UL 814

STANDARD FOR SAFETY

Gas-Tube-Sign Cable

UL Standard for Safety for Gas-Tube-Sign Cable, UL 814

Twelfth Edition, Dated July 6, 2011

SUMMARY OF TOPICS:

This revision of ANSI/UL 814 dated October 7, 2020 s 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 July 24, 2020.

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Gas-Tube-Sign Cable

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This ANSI/UL Standard for Safety consists of the Twelfth Edition including revisions through October 7, 2020.

The most recent designation of ANSI/UL 814 as a Reaffirmed American National Standard (ANS) occurred on October 6, 2020. 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 These requirements cover single-conductor, 18 – 10 AWG, gas-tube-sign cables with temperature ratings of 105°C – 250°C (221°F – 482°F), and ratings of 5000 volts, 10000 volts, or 15000 volts. The cables are for use with gas-tube systems for signs, outline lighting, and interior lighting in accordance with the National Electrical Code and the Standard for Electrical Signs, UL 48.

1.2 Assemblies that include these cables and are intended for use as components of gas-tube signs shall meet the requirements in the Standard for Electric-Sign Components, UL 879.

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 standard, reference is to be made to the designated parts of the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581. Whenever the designation "UL 2556" is used in this standard, reference it to be made to the designated parts of the Standard for Wire and Cable Test Methods, UL 2556.

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 various metric systems (practical SI and customary). Equivalent – although not necessary exactly identical – results are to be expected from applying a requirement in USA or in metric terms. Equipment calibrated in metric units is to be used when a requirement is applied in metric terms.

4 Materials

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

5 Conductors

5.1 Materials, sizes, and ratings

5.1.1 The conductor shall be of soft-annealed copper. The conductor shall be 18 – 10 AWG in size. The conductor shall not be smaller in area than indicated in Table 5.1 and shall be continuous throughout without joints in the conductor as a whole. The voltage rating of the cable shall not exceed the rating shown in Table 5.1 based on conductor size.

5.1.2 The size of a conductor shall be verified either by determination of the d-c resistance or by determination of the cross-sectional area as described in 5.1.4. Measurement of the d-c resistance is to be as described in the test, D-C Resistance, in UL 2556. Determination of the conductor size by measurement of the direct-current resistance is the referee method in all cases. The d-c resistance shall not be higher than the maximum indicated for the size in Table 5.3 or Table 5.4, as applicable.

5.1.3 The resistance of a copper conductor measured at a temperature other than 20 or 25°C is to be adjusted to the resistance at 20 or 25°C by means of the applicable multiplying factor found in the table titled "Adjustment factors for dc resistance of conductors", in UL 2556.

5.1.4 Where measured as the means of size verification (see 5.1.2), the cross-sectional area of the conductor shall not be smaller than the minimum area indicated for the size in Table 5.1. The cross-sectional area of the conductor is to be determined as the sum of the areas of its component round strands, with the individual strands measured as described in 5.1.5. Where the sum of the strand areas does not comply, the conductor area is to be determined by the weight method described in the test, Cross-Sectional Area by mass (weight) method, in UL 2556. The area determined by the weight method is to be taken as conclusive.

Table 5.1
Minimum cross-sectional area and maximum voltage rating of conductor

AWG size of copper conductor	cmil (0.98 x nominal area)	mm^2	Maximum voltage rating
18	1,588	0.807	5000 – 10000 V
17	2,009	1.02	
16	2,528	1.28	
15	3,195	1.62	
14	4,028	2.04	10001 – 15000 V
13	5,076	2.58	
12	6,399	3.24	
11	8,065	4.04	
10	10,172	5.16	

5.1.5 The diameter of each individual strand is to be measured over the tin or other metal coating by means of a micrometer caliper having flat surfaces on both the anvil and the end of the spindle and calibrated to read directly to at least 0.001 inch or 0.01 mm. It is to be assumed that any one strand is practically constant in diameter throughout its length.

5.1.6 No particular combination of the individual strands of a conductor is required; however, simple bunching (untwisted strands) shall not be used.

5.1.7 The individual wires strands used in making up a conductor are usually drawn to a specified diameter that does or does not correspond to the diameter of an established gauge number. The individual strands are not required to be all of the same diameter.

5.1.8 The length of lay of the strands in every layer of a concentric-lay-stranded conductor shall be 8 – 16 times the outside diameter of that layer. The direction of lay of the outer layer shall be left-hand.

5.1.9 The length of lay of the strands in a single-bunch bunch-stranded conductor shall not be greater than indicated in Table 5.2. The direction of lay shall be left-hand.

Table 5.2
Maximum length of lay of strands in a single-bunch bunch-stranded conductor

AWG size of conductor	Inches	mm
18, 17	1-1/4	32
16, 15	1-1/2	38
14, 13	1-3/4	44
12, 11	2	51
10	2-1/2	64

Table 5.3
Maximum direct-current resistance of copper conductors
ASTM Class C 19-strand concentric-lay conductors assumed

AWG size of conductor	Uncoated				Coated			
	20°C (68°F)		25°C (77°F)		20°C (68°F)		25°C (77°F)	
	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer
18	6.66	21.8	6.79	22.2	7.06	23.2	7.19	23.6
17	5.27	17.3	5.37	17.6	5.59	18.3	5.70	18.7
16	4.18	13.7	4.26	14.0	4.45	14.6	4.53	14.9
15	3.31	10.9	3.37	11.1	3.44	11.3	3.51	11.5
14	2.62	8.62	2.68	8.78	2.73	8.96	2.78	9.14
13	2.08	6.82	2.12	6.97	2.21	7.10	2.20	7.24
12	1.65	5.43	1.68	5.53	1.72	5.64	1.75	5.75
11	1.32	4.30	1.34	4.39	1.37	4.48	1.39	4.56
10	1.039	3.409	1.060	3.476	1.080	3.546	1.102	3.615

Table 5.4
Maximum direct-current resistance of single-bunch bunch-stranded copper conductors

AWG size of conductor	Uncoated				Coated			
	20°C (68°F)		25°C (77°F)		20°C (68°F)		25°C (77°F)	
	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer	Ohms per 1000 feet	Ohms per kilometer
18	6.72	22.1	6.85	22.5	7.23	23.7	7.36	24.6
17	5.29	17.4	5.40	17.7	5.47	17.9	5.57	18.3
16	4.18	13.7	4.26	14.0	4.54	14.9	4.58	15.0
15	3.30	10.8	3.37	11.1	3.44	11.3	3.50	11.5
14	2.63	8.64	2.67	8.76	2.82	9.25	2.89	9.48
13	2.08	6.82	2.12	6.96	2.16	7.09	2.20	7.22
12	1.65	5.42	1.69	5.55	1.78	5.84	1.81	5.94
11	1.32	4.33	1.35	4.43	1.37	4.49	1.40	4.59
10	1.040	3.420	1.063	3.380	1.120	3.680	1.140	3.740

5.2 Metal coating

5.2.1 The individual strands of a copper conductor shall each have a continuous coating of tin or other metal or alloy if the conductor is insulated with a material that is capable of corroding unprotected copper.

5.3 Separator

5.3.1 A separator between the conductor and the insulation is not required but, if provided, shall consist of a close wind or braid of material such as fine cotton, or a close wind or wrap of a material such as paper or cellophane. A separator shall be colored or opaque to make the separator clearly distinguishable from the conductor once the insulation is removed. The color shall be other than green or green and yellow and may be solid, striped, or in some other pattern.

6 Insulation

6.1 The conductor shall be insulated or integrally insulated and jacketed for its entire length with one or more of the insulation or insulation/jacket materials for which physical-properties limits are tabulated in Specific Materials, Section 50, of UL 1581 or with another such material evaluated for the use. The insulation or integral insulation/jacket that is the outermost layer on GTO Cable marked "integral sleeve" shall be of a material that has a minimum, unaged tensile strength of 1200 lbf/in^2 or 8.27 MPa (MN/m^2), or 827 N/cm^2, or 0.844 kgf/mm^2. The insulation or integral insulation/jacket material shall have a temperature rating of 105°C (221°F), 150°C (302°F), 200°C (392°F), or 250°C (482°F), shall be applied directly to the surface of the conductor or to the separator, if one is used, and shall comply with the requirements in Sections 9 – 21.

6.2 The applied insulation or integral insulation and jacket shall provide a circular cross section for the insulated or insulated/jacketed conductor, and the conductor itself shall be centered in the applied material so that, when determined by the pin-gauge or optical method, the minimum thickness at any point of the applied material is not less than 90 percent of the average thickness of the material as determined by the difference method. The average thickness of the insulation or integral insulation/jacket is not specified.

6.3 An insulation or jacket that is of material generically different from any insulation or jacket material referenced in 7.2 (new material), or that is as referenced in 6.1 or 7.2 yet does not comply with the short-term tests applicable to the material, shall be of a material and in thicknesses and with the temperature rating appropriate for the gas-tube-sign cable construction. The material shall be evaluated for the requested temperature rating as described in the test, Dry Temperature rating of new materials (long-term aging), in UL 2556. Investigation of the electrical, mechanical, and physical characteristics of the cable using either material shall show the material to be comparable in performance to the insulation or jacket materials referenced in 6.1 or 7.2. The investigation shall include tests such as crushing, abrasion, deformation, heat shock, insulation resistance, and dielectric voltage-withstand.

7 Jacket

7.1 Cable shall be provided with a jacket that enables the cables to comply with the requirements in Sections 9 – 21. The jacket shall be integral with the insulation (see 6.1 and 6.2) or shall be applied as a separate layer (see 7.2 and 7.3). The jacket that is the outermost layer on GTO Cable marked 'integral sleeve" shall be of a material that has a minimum, unaged tensile strength of 1200 lbf/in^2, or 8.27 MPa (MN/m^2), or 827 N/cm^2, or 0.844 kgf/mm^2.

7.2 A jacket consisting of a separate layer shall be of one of the jacketing materials for which physical-properties limits are tabulated in Specific Materials, Section 50, of UL 1581 or of another jacketing material evaluated for the use as indicated in 6.3. The temperature rating of the cables is the temperature rating of the insulation or the jacket, whichever is lowest.

7.3 The thickness of a separate jacket shall not be less than 0.015 inch or 0.38 mm, without any minus tolerance.

8 Copper-Wire Braid

8.1 An overall copper-wire braid is appropriate, but is not required, over the nonmetallic covering indicated in 7.1 – 7.3. When such a braid is employed, a minimum 15 mil thick nonmetallic protective jacket is required over the braid.

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9 Physical Properties Tests

9.1 Specimens prepared from sample lengths of the insulation, integral insulation/jacket, or separate jacket shall have physical properties that comply with the applicable table referenced in 6.1 or 7.2 or with separately established values of physical properties. The samples are to be taken from the finished cable and the testing is to be conducted as indicated in 9.2.

9.2 The methods of preparation of samples, of selection and conditioning of specimens, and of making the measurements and calculations for ultimate elongation, tensile strength, and set shall be as indicated in the test, Physical properties (ultimate elongation and tensile strength), in UL 2556.

10 Routine Voltage Application Test

10.1 Finished cable shall be capable of withstanding without breakdown the application of a 48 – 62 Hz essentially sinusoidal potential after immersion in water at room temperature for 1 hour and under the following conditions. Starting near zero, the applied potential shall be increased at the rate of approximately 500 V/s until the test voltage is equal to the rated voltage of the cable, shall be held at that level, and then shall be reduced to zero. The total time for increasing, holding, and reducing the test voltage shall be 5 min.

10.2 Compliance of cable with the requirement in 10.1 is to be determined by using a voltage supply that complies with 12.4. The test potential is to be applied between the conductor of the cable and an electrode immersed in the water. Throughout the test, including the 1-hour period of immersion prior to the application of the test potential, the two ends of the coil are to be kept at least 2 feet or 610 mm out of the water. Breakdown usually can be determined by a current rush resulting from the decreased resistance of the circuit, and is to be indicated by the tripping of a circuit breaker or by the illumination of a bank of lamps connected in series with the test coil. In some instances, breakdown can be noted by observing the flash at the point on the cable at which the rupture takes place.

11 Voltage Application at Elevated Temperature

11.1 A 10 foot coil of finished cable shall be capable of withstanding, without breakdown, the application of a 48 – 62 Hz essentially sinusoidal potential when the coil under test is placed in an oven at elevated temperature under the following conditions. Starting near zero, the applied potential shall be increased at the rate of approximately 500 V/s until the test voltage is equal to the rated voltage of the cable, shall be held at that level, and then shall be reduced to zero. The total time for increasing, holding, and reducing the test voltage shall be 12 hours. The test temperature shall be calculated from the following formula:

$$T_{test} = 1.02 \times [273.15 + T_{rating\,(^{\circ}C)}] - 273.15$$

11.2 Compliance of cable with the requirement in 11.1 is to be determined by using a voltage supply that complies with 12.4. For a cable containing an optional braid per 8.1, the test potential is to be applied between the copper braid and conductor of the cable. For a cable without a braid, the test potential is to be applied between the conductor and either a metallic braid applied around the cable for test purposes, or a graphite powder that the cable is placed in. Breakdown usually can be determined by a current rush resulting from the decreased resistance of the circuit, and is to be indicated by the tripping of a circuit breaker or by the illumination of a bank of lamps connected in series with the test coil. In some instances, breakdown can be noted by observing the flash at the point on the cable at which the rupture takes place.

12 Extended Voltage Application Test

12.1 When a specimen of finished cable is wound on a metal mandrel, the insulation shall be capable of withstanding for 1 hour without breakdown the application of a 48 – 62 Hz essentially sinusoidal potential as indicated in Table 12.1 and under the following conditions: starting near zero, the applied potential shall be increased at the rate of approximately 500 V/s until the required test value is reached. After an hour, the applied potential shall be reduced to zero.

Table 12.1
Test potential and mandrel diameter

Type of cable and maximum working potential in volts		Test potential in volts rms	Diameter of mandrel	
			inches	mm
GTO - 5	5,000	10,000	3/4	19
GTO - 10	10,000	20,000	1	25
GTO - 15	15,000	30,000	1-1/4	32

12.2 Finished cable with an overall copper-wire braid shall comply with the requirement in 12.1, but the mandrel need not be of metal.

12.3 Compliance of cable with the requirements of 12.1 and 12.2 is to be determined by means of:

a) A voltage supply that complies with 12.4, and

b) A rigid mandrel 24 inches or 610 mm in length and having the diameter indicated in Table 12.1.

For a sample with a nonmetallic covering, the mandrel is to be of metal and is to be covered at each end, for a distance of approximately 5-1/4 inches or 130 mm back from the end, with varnished-cloth tape and then friction tape to reduce the partial-discharge (corona) effect at the point at which the cable under test leaves the mandrel. The distance between the taped sections is to be approximately 13-1/2 inches or 340 mm. For a sample with an overall copper-wire braid, the mandrel need not be of metal but may be of wood or other rigid nonmetallic material.

12.4 The test potential is to be supplied by a 48 – 62 Hz supply whose potential is continuously variable from near zero to at least 50 kV rms at the rate of approximately 500 V rms/s. With a specimen in the circuit, the supply potential is to have a crest factor (peak voltage divided by rms voltage) equal to 95 – 105 percent of the crest factor of a pure sine wave over the upper half of the supply range. The supply voltage is to be monitored continuously by a voltmeter that, if of the analog rather than digital type, shall have a response time that does not introduce a lagging error greater than 1 percent of full scale at the specified rate of increase in voltage, and that has an overall accuracy that does not introduce an error exceeding 5 percent.

12.5 The cable is not to be twisted while being wound onto the mandrel. The free end of the cable is to adjust itself as the cable is being wound onto the mandrel. The ends of a test sample with a nonmetallic covering are to leave the metal mandrel at points near the centers of the taped sections at each end.

12.6 The spacing between centers of adjacent convolutions is to be 1-1/2 inches or 38 mm, and nine turns of the conductor are to be made around the mandrel. The conductor is to be held in position at the ends by means of one or two turns of tape around the mandrel and conductor. For a sample with a nonmetallic covering, the metal mandrel is to serve as one electrode and the conductor in the cable is to serve as the other electrode. For a sample with an overall copper-wire braid, the braid is to serve as one electrode and the conductor in the cable is to serve as the other electrode.

13 Extended Voltage Application After Immersion Test

13.1 After a finished cable is immersed in water for 1 hour, the insulation shall be capable of withstanding for a period of 4 hours without breakdown the application of a 48 – 62 Hz sinusoidal potential of 150 percent of the rated voltage of the cable. Starting near zero, the applied potential is to be increased at the rate of approximately 500 V/s until the required test value is reached. After 4 hours, the applied potential is to be reduced to zero.

13.2 Compliance of cable with the requirement in 13.1 is to be determined by means of:

a) A voltage supply that complies with 12.4, and

b) A 5-ft or 1.5-m length of 1/2 inch rigid metal conduit having square-cut ends and standard conduit bushings threaded in place.

13.3 A 9-ft or 2.7-m sample of cable is to be immersed for all but about 6 inches or 150 mm at each end in water at 25.0 ±5.0°C (77.0 ±9.0°F) for 1 hour, after which the sample is to be removed and the surface moisture is to be wiped off with a clean, dry cloth. A 7-ft or 2.1-m specimen is then to be cut from the immersed part of the 9-ft or 2.7-m sample, and 1 inch or 25 mm of the insulation is to be removed from each end. This specimen is then to be centered lengthwise in the conduit so that approximately 10 inches or 250 mm of the insulation extends beyond the conduit at each end. By means of electrical connections to one end of the conductor and to the metal conduit, the sample is to be subjected to the test potential for 4 h. During this test, any breakdown of the insulation or charring of the nonmetallic covering is unacceptable.

14 Extended Voltage Application for GTO Cables Marked "Integral Sleeve"

14.1 The test described in the Extended Voltage Application Test, Section 12 shall be conducted on samples which have been conditioned (two separate samples for each conditioning) as described below, except that the test voltage shown in Table 12.1 shall be increased by 6000 volts.

a) 720 hours carbon-arc exposure as described in the subsection of the test, Physical properties (ultimate elongation and tensile strength), titled weather (sunlight) resistance in UL 2556.

b) Ozone Exposure, as described in the Ozone Exposure Test, Section 20, except as modified above.

c) 7 day immersion in 75°C (167°F) water, immersed as described in the test, Insulation resistance, Short-term insulation resistance, Method 1 in (15°C water), in UL 2556.

d) 4 hours at -25°C (-13°F) (samples wound around the mandrel specified in Cold Bend, Section 19 while at the low temperature).

15 Surface Leakage Test

15.1 After a finished cable is immersed in water for 30 min, the nonmetallic outer surface shall be capable of withstanding for 1 min without smoking, flaming, or flashover the application of a 48 – 62 Hz sinusoidal potential as indicated in Table 15.1. Starting near zero, the applied potential is to be increased at the rate of approximately 500 V/s until the required test value is reached. After 1 minute, the applied potential is to be reduced to zero.

15.2 Compliance of cable with the requirements in 15.1 is to be determined by using a voltage supply that complies with 12.4.

15.3 A length of the cable is to be immersed, except at the ends, in tap water at 24.0 ±3.0°C (75.2 ±5.4°F) for 30 min. After removal from the water, surface moisture is to be wiped off with a clean, dry cloth, and then two bands of 18 AWG bare, solid wire are to be wrapped tightly around the surface of the nonmetallic covering, with a spacing between them as indicated in Table 15.1. Electrical connections are to be made to the two wire bands and the potential is then to be applied for 1 min.

Table 15.1
Length, spacing, and test potential

Type of cable	Length of sample		Spacings between bands		Test potential in volts rms
	inches	mm	inches	mm	
GTO-5	12	305	5	127	10,000
GTO-10	24	610	10	254	20,000
GTO-15	36	914	15	381	30,000

16 Test for Dripping of Compounds

16.1 The compounds used for the saturation and coating of a fibrous covering(s) in or on a cable shall not drip when a sample of the fibrous-covered cable is conditioned for 1 hour in air at a temperature of 10 ±1°C (18 ±1.8°F) above its rated temperature.

16.2 Compliance of the cable with the requirement in 16.1 is to be determined by suspending a 10-inch or 250-mm sample of the fibrous covered cable in a vertical position in an oven. A clean sheet of paper or of metal foil is to be placed beneath the sample to catch any compound that softens to the extent of dripping.

17 Flame Test

17.1 Type GTO cable shall comply with the requirements of the test, FV-2/VW-1 in UL 2556.

17.2 Where any specimen shows more than 25 percent of the indicator flag burned away or charred (soot that can be removed with a cloth or the fingers, and brown scorching, are to be ignored) after any of the five applications of flame, the wire, cable, or cord is to be judged capable of conveying flame along its length. Where any specimen emits flaming or glowing particles or flaming drops at any time that ignite the cotton (flameless charring of the cotton is to be ignored), or continues to flame longer than 60 seconds after any application of the gas flame, the wire, cable, or cord is to be judged capable of conveying flame to combustible materials in its vicinity. Where any specimen emits flaming or glowing particles or flaming drops at any time that fall outside the area of the testing surface covered by the cotton and/or that fall onto the wedge or burner, the test results are to be discarded and the test is to be repeated.

18 Sunlight Resistance

18.1 Specimens of the jacket or integral insulation and jacket taken from Type GTO cable shall be tested in accordance with the subsection of the test, Physical properties (ultimate elongation and tensile strength) titled weather (sunlight) resistance UL 2556 for the 720 hour exposure.