UL 1659

STANDARD FOR SAFETY

Attachment Plug Blades for Use in Cord Sets and Power-Supply Cords

UL Standard for Safety for Attachment Plug Blades for Use in Cord Sets and Power-Supply Cords, UL 1659

Third Edition, Dated April 13, 2005

Summary of Topics

This revision of ANSI/UL 1659 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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 requirements are substantially in accordance with Proposal(s) on this subject dated September 21, 2018.

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UL 1659

Standard for Attachment Plug Blades for Use in Cord Sets and Power-Supply Cords

First Edition – September, 1993
Second Edition – September, 1997

Third Edition

April 13, 2005

This ANSI/UL Standard for Safety consists of the Third edition including revisions through November 19, 2018.

The most recent designation of ANSI/UL 1659 as a Reaffirmed American National Standard (ANS) occurred on November 19, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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.

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INTRODUCTION

1 Scope

1.1 General

1.1.1 These requirements cover the blades of attachment plugs and current taps intended to be connected to the conductors of flexible cords using crimped connections, for use on cord sets and power-supply cords complying with the Standard for Cord Sets and Power-Supply Cords, UL 817, within the limits set forth in 1.2.1 for type of blades and 1.3.1 for size of conductors.

1.2 Type of blades

1.2.1 These requirements apply to blades, solid and folded, of attachment plugs and current taps rated 15 or 20 A, for general purpose use. These requirements do not apply to the grounding blade (pin) of grounding type attachment plugs or current taps.

1.3 Conductor sizes

1.3.1 These requirements apply to blades intended to be attached to 18 AWG (0.82 mm^2) – 10 AWG (5.3 mm^2) conductors.

2 Glossary

2.1 For the purpose of this Standard the following definitions apply.

2.2 BLADE – The part of an attachment plug or current tap intended to be inserted into the contacts of an outlet device of matching configuration and the integral extension of this part, located within the attachment plug or current tap, to which the conductor of a flexible cord is connected.

2.3 CONTACT SURFACE AREA – The area on each side of a blade that is intended to make electrical contact with the contacts of an outlet device.

2.4 CRIMPED CONNECTION – An electro-mechanical connection made between a blade and a conductor by compressing the portion of the blade, termed ″the integral extension″ in 2.2, against the conductor.

3 Units of Measurement

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

4 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.

CONSTRUCTION

5 General

5.1 The construction of a blade shall be such that all strands of the intended conductor will be contained within the crimp terminal.

6 Materials

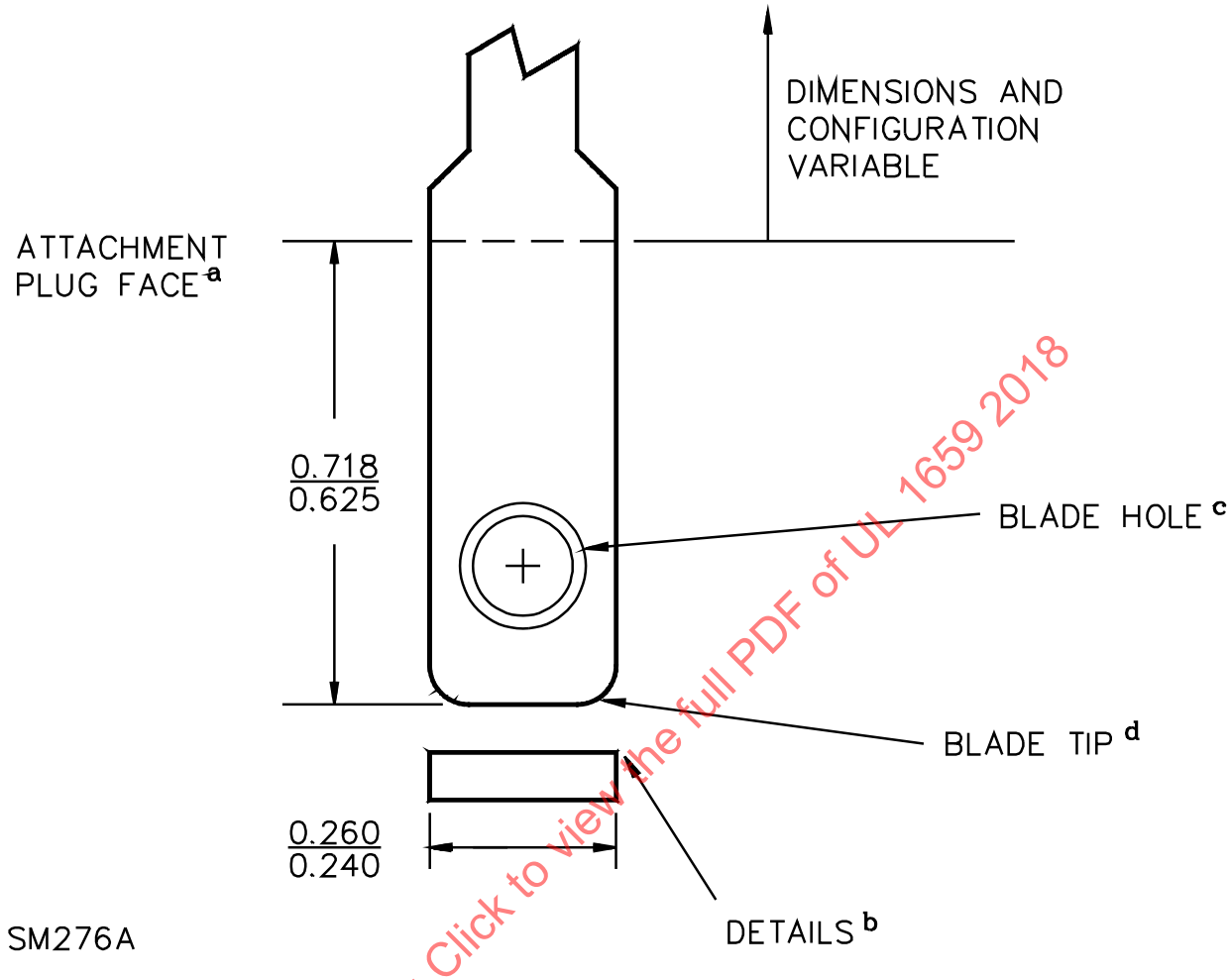
6.1 A blade shall be plated or unplated copper-zinc alloy having a minimum of 64.0 percent copper content as determined by the Electrodeposition Gravimetric Test Method described in the Standard Test Methods for Chemical Analysis of Copper Alloys, ASTM E478.

7 Dimensions

7.1 General

7.1.1 Blade dimensions shall be in accordance with Figure 7.1 or 7.2, as applicable.

Figure 7.1
Non-polarized blade



NOTES –

a) The location of the attachment plug face is shown above solely to provide a frame of reference.

b) See Figure 7.3 for details.

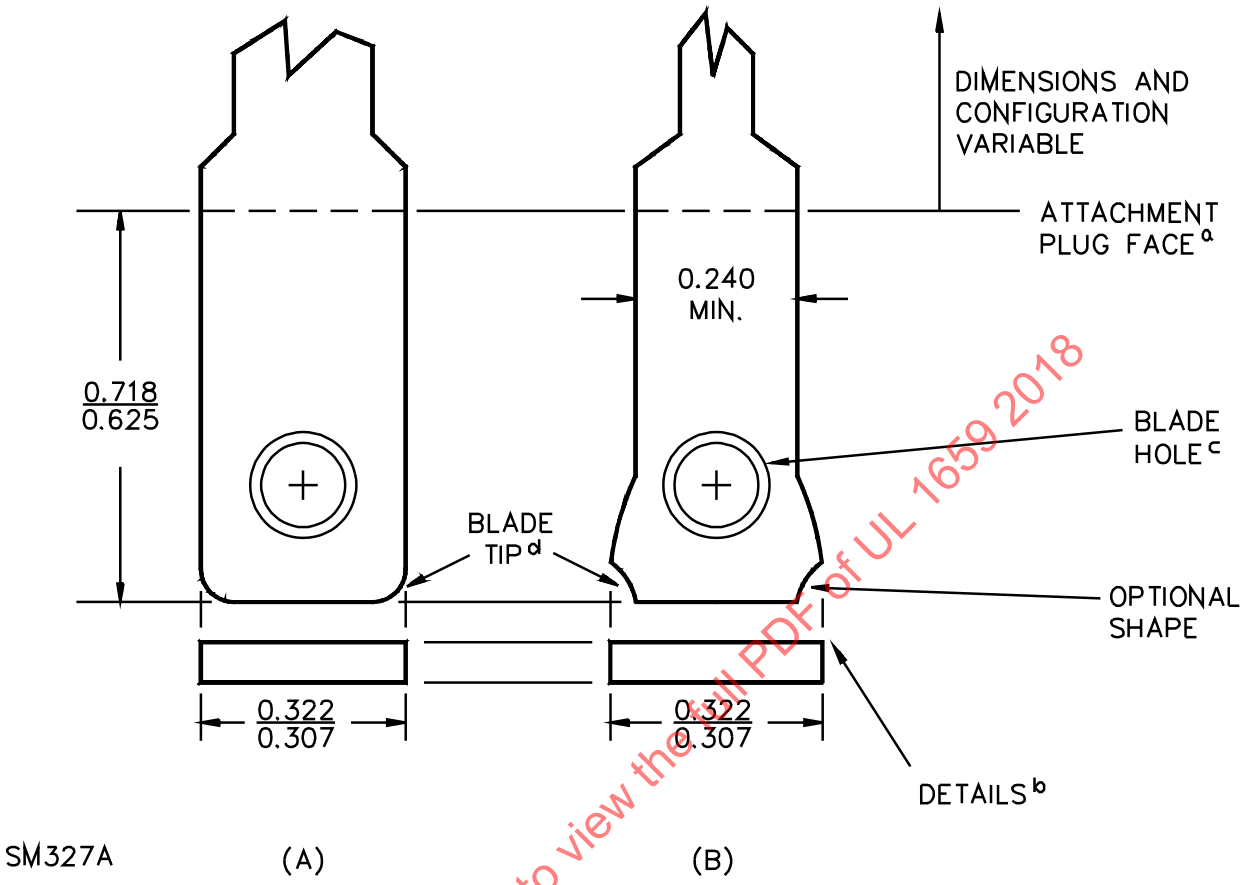
c) If used, locate as shown in Figure 7.5.

d) See Figure 7.4 for typical blade tip and stem dimensions.

All dimensions in inches

inch	mm	inch	mm
0.240	6.10	0.625	15.9
0.260	6.60	0.718	18.2

Figure 7.2
Polarized blade



NOTES –

a) The location of the attachment plug face is shown above solely to provide a frame of reference.

b) See Figure 7.3 for details.

c) If used, locate as shown in Figure 7.5.

d) See Figure 7.4 for typical blade tip and stem dimensions.

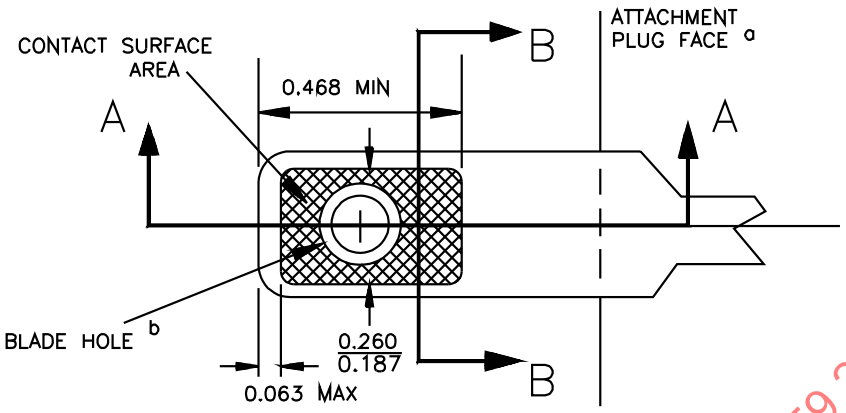
All dimensions in inches

inch	mm	inch	mm
0.240	6.10	0.625	15.9
0.307	7.80	0.718	18.2
0.322	8.18		

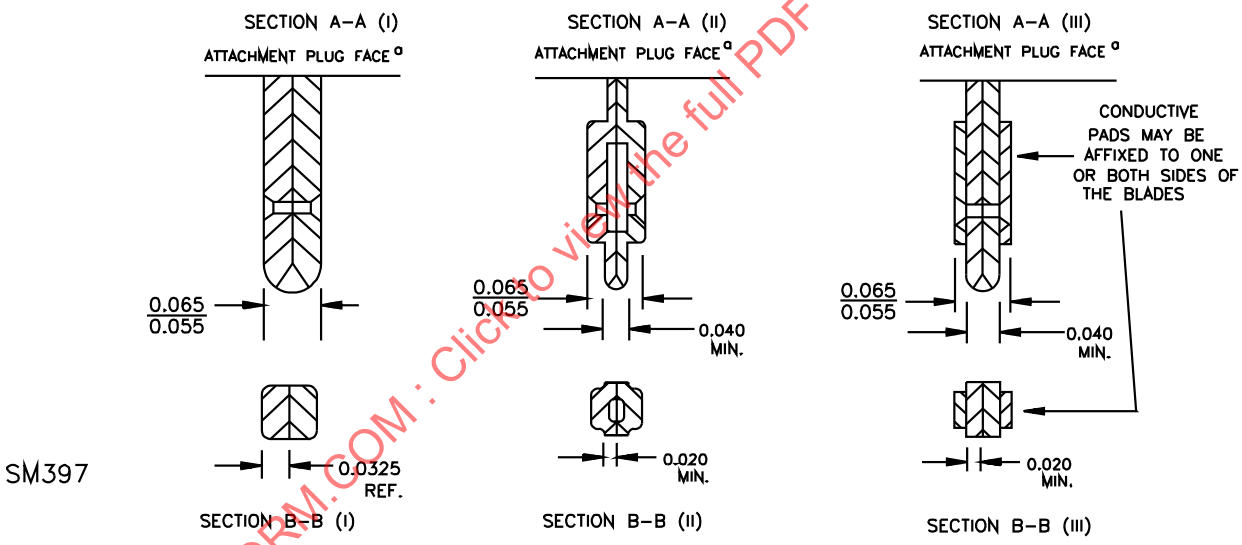
7.2 Contact surface area

7.2.1 A contact surface area shall be located on each side of a folded blade. The location and minimum size of the areas shall be as specified in Figure 7.3 except as modified in 7.2.2. A solid blade which complies with the thickness requirement in 7.3.1 is considered to have the required surface area. See 7.2.4.

Figure 7.3
Minimum blade contact area
(Blade profile not specified)



SOME POSSIBLE BLADE VARIATIONS WITHIN THE TOLERANCE SPECIFIED



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NOTES –

a) The location of the attachment plug face is shown above solely to provide a frame of reference.

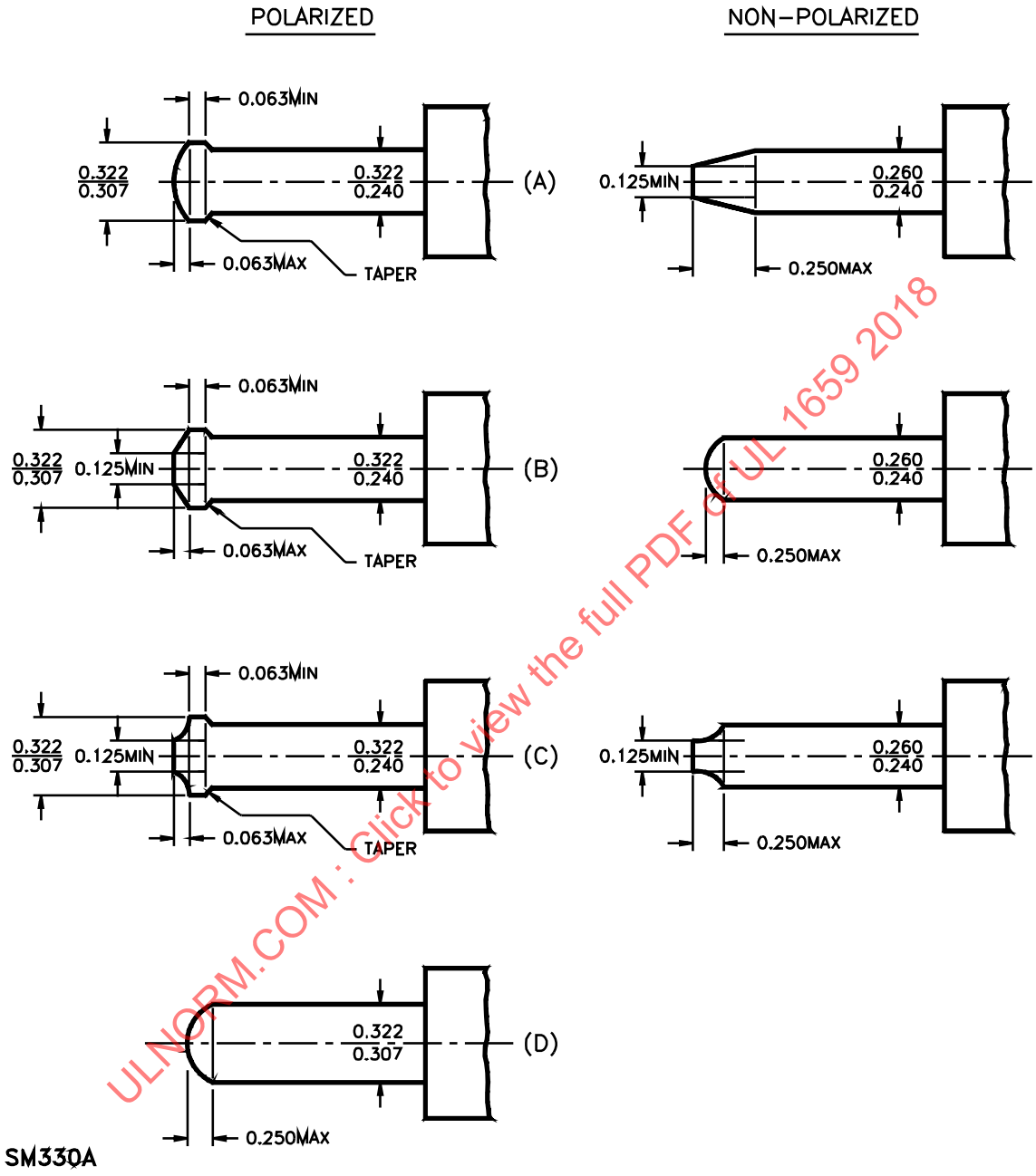
b) If used, locate as shown in Figure 7.5.

All dimensions in inches

inch	mm	inch	mm	inch	mm
0.020	0.51	0.055	1.40	0.187	4.75
0.0325	0.83	0.063	1.60	0.260	6.60
0.040	1.02	0.065	1.65	0.468	11.88

7.2.2 A contact surface area of a non-polarized folded blade shall extend into the tapered portion at the tip of the blade profiles as shown in Figure 7.4. See Compression Force Test, Section 16.

Figure 7.4
Specific blade tip and stem dimensions
(Profiles shown are typical)



All dimensions in inches

inch	mm	inch	mm	inch	mm	inch	mm
0.063	1.60	0.240	6.10	0.260	6.60	0.322	8.18
0.125	3.18	0.250	6.35	0.307	7.80		

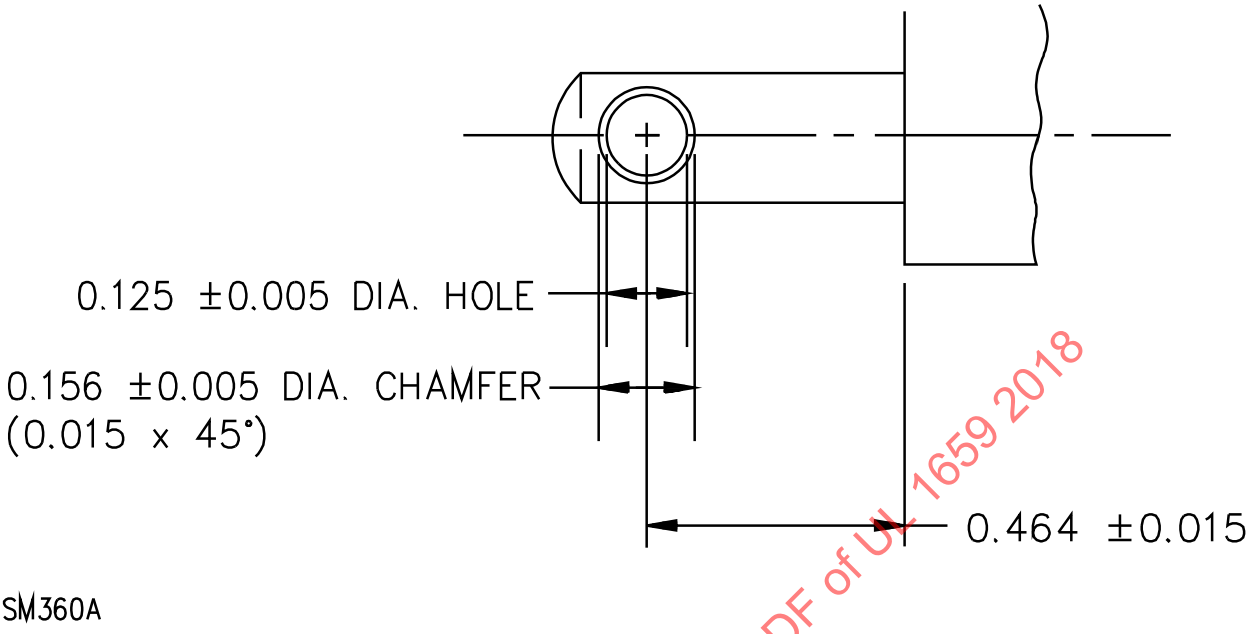
7.2.3 A contact surface area of a folded blade shall be flat and continuous except for:

a) The hole shown in Figure 7.5, if provided,

b) A close fitting seam (without gaps) that is formed by folding a blade and butting two edges together in the contact surface area, rather than along the edge of the blade, or

c) A die-stamped manufacturer's identification marking that is no deeper than needed for legibility.

Figure 7.5
Flat blade hole location



NOTE – If hole is used, locate as shown. If hole has chamfer, form as shown.

All dimensions in inches

inch	mm	inch	mm
0.015	0.38	0.156	3.96
0.125	3.18	0.464	11.79

7.2.4 A blade surface area, with or without the optional blade hole, and with or without the hole chamfer, that is totally flat (without embossing or other raised sections) is considered to have the required contact surface area for that side of the blade.

7.3 Blade thickness

7.3.1 The blade thickness shall be 0.055 – 0.065 inch (1.40 – 1.65 mm) at all points in the minimum contact surface area defined in 7.2.1 and shall be 0.040 – 0.065 inch (1.02 – 1.65 mm) in all other areas intended to be exposed.

7.3.2 A folded blade shall be formed from sheet material 0.0275 – 0.032 inch (0.70 – 0.81 mm) thick except as noted in 7.3.3.

7.3.3 A blade folded along its length or folded at the tip with both free ends intended to be located within the body of the attachment plug may be formed from sheet material at least 0.020 inch (0.51 mm) thick.

7.3.4 The thickness in the minimum contact surface area of a blade described in 7.3.3 shall not be readily compressible to less than 0.055 inch (1.40 mm) as determined by the Compression Force Test, Section 16. A blade constructed with continuous contact of the 2 blade sides around the outer periphery of the minimum contact surface area is not readily compressible for the purpose of this requirement.

7.4 Blade profile

7.4.1 A polarized or non-polarized blade shall have a profile similar to one of those shown in Figure 7.4 and shall have the dimensions specified for that profile.

7.4.2 The leading edge of a blade folded at the tip or otherwise formed to be a straight line shall be at least 0.125 inch (3.2 mm) long and formed without burrs. See Figure 7.4.

7.4.3 The stem of a blade shall be at least 0.240 inch (6.10 mm) wide and the sides of the blade profile shall be straight and parallel without notches or other discontinuities except at the end (tip) which, if shaped as shown in Figure 7.4, meets the intent of the requirement. A non-polarized blade shall not be wider than 0.260 inch (6.60 mm) at its widest exposed dimension. A polarized blade shall not be wider than 0.322 inch (8.17 mm) at its widest exposed dimension.

7.5 Polarizing features

7.5.1 In order to reduce the likelihood of inserting a polarized blade into a non-polarized slot of an outlet device, a polarized blade shall have the width specified in Figure 7.4.

7.5.2 A polarized blade shall not have sharp corners or edges that could cut into the material at the ends of a non-polarized slot in an outlet device in an attempt to insert the blade. Determination of sharp corners shall be done in accordance with the Standard for Tests for Sharpness of Edges on Equipment, UL 1439.

7.5.3 The minimum thickness of the polarizing portion of a polarized blade outside the designated blade contact area shall be 0.040 inch (1.02 mm).

7.5.4 A polarized blade profile having a tip width greater than the stem width (similar to those shown in Figure 7.4, items A, B, and C) shall have a taper from the tip width to the stem width that will reduce the likelihood of snagging the back surface of the blade on material that may surround a polarized slot in an outlet device.

7.6 Optional blade hole and chamfer

7.6.1 A blade may have a hole with or without a chamfer as shown in Figure 7.5. The edges of the hole and chamfer shall not have burrs or other projections that extend beyond the plane of the blade contact surface area.

PERFORMANCE

8 General

8.1 A blade shall perform acceptably when separate sets of assemblies are subjected to the test sequences specified in Table 8.1.

Table 8.1
Test sequence

Test sequence 1	Test sequence 2	Test sequence 3
Secureness Static Heating Heat-Cycling	Pull-Out	Compression Force

9 Representative Assemblies

9.1 Separate sets of assemblies are to be used for each of the test sequences specified in Table 8.1.

9.2 The basic set for test sequences 1 and 2 is to consist of four blade/conductor assemblies for each combination of blade and test conductor or conductors to be tested. The basic set for test sequence 3 is to consist of four blades not assembled to any conductors.

9.3 Tests conducted on a non-polarized blade are considered to represent testing on a polarized blade that differs only in the width or profile of the blade; however, tests conducted on a polarized blade are not considered to represent testing on a non-polarized blade.

9.4 Stranded flexible cord conductors described in 9.5 and 9.6 are to be used for testing. The number and size of the individual conductor strands, tinning or coating of the conductor, conductor insulation type, or other construction limitations on the type of flexible cord are to be as specified by the manufacturer.

9.5 Untinned conductors are to be used in preparing the test assemblies unless the blades are intended for use solely on tinned conductors. Tests on untinned conductors are considered to represent tests on tinned conductors.

9.6 For test sequence 1, blades are to be tested when assembled to the conductors used in the flexible cords described in Table 9.1.

Table 9.1
Assembly requirements for test sequence 1

Assembly set number	Conductors used in flexible cord type[b]	Cord conductor insulation[a,c,e]	Test conductor strandings for 18 – 10 AWG flexible cord[a,d]				
			18 AWG	16 AWG	14 AWG	12 AWG	10 AWG
1	S	Class 2.4 sulfur-cured rubber or Class 2.15 sulfur-cured neoprene	34 AWG	34 AWG	30 AWG	30 AWG	30 AWG
2	S	Class 2.4 sulfur-cured rubber or Class 2.15 sulfur-cured neoprene	30 AWG	30 AWG	26 AWG	26 AWG	26 AWG
3	SPT-3	Class 2.9, 2.29, 2.22, or 2.11 polyvinyl chloride (PVC)	36 AWG	34 AWG	34 AWG	30 AWG	30 AWG
4	SPT-3	Class 2.9, 2.29, 2.22, or 2.11 polyvinyl chloride (PVC)	30 AWG	30 AWG	30 AWG	26 AWG	26 AWG

[a] Test conductors with the insulation and stranding specified are available from Underwriters Laboratories Inc.

Table 9.1 Continued on Next Page

Table 9.1 Continued

Assembly set number	Conductors used in flexible cord type[b]	Cord conductor insulation[a,c,e]	Test conductor strandings for 18 – 10 AWG flexible cord[a,d]				
			18 AWG	16 AWG	14 AWG	12 AWG	10 AWG

[b] Test conductors may be obtained from other flexible cord types if they employ the required insulation compound and, for sets 1 and 2, the same thickness of conductor insulation as that used in Type S. See 10.3.

[c] A blade need not be tested on Class 2.4 sulfur-cured rubber or Class 2.15 sulfur-cured neoprene conductor insulation if the manufacturer opts to restrict its use to flexible cords employing only Class 2.9, 2.29, 2.22, or 2.11 polyvinyl chloride (PVC) or other thermoplastic conductor insulation. See 9.4.

[d] The values indicated represent the cord conductor strandings that are commercially available in these flexible cord sizes. The manufacturer may opt to specify the cord conductor stranding range in lieu of the values stated here. See 9.4.

[e] Class 2.4 is equivalent to Class 40, Class 2.15 is equivalent to Class 41, and Classes 2.9, 2.29, 2.22, and 2.11 are equivalent to Class 43.

9.7 For test sequence 2, blades are to be tested when assembled to the conductors used in flexible cords, described in Table 9.2.

Table 9.2
Assembly requirements for test sequence 2

Assembly set number	Test conductor strandings for 18 – 10 AWG flexible cord[a]	
	18 AWG	16 – 10 AWG
1	36 AWG	36 AWG
2	30 AWG	26 AWG

[a] The manufacturer may specify the maximum and minimum cord conductor stranding in lieu of the values stated here. See 9.4.

10 Preparation of Assemblies

10.1 To determine if a blade complies with the performance requirements, representative blades are to be assembled to flexible cord conductors of the type specified in 9.4 – 9.7 in the manner specified by the manufacturer. For the Heat-Cycling Test, a control-conductor assembly is also to be prepared as described in 10.2, 11.5, and 11.6.

10.2 All test and control cord conductors are to be previously unused and shall comply with the requirements in 9.4 – 9.7.

10.3 The insulated conductors are to be separated from the complete flexible cord prior to assembly on the blade. Jackets, braids, wraps and fillers are to be completely removed and discarded. Braidless parallel cords are to be split completely into individual conductors. Care should be taken in separating the conductors to avoid damage to the conductor insulation.

10.4 If a blade is not provided with the optional blade hole as shown in Figure 7.5, a hole of the size and location shown is to be drilled in the blades for test sequence 1 (prior to attachment of the test lead or thermocouple).

10.5 Cord conductors are to be stripped immediately prior to assembly to the blade for a distance that is proper for insertion into the crimp terminal and are to be assembled to the blade in the manner specified by the manufacturer, except that any insulation grips provided on the crimp terminal are to be left open. The conductor is not to be brushed or abraded unless such preparation is specified by the manufacturer. Any thread markers incorporated within the conductor stranding are to be left intact unless the blade manufacturer specifies a means for their removal.

10.6 The connection between the cord conductor and the blade is to be made before the start of the first test on any set. Additional adjustment is not to be done during the testing program.

10.7 If a blade is intended to be assembled to a cord conductor by means of a specific tool, this tool is to be used to assemble the blade to the cord conductor in the intended manner.

10.8 If a blade is intended to be assembled to a cord conductor by means of more than one type of specific tool, the blade shall perform acceptably in the tests when any of the specific tools is employed in the assembly operation. This requirement may necessitate conducting additional series of tests for a blade assembled by means of each type of specific tool.

11 Temperature Measurements

11.1 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2).

11.2 When thermocouples are used in determining temperatures in electrical equipment, it is common practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire and a suitable temperature indicating instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

11.3 The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements specified in the Initial Calibration Tolerances for Thermocouple table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

11.4 A control conductor is to be used in the determination of the stability factor in the Heat-Cycling Test as described in 14.3. The length of the control conductor is to be 48 inches (1.22 m). The control conductor is to be located in the test assembly as described in 13.3 and Figure 13.1 after it has been prepared in the manner described in 10.5 and 10.6.

11.5 A thermocouple on a control conductor is to be located at the midpoint of the conductor length and under the conductor insulation. The following technique is to be employed:

a) A small flap is to be cut into the conductor insulation and rolled back to expose the conductor.

b) The thermocouple bead is to be positioned on the conductor surface in the valley between conductor strands and secured as described in 11.6.

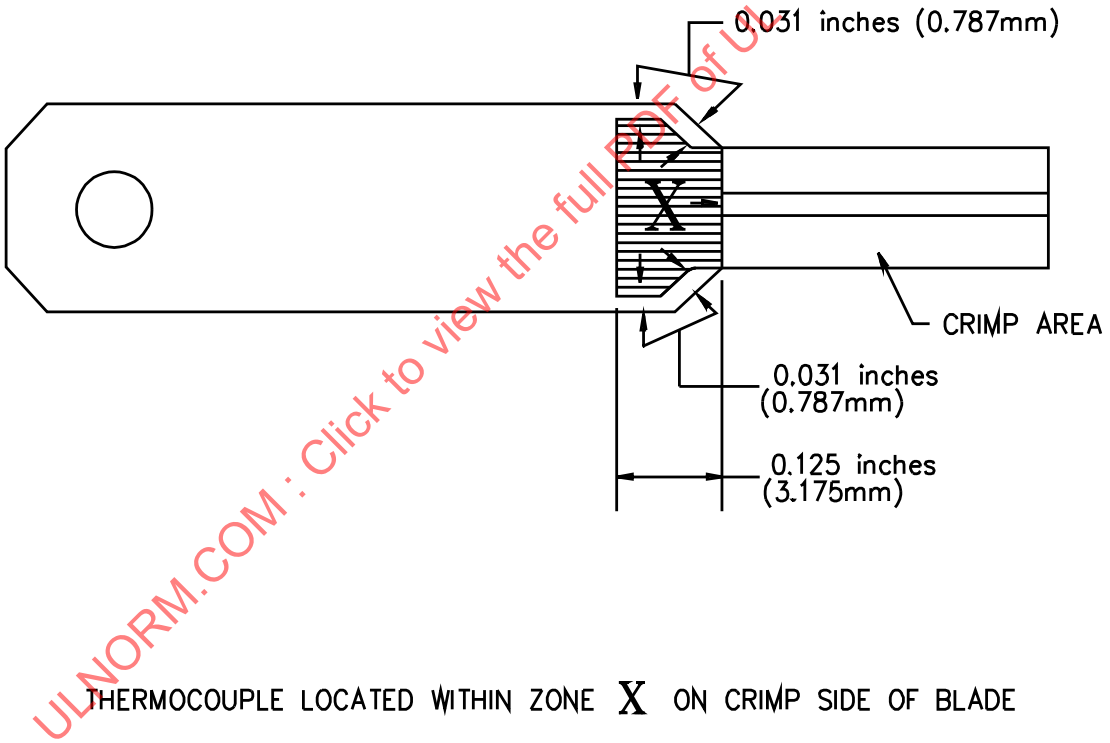
c) The flap of insulation is to be repositioned and secured by heat-shrinkable tubing extending not more than 1/2 inch (12.7 mm) on each side of the flap, or by an equivalent means of holding the test conductor insulation in place.

11.6 A thermocouple on a control conductor is to be secured by soldering, by use of a thermally conductive adhesive suitable for temperatures of at least 150°C (270°F), or by other equivalent means that will permit the replacement of the conductor insulation over the thermocouple location.

11.7 A thermocouple on a blade is to be positioned as shown in Figure 11.1. A thermocouple is to be installed so as to obtain thermal and mechanical bonding with the surface of a blade and without causing an appreciable change in the temperature of the blade and without penetration of the surface of the blade; for example, by the use of small quantities of a thermally conductive adhesive suitable for temperatures of at least 150°C (270°F) or by spot welding. Soldering or drilling and peening is not acceptable.

Exception: If the blade construction and assembly are such that the thermocouple cannot be located as shown in Figure 11.1, the thermocouple may be located on the opposite side of the blade stem near the crimp area.

Figure 11.1
Thermocouple location



11.8 Thermocouples intended to measure the ambient temperature for a blade set under test are to be installed on 2 inch (5.08 cm) square by 1/4 inch (6.4 mm) thick sections of unplated copper bus. Bus sections are to be located 2 feet in front, 2 feet in back and 2 feet on each side of the test assembly. A bus section is not to be mounted behind the test assembly. All measurements are to be made to the centerline of the nearest blade or conductor. If all thermocouples employed are the same length, they may be connected in parallel to provide an average ambient temperature reading; otherwise, the individual ambient temperature readings are to be used to calculate the average ambient temperature.

11.9 An alternate method of locating the ambient temperature thermocouple is to place one bus at the center of a loop formed by the sets.

12 Secureness Test

12.1 The joint between a blade and the wire of an assembly shall be intact after being subjected to the test described in 12.2 for 30 minutes. There shall not be any breakage of the conductor or any strand of the conductor, shearing of parts, or other damage to the blade.

12.2 A blade is to be terminated to a length of insulated flexible cord conductor that is at least 3 inches (7.62 cm) longer than the height specified in Table 12.1 and is to be rigidly secured so that the axis of the crimp connection is in a vertical position. The free end of the wire is to be passed through a bushing of the size specified in Table 12.1. The bushing is to be attached to an arm driven by a motor at a rate of approximately 9 rpm and in such a manner that the center of the bushing describes a circle in a horizontal plane as shown in Figure 12.1. The circle is to have a diameter of 3 inches (7.62 cm) and its center is to be vertically below the center of the cord conductor opening in the crimped connection of the blade. The distance between the upper side of the bushing and the cord conductor opening of the crimped connection is to be ±1/2 inch (±12.7 mm) of the distance specified in the column titled Height in Table 12.1. The bushing is to be lubricated so there is no binding, twisting, or rotation of the insulated cord conductor. A weight as specified in Table 12.1 is to be suspended from the free end of the cord conductor.

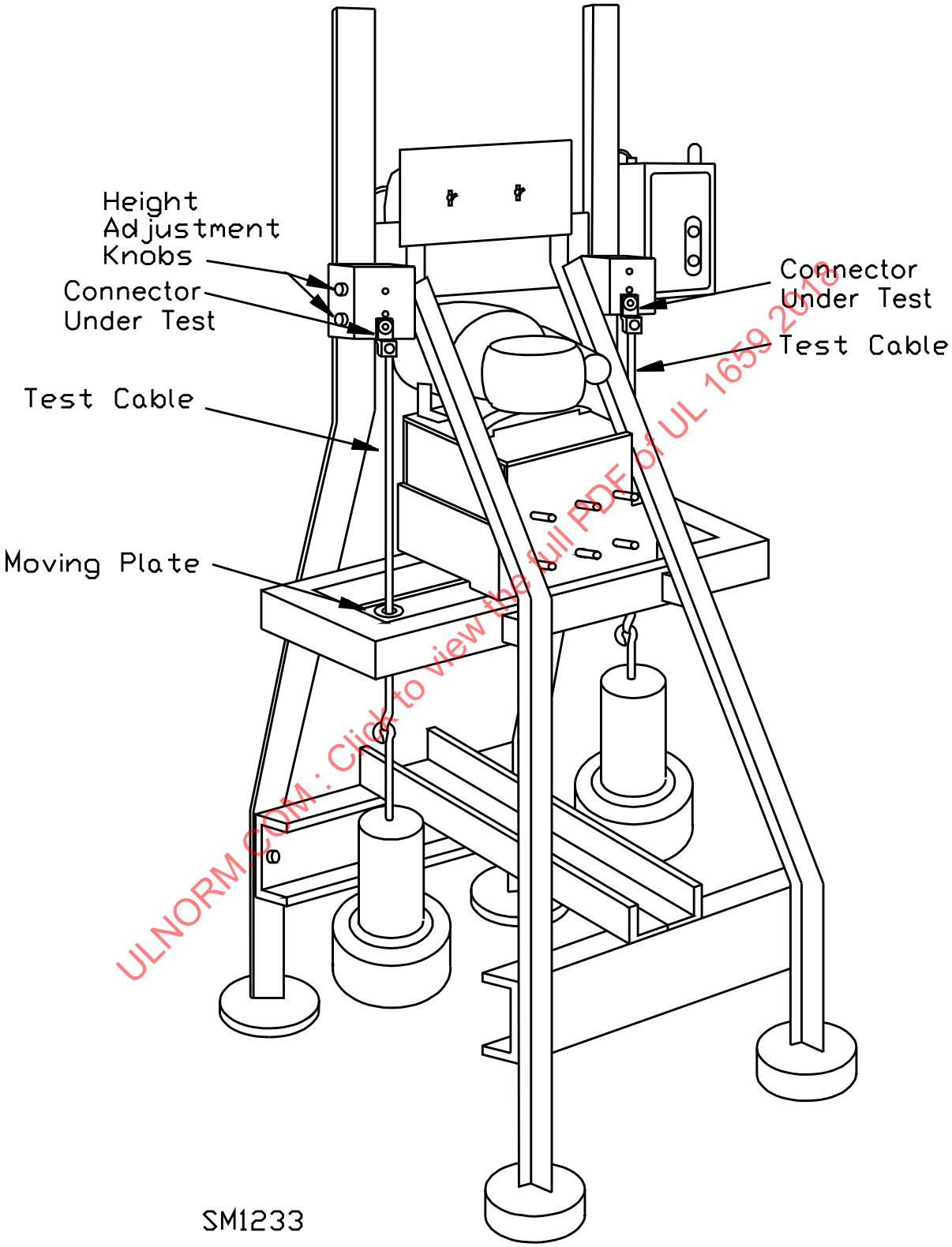
12.3 Breakage of the conductor or any strand of the conductor is to be determined by examination of the complete blade assembly after the test described in 12.2 has been completed. If the conductor or a strand of the conductor becomes visibly unattached, breakage is considered to have occurred.

Table 12.1
Secureness test values

Size of conductors		Diameter of bushing hole[a]		Height		Weight	
AWG	(mm^2)	inches	(mm)	inches	(mm)	pounds	(kg)
18 – 16	(0.82 – 1.3)	1/4	(6.4)	10-1/4	(260)	2	(0.9)
14	(2.1)	3/8	(9.5)	11	(279)	3	(1.4)
12 – 10	(3.3 – 5.3)	3/8	(9.5)	11	(279)	5	(2.3)

[a] If a hole with the diameter given is not adequate to accommodate the wire without binding, a bushing having a hole of a slightly larger diameter may be used.

Figure 12.1
Secureness test machine



13 Static Heating Test

13.1 The sets previously subjected to the Secureness Test described in Section 12 shall continuously carry the test current indicated in Table 13.1 until stable temperatures are reached without exceeding a 30°C (54°F) temperature rise above ambient temperature.

Table 13.1
Static heating test currents for conductors

Wire size		Static heating test current, amperes
AWG	(mm^2)	
18	(0.82)	10
17	(1.0)	12
17 HPN	(1.0)	13
16	(1.3)	13
16 HPN	(1.3)	15
15	(1.7)	16
15 HPN	(1.7)	17
14	(2.1)	18
12	(3.3)	25
10	(5.3)	30

13.2 After completing the Secureness Test, the test conductor on each device is to be trimmed to 12 inches (30.5 cm) in length.

13.3 The test assembly and securing hardware are to be as described in 13.4 – 13.7.

13.4 The sets are to be assembled into the test fixture shown in Figures 13.1 and 13.2. If a blade is not provided with the optional blade hole as shown in Figure 7.5, a hole of the size and location shown is to be drilled in the blade and deburred (prior to attachment of the test lead or thermocouple). Individual blade/conductor assemblies are to be separated by at least 7 inches (17.8 cm) when measured center-to-center. The No. 4-40 brass screws used to secure the blades in the test fixture are to be tightened with a torque of 7 in-lbf (0.8 N·m).

13.5 The test fixture and assemblies are to be mounted a minimum of 24 inches (61 cm) from the building floor, ceiling, and walls.

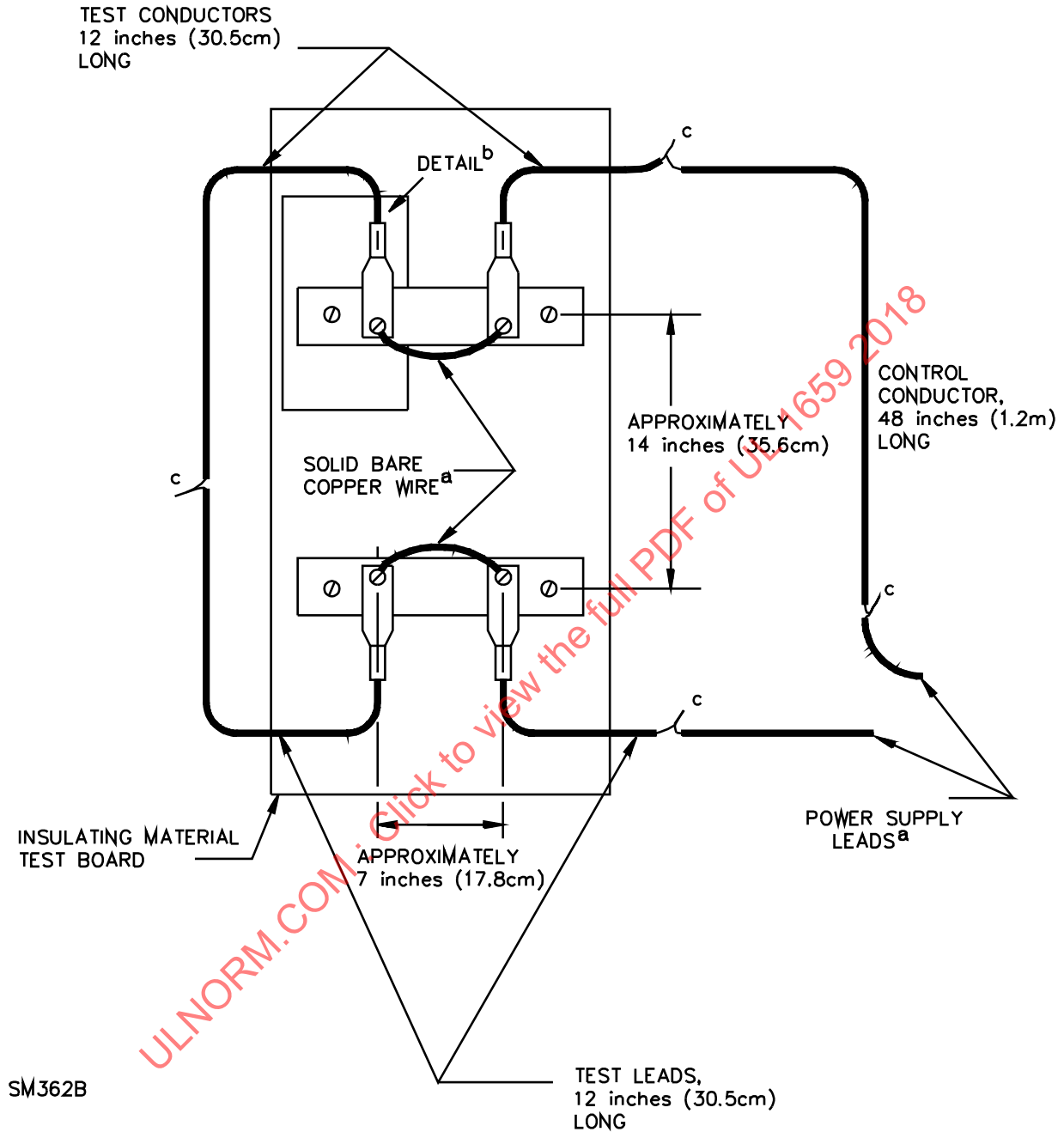
Exception: The spacing need not be maintained if a solid thermal insulating backboard separates the test devices from the building floor, ceiling, or walls. Devices are to be spaced at least 4 inches (10.2 cm) from the thermal insulating backboard.

13.6 Test assemblies are to be located in a substantially vibration- and draft-free location where the average ambient air temperature can be maintained in the range of 25 ±5°C (77 ±9°F). The air flow in the testing location is not to exceed 25 feet per minute (7.62 meters per minute).

13.7 Test sets and the control conductor are to be connected in series and to a current source that is maintained at or above the required value by regulation or frequent adjustment. The test current is to flow through the blades at any potential that will result in the required current. Temperature measurements are to be taken in the manner described in Temperature Measurements, Section 11.

13.8 A test device is considered to have attained a stable temperature during the Static Heating Test when three readings, taken at not less than 5-minute intervals, show no further rise above the ambient temperature.

Figure 13.1
Test assembly



NOTES –

a) Two wire sizes larger than test conductor.

b) See Figure 13.2 for detail.

c) All conductors are connected by twisting and soldering.