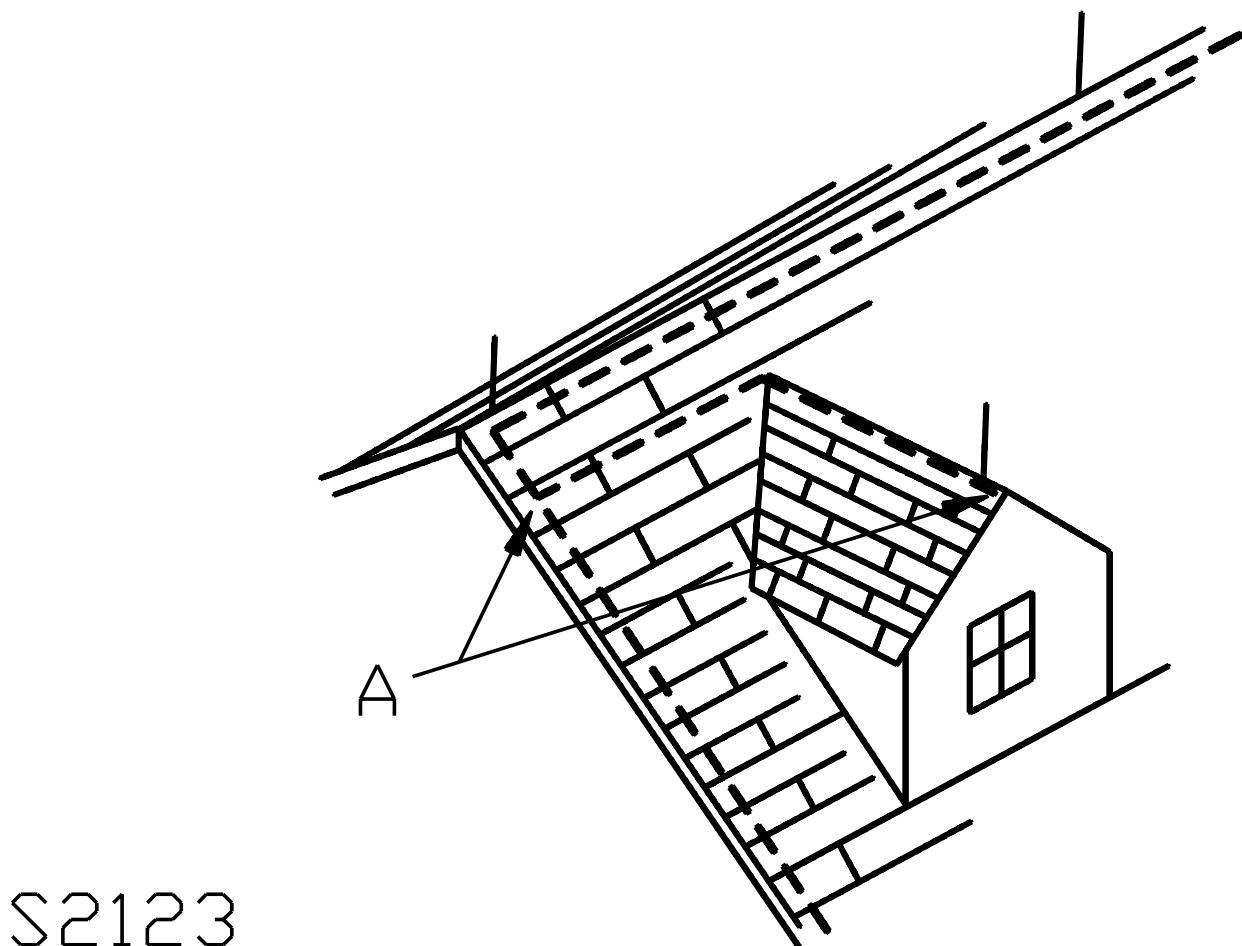


Document Was Downloaded By Keith Sterling For Use By STORM SHIELD LIGHTNING RODS

26045 : 12/10/2008 - 11:38 AM

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

Figure 9.2
Dead end



A = Dead end conductor on a secondary lower roof. Total length 16 feet (4.9 m) maximum. See Exception No. 2 to 9.1.1.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

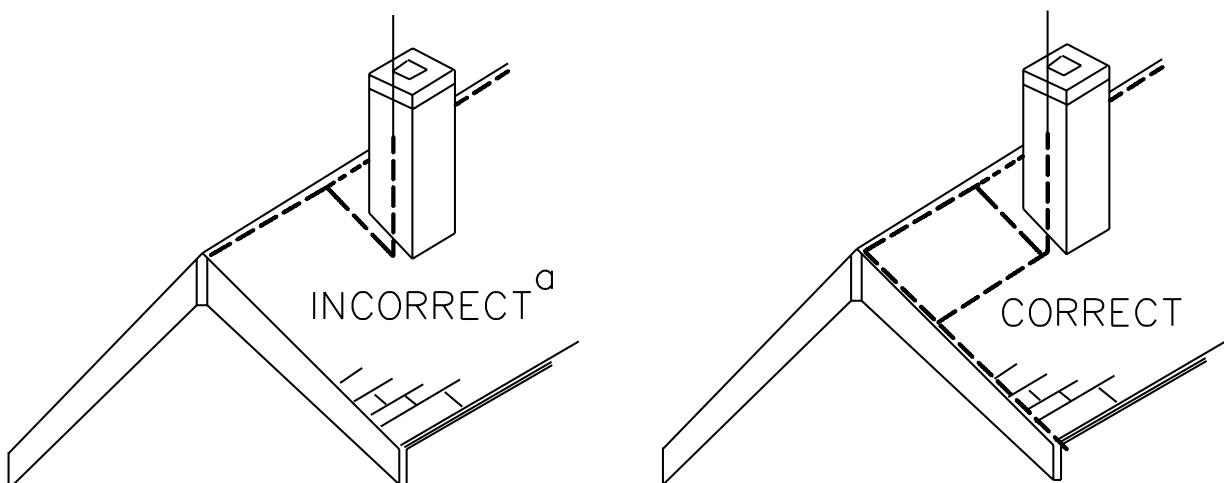
9.1.2 Metal roofing and siding having a metal thickness less than 3/16 inch (4.8 mm) shall not be substituted for the main conductor. Replaceable parts such as eave troughs, downspouts, ladders, handrails or chutes shall not be substituted for the main conductor.

Exception: Permanent metal handrails that are electrically continuous where the minimum thickness is 0.064 in (1.63 mm) or more shall be permitted to be substituted for main conductors.

9.1.3 Conductors shall maintain a horizontal or downward course, free from "U" or "V" (down and up) pockets. See Figure 9.3.

Exception: Conductors coursing at no more than 3 inches of rise in 12 inches of run are permissible.

Figure 9.3
U and V pockets



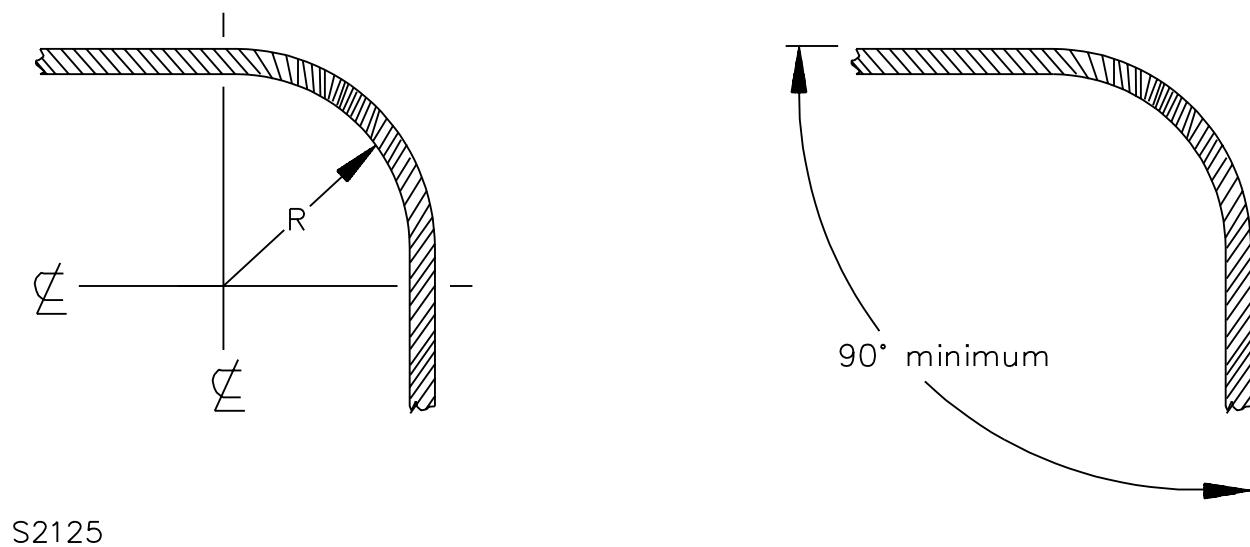
S2124A

^a See 9.1.3.

9.1.4 No bend of a conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches (203 mm). See Figure 9.4.

Exception: "T" splice and through roof and wall connectors need not comply with this requirement.

**Figure 9.4
Bends**



S2125

R = Radius of bend, 8 inches (203 mm) minimum. See 9.1.4.

9.1.5 A conductor shall not be run through air without support for a distance of more than 3 feet (0.91 m). For a distance greater than 3 feet (0.91 m), the conductor shall be rigidly supported for the entire distance.

9.2 Roof conductors

9.2.1 Roof conductors shall be run along ridges of gable, gambrel and hip roofs and around the perimeter of flat and gently sloping roofs. Conductors shall be run through or around obstructions, such as cupolas and ventilators in a horizontal plane with the main conductor.

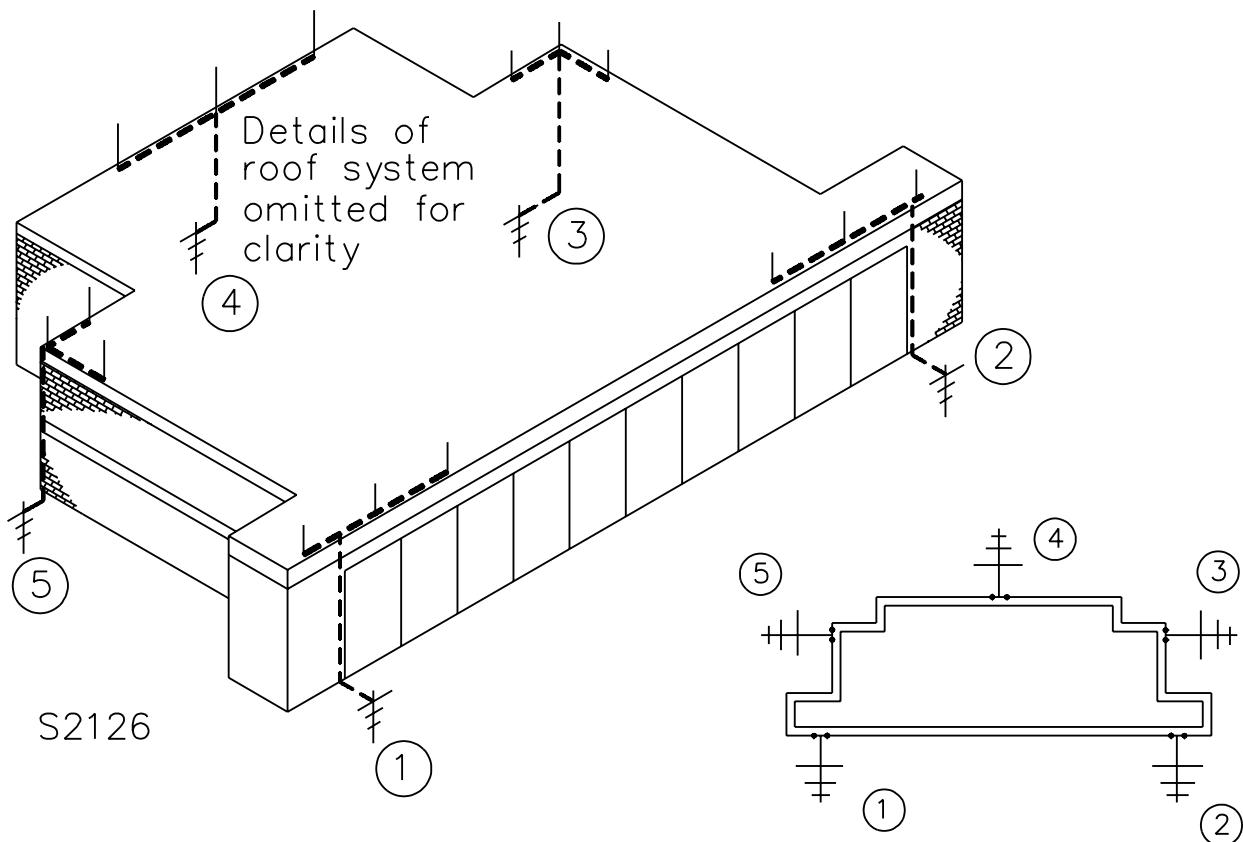
9.2.2 Main size cross run conductors shall be provided to interconnect the air terminals on flat or gently sloping roofs as required by 8.1.4. These cross-run conductors shall be connected to main perimeter conductors or down conductors at intervals not exceeding 150 feet (45.7 m). See Figure 8.1.

9.3 Down conductors

9.3.1 Down conductors shall be as widely separated as practical and located at the perimeter, outer most walls, of a structure. Their location depends on such factors as: the placement of air terminals; the most direct coursing of conductors; earth conditions; security against displacement; the location of large metallic bodies; and the location of underground metallic piping systems.

9.3.2 At least two down conductors shall be installed regardless of the kind of structure, including steeples except as permitted in Section 16, General. Structures exceeding 250 feet (76.2 m) in perimeter shall have a down conductor for every 100 feet (30.5 m) of perimeter or fraction thereof. The total number of down conductors shall be such that the average distance between all down conductors does not exceed 100 feet (30.5 m), (including the first 250 feet (76.2 m) of perimeter). When determining the perimeter of a structure, only the perimeter of the roof area requiring protection is to be measured. Lower roofs or projections which are located within a zone of protection are to be excluded. See Figure 9.5. When determining the perimeter of a pitched roof structure, measuring the horizontal projection (footprint) of the roof meets the intent of this requirement.

Figure 9.5
Down conductors



S2126

Spacings:	Feet	(m)
1 – 2	130	(39.6)
2 – 3	85	(25.9)
3 – 4	85	(25.9)
4 – 5	85	(25.9)
5 – 1	85	(25.9)
Total Perimeter:	470	(143.3)
Required Down Conductors (Grounds):	5	
See 9.3.2.		

UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

9.3.3 Each down conductor located in a runway, driveway, school playground, cattle yard, public walk, or other similar location shall be protected from mechanical damage or displacement. A conductor that runs through metal pipe or tubing shall be bonded to both ends of the pipe or tubing. The down conductor shall be protected for a minimum distance of 6 feet (1.8 m) above grade level. See 7.4.

9.3.4 A down conductor entering corrosive soil shall be protected from corrosion by a protective coating for a distance not less than 3 feet (914 mm) above grade level and for the entire length below grade level.

9.3.5 A down conductor shall not be routed within a downspout, or be wholly or partially supported by a downspout.

9.4 Interconnecting conductors

9.4.1 A main-sized conductor and bonding connector shall be used for interconnection of metallic water systems, steam or hot water heating systems, sprinkler pipes, electric service, telephone systems, antenna grounds, and other large grounded metallic masses.

9.4.2 A secondary bonding conductor shall not be smaller than 6 AWG (13.3 mm²) copper or equivalent.

10 Grounding

10.1 General

10.1.1 Each down conductor shall terminate in a grounding electrode.

10.1.2 Grounding electrode placement and configuration shall be any combination of the specifications outlined in this section.

10.1.3 Grounding electrodes shall be solid wire or strip, rod, solid plate, concrete-encased electrodes, ground ring electrode (loop conductor), or trenched electrode. The use of stranded cable as a grounding electrode shall be limited to a concrete-encased electrode, ground ring electrode (loop conductor), or trenched electrode.

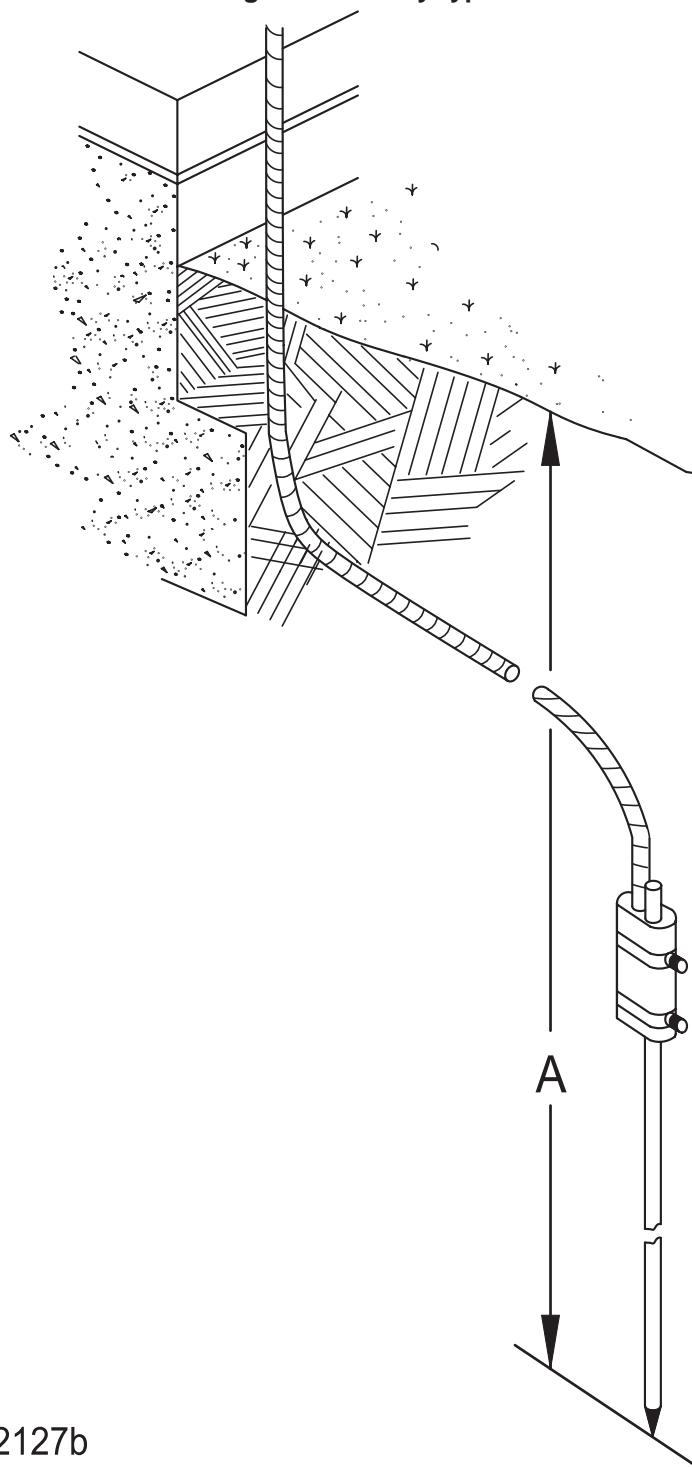
10.1.4 Each ground rod shall be not less than 1/2 inch (12.7 mm) in diameter and not less than 8 feet (2.4 m) long and shall be made of copper-clad steel, solid copper, stainless steel, or stainless steel clad.

10.1.5 Ground rod connections shall be made by main size clamp type connectors, by welding, or by brazing. Clamps shall make contact with the ground rod and conductor for a distance of not less than 1-1/2 inches (38 mm) measured parallel to the axis of the ground rod. Clamps shall be secured with at least two bolts or machine screws. Welded connections shall have a weld area at least two times the cross-sectional area of the conductor.

10.1.6 Grounding electrodes shall be located at least 2 feet (610 mm) from the foundation wall. Ground rods shall extend vertically not less than 10 feet (3 m) into the earth. The earth shall be compacted and made tight against the full length of the conductor or grounding electrode. See Figure 10.1.

10.1.7 Where not practicable to locate grounding electrodes outside the foundation, they shall be permitted to be located internally to the structure as near as possible to the perimeter.

Figure 10.1
Grounding in moist clay type soil



s2127b

A = 10 feet (3 m) minimum.

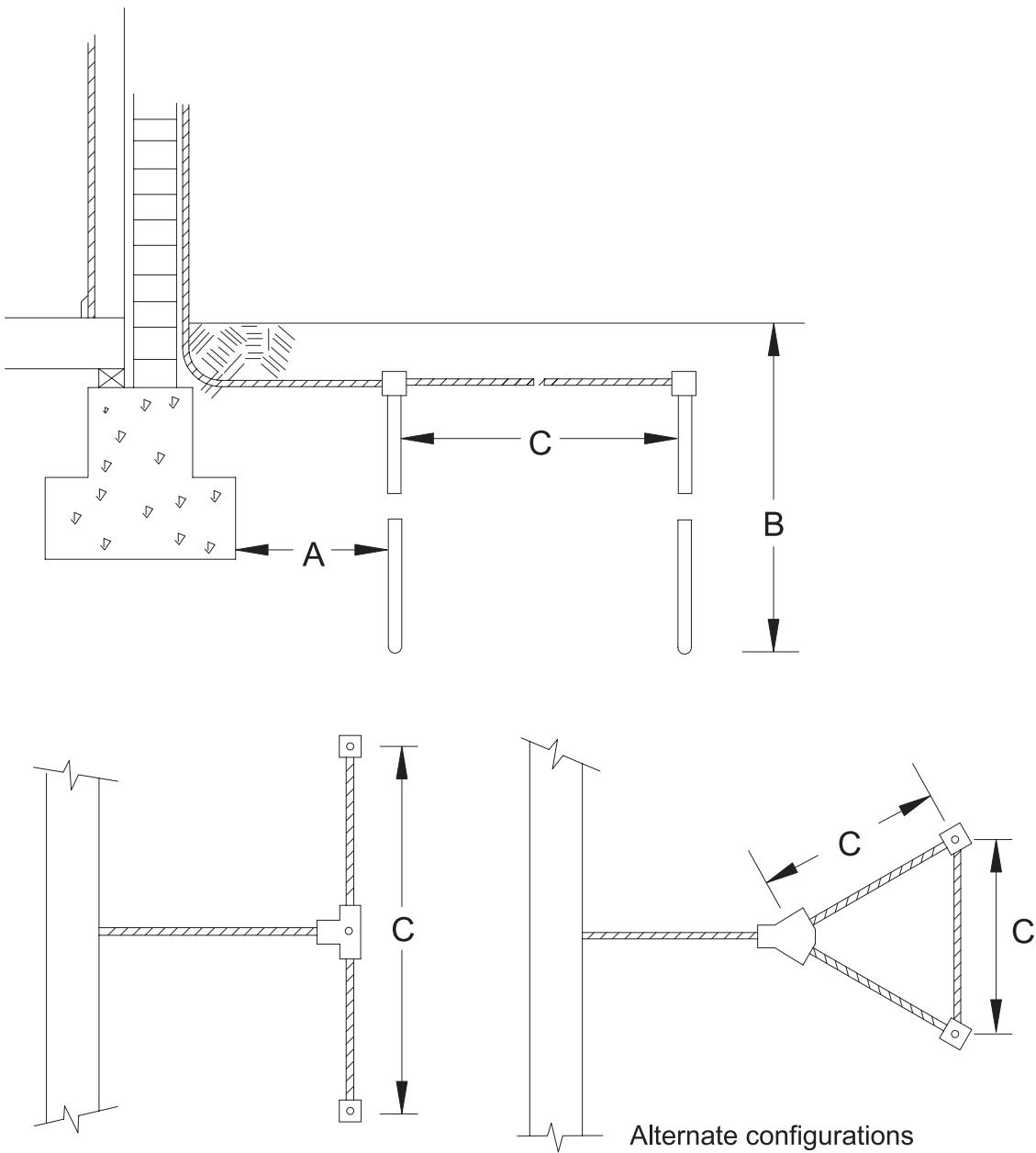
**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

10.2 Multiple ground rods

10.2.1 Where multiple ground rods are used, the minimum separation between any two rods shall be equal to the sum of the rods length. Each rod shall be driven vertically to a depth of 10 feet (3 m) or more below grade. See Figure 10.2.

10.2.2 Where sand or gravel soil conditions exist, multiple ground rods shall be used as specified in 10.2.1.

Figure 10.2
Multiple ground rods



s2128b

A = 2 feet (610 mm) minimum.

B = 10 feet (3.0 m) minimum.

C = The sum of the length of the rods length.

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

10.3 Shallow topsoil

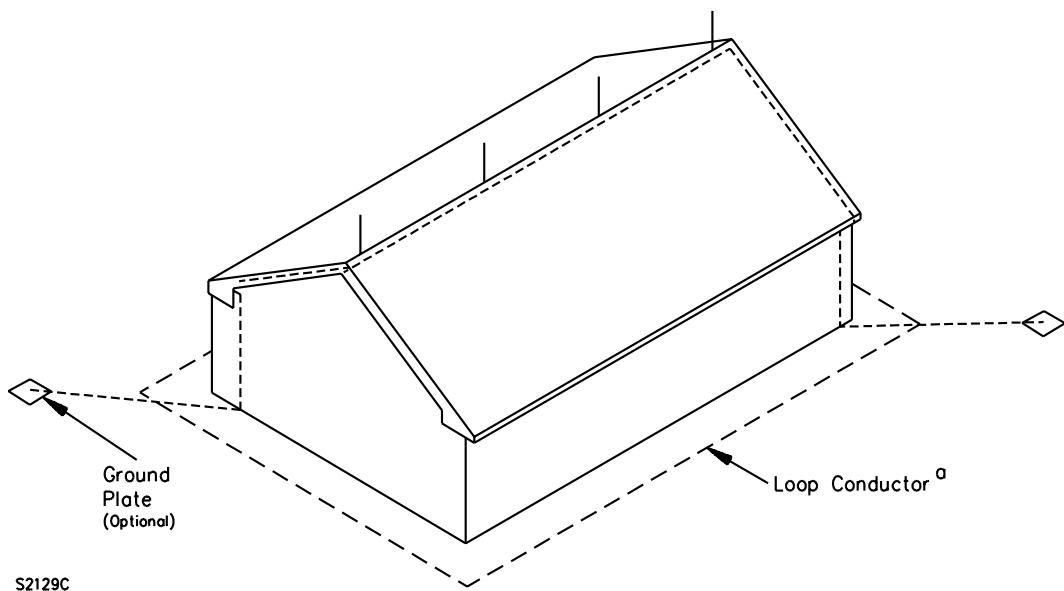
10.3.1 If bedrock is near the surface, the conductor shall be laid in trenches extending away from the building at each down conductor. These trenches shall be at least:

- a) 12 feet (3.7 m) long and 2 feet (610 mm) deep in clay soil; and
- b) 24 feet (7.3 m) long and 2 feet (610 mm) deep in sandy or gravelly soil.

Exception: If these methods are impracticable, main-size conductor may be laid in trenches 2 feet (610 mm) deep, or directly on the bedrock when the bedrock is less than two feet below the surface; a minimum distance of 2 feet (610 mm) from the foundation or exterior footing and terminate by attachment to a buried copper ground plate that is at least 0.032 inch (0.8 mm) thick and has a minimum surface area of 2 square feet (0.18 m^2).

10.3.2 If the soil is less than 1 foot (305 mm) deep, the structure shall be encircled with a main-sized conductor (a loop conductor) laid in a trench or in rock crevices. Copper ground plates, as specified in the Exception to 10.3.1, are optional. See Figure 10.3.

Figure 10.3
Ground ring and grounding in soil less than 1 foot (305 mm) deep



^a See 10.3.2

10.4 Common grounds

10.4.1 Each grounding system shall be bonded together. This includes electric, telephone, and antenna system grounds, metal well casings within 25 feet (7.6 m) of the protected structure, and underground metallic piping systems that enter the structure. These systems include water service, gas piping, underground conduits, underground liquefied petroleum gas piping systems, sprinkler systems, fuel oil lines, tank and tank lines, and similar piping systems.

10.4.2 If electric, telephone or other systems are grounded to a metallic water pipe, only one bonding connection to the water pipe system is required provided the water pipe is electrically continuous between all systems. If it is not electrically continuous because of the use of plastic pipe sections or for other reasons, the nonconductive sections shall be bridged with main-sized conductors, or the bonding connections shall be made at a point where there is electrical continuity.

Exception: Common bonding of other grounded services may be achieved if interconnected with the water piping system or bonding buss as long as the water piping/bonding buss are bonded with a full size lightning conductor. Connections between the grounded services and their water pipe ground connection or bonding buss needs only to be sized as recommended by their own grounding requirements, for example, the National Electrical Code, ANSI/NFPA 70.

10.4.3 Main-sized conductors and connectors shall be used for common ground connections.

10.5 Concrete-encased electrodes

10.5.1 Concrete-encased electrodes shall be used only in new construction and are to be utilized in addition to other grounding methods (e.g. ground rods, ground plates, and ground rings) as specified in 10.1.

10.5.2 The electrode shall be located near the bottom of a concrete foundation or footing that is in direct contact with the earth and shall be encased by not less than 2 inches (50 mm) of concrete.

10.5.3 The encased electrode shall consist of one of the following:

- a) Not less than 20 feet (6.1 m) of bare copper main-size conductor; or
- b) At least 20 feet (6.1 m) of one or more steel reinforcing bars or rods not less than 1/2 inch (12.7 mm) in diameter that have been effectively bonded together by either welding or overlapping 20 diameters and wire-tying.

10.6 Ground ring electrode

10.6.1 A ground ring electrode encircling a structure shall be in direct contact with earth at a depth of not less than 18 inches (460 mm) and at a minimum distance of 2 feet (610 mm) from the foundation wall or encased in a concrete footing in accordance with 10.5.3.

Exception: Compliance with 10.3 satisfies this requirement.

10.6.2 The ground ring electrode shall be a main-size lightning conductor.

11 Metal Bodies Subject to Direct Strikes

11.1 Each metal body having a thickness of 3/16 inch (4.8 mm) or more, that is as high as or higher than adjacent air terminals shall be connected to the lightning protection system as defined in 8.1.4 unless located entirely within a zone of protection.

11.2 A power air handling unit (domed, square, or rectangular) less than 3/16 inch (4.8 mm) thick, with a surface area or volume less than 400 square inches (0.258 m^2) or 1000 cubic inches (0.016 m^3) shall have air terminals and cable connections to the main system as defined in 8.1.4 unless located entirely within a zone of protection. See Figures 11.1 and Figure 11.2 as applicable.

Figure 11.1

Example of a power air handling unit less than 3/16 inch (4.8 mm) thick with surface area or volume less than 400 square inches (0.258 m^2) where the air terminal is dead ended

(See Exception 2 to 9.1.1)

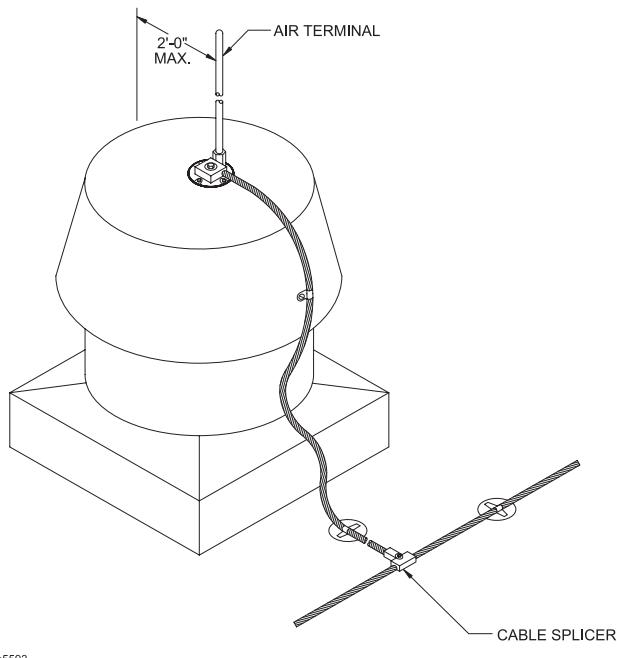
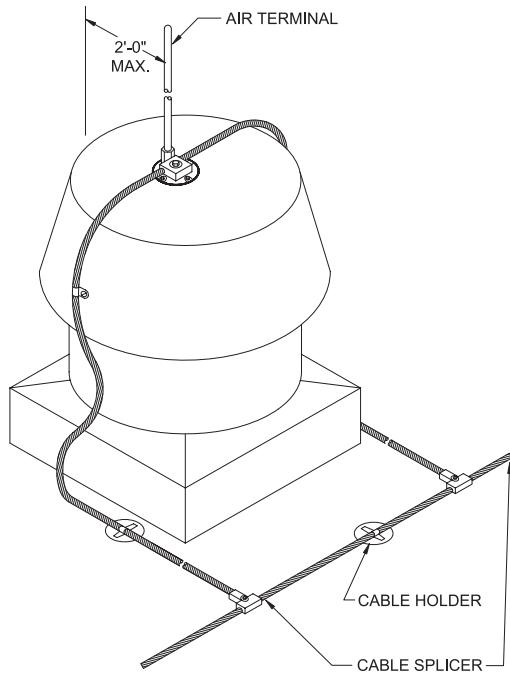


Figure 11.2

Example of a power air handling unit less than 3/16 inch (4.8 mm) thick with surface area or volume less than 400 square inches (0.258 m²)

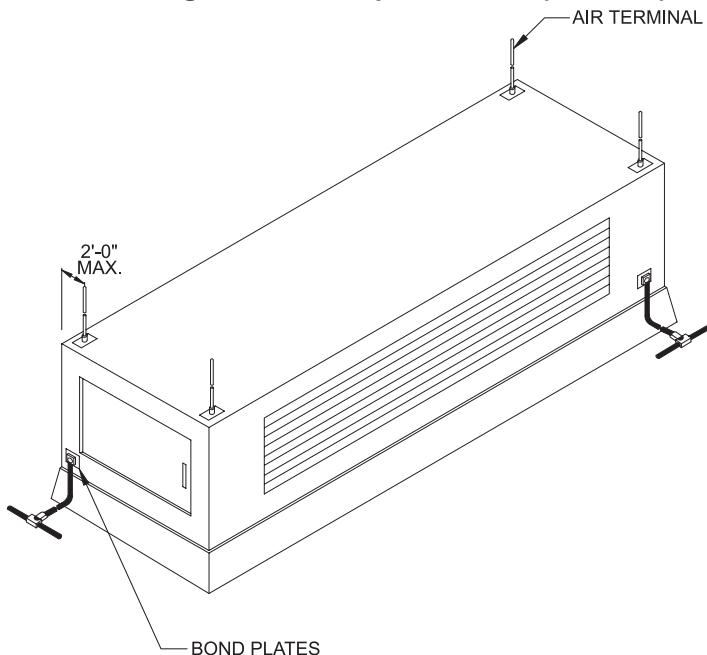


s5594

11.3 A power air handling unit less than 3/16 inch (4.8 mm) thick, with a surface area or volume larger than 400 square inches (0.258 m²) or 1000 cubic inches (0.016 m³) shall have air terminals installed, and shall have a minimum of two main-size bonding plates with cable connections to the main system. The number of air terminals installed shall be such that no outside part of the vent is more than 2 feet (610 mm) away from an air terminal. See Figure 11.3.

Exception: Locating an air terminal so that the unit is within a zone of protection, in accordance with Air Terminals, Section 8, meets the intent of this requirement.

Figure 11.3
Example of a power air handling unit less than 3/16 inch (4.8 mm) thick with a surface area or volume larger than 400 square inches (0.258 m²)



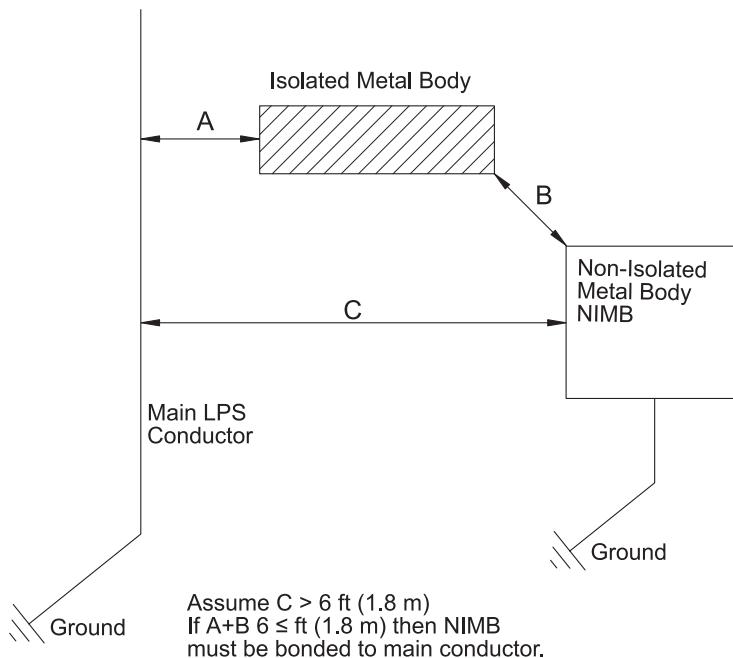
S5595

11.4 Grounded metal bodies that are within 6 feet (1.8 m) of the main conductor shall be bonded to the system.

11.5 Grounded metal bodies that are more than 6 feet (1.8 m) from the main conductor where an isolated metal body will influence the distance shall comply with 11.6.

11.6 Where the sum of the distances between an isolated metal body and a grounded metal body and the distance between this isolated metal body and the main conductor is less than 6 feet (1.8 m) as illustrated in Figure 11.4, bonding from the grounded metal body to the main conductor is required.

**Figure 11.4
Metal bodies**



S5260B

11.7 Isolated metal bodies that show no conductance to ground shall not require bonding.

Exception: For down conductors, only grounded metal bodies that are within the first 6 feet (1.8 m) of the main conductor shall be bonded to the system. Isolated metal bodies that comply with 11.7 need no further bonding.

11.8 A grounded metal body shall be bonded at the closest point to the system using bonding conductors and fittings. See 9.4.2 and Table SA1.2 for secondary conductors. See 12.11.

12 Connectors and Fittings

12.1 Conductor fasteners shall be spaced not more than 3 feet (914 mm) apart and shall be securely attached to the building or other object upon which they are placed.

12.2 Fasteners shall not be subject to breakage and shall be secured with nails, screws, bolts, of the same material as the conductor or adhesives or other material that has no tendency towards electrolytic corrosion in the presence of moisture because of contact between the different parts. See 7.2.

12.3 For membrane roofs, air terminal base fittings shall be secured to the roofing system using an adhesive that is compatible with the roof material. Cables shall be secured every 3 feet (914 mm) by securing with fasteners complying with the Standard for Lightning Protection Components, UL 96.

12.4 A masonry anchor shall have a diameter of 1/4 inch (6.4 mm) or more, and shall be set so that it does not come loose.

12.5 A hole to receive the shank of a fastener or fitting shall be of correct size, and made in the brick or stone rather than in the mortar joints. The fit shall be tight to protect against moisture and the effect of frost.

12.6 A connector fitting shall be used on each lightning conductor at each end-to-end, T, or Y splice.

12.7 Fittings for connection to metal tracks, gutters, downspouts, ventilators, chimney extensions, or other metal parts on the structure shall be made attached to the object by compression under bolt heads.

12.8 Connections and fittings shall be rated for use with the conductor and the surfaces on which they are installed. Bimetallic connectors and fittings shall be used for splicing or bonding dissimilar metals. Constructions involving dissimilar metals shall comply with 7.2.

12.9 Aluminium materials shall not be used within 18 inches (460 mm) of the point where the lightning protection system conductor comes into contact with the earth.

12.10 A main-sized bonding plate/connector shall have a surface contact area of not less than 3 square inches (1900 mm^2) except as noted in 15.4.

12.11 A secondary bonding plate/connector shall have a surface contact area not less than the cross-sectional area of the secondary cable.

12.12 All connectors and bonding plates shall be attached to a clean metal surface.

12.13 Class I installations may have crimp type connectors, bolted clamps, splicers of stamped or cast metal.

12.14 Class II installations shall have bolted clamps and splicers of stamped or cast metal. Crimp type connector or splicers shall not be used.

13 Surge Protection

13.1 A surge protective device complying with the Standard for Transient Voltage Surge Suppressors, UL 1449 and ANSI/IEEE C62.11, Standard for Metal – Oxide Surge Arresters for AC Power Circuits installed on the supply or load side of the service disconnect overcurrent protection in accordance with Article 285 (Type 1 SPD) of the National Electrical Code, ANSI/NFPA 70, or a Transient Voltage Surge Suppressor marked for LPS application, installed on the load side of the service disconnect overcurrent protection in accordance with Article 285 (Type 2 SPD) of the National Electrical Code, ANSI/NFPA 70 shall be installed on each electric service entrance. Type 1 or Type 2 Surge Protective Devices (SPDs) rated 20 kA or more nominal discharge current (I_{n}) in accordance with the Standard for Surge Protective Devices, UL 1449, installed in accordance with Article 285 of the National Electrical Code, ANSI/NFPA 70, may also be used in this application.

13.2 Surge protection suitable for the application shall be provided for all conductive signal, data, and communication lines at the point of entrance. The protection provided shall be installed in accordance with Articles 800, 810, 820, or 830 (as applicable) of the National Electrical Code, ANSI/NFPA 70 and shall comply with the Standard for Antenna-Discharge Units, UL 452, the Standard for Protectors for Paired-Conductor Communications Circuits, UL 497, and the Standard for Protectors for Coaxial Communications Circuits, UL 497C.

13.3 Surge arresters for use on circuits over 1 KV, 48 – 60 Hz, installed in accordance with Article 280 of the National Electrical Code, ANSI/NFPA 70, shall be acceptable for the particular application and comply with ANSI/IEEE C62.11, Standard for Metal – Oxide Surge Arresters for AC Power Circuits or ANSI/IEEE C62.1, Standard for Gapped Carbide Surge Arresters for AC Power Circuits.

14 Concealed Installations

14.1 Concealed installations shall comply with the requirements of this standard including fastening in accordance with 12.1. Conductors shall be run the same except that it is acceptable to run the conductors under roofing material, under the roof framing, behind an exterior wall facing, between studding of partitions or outside walls, in concealed or embedded conduit, or for copper conductors only, to embed the copper conductor directly in concrete. If a conductor is run in metal conduit, it shall be bonded to the conduit at the points where it enters and where it emerges from the conduit.

14.2 Chimney air terminals and chimney conductors shall be built into the masonry of a chimney, or attached to the outside of a chimney and passed through the roof to the main concealed conductor.

14.3 Conductors that are embedded in concrete, shall be bonded to the reinforcing steel with a main-size conductor. Reinforcing steel shall be bonded at the top and bottom of each embedded down lead. Roof conductors that are similarly embedded shall be connected to reinforcing steel at intervals not exceeding 100 feet (30.5 m).

14.4 Grounding shall be carried out as specified in Section 10, Grounding.

15 Structural Steel Framing

15.1 Where the structural steel framework 3/16 inch (4.8 mm) or greater of a building may be utilized as the main conductor of a lightning protection system providing it is electrically continuous.

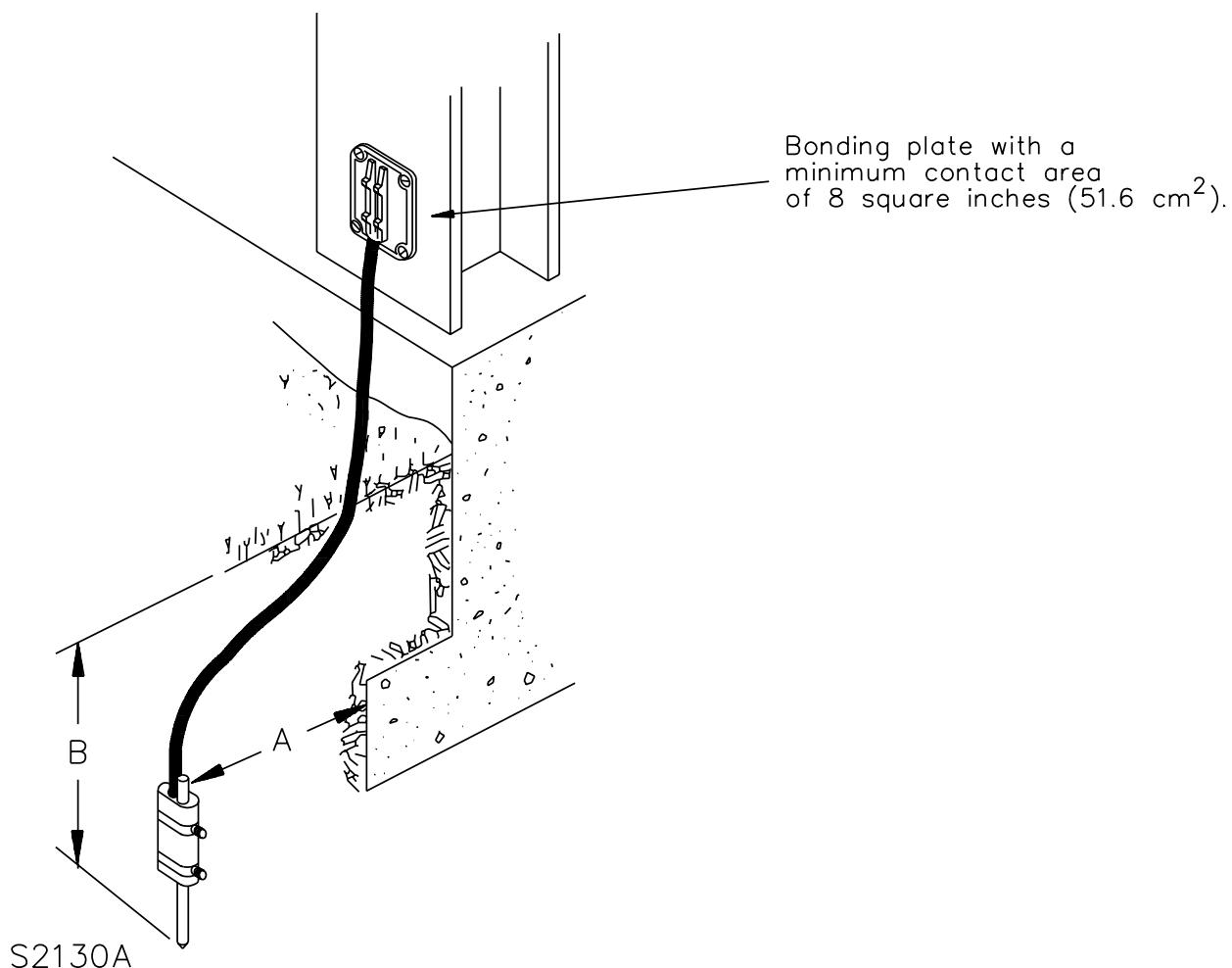
15.2 Each air terminal shall be bonded directly to the steel framework as specified in 15.4 or shall be connected to a main-size conductor that is bonded to the steel framework as specified in 15.4.

15.3 When a conductor is employed on the roof area, the perimeter conductor shall be connected to the steel framework at intervals not exceeding 100 feet (30.5 m). Connections to the steel framework shall be as specified in 15.4.

15.4 Each connection shall be made to a cleaned area of the steel framework by a bonding plate provided with pressure cable connectors or by a welded or a brazed conductor. A bonding plate shall have a minimum of 8 square inches (51.6 cm^2) of surface contact area bolted or welded to the steel. Drilling and tapping a steel column to accept a threaded connector complies with this requirement when the threaded connector has at least five threads fully engaged in the column, the threaded connector is secured with a locking device, and the connector's diameter is not less than 1/2 inch (12.7 mm). The weld area of a conductor shall be at least two times the cross-sectional area of the conductor.

15.5 Base connections as specified in 15.4 that lead to ground terminations shall be made at approximately every other outermost steel column around the perimeter and shall not average more than 60 feet (18.3 m) apart and be at the lowest available point and shall comply with the requirements of Section 9, Conductors. See Figure 15.1. A steel column that extends to a point not less than 10 feet (3 m), the number of connections to steel columns shall be based on the perimeter of the roof requiring protection.

Figure 15.1
Grounding connections



A = 2 feet (610 mm) minimum.

B = 10 feet (3.0 m) minimum. See 15.1.

Bonding plate with a minimum contact area of 8 square inches (51.6 cm^2).

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

15.6 Metal bodies requiring bonding are not required to be separately bonded when they are electrically continuous with the lightning protection system through the steel framework.

PROTECTION FOR MISCELLANEOUS STRUCTURES

16 General

16.1 All requirements in Sections 3 – 15 apply except as modified.

16.2 A mast, spire, flagpole, or similar slender structure shall be provided with at least one air terminal, down conductor, and grounding electrode.

Exception: An electrically continuous metal structure is not required to have air terminals or down conductors but shall be bonded at the base with main-size bonding plate and conductor to a grounding electrode.

16.3 Metallic pool enclosures attached to structures having structural members less than 3/16 inch (3 mm) thick shall have air terminals bonded at the top as described in 8.1.5. The metal pool enclosure shall be grounded on average every 60 feet (18.3 m) and with main-size conductor with a minimum of 2 ground terminations. The enclosure's structural components shall not be used as down conductors for the main protected structure.

16.4 Metallic-frame screened enclosures, attached to structures, having structural members less than 3/16 inch (4.8 mm) thick shall have air terminals bonded at the top as described in 8.1.5. Where the metallic-frame screened enclosure structural members meet the requirements for main conductor solid strip as specified in Table SA1.1 for Class I or Table SA1.2 for Class II, no additional down conductors are required for these enclosures. These structural members shall be grounded a maximum of every 60 feet (18.3 m) with a minimum of 2 ground terminations. The enclosure's structural components shall not be used as down conductors for the main protected structure.

16.5 Each communication (radio, television, microwave) mast of metal, located on a protected building, shall be bonded to the lightning protection system with main-sized conductor and fittings, unless located within a zone of protection.

Exception: For antennas that cannot be placed in the zone of protection due to functional requirements, only the base need be bonded with main-size conductors and fittings. The antennas shall not be used to provide a zone of protection.

16.6 A satellite dish shall be protected so that it is located within a zone of protection.

PROTECTION FOR HEAVY-DUTY STACKS

17 Mechanical Execution of Work

17.1 Lightning protection systems shall be installed in a neat, professional manner.

18 Components

18.1 Components shall be Class II except as described and modified in this section.

18.2 All components on the upper 25 feet (7.6 m) shall be copper, copper alloy, bronze, or stainless steel. All components are prohibited from being aluminum.

19 Corrosion Protection

19.1 Copper components on the upper 25 feet (7.6 m) of a stack shall have a continuous covering of lead, at least 1/16 inch (1.6 mm) thick to resist corrosion by flue gases. Such components include conductors, air terminals connectors, splicers, and cable holders. Stacks that extend through a roof less than 25 feet (7.6 m) shall have a lead covering on those components extending above the roof level.

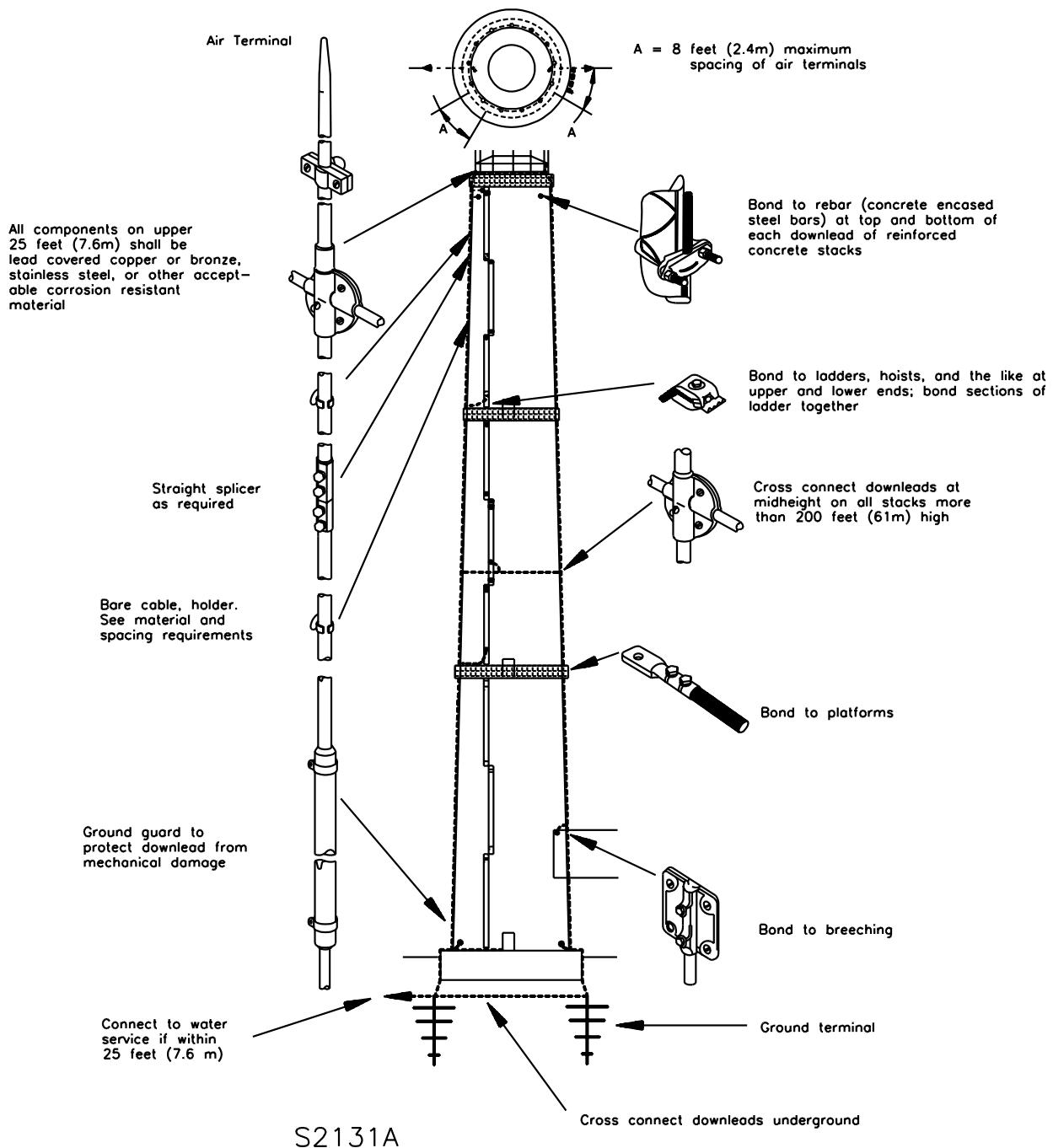
20 Air Terminals

20.1 Air terminals shall be made of solid copper, copper alloy, stainless steel, titanium, or monel metal.

20.2 Air terminals shall be uniformly distributed around the rim of a cylindrical stack at intervals not exceeding 8 feet (2.4 m). On a square or rectangular stack, air terminals shall be located not more than 2 feet (610 mm) from the corners and shall be spaced not more than 8 feet (2.4 m) apart around the perimeter. See Figure 20.1.

Exception: Air terminals are not required for a heavy-duty metal stack having electrically continuous steel at least 3/16 inch (4.8 mm) thick covering the lining and column. The hood shall serve as a top loop conductor and shall be connected to each down conductor using a connection plate of not less than 8 square inches (52.0 cm²) securely bolted or welded to the hood.

Figure 20.1
Heavy duty stacks



UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL

20.3 The height of an air terminal above a stack shall be not less than 18 inches (460 mm) nor more than 30 inches (762 mm). An air terminal shall be at least 5/8 inch (15 mm) in diameter, exclusive of corrosion protection. A top-mounted air terminal shall not extend more than 18 inches (460 mm) above the top of the stack.

20.4 Each air terminal shall be secured to the stack and the lower ends shall be connected together with a lead-covered copper conductor forming a closed loop around the stack.

20.5 A side-mounted air terminal shall be secured to the stack with at least two fastenings. An anchored base is determined to be one fastening.

21 Conductors

21.1 Conductors shall be Class II modified components complying with the Standard for Lightning Protection Components, UL 96.

21.2 Not less than two down conductors shall be provided. They shall be located on opposite sides of the stack, and lead from the encircling conductor at the top to the grounding electrodes. Down conductors shall be interconnected at the base of the stack unless individually connected to a common water pipe or metal breeching that will provide the interconnection. Conductors shall also be interconnected at midheight on all stacks exceeding 200 feet (61 m) in height. Down conductors shall be protected from damage or displacement for a distance of not less than 8 feet (2.4 m) above grade.

Exception: Down conductors are not required for a metal stack.

21.3 Vertical conductors shall be fastened at intervals not exceeding 4 feet (1.2 m) and horizontal conductors at intervals not exceeding 2 feet (610 mm).

22 Fasteners

22.1 A fastener shall be of copper, copper alloy, or stainless steel.

22.2 A fastener shall be anchored to the stack by masonry anchors or lay-in attachments. The threaded shank of a fastener shall not be less than 1/2 inch (13 mm) diameter for an air terminal and 3/8 inch (10 mm) diameter for a conductor.

23 Bonding

23.1 An extended metal part located within 6 feet (1.8 m) of a lightning protection system shall be bonded to the system. Metal parts shall be interconnected even though they are over 6 feet (1.8 m) from a lightning conductor, if they are within 6 feet (1.8 m) of a metal part already connected. A metal lining and a metal ladder shall be bonded to the system at both the upper and lower ends of the lining or ladder.

Exception: In a reinforced concrete stack, interior lining bands located more than 3 feet (914 mm) from an interior work platform need not be bonded to the lightning protection system.

23.2 A bonding plate shall provide a surface contact area of not less than 3 square inches (19 cm^2).

24 Splices

24.1 All connections shall be made by bolting, welding, or brazing and shall make contact with the conductor for at least 1-1/2 inches (38 mm), measured parallel to the axis of the conductor.

24.2 A grounding electrode shall be provided for each down conductor. It shall be suitable for the soil conditions encountered. A grounding electrode shall be a driven rod, copper plate, or conductor laid in a trench. A grounding electrode rod shall not be less than 5/8 inch (15.9 mm) in diameter and 10 feet (3 m) in length. The rod shall be made of copper-clad or stainless clad steel, solid copper, or stainless steel. A ground grid used in lieu of ground rods is acceptable if the grid conductors comply with the minimum conductor size and material requirements in accordance with Supplement SA of this standard.

24.3 A metal water pipe system within 25 feet (7.6 m) of a stack or metal breeching shall be connected to the stack or breeching, using a main-sized conductor. An inherent or separate connection between a metal breeching and a water supply system is acceptable as the required water-pipe bond.

24.4 Reinforcing steel in a concrete stack shall be electrically continuous and shall be bonded to the lightning protection system at its upper and lower ends at down-lead locations. Tying or clipping of reinforcing bars is not a requirement providing continuity. Clamps shall be used for the top and bottom connections.

25 Metal Stacks

25.1 A metal stack shall be grounded by at least two grounding electrodes located on opposite sides of the stack.

25.2 A metal stack that is an adjunct of a building or is located within 6 feet (1.8 m) of a building shall be connected to the lightning protection system of the building. If a stack is set within the perimeter of a building, two connections shall be made to the nearest main conductors.

26 Metal Guy Wires and Cables

26.1 Metal guy wires and cables shall be grounded at their lower ends if they are set in concrete or attached to a building or other nonconductive support.

No Text on This Page

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**

SUPPLEMENT SA - MATERIAL REQUIREMENTS

Tables SA1.1 and SA1.2 are provided reference only. The material requirements are from the Standard for Lightning Protection Components, UL 96.

**Table SA1.1
Class 1 material requirements**

Type of conductor		Copper		Aluminum	
		Standard	Metric	Standard	Metric
Air terminal, solid	Minimum diameter	3/8 inch	9.5 mm	1/2 inch	12.7 mm
Air terminal, tubular	Minimum diameter	5/8 inch	15.9 mm	5/8 inch	15.9 mm
	Minimum wall thickness	0.032 inch	0.81 mm	0.064 inch	1.63 mm
	Minimum size each strand	0.045 inch	1.15 mm	0.064 inch	1.63 mm
Main conductor, cable	Weight per length	187 lbs/1000 ft	278 g/m	95 lbs/1000 ft	141 g/m
	Cross section area	57,400 CM	29 mm ²	98,600 CM	50 mm ²
Main conductor, solid strip	Thickness	0.051 inch	1.30 mm	0.064 inch	1.63 mm
	Width	1 inch	25.4 mm	1 inch	25.4 mm
Secondary conductor, cable	Wire size	0.045 inch	1.15 mm	0.064 inch	1.63 mm
	Number of wires	14	14	10	10
Secondary conductor, solid strip	Thickness	0.051 inch	1.30 mm	0.064 inch	1.63 mm
	Width	1/2 inch	12.7 mm	1/2 inch	12.7 mm
Secondary conductor, solid rod	Diameter	0.162 inch	4.11 mm	0.204 inch	5.18 mm

**Table SA1.2
Class II material requirements**

Type of conductor		Copper		Aluminum	
		Standard	Metric	Standard	Metric
Air terminal, solid	Minimum diameter	1/2 inch	12.7 mm	5/8 inch	15.9 mm
	Minimum size each strand	0.057 inch	1.45 mm	0.072 inch	1.83 mm
Main conductor, cable	Weight per length	375 lbs/1000 ft	558 g/m	190 lbs/1000 ft	283 g/m
	Cross section area	115,000 CM	58 mm ²	192,000 CM	97 mm ²
Main conductor, solid strip	Thickness	0.064 inch	1.63 mm	0.1026 inch	2.61 mm
	Width ^a	1.40 inch	35.58 mm	1.462 inch	37.16 mm
Secondary conductor, cable	Wire size	0.045 inch	1.15 mm	0.064 inch	1.63 mm
	Number of wires	14	14	10	10
Secondary conductor, solid strip	Thickness	0.051 inch	1.30 mm	0.064 inch	1.63 mm
	Width	1/2 inch	12.7 mm	1/2 inch	12.7 mm
Secondary conductor, solid rod	Diameter	0.162 inch	4.11 mm	0.204 inch	5.18 mm

^a This is the minimum width for a strip without perforations. If perforated, the minimum intended width is to be increased by the diameter of the perforations.

No Text on This Page

**UL COPYRIGHTED MATERIAL –
NOT AUTHORIZED FOR FURTHER REPRODUCTION OR
DISTRIBUTION WITHOUT PERMISSION FROM UL**