UL 4

STANDARD FOR SAFETY

Armored Cable

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UL Standard for Safety for Armored Cable, UL 4

Fifteenth Edition, Dated January 15, 2004

SUMMARY OF TOPICS

This revision of ANSI/UL 4 dated March 17, 2021 includes the following:

- ***Addition of Test References to the Standard for Wire and Cable Test Methods, UL 2556; 2.3, 2.4, 9.2, 11.2, 11.3, Figure 11.1, 12.3, Figure 12.1, 12.4, 15.2, Figure 15.1, 16.2 – 16.5***

- ***Marking Changes with Respect to Limited or Low Smoke; 17.6***

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 October 2, 2020.

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This ANSI/UL Standard for Safety consists of the Fifteenth Edition including revisions through March 17, 2021.

The most recent designation of ANSI/UL 4 as an American National Standard (ANSI) occurred on March 17, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 4 on June 14, 1989. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 These requirements cover interlocked steel or aluminum armored cables that contain 2, 3, or 4, 14 – 1 AWG insulated circuit conductors with or without grounding conductors and are for use as Type AC Armored Cable in accordance with Article 320 and other applicable parts of the National Electrical Code (NEC), ANSI/NFPA 70.

1.2 These requirements cover cables for use at potentials of 600 V or less and at temperatures that are not higher than 75°C (167°F) for Type ACTH, or 90°C (194°F) for Types ACHH and ACTHH, depending upon the temperature rating of the insulated conductors used. Cables with aluminum armor are suitable only for use with connectors other than the direct-bearing set-screw type and only in alternating-current circuits.

2 References

2.1 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.

2.2 Wherever the designation" UL 1581" is used in this wire standard, reference is to be made to the designated part(s) of the Reference Standard for Electrical Wires, Cables, and Flexible Cords (UL 1581).

2.3 Wherever the designation of “UL 2556” is used in this wire standard, reference is to be made to the designated part(s) of the Standard for Wire and Cable Test Methods, UL 2556.

2.4 Wherever the designation to “UL 2885” is used in this wire standard, reference is to be made to the designated part (s) of the Outline of Investigation for Acid Gas, Acidity and Conductivity of Combusted Materials and Assessment of Halogens.

3 Units of Measurement

3.1 In addition to being stated in the inch/pound units that are customary in the USA, each of the requirements in this standard is also stated in units that make the requirement conveniently usable in countries employing the metric system (practical SI). Equivalent – although not necessarily exactly identical – results are to be expected from applying a requirement in USA or metric terms. Equipment calibrated in metric units is to be used when a requirement is applied in metric terms.

CONSTRUCTION

4 Materials

4.1 Each material used in an armored cable shall be compatible with all of the other materials used in the cable.

5 Conductors

5.1 General

5.1.1 Only copper, copper-clad aluminum, or an acceptable aluminum alloy shall be used for the conductors in a cable. Soft-annealed copper shall comply with the American Society for Testing and Materials Standard Specification for Soft or Annealed Copper Wire, ASTM B 3. Solid 12 – 8 AWG aluminum conductors shall comply with the requirements for aluminum-wire stock (aluminum-alloy

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conductor material). All aluminum conductors shall comply with the requirements for semi-annealed 8000 series conductors in Section 10 of UL 1581. Copper-clad aluminum conductors shall comply with the requirements for copper-clad aluminum conductors in Section 11 of UL 1581. In a given cable, all conductors need not be of the same metal.

5.1.2 A copper conductor shall not be smaller than 14 AWG and shall not be larger than 1 AWG. An aluminum or copper-clad aluminum conductor shall not be smaller than 12 AWG and shall not be larger than 1 AWG.

5.1.3 Each 6 – 1 AWG conductor shall be stranded. Conductors shall comply with the requirements in the Standard for Thermoset-Insulated Wires and Cables, UL 44, or in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83, except as modified in this Section.

5.2 Circuit conductors

5.2.1 The circuit conductors in Type ACHH cable shall be Type RHH or Type XHH complying with the Standard for Thermoset-Insulated Wires and Cables (UL 44).

5.2.2 The circuit conductors in Type ACTH cable shall be Type THW complying with the Standard for Thermoplastic-Insulated Wires and Cables (UL 83).

5.2.3 The circuit conductors in Type ACTHH cable shall be Type THHN complying with the Standard for Thermoplastic-Insulated Wires and Cables (UL 83) or insulated conductors that comply with the requirements for conductors for use in Type ACTHH cable in UL 83 (these conductors have insulation of PVC or a thermoplastic other than PVC and do not have a nylon jacket).

5.2.4 Surface marking of the conductors indicated in 5.2.1 – 5.2.3 is not required, however, they shall not be marked with any designation such as THWN, THW, or RHW that indicates that they are for use in wet locations.

5.2.5 Conductors shall be without splices or joints of any kind within the armor, other than those that comply with the requirements for splices and joints in the applicable standard mentioned in 5.2.1 – 5.2.3.

5.3 Grounding conductor

5.3.1 One or more grounding conductors are acceptable in a cable but are not required. Each grounding conductor shall be either of the same construction as the circuit conductors, or an uninsulated copper or aluminum conductor with or without a paper covering. A maximum of one uninsulated grounding conductor is acceptable in a cable. Each grounding conductor shall be cabled with the circuit conductors and shall be entirely in one location in the cable – that is, it shall not be divided into two or more parts cabled separately or distributed helically – and, if insulated, shall be identified as indicated in 17.4. Each grounding conductor shall not be smaller than indicated in Table 5.1 or Table 5.2. Provision of an uninsulated grounding conductor with or without a paper covering or insulated grounding conductors does not remove the need for the aluminum bonding strip required in 7.6.1.

5.4 Fibrous coverings

5.4.1 Uninsulated grounding conductor with a paper covering

5.4.1.1 A covering is not required on an uninsulated grounding conductor but, if provided, shall consist of a strip of unreinforced 30-lb or 47-g/m^2 or heavier kraft paper that is at least 3 mils or 0.08 mm thick and is applied either:

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a) Longitudinally with an overlap of approximately 100 percent and a seal to keep the paper from unravelling, or

b) Helically with an overlap of at least 50 percent.

The paper shall be saturated with a preservative and moisture-resistant compound.

5.4.2 Conductors in Type ACHH cable

5.4.2.1 All thermoset-insulated conductors (plus any uninsulated grounding conductor with or without a paper covering) in armored cable shall have an overall covering of fibrous material applied directly over the grouped conductors in the cable. The overall fibrous covering shall be continuous and of a uniform cross section, and shall be at least 5 mils or 0.13 mm thick where 25-mil or 0.64-mm armor is employed and shall be at least 8 mils or 0.20 mm thick where 34-mil or 0.86-mm armor is employed. All fibrous coverings shall be saturated with a preservative and moisture-resistant compound.

5.4.3 Conductors in Type ACTH and ACTHH cable

5.4.3.1 Each insulated circuit conductor and any insulated grounding conductor in a Type ACTH or ACTHH armored cable shall have an individual fibrous covering applied directly over the finished insulated conductor. The covering shall be of paper and shall comply with the thickness, saturation, and application requirements in 5.4.1.1.

5.4.3.2 In addition to having the covering required in 5.4.1 on each of its thermoplastic-insulated conductors, a Type ACTH or ACTHH cable that is provided with an uninsulated grounding conductor without a paper covering shall have an overall covering of fibrous material applied directly over the grouped circuit and grounding conductors to keep the bare conductor from contacting the armor. The overall fibrous covering shall be continuous and of a uniform cross section and shall consist of a strip of unreinforced 30-lb or 47-g/m^2 or heavier kraft paper that is at least 5 mils or 0.13 mm thick and is applied helically with an overlap of at least 50 percent. The paper shall be saturated with a preservative and moisture-resistant compound.

Table 5.1
Grounding conductor in Type ACTH cable

AWG size of circuit conductor		Smallest AWG size of grounding conductor	
Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum
14	12	14	12
12	10	12	10
10 – 8	8 – 6	10	8
6 – 4	4 – 1	8	6
2 – 1	–	6	4

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Table 5.2
Grounding conductor in Type ACHH or ACTHH cable

AWG size of circuit conductor		Smallest AWG size of grounding conductor	
Copper	Aluminum or copper-clad aluminum	Copper	Aluminum or copper-clad aluminum
14	12	14	12
12	10	12	10
10 – 8	8 – 6	10	8
6 – 4	4 – 2	8	6
3 – 1	1	6	4

5.4.3.3 If the configuration, size, and number of conductors in a cable containing thermoplastic-insulated circuit conductors and an uninsulated grounding conductor with a paper covering results in the armor bearing on the paper covering on the grounding conductor, the armor shall be kept from cutting the paper covering on the grounding conductor by an overall covering of fibrous material applied directly over the grouped circuit and grounding conductors. The overall fibrous covering shall comply with 5.4.3.2.

5.5 Lay of conductors

5.5.1 The insulated conductors shall be cabled with a left-hand lay. The length of lay shall not be longer than indicated in Table 5.3.

Table 5.3
Lay of conductors

Number of circuit and grounding conductors in cable	Maximum length of lay[a]
	30 times conductor diameter
3	35 times conductor diameter
4	40 times conductor diameter
5	15 times the diameter over the five assembled conductors

[a] For a thermoset-insulated circuit conductor and for a thermoset-insulated grounding conductor, "conductor diameter" is the diameter over one of the finished, insulated circuit conductors of which the cable is composed. For a thermoplastic-insulated circuit conductor and for a thermoplastic-insulated grounding conductor, "conductor diameter" is the diameter over the paper wrap on one of the insulated circuit conductors composing the cable.

5.5.2 The length of lay of the conductors is to be determined by measuring the distance between successive convolutions of any given conductor along the longitudinal axis of the cable.

6 Fillers

6.1 If fillers are used to produce a round conductor assembly before armoring, they shall be located within the fibrous overall covering described in 5.4.2.1.

7 Armor

7.1 General

7.1.1 The cable shall be enclosed in metal armor that is applied directly over the conductors with fibrous covering described in 5.4.1.1 – 5.4.3.2. The armor shall consist of an interlocked steel or aluminum strip.

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7.1.2 It is acceptable to provide color identification for a cable by applying a coating on the external surface of the metal strip before forming or on the formed armor of the finished cable. Neither the color nor the composition of the coating is specified. See 15.2.

7.2 Dimensions of unformed metal strip

7.2.1 The strip shall be made of an aluminum-base alloy with a copper content of 0.40 percent or less, or of steel. Steel strip shall be made corrosion-resistant by a coating of zinc (see Section 10) on all surfaces, including edges and splices. The coating on each surface shall be evenly distributed, shall adhere firmly at all points, and shall be smooth and free from blisters and all other defects that can diminish the protective value of the coating.

7.2.2 The strip shall be uniform in width, thickness, and cross section and shall not have any burrs, sharp edges, pits, scars, cracks, or other flaws that can damage the underlying cable. Splices shall not materially increase the width or thickness of the strip nor shall they lessen the mechanical strength of the strip or adversely affect the formed armor.

7.2.3 The metal strip shall not be wider or thinner than indicated in Table 7.1. The thickness and width of the strip are to be measured before forming. Measurements are to be made by means of a machinist's micrometer caliper having an anvil and spindle that are round and are not larger than 0.200 inch or 5.1 mm in diameter, with flat surfaces on each.

Table 7.1
Dimensions of unformed metal strip

Calculated diameter over the assembly under the armor		Widest tape before forming		Thinnest tape before forming	
inch	mm	inch	mm	inch	mm
0 – 0.500	0 – 12.70	0.385	9.78	0.025	0.63
over 0.500	over 12.70	0.510	12.95	0.034	0.86

7.2.4 Aluminum strip shall have a tensile strength of not less than 38,000 lbf/in^2 or 262 MPa. Zinc-coated steel strip shall have a tensile strength of not less than 40,000 lbf/in^2 or 276 MPa. The tensile strength shall be determined on longitudinal specimens consisting of the full width of the strip when practical and otherwise on a straight specimen slit from the center of the strip. The test shall be made prior to application of the strip to the cable.

7.3 Weight

7.3.1 The weight of armor shall not be less than 76.29 percent of the weight of a solid-walled steel or aluminum tube of the same internal diameter as the armor and having a wall thickness equal to twice the thickness of the strip used.

7.3.2 The following formulas are to be used for determining the minimum acceptable weight of armor:

$$General:\ W_{lb/100\,ft} = 0.5992 \times L \times C \times (D^2 - d^2)$$

$$Simplified:\ W_{lb/100\,ft}(aluminum) = 70.46\,(D^2{}_{in} - d^2{}_{in})$$

$$Simplified:\ W_{lb/100\,ft}(steel) = 203.48\,(D^2{}_{in} - d^2{}_{in})$$

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in which:

W is the minimum acceptable weight of armor in pounds per 100 feet,

L is the length of armor in inches (1200 inches),

C is the weight of one cubic inch of steel (0.283 lb nominal), or aluminum (0.098 lb nominal) – the actual value for the alloy is to be used where known,

d is the measured internal diameter of armor in inches, and

D is equal to d plus four times the thickness of strip used, in inches.

$$General\ (metric):\ W_{kg/75\,M} = 0.7629 \times 0.7854 \times L \times C \times (D^2 - d^2) \times 10^{-6}$$

$$Simplified: W_{kg/75\,M}(aluminum) = 0.121\,(D^2{}_{mm} - d^2{}_{mm})$$

$$Simplified: W_{kg/75\,M}(steel) = 0.352\,(D^2{}_{mm} - d^2{}_{mm})$$

in which:

W is the minimum normal weight of armor in kilograms per 75 meters,

L is the length of armor in meters (75 m),

C is the weight of one cubic meter of steel (7833 kg nominal), or aluminum (2700 kg nominal) – the actual value for the alloy is to be used where known,

d is the measured internal diameter of armor in millimeters, and

D is equal to d plus four times the thickness of strip used, in millimeters.

To determine "d", remove the conductor assembly from a short piece of the finished cable, measure the internal diameter of armor by means of a plug gauge. Except for the external diameter, which shall not be less than 0.415 inch or 10.5 mm, the internal and external diameters of the armor are not specified.

7.3.3 The weight per 100 feet or per 75 meters of armor is to be computed from the measurement of the weight of one or more known lengths of the finished cable, and the measurement of the weight of one or more equivalent lengths of the unarmored conductor assembly of the construction used in the finished cable, using scales that can be read to at least 1/4 lb or 0.1 kg. The weight per unit length of the armor is then to be computed as the difference between the unit weight of the finished cable and the unit weight of the conductor assembly.

7.4 Diameter

7.4.1 Except for the external diameter, which shall not be less than 0.415 inch or 10.5 mm, the internal and external diameters of the armor are not specified.

7.5 Interior of armor

7.5.1 The interior of the armor shall not have any burrs or sharp edges that can damage any covering on a conductor or on the conductor assembly.

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7.5.2 The condition of the interior of armor is to be determined by removing the conductor assembly from a short length of the finished cable and by looking through the armor from one end and then the other. An incandescent electric lamp with a clean, frosted bulb is to be at the end of the tube opposite the examiner.

7.6 Bonding strip

7.6.1 Armored cable shall have an uninsulated bonding strip located between the conductor assembly and the armor throughout its entire length. The bonding strip, which enhances the grounding ability of the interlocked armor, shall be of aluminum and shall not be smaller than 16 AWG.

8 Bushings

8.1 The construction of armored cable shall be such that an acceptable insulating bushing or its equivalent protection can be inserted readily between the conductors and the armor at each termination of the armor.

8.2 To determine whether or not armored cable complies with the requirement in 8.1, a 2-inch or 50-mm length of armor is to be removed from one end of a length of cable. If it is intended that a fibrous covering is to be removed before a bushing is inserted, such covering shall be removed manually from the conductors. If the bushing can then be inserted readily between the conductors and the armor so that the flange on the bushing comes in contact with the cut end of the armor, and if it remains in that position after pressure is removed, the construction is acceptable.

8.3 Insulating bushings supplied with armored cable, shall be intended for the purpose and shall be of a readily distinguishable bright color such as red, orange, or yellow. At least 35 bushings shall accompany each 250-ft or 75-m length.

PERFORMANCE TESTS

9 Continuity of Conductors

9.1 All of the circuit conductors and any grounding conductor in armored cable shall be continuous throughout. Finished cable shall be tested for continuity of each 14 – 10 AWG conductor by the cable manufacturer at the cable factory.

9.2 To determine whether or not armored cable complies with the requirement in 9.1, the test shall be carried out in accordance to and comply with the Standard for Wire and Cable Test Methods, UL 2556, Continuity, Method 1.

10 Zinc Coating

10.1 The coating of zinc on steel armor shall be such that all of the following requirements are complied with:

a) A specimen of the zinc-coated strip tested before forming shall not show a bright, adherent deposit of copper on any surface, including edges, after two 60-s immersions in a solution of copper sulfate.

b) A specimen of the partially uncoiled armor from finished cable:

1) Shall not show a bright, adherent deposit of copper after one 60-s immersion in a solution of copper sulfate, and

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2) Shall not show a bright, adherent deposit of copper on more than 25 percent of any surface, including edges, after two 60-s immersions in the copper sulfate solution.

10.2 The solution of copper sulfate is to be made from distilled water and the American Chemical Society (ACS) reagent grade of cupric sulfate ($CuSO_4$). In a copper container or in a glass, polyethylene, or other chemically nonreactive container in which a bright piece of copper is present, a quantity of the cupric sulfate is to be dissolved in hot distilled water to obtain a solution that has a specific gravity slightly higher than 1.186 after the solution is cooled to a temperature of 18.3°C (65.0°F). Any free acid that might be present is to be neutralized by the addition of approximately 1 gram of cupric oxide (CuO) or 1 gram of cupric hydroxide [$Cu(OH_2)$] per liter of solution. The solution is to be diluted with distilled water to obtain a specific gravity of exactly 1.186 at a temperature of 18.3°C (65.0°F). The solution is then to be filtered.

10.3 At one end of a sample length of finished cable, the armor is to be unwound from the outside to expose to view both edges and the inner surface of the formed strip, and to facilitate working cheesecloth between the turns onto the inner surface to dry that surface during the test. To reduce the damage to the zinc coating, the strip is not to be straightened as it is unwound but is to remain in the helical form with a diameter that is not larger than about three times the cable diameter. Three 6-inch or 150-mm (axial measurement) specimens are to be cut from the partially uncoiled armor. Additionally, three straight 6-inch or 150-mm specimens are to be cut from a sample length of the zinc-coated steel strip before forming.

10.4 With prudent attention to the risks to health and to the risk of fire, the six specimens are to be cleaned with an organic solvent. Each specimen is to be examined for evidence of damage to the zinc coating occurring during specimen preparation, not during forming, and only specimens that are not damaged are to be selected for use in the test. One specimen of the unformed strip and one specimen of the armor are to be tested.

10.5 The two selected specimens are to be rinsed in water, and all of their surfaces are to be dried with clean cheesecloth. As much of the water as possible is to be removed in the drying operation because water slows the reaction between the zinc and the solution, thereby adversely affecting the test results. The surface of the zinc is to be dry and clean before a specimen is immersed in the copper sulfate solution. The specimens are not to be touched by the hands or anything else that can contaminate or damage the surfaces.

10.6 A glass, polyethylene, or other chemically nonreactive beaker having a diameter equal to twice the diameter measured over the specimen of partially uncoiled armor is to be filled with the solution of copper sulfate to a depth of not less than 3 inches or 76 mm. The temperature of the solution is to be maintained at 18.3 ±1.1°C (65.0 ±2.0°F).

10.7 One of the selected specimens is to be immersed in the solution and supported on end in the center of the beaker so that not less than half of its axial length is immersed. The specimen is to remain in the solution for 60 s, during which time it is not to be moved nor is the solution to be stirred.

10.8 At the end of the 60-s period, the specimen is to be removed from the beaker, rinsed immediately in running tap water, rubbed with clean cheesecloth (a clean soft-bristle test-tube or bottle brush in good condition and of applicable size may be used to rub the interior surfaces of the specimen of partially uncoiled armor, but cheesecloth is to be used on the other surfaces of this specimen and on the unformed strip) until any loosely adhering deposits of copper are removed, and is then to be dried with clean cheesecloth. The turns of the specimen of partially uncoiled armor are not to be further separated during this process. Again, the hands and other damaging and contaminating objects and substances are not to touch the surfaces that were immersed. The part of the specimen that was immersed is to be examined, considering each edge and broad surface separately and disregarding the portion of the specimen within 1/2 inch or 13 mm of its immersed end.

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10.9 If the part of the specimen that was immersed has any deposit of bright, firmly adhering copper outside the 1/2-inch or 13-mm end portion, an estimate is to be made and recorded of the percentage of each edge and broad surface that is covered with copper.

10.10 Regardless of whether the first dip results in a bright, adherent deposit of copper, the immersion, washing, rubbing, drying, examining, estimating, and recording operations are to be repeated once using the same specimen and beaker of solution. After the second dip, the solution in the beaker is to be discarded.

10.11 The remaining specimen is to be subjected to the 2-dip procedure described in 10.6 – 10.10.

11 Tightness of Armor on Conductors

11.1 The armor shall grip the cable to keep the conductor assembly from being withdrawn from a sample 10 ft or 3 m long by the application of a weight that exerts 30 lbf or 133 N or 13.6 kgf.

11.2 The test shall be carried out in accordance with UL 2556, Tightness of armor with the weight specified in 11.1. The cable is not acceptable if the end of the cable recedes into the armor at the upper end, a distance greater than 1/8 in or 3 mm.

11.3 *Deleted*

Figure 11.1

Tightness of armor test

Figure deleted

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12 Flexibility

12.1 The flexibility of armored cable shall be such that the finished cable can be bent around a mandrel having a diameter as indicated in Table 12.1, without damage to the conductor assembly and without the armor opening up at any point to expose the conductor assembly.

12.2 Sizes that are not indicated in Table 12.1 shall comply with the requirements in 12.1, with the diameter of the mandrel being eight times the outside diameter of the armor.

12.3 The apparatus and test shall be carried out in accordance with UL 2556, Flexibility of armored cable and metal-sheathed cable, Method 1. The sample is to be wrapped once around the cylindrical section of the specified diameter with the tension applied to the sample, causing the sample to just conform closely to the periphery of the cylinder. The tested specimen shall comply with the results and calculations section.

Table 12.1
Mandrel size

AWG size of circuit conductors	Number of circuit conductors	Diameter of mandrel	
		inches	mm
14	2	3.000	76
14	3	3.500	89
14	4	4.000	102
12	2	3.500	89
12	3	4.000	102
12	4	4.500	114
10	2	4.500	114
10	3	5.000	127
10	4	5.500	140
8	2	6.000	152
8	3	6.500	165
8	4	7.000	178

Figure 12.1

Stepped cone for flexibility test
Figure deleted

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12.4 *Deleted*

13 Elongation

13.1 Armored cable shall not show a permanent elongation of more than 3 inches or 76 mm after a 3-ft or 915-mm sample is subjected for 1 min to an axial tension imparted by a weight that exerts 100 lbf or 445 N or 45.4 kgf.

13.2 This test is to be made with the apparatus and according to the method described in 14.2 – 14.5, but the conductor assembly is not to be removed from the armor and the weight employed is to exert 100 lbf or 445 N or 45.4 kgf.

13.3 After the weight is supported by the sample for 1 min and is then released and the weight and clamps removed, measurement is to be made of the distance that the ends of the conductor assembly have receded into the armor at both ends of the sample. Measurements are to be made by inserting into the ends of the armor a scale reading directly to 64ths of an inch or 0.5 mm. The sum of the two measurements is the elongation of the sample.

14 Tension

14.1 The armor shall be capable of withstanding for 1 min, without opening up at any point, an axial tension imparted by a weight that exerts 300 lbf or 1334 N or 136 kgf applied to the ends of a 3-ft or 915-mm length of armor of circular cross section and, similarly, an axial tension imparted by a weight that exerts 150 lbf or 667 N or 68 kgf for armor of flattened cross section.

14.2 The apparatus is to consist of a pair of clamps, two weights – one that exerts 150 lbf or 667 N or 68 kgf, and one that exerts 300 lbf or 1334 N or 136 kgf – and a secure means for suspending the weight from a support. See Figure 14.1.

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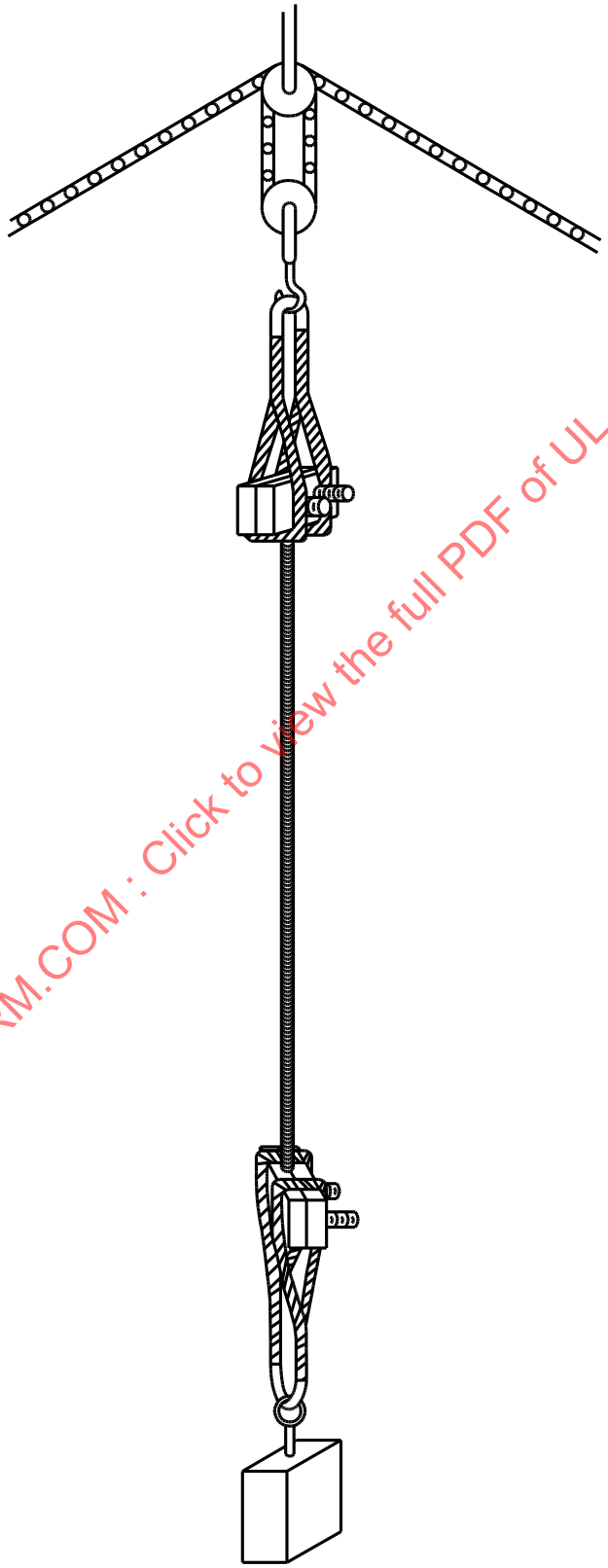
Figure 14.1

Apparatus for tension test



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