UL 1063

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Machine-Tool Wires and Cables

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UL Standard for Safety for Machine-Tool Wires and Cables, UL 1063

Seventh Edition, Dated December 20, 2006

SUMMARY OF TOPICS:

This new edition of UL 1063 is being issued to ensure that UL's Standards remain up-to-date with regard to format and editorial issues. This new edition also includes revised requirements for the following:

1. Deletion of "New and Different" Paragraph from the Scope

2. Addition of an Additional Significant Digit to Metric Equivalents in Table 6.8 for Conductor Dimensions

3. Revision of SI Units in Table 8.1 for PVC Insulation and Jacket Properties

4. Replacement of the Term "Natural Grey" with "Gray" in the Identification of Circuit Conductor Requirements

5. Deletion of Table for Markings of Additional Uses of Machine Tool Wire

6. Miscellaneous Editorial Corrections and Clarifications

7. Editorial Reorganization of Units for Conductor Sizes and Clarification of Conductor Size Ranges

The new and/or revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated July 12, 2006 and October 6, 2006.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html.

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December 20, 2006

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This ANSI/UL Standard for Safety, which consists of the Seventh Edition with revisions through December 20, 2006, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

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

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. 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 http://csds.ul.com.

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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). These 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 such as cutting oils and the like.

Table 1.1
Single-conductor constructions

Conductor[a] size, AWG or kcmil	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-strand only; 20 – 12	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	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 27.2 and with each of the following:

a) 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 6.9 or 6.10.

b) 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.

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2 Units of Measurement

2.1 When a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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.

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6.2 Sizes

6.2.1 Conductors shall not be smaller than 22 AWG and shall not be larger than 1000 kcmil.

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.

6.3 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 6.5, 6.6, or 6.7. 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 6.5, 6.6, and 6.7 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.

6.3.2 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 6.5 and shall not be smaller in average diameter than the minimum diameter indicated for the size under Z in Table 6.5 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.

6.3.3 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.

6.3.4 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.

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6.3.5 Each minimum and maximum diameter indicated in Table 6.5 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.

6.4 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.

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

Size of conductor, AWG or kcmil	Maximum length of lay	
	inches	mm
22 – 17	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 – 1000	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.

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

a) As the sum of the areas of its component round strands (see 6.6.3), or

b) 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 an 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 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 an 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 an 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.

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Figure 6.1
Conductor diameter measurement

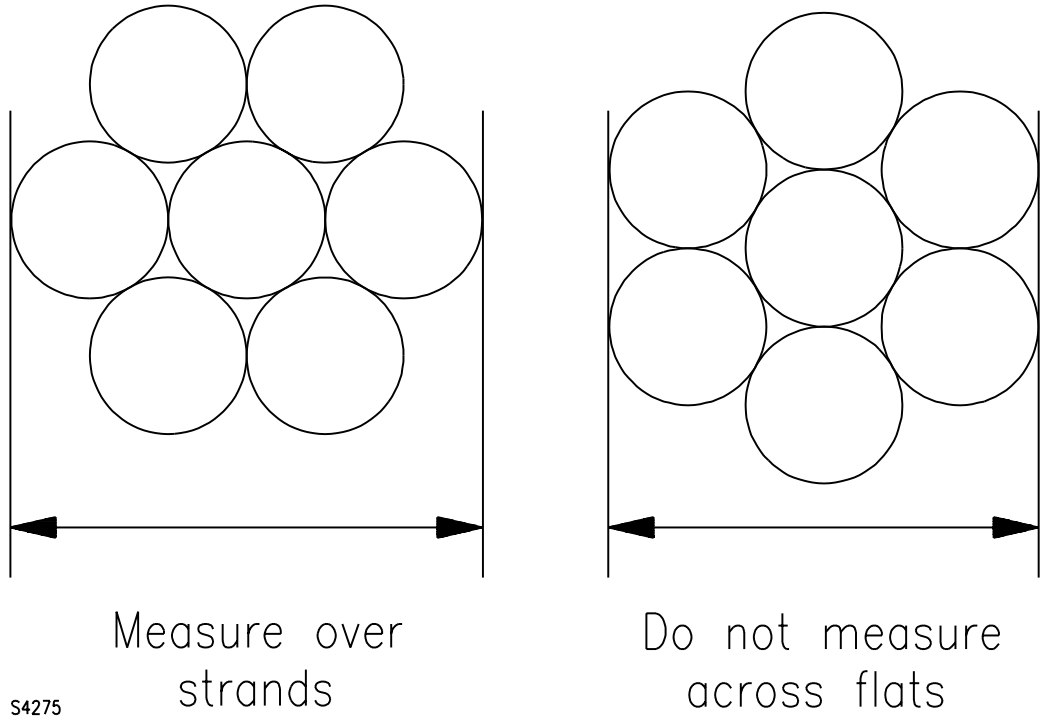

Table 6.2
Cross-sectional areas of conductors

Conductor size, AWG or kcmil	Nominal		Minimum acceptable	
	cmil	mm^2	cmil	mm^2
22	700	0.355	686	0.348
20	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	–	127	245	124.5
300	–	152	294	149.0
350	–	177	343	173.5

Table 6.2 Continued on Next Page

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Table 6.2 Continued

Conductor size, AWG or kcmil	Nominal		Minimum acceptable	
	cmil	mm^2	cmil	mm^2
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 –

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

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

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