UL 96A

STANDARD FOR SAFETY

Installation Requirements for Lightning Protection Systems

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

Thirteenth Edition, Dated March 18, 2016

Summary of Topics

This revision of UL 96A dated October 12, 2022 includes the following changes in requirements:

– Addition of Connector Definitions to the Glossary; 5.7A

– Clarification of Requirements for Dead Ends; 9.1.1

– Addition to Paragraph 2.5 Exception Regarding Accessories

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated February 4, 2022 and August 19, 2022.

No Text on This Page

MARCH 18, 2016
(Title Page Reprinted: October 12, 2022)

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, 2007

Thirteenth Edition

March 18, 2016

This UL Standard for Safety consists of the Thirteenth Edition including revisions through October 12, 2022.

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 https://csds.ul.com.

No Text on This Page

CONTENTS

INTRODUCTION

PROTECTION FOR ORDINARY BUILDINGS

PROTECTION FOR MISCELLANEOUS STRUCTURES

PROTECTION FOR HEAVY-DUTY STACKS

SUPPLEMENT SA – MATERIAL REQUIREMENTS

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 shall not apply to adjacent structures.

1.4 Adjacent structures shall be considered separate structures.

1.5 Adjacent structures with lightning protection shall be considered part of the structure if the adjacent structure's lightning protection system complies with this standard and is connected to the lightning protection system of the structure in accordance with Section 10.4.

1.6 Walkways that are attached to a structure shall be considered part of that structure.

1.7 Free standing Walkways shall be considered an adjacent structure under the following conditions:

a) It is separated by a fire wall and conductive media that is shared by both facilities has an SPD in accordance with Section 13.

b) It is isolated by a distance of not less than six feet and conductive media that is shared by both facilities has an SPD in accordance with Section 13.

1.8 This standard does not cover lightning protection for:

a) Electric transmission lines or open air distribution racks,

b) Outdoor substations or switch yards, and

c) Electric generators unenclosed by a building or other enclosed structures.

1.9 Enclosed generators and conventional building structures at or associated with generators or power plants, etc. are covered.

1.10 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 or other applicable UL Standards.

Exception: Screws, bolts, nuts, washers, nails and accessories as defined in 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 ADJACENT STRUCTURE – A structure that is physically separated by a fire wall or greater than six feet of distance separating it from a structure with lightning protection.

5.3 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.

5.4 BONDING (POTENTIAL EQUALIZATION) – An electrical connection between an electrically conductive object and a component of a lightning protection system with a secondary or main-size conductor intended to significantly reduce potential differences created by lightning currents in the main lightning conductors and other grounded metal objects.

5.5 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.

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

5.7 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.

5.7A CONNECTOR – A device to splice, tap, or terminate a conductor.

a) Exothermic Weld – A welding process that employs molten metal to form a permanent connection.

b) Bolted Connector – A device that employs mechanical fasteners to maintain conductivity.

c) Crimp Connector – A device that employs metal tabs (i.e. fingers) that enclose the conductor to maintain conductivity.

d) High-Compression Connector – A device that utilizes a high tonnage compression tool to permanently deform the connector material to maintain conductivity.

5.8 EARTH – Finished grade level around a structure.

5.9 ELECTRICALLY CONTINUOUS – An uninterrupted electrically conductive path or one made electrically continuous by being bonded together by welding, brazing, compression fitting or suitable bonding plate.

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

5.11 GALVALUME – An aluminum coated sheet steel product. It is comprised of 55% aluminum, 1.6% silicon and 43.4% zinc. The coating is applied to the base metal in a continuous hot dip method. The product is described in ASTM-792, coating classes of AZ 50, AZ 55 and AZ 60. These classes equate to an average minimum coating thickness of .50, .55 and .60 ounces per square foot.

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

5.13 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.

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

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

5.16 LOOP CONDUCTOR – A conductor:

a) That encircles a structure; and

b) That is used to interconnect grounding electrodes, main conductors, or other grounded bodies.

5.17 METAL BODY:

a) Grounded (Non-Isolated) Metal Body – A metal body having a ground path independent of the lightning protection system.

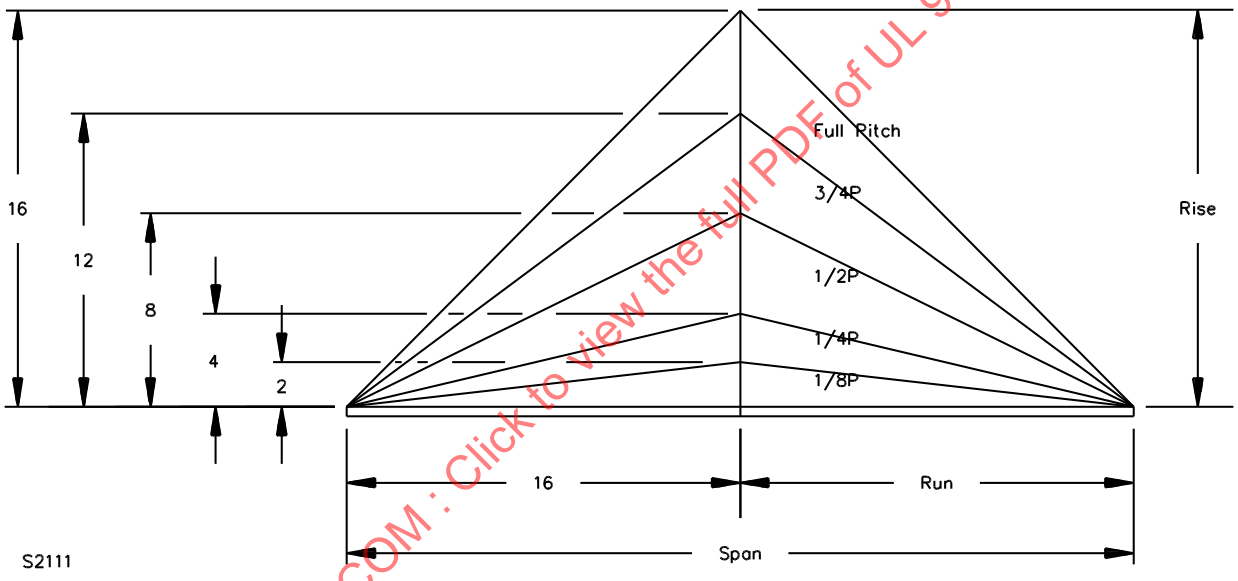
b) Isolated (Ungrounded) Metal Body – A metal body having no ground path.

5.18 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.

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

Figure 5.1

Determination of roof pitch



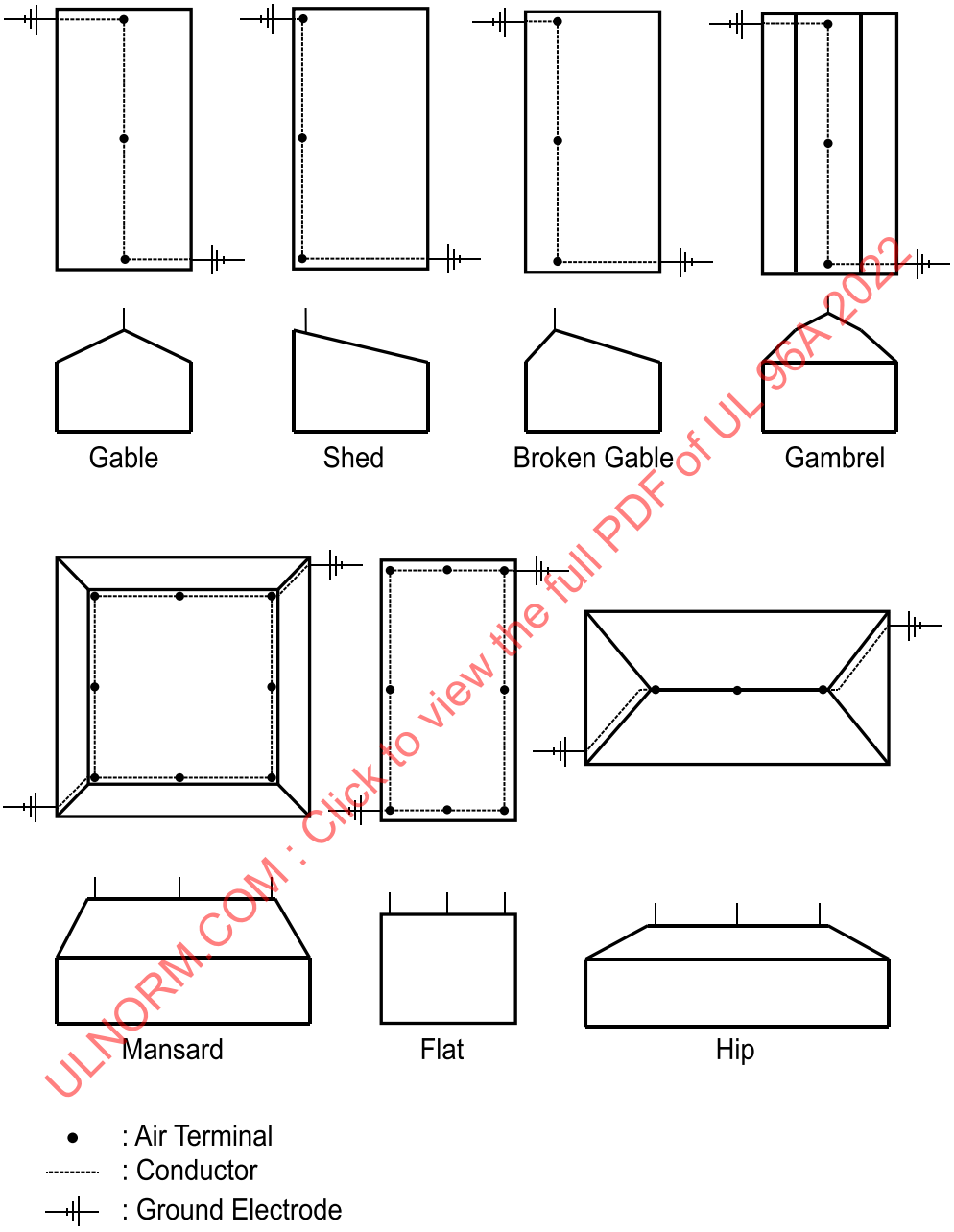
$$Pitch\ (P) = Rise\ /\ Run$$

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

Figure 5.2

Roof types

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



su1473

Reproduced with permission from 2013 "Annual Revision Cycle Report on Comments" for NFPA 780 Standard for the Installation of Lightning Protection Systems, Copyright © 2012 National Fire Protection Association. This material has not been finally adopted as part of the referenced standards and is subject to revision or deletion as part of the NFPA document development process. It is not the complete and official position of the NFPA on the referenced subject which is represented solely by the standard in its entirety.

5.20 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.

5.21 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).

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

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

5.24 STRUCTURE – That which is built or constructed.

5.25 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.

5.26 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 requirement is applicable to lightning protection system components as well as the surface material on which they are mounted. For example, a combination of copper and aluminum shall not be used. See 7.4 – 7.7. Some examples of metals acceptable for use with copper and aluminum are as follows:

a) Metals acceptable for use with copper:

Nickel

Brass

Tin

Lead

Stainless Steel

Monel

b) Metals acceptable for use with aluminum:

Magnesium

Zinc

Galvanized Steel

Stainless Steel

Lead

Wrought Iron

Galvalume

7.3 A conductor that runs through metal pipe or tubing shall be galvanically compatible as specified in 7.2.

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

Exception: Copper conductor shall be allowed to be run in galvanized conduit when the conductor is bonded to the conduit at the top and bottom and is sealed at the top with a through roof assembly listed for the purposes.

7.5 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.

7.6 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.

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

7.8 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 a main size bonding plate/connector as described 12.10 and shall have 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. See Figure 8.3. Each terminal that is more than 24 inches (610 mm) in length shall be supported either:

a) Utilizing a brace that is at a point no less than one-half the height of the air terminal, or

b) Secured to the object or structure at a minimum of two locations, separated by a minimum distance between the securement points of 18 inches (457.2 mm) and a maximum distance from the highest securement point and the tip of the air terminal not exceeding 60 inches (1524 mm). The attachment of the air terminal to the base is not considered one of the two bracing locations.

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 shall be determined by one or more of the methods described in 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 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 Figure 8.4, Figure 8.5, Figure 8.6, and Figure 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 or guardrails, including metal cables, 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 or guardrail shall be bonded at each end as specified in 8.1.1. When the handrail exceeds 100 ft (30.5 m) in length it shall be bonded every 100 ft (30.5 m) or fraction thereof with main size conductor and clamps to the lightning protection system. The average distance between bonds shall not exceed 100 ft (30.5 m).

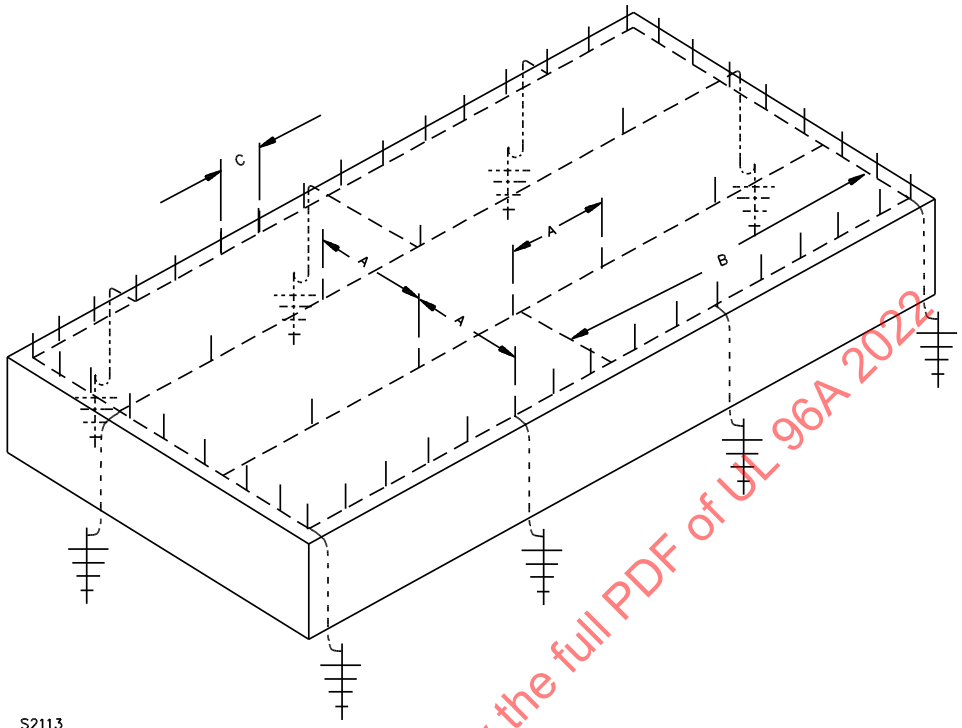
8.8.2 Chimneys, vents, or roof top metal bodies that have metal that is 3/16 inch (4.8 mm) thick or more shall only require bonding to the lightning protection system with two paths as required and defined in 8.1.1 and 8.8.3.

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



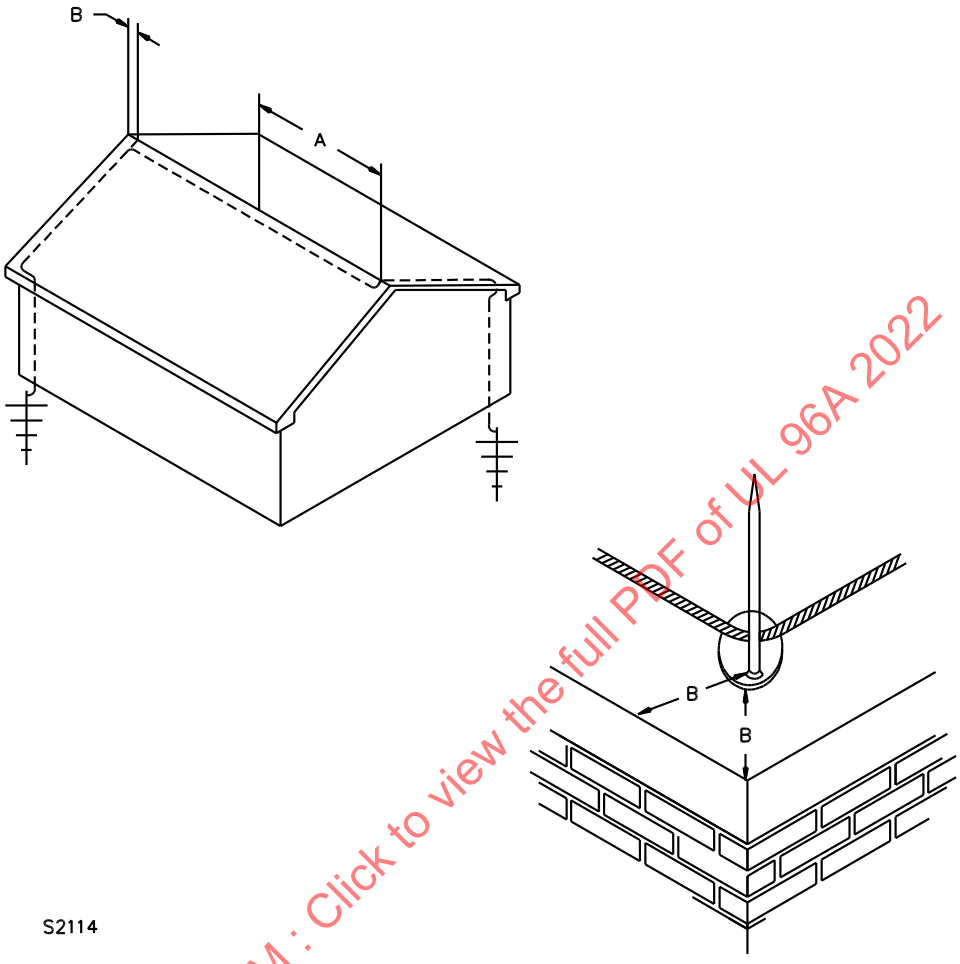
A = 50 feet (15.2 m) maximum spacing between air terminals. See 8.2.2.2.

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.

Figure 8.2

Air terminal locations

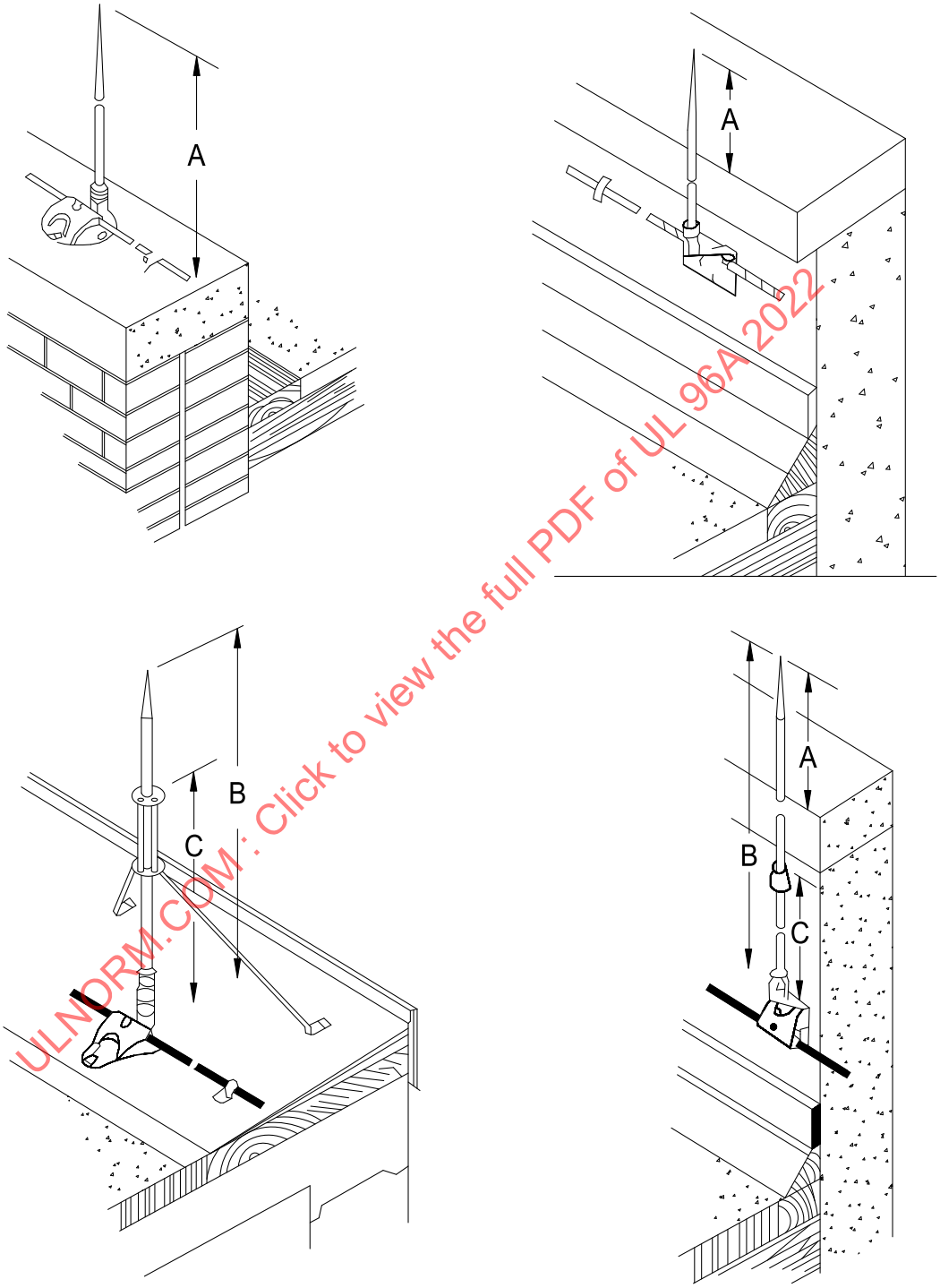


A = 20 feet (6.1 m) maximum spacing for 10 inch (254 mm) air terminal height or 25 feet (7.6 m) maximum spacing for 24 inch (610 mm) air terminal height.

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

Figure 8.3

Air terminals



S2115B

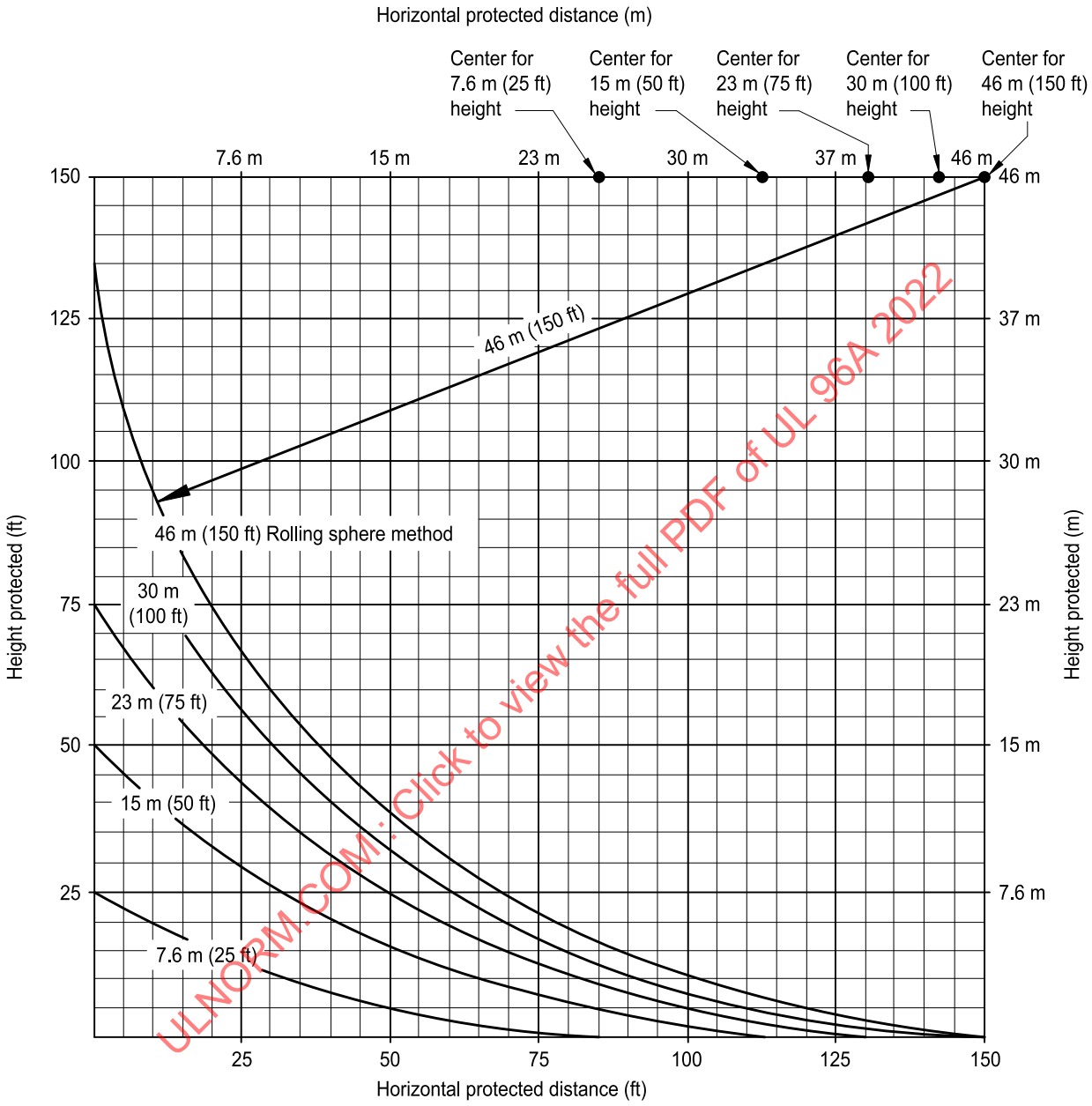
A = Air terminal minimum height. See 8.2.2.1.

B = Air terminal total height. See 8.1.6.

C = Air terminal support height. See 8.1.6.

Figure 8.4

Zone of protection utilizing rolling sphere method



su0637a

The distance may be determined analytically with the following equation:

$$d = \sqrt{h_1 (D - h_1)} - \sqrt{h_2 (D - h_2)}$$

In which:

d is the horizontal distance

h_1 is the height of higher roof

h_2 is the height of lower roof (top of object)

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

Figure 8.5

Zone of protection for buildings of various heights

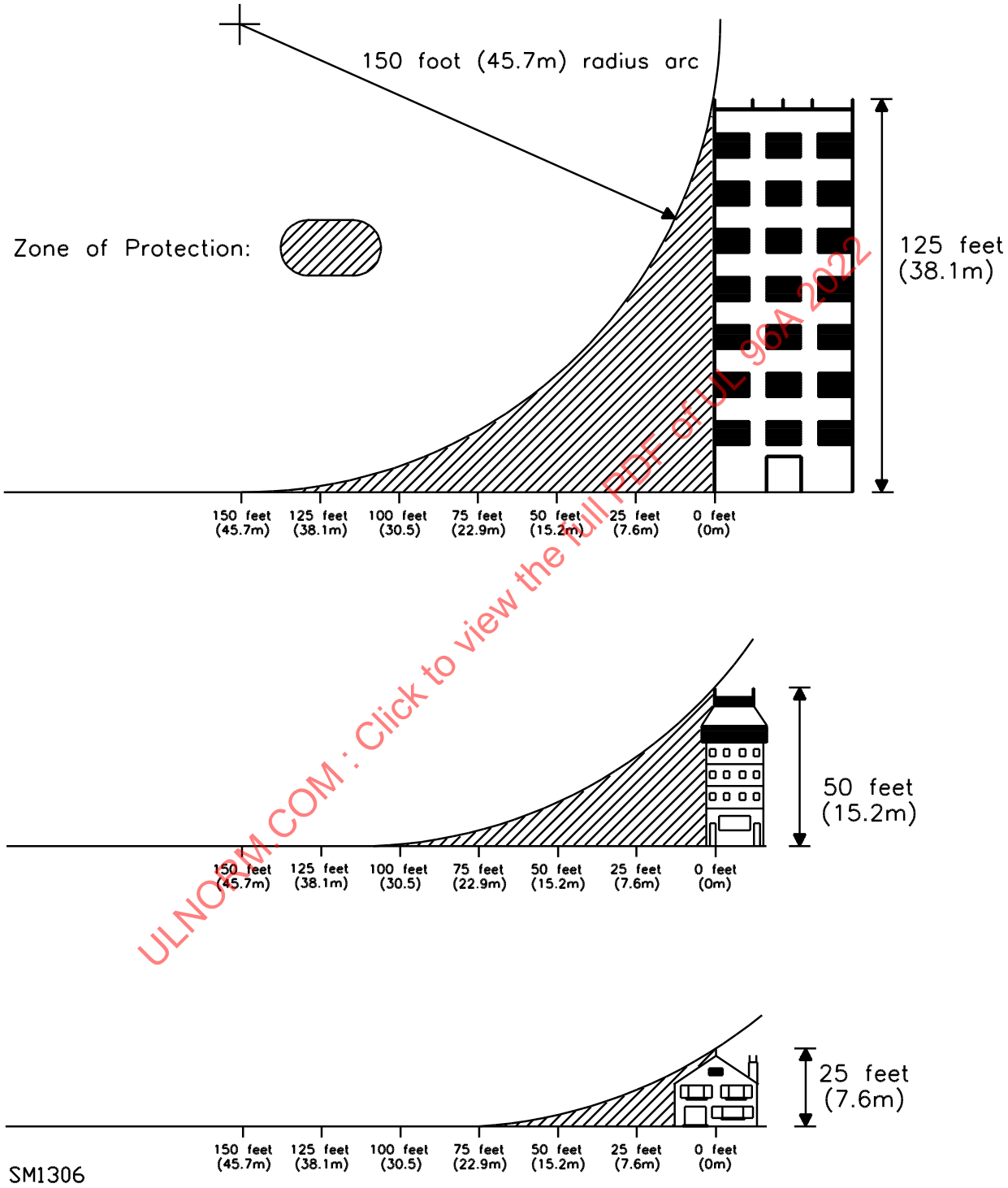
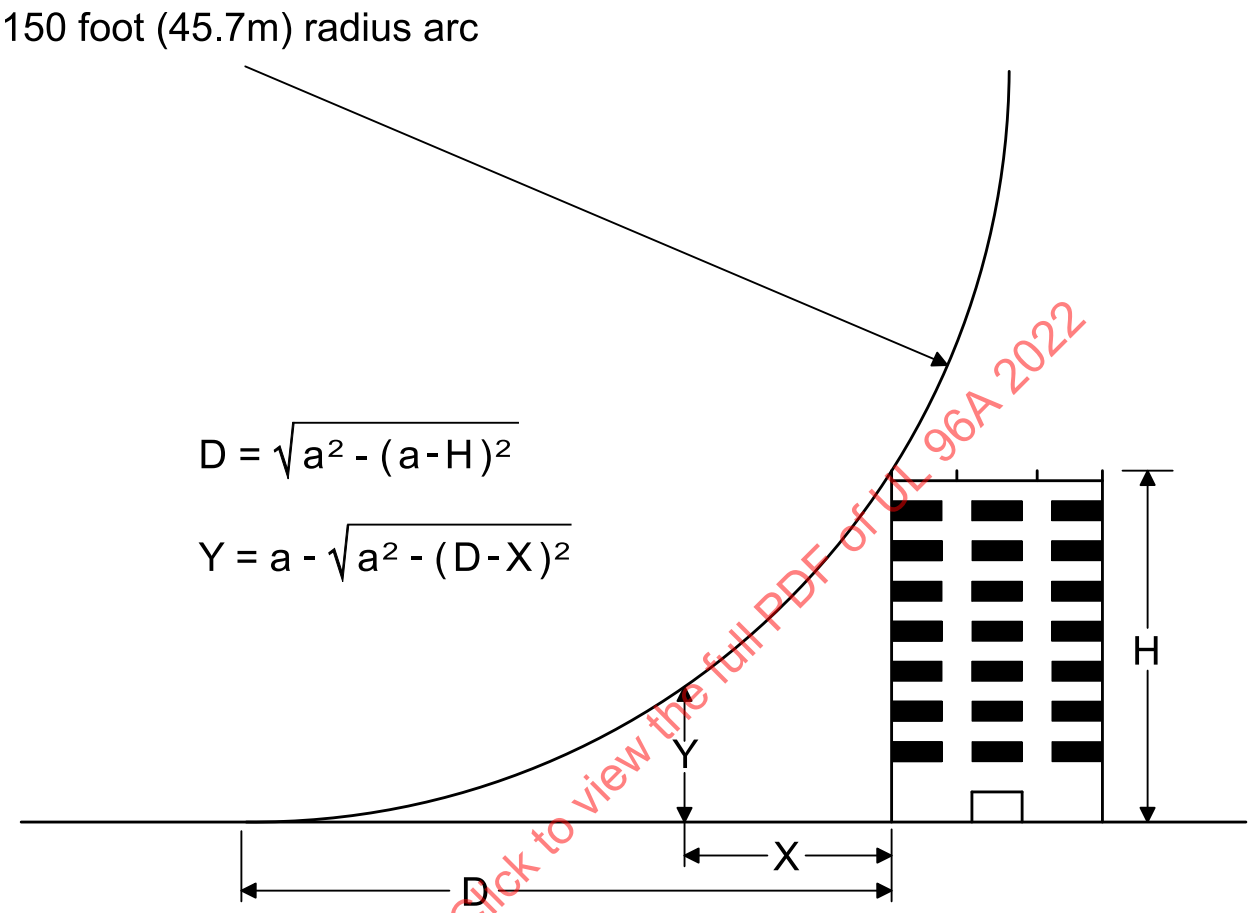


Figure 8.6

Design equations for zone of protection



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

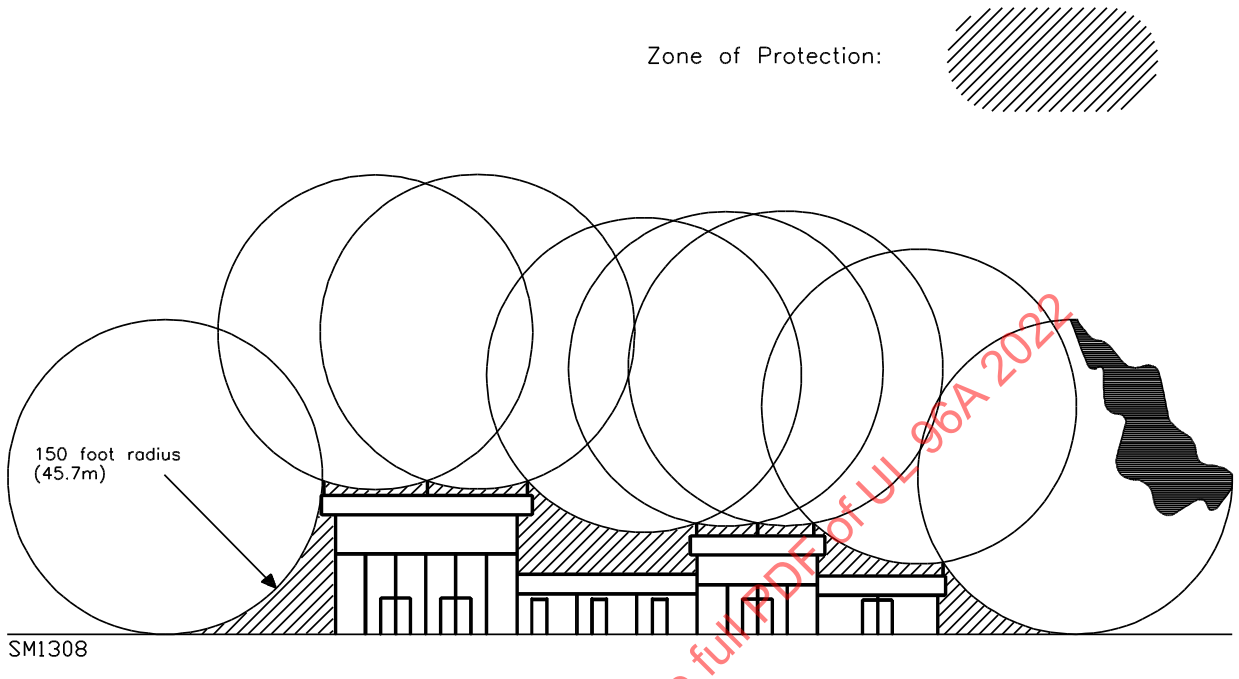
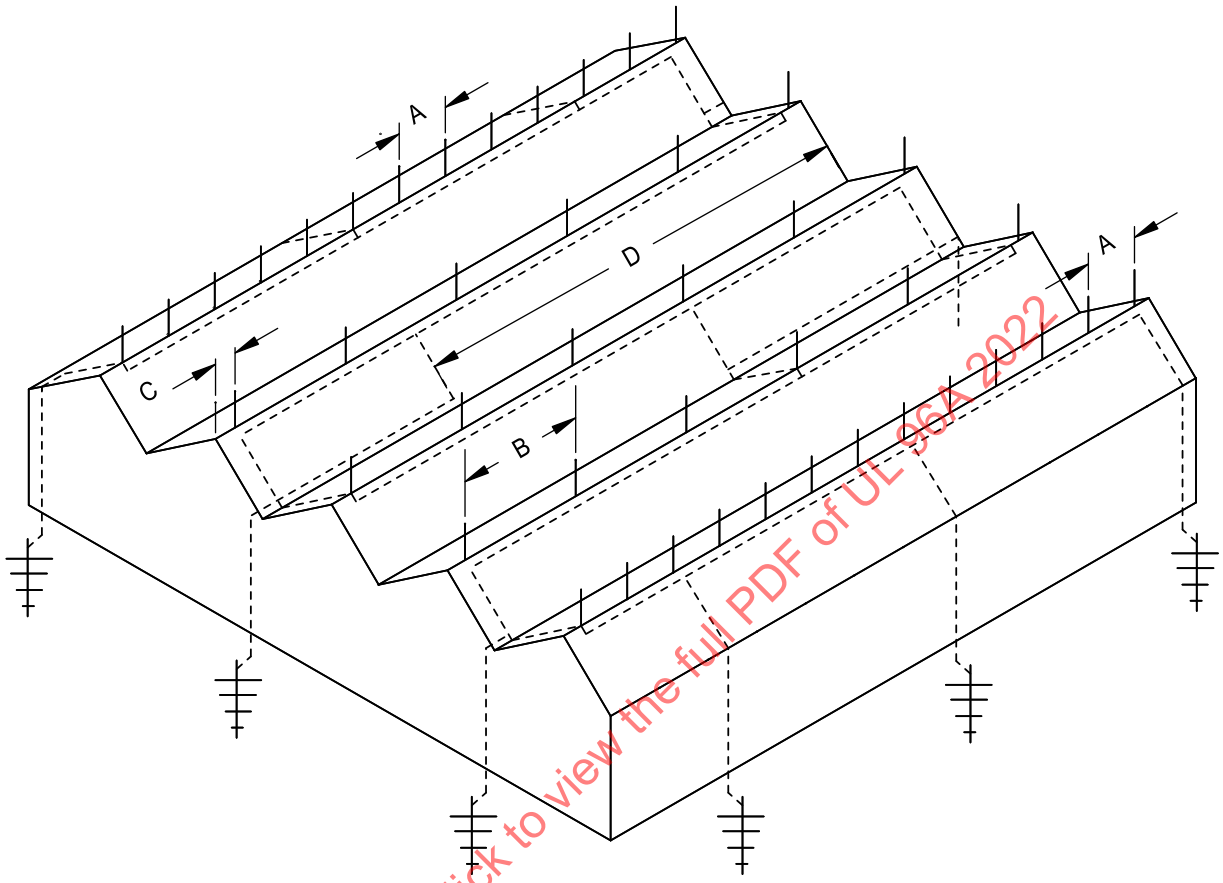


Figure 8.8

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.

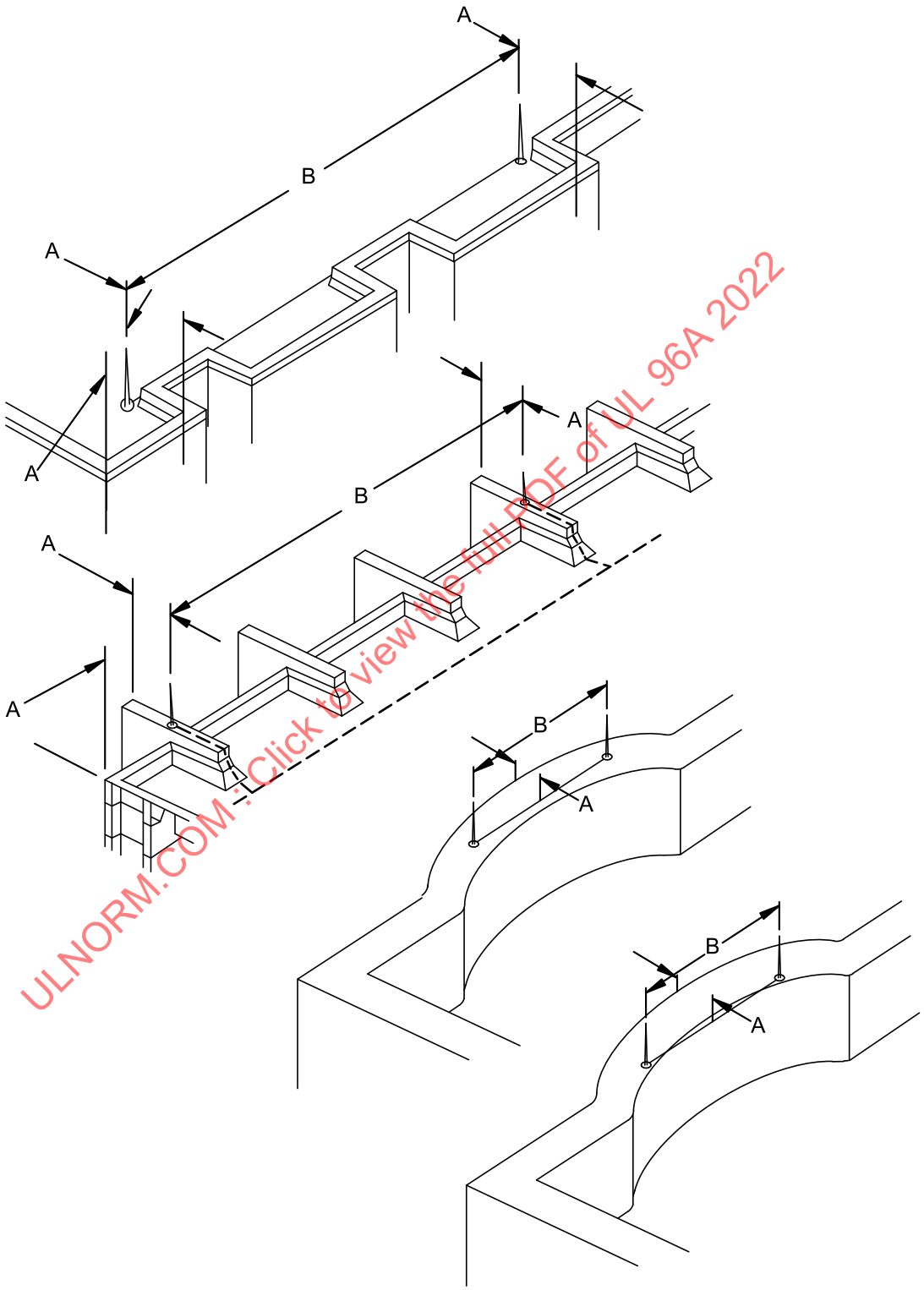
B = 50 feet (15.2 m). See 8.2.2.2.

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

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

Figure 8.9

Irregular roof lines



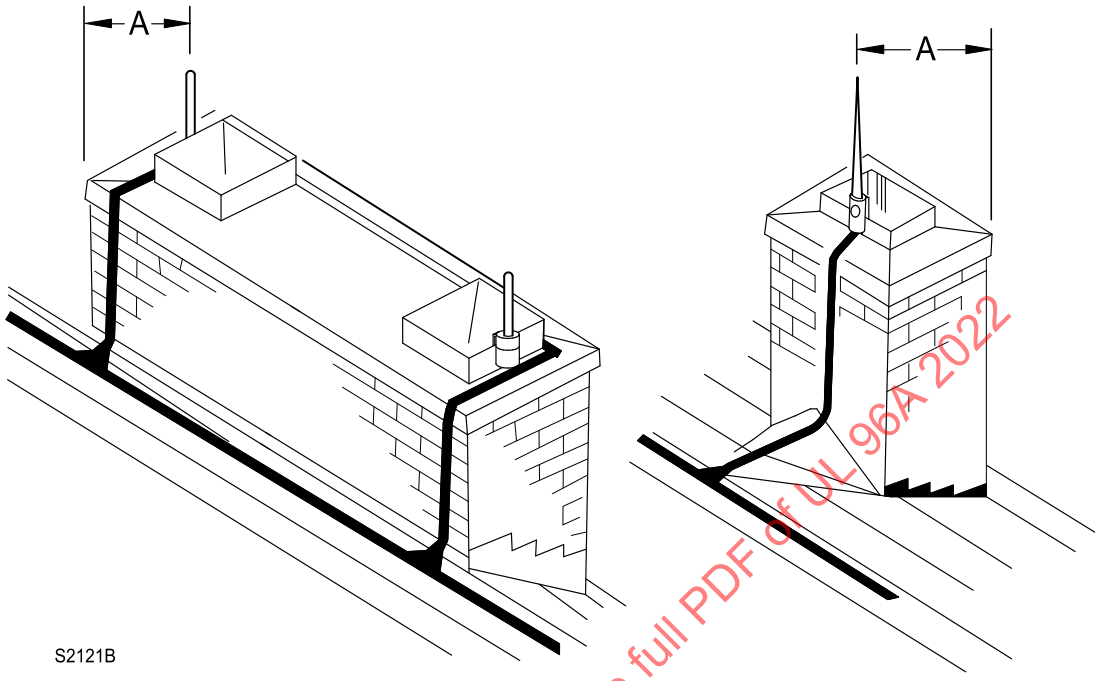
S2120C

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

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

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 horizontal 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 horizontal 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

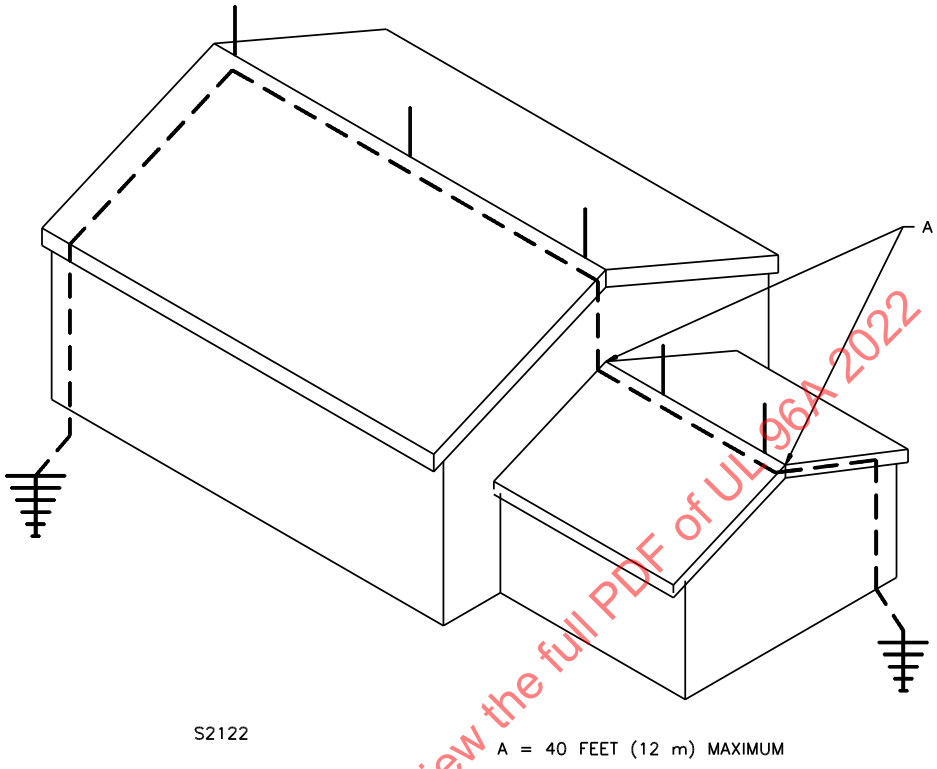
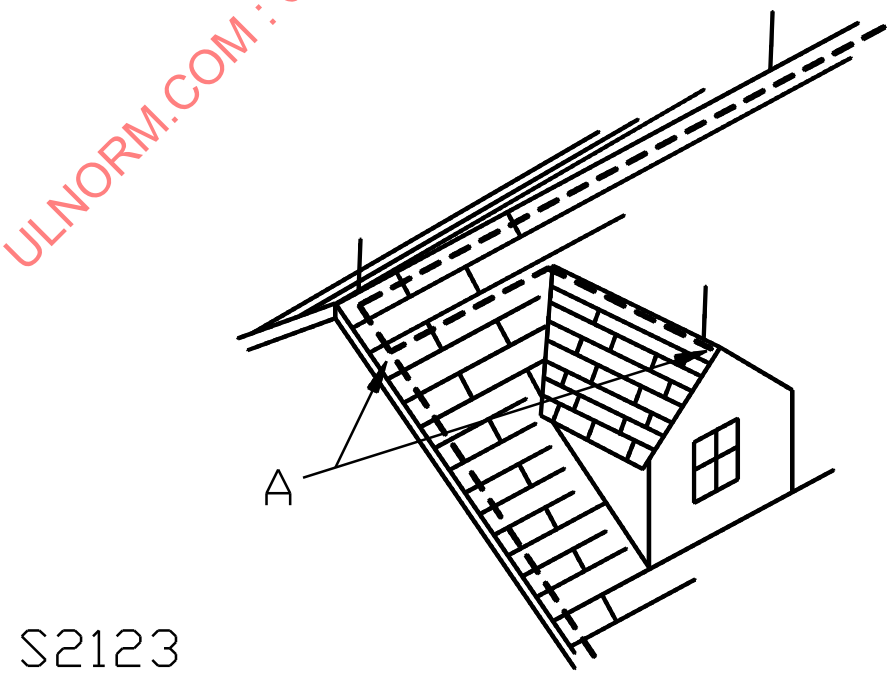


Figure 9.2

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.

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 0.1026 in (2.61 mm) or more shall be permitted to be substituted for main conductors. Handrails located where they are susceptible to a direct strike shall comply with the minimum thickness requirements of 8.1.1.

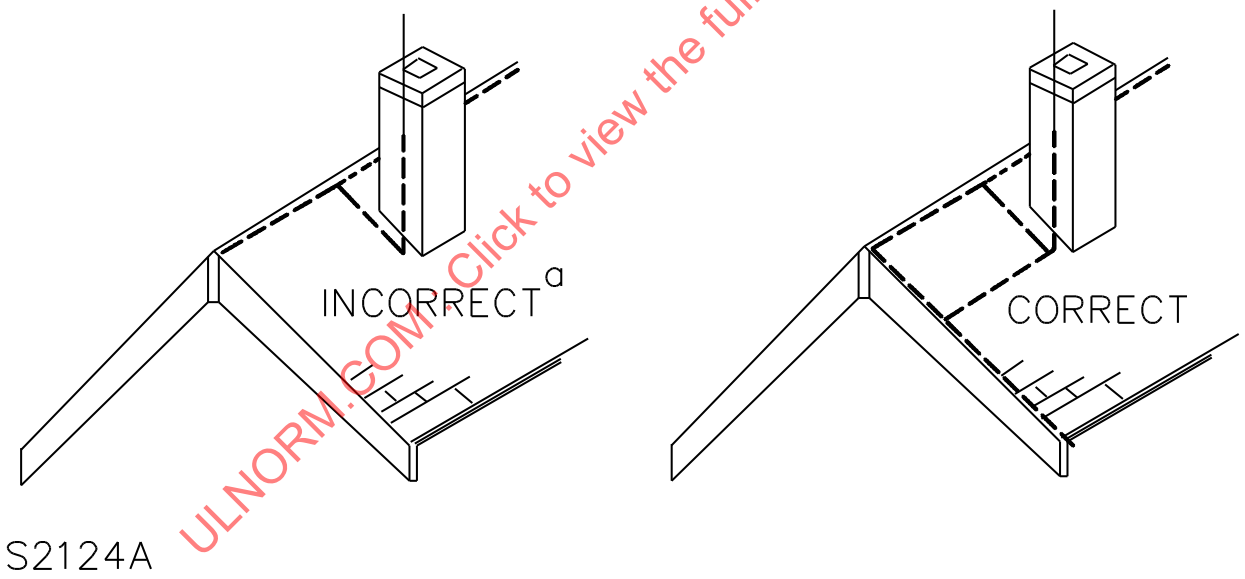
9.1.3 Main conductors shall maintain a horizontal or downward course, free from "U" or "V" (down and up) pockets. See Figure 9.3.

Exception No. 1: Conductors coursing at no more than 3 inches of rise in 12 inches of run are permissible.

Exception No. 2: At through roof connections only, the conductor shall be secured a maximum of 3 ft from the base of the through roof connection and gradually rise to the through roof connector.

Figure 9.3

U and V pockets



[a] See 9.1.3.

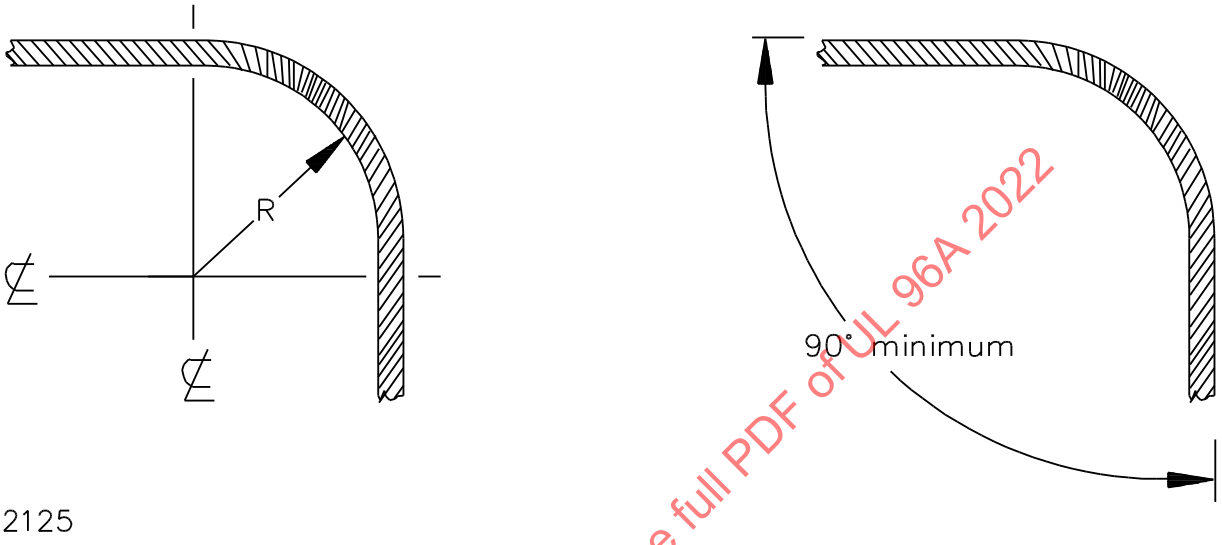
9.1.4 No bend of a main or secondary conductor shall form an included angle of less than 90 degrees or have a radius of bend less than 8 inches (203 mm). See Figure 9.4.

Exception No. 1: "T" splice and through roof and wall connectors need not comply with this requirement.

Exception No. 2: Where a cable bend is shown to be unavoidable, and there is no other option, a transitional assembly (through roof and wall connector) for dropping cable into the top end of PVC conduit may be employed once on a structure.

Figure 9.4

Bends



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 distances greater than 3 feet (0.91 m), the conductor shall be provided with a rigid means of support that will prevent damage or displacement of the conductor. When a metallic support is used it shall comply with paragraphs 7.5 and 7.6.

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.

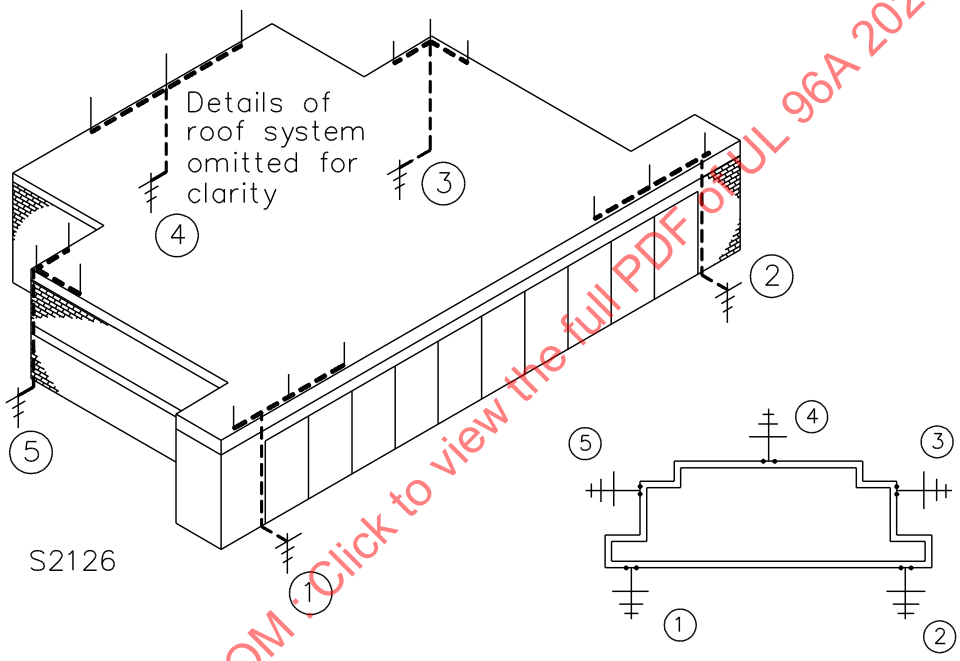
9.3 Down conductors

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



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.

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.

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, gutter or leader. A down conductor may be supported on the exterior of these parts provided they are constructed of materials having a minimum thickness of .0179 inches (0.455 mm) (for example, 26 gauge steel or 25 gauge aluminum) and are permanently fastened to the structure being protected.

9.4 *Deleted*

9.4.1 *Deleted*

9.4.2 *Deleted*

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.

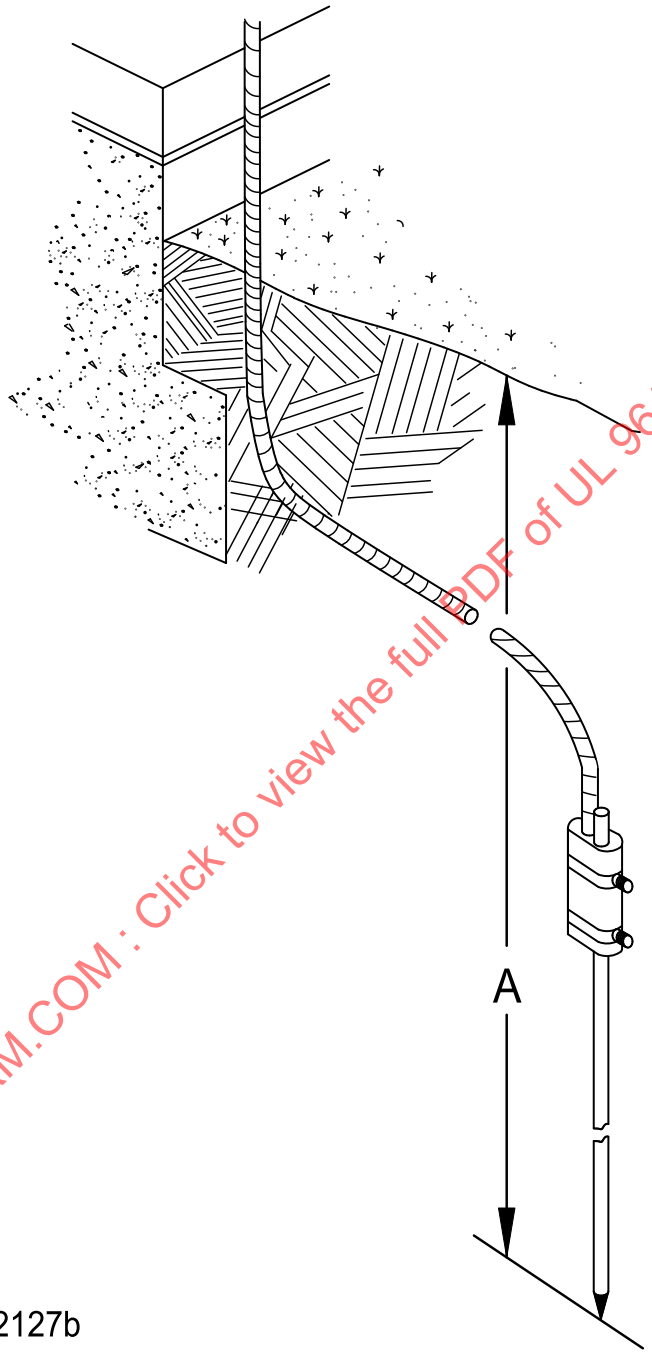
10.1.5 Ground rod connections shall be made by main size clamp type connectors, by welding, or by brazing. Clamps shall make contact with the ground rod and conductor for a distance of not less than 1-1/2 inches (38 mm) measured parallel to the axis of the ground rod. Clamps shall be secured with at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



A = 10 feet (3 m) minimum.

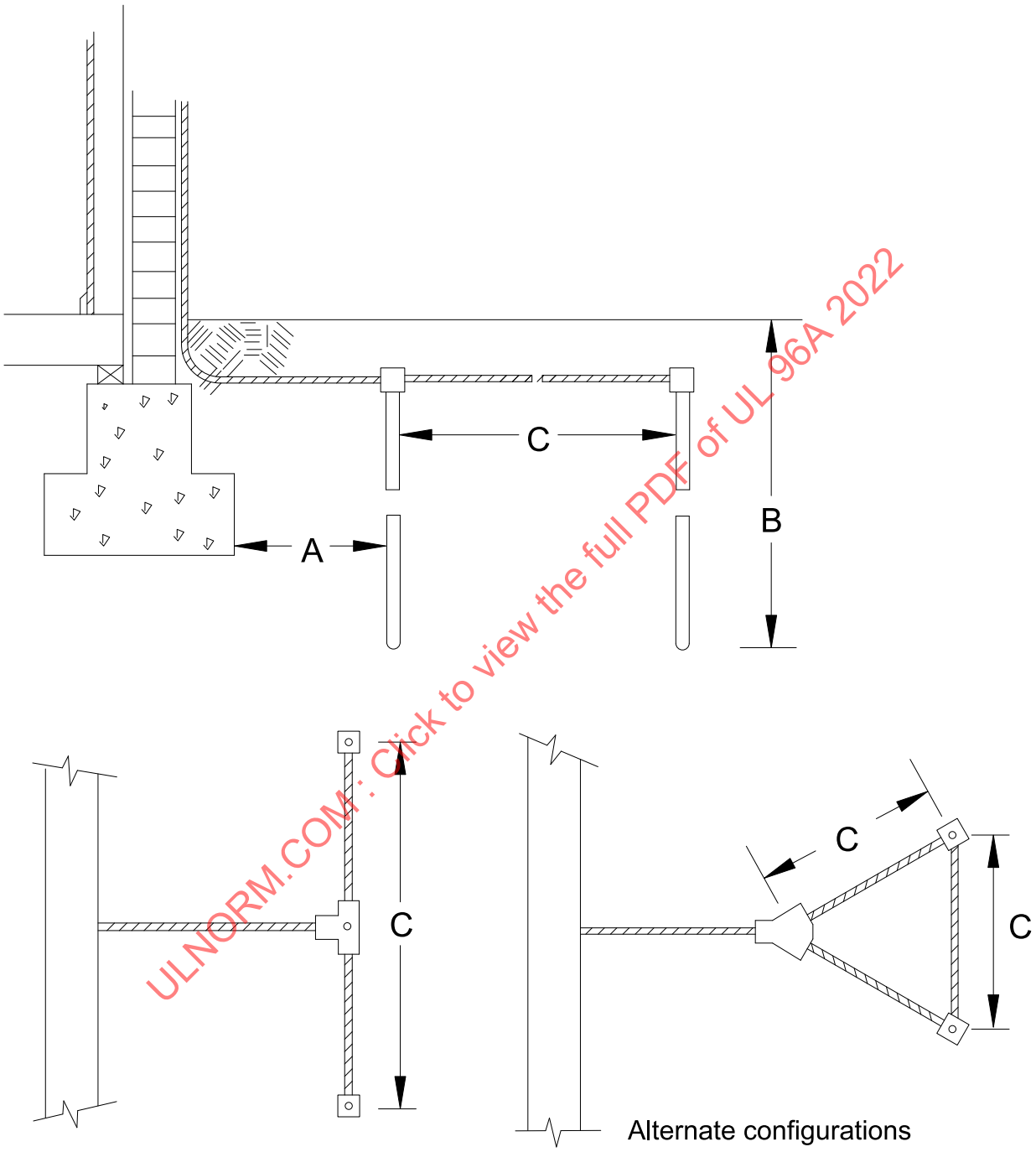
10.2 Multiple ground rods

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.

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

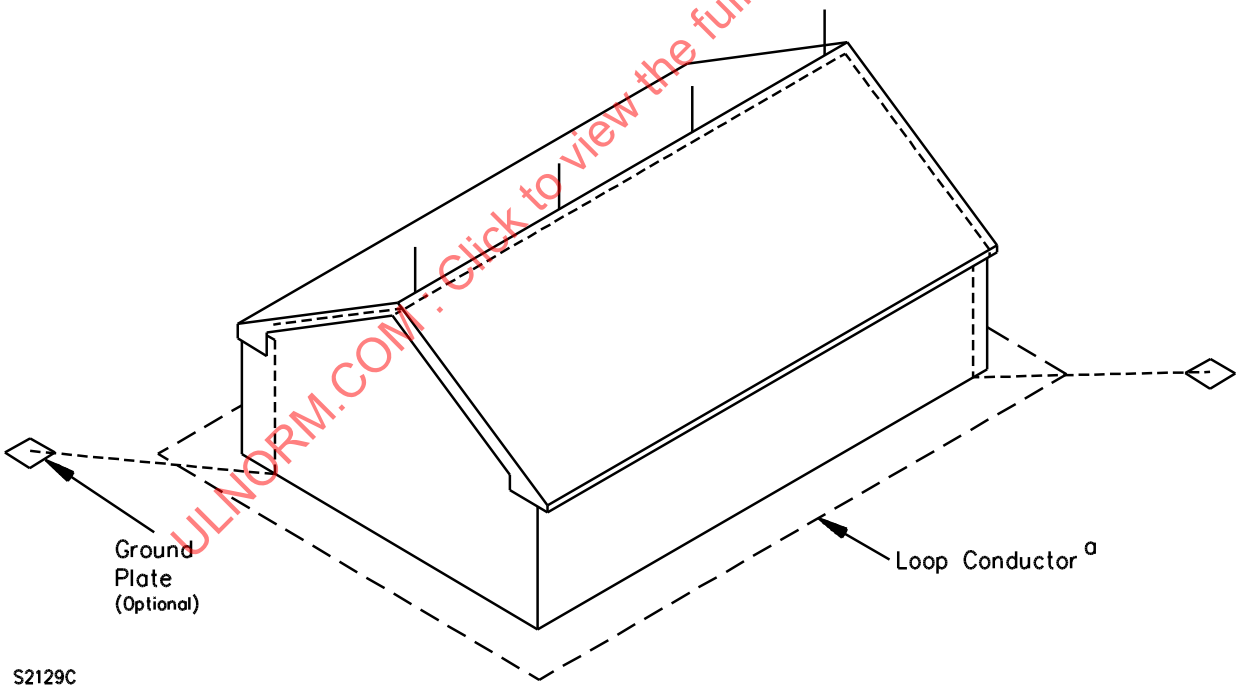
b) 24 feet (7.3 m) long and 2 feet (610 mm) deep in sandy or gravelly soil.

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 with main size conductors and main size connectors, see 12.10.

10.4.1A Each grounding system shall be bonded together by one or more of the methods described in 10.4.1, 10.4.2 or 10.4.3.

10.4.1B The grounding systems include 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.

10.4.1C Underground metallic piping systems shall include water service, gas piping, conduits, liquefied petroleum gas piping systems, sprinkler systems, fuel oil lines, tank and tank lines, other similar piping systems and other large underground metallic elements.

10.4.2 If electric, telephone or other systems are grounded to a metallic water pipe, only one bonding connection, using main size conductors and main size connectors from the water pipe system to the lightning protection 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: Connections between the grounded services and their water pipe ground connection need only to be sized as specified in the National Electrical Code, ANSI/NFPA 70.

10.4.3 When the building grounded systems noted above are interconnected at a common accessible point in or on the structure, the lightning protection system shall have a main size conductor and main size connector connected to the common bonding point. This common bonding point shall include a ground bar, a section of metallic water pipe in a structure, ground loop or the metallic structural frame per NFPA 70. Connections between the grounded services and the common accessible bonding point connection need only to be sized as specified in the National Electrical Code, ANSI/NFPA 70.

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 Bonding of Grounded Metal Bodies

11.1 Metal bodies subject to direct strike

11.1.1 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.

11.1.2 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 Figure 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)

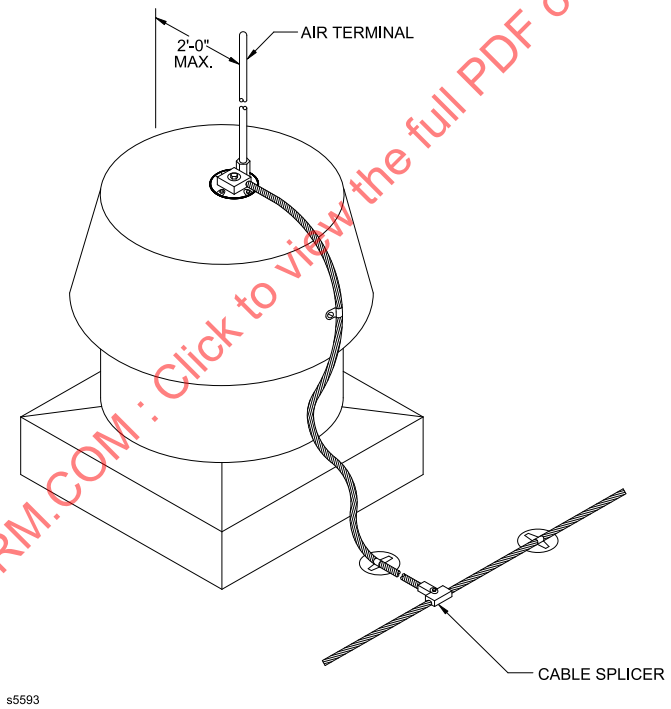
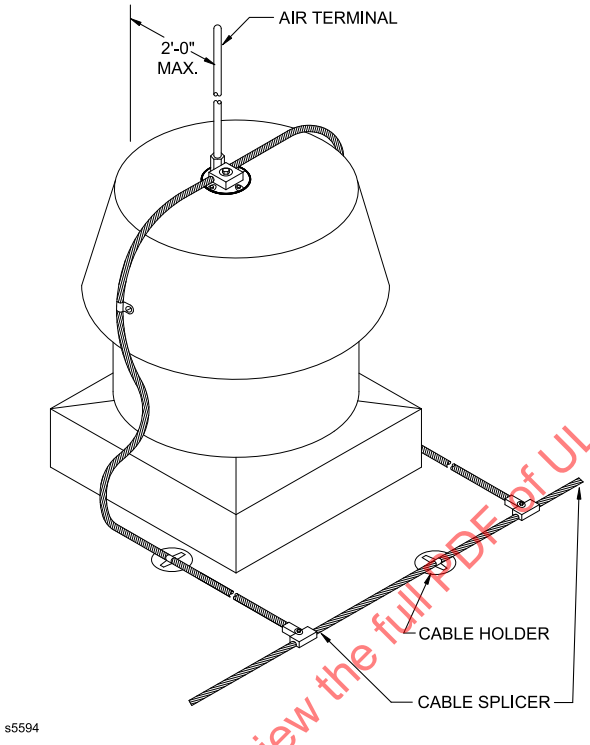


Figure 11.2

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 m^2)

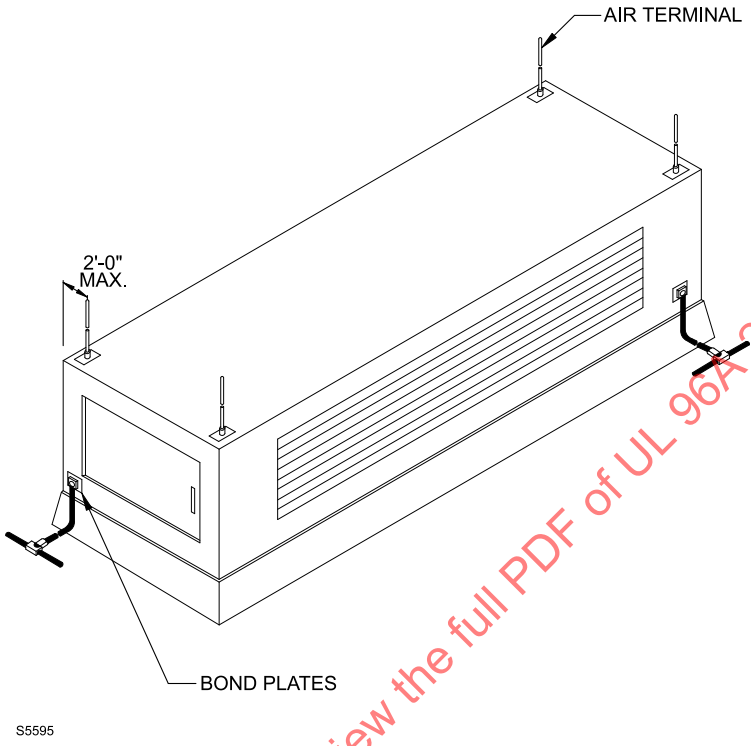


11.1.3 A power air handling unit less than 3/16 inch (4.8 mm) thick, with a surface area or volume larger than 400 square inches (0.258 m^2) or 1000 cubic inches (0.016 m^3) shall have air terminals installed, and shall have a minimum of two main-size bonding plates with cable connections to the main 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 m^2)



11.2 Metal bodies not subject to direct strike

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

11.2.2 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 11.2.3.

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 11.2.4 need no further bonding.

11.2.3 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.