

UL 1063

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Machine-Tool Wires and Cables

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Machine-Tool Wires and Cables, UL 1063

Sixth Edition, Dated July 24, 1998

Revisions: This Standard contains revisions through and including June 4, 2001.

Announcement Bulletin(s): This Standard contains the announcement bulletin(s) dated August 25, 1997. The announcement bulletin is located at the end of the Standard (after the adoption bulletin(s)).

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Page numbers 40 and 41 have been intentionally deleted, however, no text has been omitted.

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The revisions dated June 4, 2001 include a reprinted title page (page1) for this Standard.

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Page	Date
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3	August 10, 1999
4	July 24, 1998
5	June 4, 2001
6	November 1, 2000
7-18A	June 4, 2001
18B	November 1, 2000
19	August 10, 1999
20-26B	June 4, 2001
26C	November 1, 2000
26D-28	June 4, 2001
29-30B	November 1, 2000
31-33	August 10, 1999
34-35	November 1, 2000
36	June 4, 2001
37	November 1, 2000
38-39	June 4, 2001
42	August 10, 1999
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July 24, 1998

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

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Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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No Text on This Page

CONTENTS

FOREWORD	4
----------------	---

INTRODUCTION

1 Scope	5
2 Units of Measurement	6
3 References	6
4 Terms	6

CONSTRUCTION

5 General	6
5.1 Materials	6
5.2 PVC	6
6 Conductors	7
6.1 Metal	7
6.2 Sizes	7
6.3 Number and assembly of strands and conductor diameters	7
6.4 Lay	8
6.5 Joints	8A
6.6 Area	8A
6.7 Resistance	27
7 Separator	27
7.1 General	27
8 Insulation and Nylon	27
8.1 General	27
8.2 Average thickness of insulation	28
8.3 Minimum thickness at any point of insulation and of nylon	30
8.4 Physical properties	31
9 Nylon Jacket Over Insulation	32
9.1 General	32
10 Shielding	32
10.1 General	32
11 Cable Assembly	33
11.1 Flat and round cables	33
11.2 Conductor lay	33
11.3 Fillers	33
12 Binder	33
12.1 General	33
13 Overall Jacket	34
13.1 General	34

PERFORMANCE

14 Flexibility Tests	34
15 Deformation Test	34
16 Flame Tests	35
17 Tests for Relative Permittivity and Changes in Capacitance	35
18 Dielectric Voltage-Withstand and Breakdown Tests	36
18.1 General	36

18.2 In air at room temperature	36
18.3 In air at rated temperature	37
19 Spark Testing of Single Conductors and Individuals	37
20 Dielectric Testing of Multiple-Conductor Cable	38
21 Insulation-Resistance Tests	38
21.1 Short time in water	38
21.2 Long time in water (duration)	38A
21.3 Long time in water (rate of decrease)	38A
21.4 Short time in air at 97°C	38A
22 Penetration Test	39

FINISH

23 Coverings, Lubricants, and Color Coatings	39
--	----

MARKINGS

24 Location and Repetition Interval	39
25 Manufacturer's Identification	42
26 Factory Identification	42
27 Ink-Printing Test	42
28 Type Letters, Size, and Voltage	43
29 Flexing and Constant-Flexing Services	43
30 Identification of Conductors	44
31 Identification of Circuit Conductors in Multiple-Conductor Cable	45
32 Identification of Grounding Conductor in Multiple-Conductor Cable	45
33 Tag, Reel, or Carton Markings	45
34 Current and Temperature Markings	46
35 Additional Use Markings	46
36 Date of Manufacture	50

No Text on This Page

1
2
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4
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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover all-thermoplastic Type MTW 600-V machine-tool wires and cables for use as specified in the National Electrical Code (ANSI/NFPA 70), and in the National Fire Protection Association Electrical Standard for Industrial Machinery (ANSI/NFPA 79). The PVC insulation and the finished wires and cables comply with a flame test and are for use at 90°C (194°F) and lower temperatures in dry locations and at 60°C (140°F) and lower temperatures where exposed to moisture, oil, or coolants that is, to cutting oils and the like.

1.1 revised November 1, 2000

Table 1.1
Single-conductor constructions

Table 1.1 revised November 1, 2000

Conductor ^a size	NEC construction A (Nylon jacket not used)				NEC construction B					
	Minimum average thickness of the insulation		Minimum thickness of any point of the insulation		Minimum average thickness of the insulation		Minimum thickness of any point of the insulation		Minimum thickness of any point of nylon jacket	
	Mils	mm	Mils	mm	Mils	mm	Mils	mm	Mils	mm
22 – 7; 20 – 12 AWG	30	0.76	27	0.69	15	0.38	13	0.33	4	0.10
11 – 10	30	0.76	27	0.69	20	0.51	18	0.46	4	0.10
9, 8	45	1.14	40	1.02	30	0.76	27	0.69	5	0.13
7, 6	60	1.52	54	1.37	30	0.76	27	0.69	5	0.13
5, 4 – 2	60	1.52	54	1.37	40	1.02	36	0.91	6	0.15
1 – 4/0	80	2.03	72	1.83	50	1.27	45	1.14	7	0.18
213 – 500 kcmil	95	2.41	86	2.18	60	1.52	54	1.37	8	0.20
501 – 1000	110	2.79	99	2.51	70	1.78	63	1.60	9	0.23

^a A conductor is appropriate for use with a cross-sectional area that does not correspond to one of the AWG or kcmil sizes in Table 6.2 when the finished wire or cable complies with the marking requirement in 28.2 and with each of the following:

- The conductor shall have a dc resistance that is not larger than the resistance determined by interpolation (by cross-sectional area) between the resistances of the next larger and smaller sizes shown in the applicable Table 6.7 or 6.8.
- The number of strands, the thicknesses of insulation, the thickness of any nylon jacket, and other particulars shall comply with the requirements applicable to the next smaller size shown in Table 6.2.

1.2 The two single-conductor constructions covered are described in Table 1.1. Both are PVC-insulated and one includes a nylon jacket over the insulation. The multiple-conductor constructions covered consist of assemblies of these single-conductor constructions (sizes and styles may be mixed) enclosed by a PVC jacket.

1.3 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific

requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.3 revised November 1, 2000

2 Units of Measurement

2.1 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 requirements conveniently usable in countries employing the various metric systems (practical SI and customary). Equivalent – 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.

3 References

3.1 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.

4 Terms

4.1 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).

CONSTRUCTION

5 General

5.1 Materials

5.1.1 Each material used in a machine-tool wire or cable shall be compatible with all of the other materials used in the wire or cable.

5.2 PVC

5.2.1 Wherever "PVC" appears in these requirements the intention is to designate a synthesized compound whose characteristic constituent is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

6 Conductors

6.1 Metal

6.1.1 Each conductor shall be only of stranded soft-annealed copper with or without continuous coating of tin or a tin/lead alloy applied before the conductor is stranded or insulated.

6.2 Sizes

6.2.1 Conductors shall not be smaller than size 22 – 7 or No. 20 AWG and shall not be larger than 1000 kcmil.

6.2.1 revised November 1, 2000

6.2.2 The size of each conductor shall be verified either by determination of the d-c resistance or by determination of the cross-sectional area as described in 6.6.1. Determination of the conductor size by measurement of the direct-current resistance as described in 6.7.1 is the referee method in all cases.

6.2.2 added June 4, 2001

6.3 Number and assembly of strands and conductor diameters

6.3.1 Conductors shall be stranded with at least the number of strands indicated in the applicable Table 6.5A, 6.5B, or 6.5C. A 19-wire combination round-wire unilay-stranded soft-annealed copper conductor shall be round and shall consist of a straight central wire, an inner layer of six wires of the same diameter as the central wire with the six wires having identical lengths of lay, and an outer layer consisting of six wires of the same diameter as the central wire alternated with six smaller wires having a diameter of 0.732 times the diameter of the central wire and with all twelve wires of the outer layer having the same length of lay and direction of lay as the six wires of the inner layer. Otherwise, no particular assembly of the individual strands is required; however, untwisted strands shall not be used for the entire conductor or any part thereof. Class B or C 16 AWG – 1000 kcmil conductors shall be with or without compressed strands. Compressed stranding shall not be used in the Size 22-7 or in the Class K and M constructions. Otherwise, any stranding other than single-bunch, bunch stranding and the concentric, rope-lay, and 19-wire combination unilay assemblies indicated in Tables 6.5A, 6.5B, and 6.5C shall not be used unless the results of an evaluation demonstrate that the stranding is appropriate for the application. Compact stranding shall not be used.

6.3.1 revised June 4, 2001

6.3.2 A compressed round concentric-lay-stranded conductor shall be a round conductor consisting of a central core wire surrounded by one or more layers of helically laid wires with, for the 6 AWG – 1000 kcmil sizes, the direction of lay reversed in successive layers. The strands of one or more layers shall be slightly compressed by rolling, drawing, or other means to slightly change the originally round strands to various shapes that fill some of the spaces originally present between the strands. A finished compressed-stranded Class B or C conductor shall not be larger in average diameter than the maximum diameter indicated for the size under Y in Table 6.5A and shall not be smaller in average diameter than the minimum diameter indicated for the size under Z in Table 6.5A. Class B or C 16 AWG – 1000 kcmil conductors with uncompressed strands shall not be larger or smaller in average diameter than the maximum and minimum diameters indicated for the size in Tables 20.4 (Class B) and 20.4.1 (Class C) of UL 1581. The average diameter of the conductor is to be determined and compared with the table in the manner described in 6.3.4 and 6.3.5.

6.3.2 revised June 4, 2001

6.3.3 A finished 19-wire combination unilay conductor shall not be larger in average diameter than the maximum diameter indicated for the size in the UL 1581 Table 20.6. The average diameter of the conductor is to be determined and compared with the table in the manner described in 6.3.4 and 6.3.5.

6.3.3 added June 4, 2001

6.3.4 For diameter measurements, the insulation is to be removed at a single place at the center of a straight length of the finished conductor. Measurements of the conductor diameter are to be made over the metal-coated or uncoated conductor strands by means of a machinist's micrometer caliper having flat surfaces both on the anvil and on the end of the spindle. The measurements for all constructions for which the diameter requirements apply are to be made over the strands rather than across flats; this is illustrated in Figure 6.1 only for a 7-strand construction. The measurements are to be made on a line extending through the center of the conductor and through the center of two wires (strands) in the outer layer that are 180° apart. The micrometer is to be calibrated to read directly to at least 0.001 inch or 0.01 mm, with each division of a width that facilitates estimation of each measurement to at least 0.0001 inch or 0.001 mm. The maximum and minimum diameters at that point are each to be recorded to the nearest 0.0001 inch or 0.001 mm, added together, and divided by 2 without any rounding of the sum or resulting average.

6.3.4 added June 4, 2001

6.3.5 Each minimum and maximum diameter indicated in Table 6.5A and in UL 1581 Tables 20.4, 20.4.1, and 20.6 is absolute. The unrounded average of the two diameter readings is therefore to be compared directly with both the minimum and the maximum in the table.

6.3.5 added June 4, 2001

6.4 Lay

6.4.1 Concentric conductors

6.4.1.1 The length of lay of the strands in both layers of a 19-wire combination round-wire unilay-stranded copper conductor shall be 8 – 16 times the outside diameter of the completed conductor. Otherwise, the length of lay of the strands in every layer of a concentric-lay-stranded conductor consisting of fewer than 37 strands shall be 8 – 16 times the outside diameter of that layer. The length of lay of the strands in the outer two layers of a concentric-lay-stranded conductor consisting of 37 or more strands shall be 8 – 16 times the outside diameter of that layer. The direction of lay of the outer layer shall be left-hand.

6.4.2 Single-bunch bunch-stranded conductors

6.4.2.1 The length of lay of the strands in a single-bunch bunch-stranded conductor shall not be greater than indicated in Table 6.1. The direction of lay shall be left-hand.

6.4.3 Rope-lay bunch-stranded conductors

6.4.3.1 The length of lay of the individual strands in a bunch-stranded member of a rope-lay-stranded conductor shall not be more than 30 times the overall diameter of the member, and the length of the lay of the members in the outer layer shall neither be less than 8 nor more than 16 times the overall conductor diameter. The direction of lay of the outer layer shall be left-hand.

6.5 Joints

6.5.1 A joint in one strand of a stranded conductor shall be made in a workmanlike manner, shall not change the diameter of the strand or of the overall conductor, and shall not lessen the mechanical strength of the overall conductor. A joint shall be made by separately joining each strand. A joint shall not impair the flexibility of the conductor. A joint in a compressed-stranded conductor shall be made before compressing.

Table 6.1
Length of lay of strands in a single-bunch stranded conductor^a

Table 6.1 revised June 4, 2001

Size of conductor	Maximum length of lay	
	inches	mm
20 – 17 AWG	1	25
16, 15	1-1/4	32
14, 13	1-5/8	41
12, 11	2	51
10, 9	2-1/2	64
8, 7	2-3/4	70
6	3-3/8	86
5 AWG – 1000 kcmil	16 times the diameter of the conductor	

^a Includes the constructions in note ^a to Table 6.4

6.6 Area

6.6.1 Where measured as the means of size verification (see 6.2.2) the cross-sectional area of a conductor shall not be smaller than the minimum indicated for the size in Table 6.2.

6.6.1 revised June 4, 2001

6.6.2 The cross-sectional area of a conductor having round strands is to be determined either:

- As the sum of the areas of its component round strands (see 6.6.3), or
- By the weight method outlined in 6.6.4 – 6.6.7.

The cross-sectional area of a round compressed-stranded conductor is to be determined by the weight method outlined in 6.6.4 – 6.6.7.

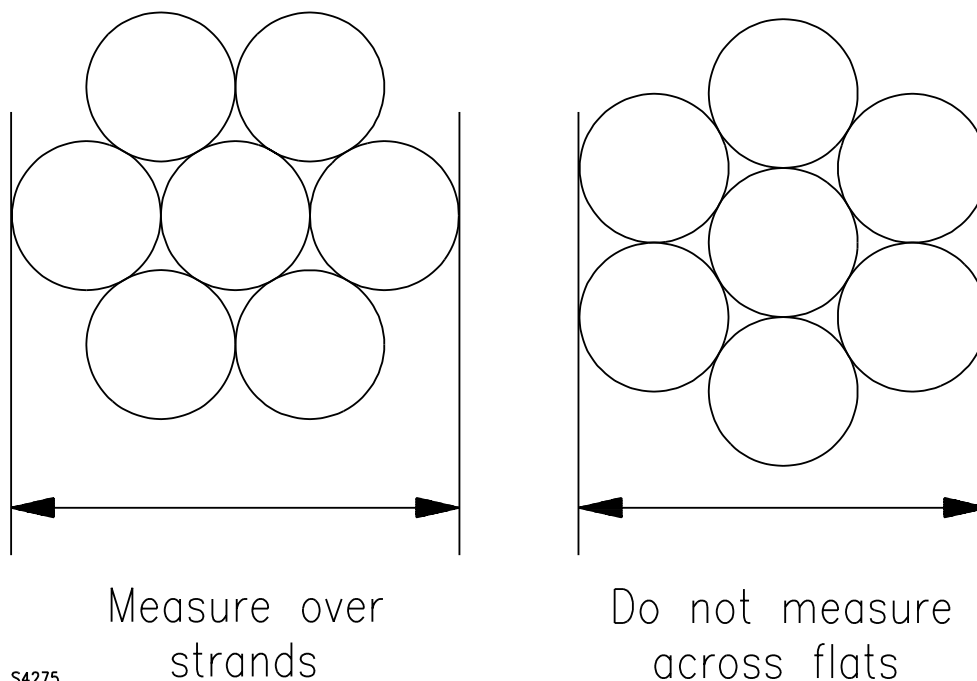
6.6.3 The diameter of a round strand is to be measured over any tin or other metal coating by means of a machinist's micrometer caliper having flat surfaces on the anvil and on the end of the spindle. The caliper is to be calibrated to read directly to at least 0.001 inch or 0.01 mm with each division of a width that facilitates estimation of each measurement to 0.0001 inch or 0.001 mm.

6.6.4 For determining the cross-sectional area of a conductor by the weight method, the test specimen is to consist of a straight length of a single conductor cut from a sample of the finished wire or cable. The specimen is to be at any convenient room temperature, is to have both of its ends perpendicular to the longitudinal axis of the conductor, and is to have any insulation, separator, and other coverings removed. For a No. 8 AWG or smaller conductor (8.367 mm^2 or smaller), the specimen is to be at least 48 inches or 1220 mm long. For a conductor larger than No. 8 AWG (larger than 8.367 mm^2), the specimen is to be at least 24 inches or 610 mm long. The length of the specimen is to be measured to the nearest $1/32$ inch or 1 mm. The specimen is to be weighed by means of a precision balance to within 0.1 percent of the weight of the specimen. For example, a 4-ft or 1220-mm specimen of a No. 8 AWG conductor having 19 round strands (Class C) weighs about 0.2 lb or 91 g. One tenth of 1 percent of these figures is, respectively, 0.0002 lb and 0.09 g, which means that the weight of a No. 8 AWG conductor must be determined to the fourth decimal place if in pounds mass and to the nearest 0.1 g if in grams mass.

6.6.4 revised June 4, 2001

Figure 6.1
Conductor diameter measurement

Figure 6.1 added June 4, 2001



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Table 6.2
Cross-sectional areas of conductors

Table 6.2 revised November 1, 2000

Conductor size	Nominal		Minimum acceptable	
	cmil	mm ²	cmil	mm ²
22 – 7	700 cmil	0.355	686 cmil	0.348
20 AWG	1020	0.519	1000	0.507
18	1620	0.823	1571	0.798
16	2580	1.31	2528	1.28
14	4110	2.08	4028	2.04
12	6530	3.31	6399	3.24
10	10380	5.261	10172	5.16
8	16510	8.367	16180	8.20
6	26240	13.30	25715	13.03
4	41740	21.15	40905	20.73
3	52620	26.67	51568	26.14
2	66360	33.62	65023	32.95
1	83690	42.41	82016	41.56
1/0	105600	53.49	103488	52.42
2/0	133100	67.43	130438	66.08
3/0	167800	85.01	164444	83.31
4/0	211600	107.2	207368	105.1
250 kcmil	—	127	245 kcmil	124.5
300	—	152	294	149.0
350	—	177	343	173.5
400	—	203	392	198.9
450	—	228	441	223.4
500	—	253	490	247.9
550	—	279	539	273.4
600	—	304	588	297.9
650	—	329	637	322.4
700	—	355	686	347.9
750	—	380	735	372.4
800	—	405	784	396.9
900	—	456	882	446.9
1000	—	507	980	496.9

6.6.5 The conductor cross-sectional area in circular mils is to be calculated by whichever of the following formulas applies to the conductor material (as a convenience for the common strandings, it is acceptable to compare the specimen weight directly with the weight in Table 6.3 instead of calculating the cross-sectional area):

For a copper conductor that has each of its strands uncoated or coated with tin or a tin/lead alloy –

$$A_{\text{cmil}} = \frac{33.036 \times 10^6 \times W_{\text{lb}}}{(100 + k) \times L_{\text{ft}}}$$

in which:

A_{cmil} is the cross-sectional area in circular mils,

W_{lb} is the weight of the specimen in pounds mass,

L_{ft} is the length of the specimen in feet, and

k is the percentage increase in weight applicable to the type of stranding used from Table 6.4.

For a copper conductor that has each of its strands coated with nickel or silver, the formula is

$$A_{\text{cmil}} = \frac{100.000 \times W_{\text{lb}}}{(100 + k) \times L_{\text{ft}} \times f}$$

in which:

A_{cmil} , W_{lb} , k , and L_{ft} are as noted above, and

f is the weight factor in (lb-cmil)/10³ ft applicable to the thickness and the metal of the coating used.

6.6.6 The conductor cross-sectional area in square millimeters is to be calculated by whichever of the following formulas applies to the conductor material (as a convenience for the common strandings, it is acceptable to compare the specimen weight directly with the weight in Table 6.3 instead of calculating the cross-sectional area):

For a copper conductor that has each of its strands uncoated or coated with tin or a tin/lead alloy –

$$A_{\text{mm}^2} = \frac{11248 \times W_g}{(100 + k) \times L_{\text{mm}}}$$

in which:

A_{mm^2} is the cross-sectional area in square millimeters,

W_g is the weight of the specimen in grams mass,

L_{mm} is the length of the specimen in millimeters, and

k is the percentage increase in weight applicable to the type of stranding used from Table 6.4.

For a copper conductor that has each of its strands coated with nickel or silver, the formula is

$$A_{\text{mm}^2} = \frac{45.154222 \times W_g}{(100 + k) \times L_{\text{mm}} \times f}$$

in which:

A_{mm^2} , W_g , k , and L_{mm} are as noted above, and

f is the weight factor in $(\text{kg} \cdot \text{mm}^2)/\text{km}$ applicable to the thickness and the metal of the coating used.

Table 6.3
Minimum acceptable weight of specimens of conductors^a for which k is 2^{b,c}

Table 6.3 revised June 4, 2001

Length of specimen	Size of conductor	lb	g
48 inches or 1220 mm	16 AWG	0.03122	14.16
	14	0.04975	22.57
	12	0.07903	35.85
	10	0.1256	56.97
	8	0.1998	90.63
24 inches or	6 AWG	0.1588	72.03
	4	0.2526	114.6
	3	0.3184	144.4
	2	0.4016	182.2

Table 6.3 Continued on Next Page