

UL 1569

ISBN 0-7629-0451-8

Metal-Clad Cables

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety for Metal-Clad Cables, UL 1569

Third Edition, Dated August 31, 1999

Revisions: This Standard contains revisions through and including April 12, 2001.

Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The new and/or revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated December 22, 1999. The bulletin(s) is now obsolete and may be discarded.

The revisions dated April 12, 2001 include a reprinted title page (page1) for this Standard.

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As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

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This Standard consists of pages dated as shown in the following checklist:

Page Date

1	April 12, 2001
2-3	November 8, 2000
4-5	April 12, 2001
6-8	August 31, 1999
9	January 25, 2000
10-30	August 31, 1999
31-32B	November 8, 2000
33	January 25, 2000
34-36	August 31, 1999
37	January 25, 2000
38-41	August 31, 1999
42-43	January 25, 2000
44-46B	April 12, 2001
47-49	January 25, 2000
50-52	April 12, 2001
53	August 31, 1999
54	January 25, 2000
55-56	April 12, 2001

No Text on This Page

AUGUST 31, 1999



(Title Page Reprinted: April 12, 2001)

UL 1569

Standard for Metal-Clad Cables

First Edition – July, 1983 Second Edition – May, 1995

Third Edition

August 31, 1999

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

Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated August 31, 1999, January 25, 2000 and November 8, 2000. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

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

Approved as ANSI/UL 1569 – 1985, November 5, 1985 Approved as ANSI/UL 1569 – 1992, April 6, 1992 Approved as ANSI/UL 1569 – 2000, June 30, 2000

The Department of Defense (DoD) has adopted UL 1569 on July 23, 1983. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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.

ISBN 0-7629-0451-8

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No Text on This Page

CONTENTS

FOREWORD 6

1 Scope 7

2 Units of Measurement 8

3	References	8
4	Materials	8
5	General	8
6	Conductors	8
6.1	General	8
7	Circuit Conductors	14
7.1	General	14
7.2	NEC types	14
7.3	Other insulated conductors	15
8	Optical Fiber Member(s)	16
9	Assembly	16
9.1	Optical-fiber member(s)	16
9.2	Circuit and grounding conductors	17
10	Fillers	18
11	Shields	18
12	Covering under Armor	19

13 Armor	26
----------------	----

14 Covering over Armor	27
------------------------------	----

PERFORMANCE

15 Continuity Test of Conductors	29
--	----

16 Test of Zinc Coating on Steel Armor	29
--	----

17 Deformation Test of Thermoplastic and XL Jackets	30
---	----

18 Test for Tightness of Armor on Conductors	31
--	----

19 Flexibility Test	32
---------------------------	----

20 Cold-Bend Test	32A
21 Cold-Impact Test	33

22 Dielectric Voltage-Withstand Test	33
--	----

23 Tension Test	34
-----------------------	----

24 Impact Test	36
----------------------	----

25 Crushing Test–All Cable	38
----------------------------------	----

26 Crushing Test–Cable Marked for Direct Burial	39
---	----

27 Overload Current Tests	40
28 Cable Flame Test (Overall Jacket in Place)	41
29 Vertical-Tray Flame Tests on Cables	42
29.1 General	42
29.2 UL test	42
29.3 FT4/IEEE 1202 test	42
30 Vertical-Tray Fire and Smoke Release Test for Jacketed Cables with Optional "-LS" Marking.	42
31 Sunlight-Resistance Test	43
32 Test for Mechanical Water Absorption	43
33 Test for Surface Print on Inner and Overall Jackets	43

MARKINGS

34 Intervals	44
35 Color of Insulated Grounding Conductor	44
36 Identification of Ungrounded Circuit Conductor(s)	45
37 Identification of Grounded Circuit Conductor(s)	45
38 On or in the Cable	46

39 On the Tag, Reel, or Carton	48
39A Date of Manufacture	50
40 Insulated Equipment-Grounding Conductors	50A
41 Isolated-Grounding Conductors	51
42 Copper-Clad Aluminum	52
43 Aluminum	53
44 Compact-Stranded Copper Conductors	53
45 Responsibility for the Insulated Conductors	53
45.1 No identification needed	53
45.2 Only factory identification needed	53
45.3 Organization and factory identification needed	54
46 Dual Marking	54

PART1–MC CABLE

INTRODUCTION

PART 2 – NOS. 18 – 13 AWG INSULATED CONDUCTORS NOT AVAILABLE AS A STANDARD NEC TYPE

CONSTRUCTION

47 Conductor Diameter and Cross-Sectional Area	54
48 Metal Coating	54

49 Splices	54
50 Resistance	54
51 Stranding	54
52 Separator	54
53 Insulation	54
54 Jacket or Braid	54

PERFORMANCE

55 Horizontal-Specimen Flame Test	55
56 Vertical-Specimen Flame Test	55
57 Test for Falling Particles and Dripping from Braid-Covered, Insulated Conductors	55
58 Test for Absorption of Moisture by Braid	55
59 Cold-Bend Test	55
60 Nylon-Jacket Wrap Test	55
61 Conductor Corrosion Test	55
62 Dielectric Voltage-Withstand Test	55

63 Insulation Resistance Test at 60.0°F (15.6°C)	55
64 Insulation Resistance in Water at 75°C (167°F)	55
65 Insulation Resistance in Air at 97.0°C (206.6°F)	55
66 Alternative Spark Test	55
67 Tests for Capacitance and Stability Factor of 75°C (167°F) Wet-Locations Thermoset Insulation	56
68 Test for Capacitance of 75°C (167°F) Wet-Locations PVC Insulation	56
69 Heat-Shock Test	56
70 Cold-Bend Test	56
71 Deformation Test	56

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.

PART1-MC CABLE

INTRODUCTION

1 Scope

1.1 These requirements cover round or flat metal-clad cables that contain No. 18 AWG – 2000 kcmil insulated circuit conductors with or without one or more optical-fiber members, all enclosed in armor consisting of interlocked metal strip or a smooth or corrugated metal tube. Round cables contain one or more insulated circuit conductors. Flat cable contains two or three insulated circuit conductors. These electrical and hybrid electrical/optical-fiber cables are for use (optical and electrical functions associated in the case of a hybrid cable) as Type MC cable in accordance with Article 334 and other applicable parts of the National Electrical Code.

1.1 revised August 31, 1999

2. 1.2 These requirements cover round or flat armored cables that have thermoplastic or thermoset insulation and are for use at potentials not exceeding 600 V (thermoplastic) or 600 or 2000 V (thermoset) where subjected to temperatures not exceeding 75°C (167°F) or 90°C (194°F), depending upon the voltage and temperature ratings of the circuit conductors in the cable. Cables with 600 V conductors that also include one or more optical-fiber members have "-OF " supplementing the type letters and are limited to carrying optical energy that has been ruled not hazardous to the human body.

3. 1.3 Type MV (medium-voltage) cables rated for 5000 – 35000 V are covered in separate requirements. A multiple-conductor Type MV cable with a smooth (other than lead) or corrugated metal sheath or with interlocked metal armor may be marked for use also as Type MC cable.

4. 1.4 These requirements do not cover Type AC armored cables (see the UL 4 Standard for Armored Cables). Metal-clad cables for use in Division 1 and Zone 1 hazardous locations are required to comply with UL 1569 and the UL 2225 Standard for Metal-Clad Cables and Cable-Sealing Fittings for Use in Hazardous (Classified) Locations.

5. 1.5 These requirements do not cover the optical or other performance of any optical-fiber member or group of such members. See 8.3.

6. 1.6 A cable to which the designation "-LS " (signifying "limited smoke") is applied as a type-letter suffix complies with the test criteria for smoke release and for cable damage height stated in the Standard Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables, UL 1685. See Vertical-Tray Fire and Smoke Release Test for Jacketed Cables with Optional "-LS" Marking, Section 30 (test requirement) and 38.1 (marking requirement).

7. 1.7 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, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements to determine that the level of safety as originally anticipated by the intent of this Standard is maintained. A product whose features, characteristics,

components, materials, or systems conflict with specific requirements or provisions of this Standard shall not be judged to comply with this Standard. Where appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard.

1.7 revised August 31, 1999

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 requirement conveniently usable in countries employing the various metric systems (practical SI and customary). 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.

3 References

3.1 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).

4 Materials

4.1 Only materials that are acceptable for the particular use shall be employed in a cable.

5 General

1. 5.1 Metal-clad cable shall be designated as Type MC and shall comply in all respects with the applicable requirements for construction details, test performance, and markings.
2. 5.2 The insulation in each of the following cables shall be of a material that is acceptable for use in wet locations if the cable has armor consisting of interlocked metal strip but does not include a jacket over the assembly under the armor:

- a) Cable that is marked for direct burial.
- b) Cable that is intended for use in wet locations.

6 Conductors

6.1 General

1. 6.1.1 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 ASTM B 3-95. Solid aluminum conductors in size Nos. 12 – 8 AWG shall comply with the requirements for aluminum-wire stock (aluminum-alloy conductor material). All other aluminum conductors shall comply with the requirements for semi-annealed 8000 series aluminum conductors in Section 10 of UL 1581. Copper-clad aluminum conductors shall comply with the requirements in Section 11 of UL 1581. In a given cable, all conductors need not be of the same metal.
2. 6.1.2 A copper conductor shall not be smaller than No. 18 AWG and shall not be larger than 2000 kcmil. An aluminum or copper-clad aluminum conductor shall not be smaller than No. 12 AWG and shall not be larger than 2000 kcmil.
3. 6.1.3 Each No. 6 AWG – 2000 kcmil conductor shall be stranded. No. 18 to 16 AWG copper conductors shall comply with the requirements for fixture wire conductors in the Standard for Flexible Cord and Fixture Wire, UL 62. No. 14 AWG and larger copper, or 12 AWG and larger aluminum conductors shall comply with the requirements in Sections 8, 9, 11, 12, and 13 of the

Standard for Thermoset-Insulated Wires and Cables, UL 44, or in Sections 8, 9, 10, 12, and 13 of the Standard for Thermoplastic-Insulated Wires and Cables, UL 83, except as modified in this Section.

4. 6.1.4 Any joint in a conductor shall comply with the applicable Standard indicated in 7.2.1, except that a splice is acceptable in a No. 18 – 10 AWG stranded conductor as a whole if the splice (butt splice) is made by machine brazing or welding such that the resulting solid section of the stranded conductor is not longer than 1/2 inch or 13 mm, the splice does not increase the diameter of the conductor, there are no sharp points, and the distance between splices in a single conductor does not average less than 3000 ft or 915 m in any reel length of that single insulated conductor. A butt splice shall be made before insulating or after insulating and prior to further processing. Butt splices of stranded conductors made after insulating and splices of insulated solid conductors made with other than the original insulation shall be the subject of an investigation that includes tests to determine that all electrical, physical, and mechanical properties of the original system of insulation and any jacket on the conductor have been restored at the point of each splice. All finished, insulated stranded conductors containing a butt splice or splice made with other than the original insulation shall not be marked as an NEC type but the following are acceptable:

a) POLARITY IDENTIFICATION – Color coding and/or surface printing of hash marks, numbers, color names, or the like.

b) RATINGS ON NON-NEC CONDUCTORS – Surface marking of the 39.1 (c)(1) temperature and dry/wet ratings from Table 9.1.

6.1.4 revised January 25, 2000

1. 6.1.5 Cable having interlocked armor shall contain one copper, aluminum, or copper-clad aluminum grounding conductor that is in one location or in several sections (see 6.1.8) and is not smaller than indicated under the heading "Grounding Conductor" in Table 6.1 (90°C or 194°F circuit conductors) or in Table 6.2 (75°C or 167°F circuit conductors). One or more additional copper, aluminum, or copper-clad aluminum grounding conductors may be provided. Each additional grounding conductor shall not be sectioned and shall not be smaller than indicated in Table 6.1 or 6.2 as applicable. If only one grounding conductor is provided, it may be bare or it may be insulated in accordance with 40.1. If more than one grounding conductor is provided, one grounding conductor (the required conductor) may be bare or insulated and every other grounding conductor shall be insulated in accordance with 40.2 or 40.3, as applicable. See 6.1.10.

2. 6.1.6 Cable having corrugated-or smooth-sheath armor with a resistance greater than indicated in one of the last four columns of Table 6.1 (90°C or 194°F circuit conductors) or in Table 6.2 (75°C or 167°F circuit conductors) shall contain one copper, aluminum, or copper-clad aluminum grounding conductor that is in one location or in several sections (see 6.1.8) and is of a size such that the measured resistance (see

6.1.9) of the grounding conductor in parallel with the armor is not higher than indicated in one of the last four columns of Table 6.1 or 6.2 as applicable. One or more additional copper, aluminum, or copper-clad aluminum grounding conductors may be provided. Each additional grounding conductor shall not be sectioned and shall not be smaller than indicated in Table 6.1 or 6.2 as applicable. If only one grounding conductor is provided, it shall be bare or it shall be insulated in accordance with 40.1. If more than one grounding conductor is provided, one grounding conductor (the required conductor) shall be bare or insulated and every other grounding conductor shall be insulated in accordance with 40.2 or 40.3, as applicable. See 6.1.10.

6.1.6 revised August 31, 1999

3. 6.1.7 Cable having corrugated-or smooth-sheath armor that has a resistance equal to or lower than indicated in one of the last four columns of Table 6.1 or 6.2 may contain one or more copper, aluminum, or copper-clad aluminum grounding conductors. Each grounding conductor shall not be smaller than indicated under the heading "Grounding Conductor" in Table 6.1 (90°C or 194°F circuit conductors) or in Table 6.2 (75°C or 167°F circuit conductors). If only one

grounding conductor is provided, it may be bare and may be sectioned (see 6.1.8) or it may be insulated in accordance with 40.1. If more than one grounding conductor is provided, one grounding conductor may be bare and may be sectioned (see 6.1.8)

and every other grounding conductor shall not be sectioned and shall be insulated in accordance with 40.2 or 40.3, as applicable. See 6.1.10.

Table 6.1 revised August 31, 1999

Table 6.2 revised August 31, 1999

1. 6.1.8 A grounding conductor shall not be distributed helically (concentric). A copper grounding conductor smaller than No. 14 AWG shall not be sectioned. No part of a sectioned grounding conductor shall be smaller than No. 18 AWG.
2. 6.1.9 The resistance of corrugated-or smooth-sheath armor, and any grounding conductor required to parallel the armor, is to be determined by placing a length of the finished cable in a wooden, V-shaped trough having stud-type wire connectors at the ends (spaced 10 ft or 3048 mm between centers) as shown in Figure 6.1. The ends of the armor and any required grounding conductor are to be secured firmly in the wire connectors. The required grounding conductor is to be folded around each end of the armor and gripped against the armor by the wire connectors. The wires of a stranded grounding conductor are to be spread out somewhat to result in maximum contact. Any isolated-grounding conductors in the cable are to be disregarded. Leads are to be brought out to a Kelvin double-bridge ohmmeter that has a range of 0.001 – 11 ohms and is accurate to within 2 percent of the value read. The resistance of the armor and any required grounding conductor is to be read directly in ohms.

6.1.9 revised August 31, 1999

Figure 6.1 Apparatus for measuring resistance of armor and any required grounding conductor

6.1.10 Grounding-conductor insulation and any covering over that insulation shall comply with Circuit Conductors, Section 7 as if the insulated grounding conductor were a circuit conductor and shall comply with 9.2.1. Any or all additional insulated grounding conductors (these are insulated grounding conductors that are not required but are provided in accordance with 6.1.5, 6.1.6, or 6.1.7) may be designated as isolated-grounding conductors, with the outer surface of each such conductor marked as indicated in Isolated-Grounding Conductors, Section 41. See 9.2.4 (cabling) and 35.1 (color) and 39.1(l) (tag marking).

6.1.10 revised August 31, 1999

7 Circuit Conductors

7.1 General

7.1.1 Each circuit conductor shall be either an NEC Type as shown in 7.2 or a non-NEC Type as shown in 7.3.

7.1.1 revised August 31, 1999

2. 7.2 NEC types

Subsection 7.2 revised August 31, 1999

7.2.1 Each circuit conductor that is available as a National Electrical Code type shall comply with this Standard and shall be one of the following types:

- a) No. 14 – 4/0 AWG and 250 – 2000 kcmil branch-circuit types complying with the Standard for Thermoset-Insulated Wires and Cables (UL 44) or the Standard for Thermoplastic-Insulated Wires and Cables (UL 83):

Table Continued on Next Page
Table Continued

Type(s)	
UL Standard	Ratings for Type MC application
THWN 75°C (167°F) wet or dry 600 V	83
THHN or THWN 90°C (194°F) dry	83
	75°C (167°F) wet 600 V
Z 150°C (302°F) dry 600 V special applications	83
	83 or
	90°C (194°F) dry 600 V
ZW 150°C (302°F) dry 600 V special applications	83
	83 or
90°C (194°F) dry 600 V	75°C (167°F) wet
b) Fixture-wire types rated 600 V and complying with the Standard for Flexible Cord and Fixture Wire (UL 62):	

Type(s)

PF and PGF

PFF and PGFF

150°C (302°F) dry 600 V 18 –

SF-2

90°C (194°F) dry 600 V 18 –

SFF-2

90°C (194°F) dry 600 V 18 –

TFN

90°C (194°F) dry 600 V 18 –

TFFN

90°C (194°F) dry 600 V 18 –

RFH-2

75°C (167°F) dry 600 V 18 –

FFH-2

75°C (167°F) dry 600 V 18 –

Ratings for Type MC application

Size range

7.3 Other insulated conductors

Subsection 7.3 revised August 31, 1999

7.3.1 Insulated conductors other than those described in 7.2.1 (a) and (b) shall have insulations in thicknesses and with temperature ratings appropriate for the specific construction of Type MC cable in which they are to be used. The insulation shall be evaluated for the requested temperature rating as described in Long-Term Aging, Section 481 of the UL 1581 Reference Standard for Electrical Wires, Cables, and Flexible Cords. Investigation of the electrical, mechanical, and physical characteristics of these insulated conductors shall show these conductors to be comparable to the conductors described in

7.2. The investigation shall include tests such as crushing, impact, abrasion, deformation, heat shock,

insulation resistance, and dielectric voltage-withstand.

Table 6.1 Smallest acceptable grounding conductor in cable containing 90°C (194°F) circuit conductors Size of largest ungrounded circuit conductor in cable	Grounding conductor		Maximum acceptable D-C resistance of ground patha	Aluminum
	Copper			
	Smallest acceptable AWG size of unsectioned grounding conductor			
	Copper Aluminum or copper-clad aluminum	20°C (68°F)		
	Ohms based on 1000 feet of armor Ohms based on 1 kilometer of armor			

18 AWG – 17 – 16 – 15 – 14 12 AWG 13 11 12 10 11 9 10 – 8 8 – 6 7 – 4 5 – 2 3 – 2/0 1 – 3/0 3/0 AWG – 250 kcmil 4/0 AWG – 350 kcmil 300 – 400 400 – 600 450 – 650 700 – 1000 700 – 900 1100 – 1500 1000 – 2000 1600 – 2000	18 17 16 15 14 13 12 11 10 8 6 4 3 2 11/0	——12 11 10 9 8 6 4 2 11/0 2/0 3/0	7.06 23.2 5.59 18.3 4.45 14.6 3.44 11.3 2.73 8.96 2.16 7.10 1.72 5.64 1.37 4.48 1.080 3.546 0.6795 2.230 0.4276 1.403 0.2689 0.8820 0.2132 0.6996 0.1691 0.5548 0.1340 0.4398 0.1063 0.3487	7.19 23.6 5.70 18.7 4.53 14.9 3.51 11.5 2.78 9.14 2.20 7.24 1.75 5.75 1.39 4.56 1.102 3.615 0.6929 2.274 0.4359 1.430 0.2742 0.8993 0.2175 0.7133 0.1724 0.5657 0.1367 0.4485 0.1084 0.3556
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a Smallest acceptable total cross-sectional area of sectioned grounding conductor, of corrugated-or smooth-sheath armor in cable without a required grounding conductor, and of the parallel combination of required grounding conductor and armor in cable having corrugated-or smooth-sheath armor of higher resistance than indicated in these 4 columns.

Table 6.2 Smallest acceptable grounding conductor in cable containing 75°C (167°F) circuit conductors Size of largest ungrounded circuit conductor in cable	Grounding conductor		Maximum acceptable D-C resistance of ground patha		Aluminum
	Copper				Smallest acceptable AWG size of unsectioned grounding conductor
			20°C (68°F)		
			Copper Aluminum or copper-clad aluminum	Ohms based on 1000 feet of armor Ohms based on 1 kilometer of armor	
18 AWG – 17 – 16 – 15 – 14 12 AWG 13 11 12 10 11 9 10 – 7 8 – 5 6 – 3 4 – 1 2 – 3/0 1/0 – 4/0 4/0 AWG – 300 kcmil 250 – 450 kcmil 350 – 550 500 – 800 600 – 800 900 – 1300 900 – 1300 1400 – 2000 1400 – 2000 –	18 17 16 15 14 13 12 11 10 8 6 4 3 2 11/0	——12 11 10 9 8 6 4 2 11/0 2/0 3/0	7.06 23.2 5.59 18.3 4.45 14.6 3.44 11.3 2.73 8.96 2.16 7.10 1.72 5.64 1.37 4.48 1.080 3.546 0.6795 2.230 0.4276 1.403 0.2689 0.8820 0.2132 0.6996 0.1691 0.5548 0.1340 0.4398 0.1063 0.3487	7.19 23.6 5.70 18.7 4.53 14.9 3.51 11.5 2.78 9.14 2.20 7.24 1.75 5.75 1.39 4.56 1.102 3.615 0.6929 2.274 0.4359 1.430 0.2742 0.8993 0.2175 0.7133 0.1724 0.5657 0.1367 0.4485 0.1084 0.3556	