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NEMA STANDARDS PUBLICATIO

NEMA WC 63.1

PERFORMANCE STANDARD FOR TWISTED PAIR PREMISE VOICE AND DATA COMMUNICATIONS CABLE

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NEMA Standards Publication No. WC 63.1-2000

PERFORMANCE STANDARD FOR TWISTED PAIR PREMISE VOICE AND DATA COMMUNICATIONS CABLES

Published by

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Foreword

Compliance with this Standard may require use of an invention covered by patent rights. By publication of this Standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and non-discriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

This standard has been developed by the Premise Wiring Subcommittee of the High Performance Wire and Cable Section of NEMA in close coordination between manufacturers, users, third party certifying agencies, and others having specialized experience. The High Performance Wire and Cable Section of NEMA periodically reviews this standard for any revisions necessary to keep it up to date. Proposed revisions or comments should be submitted to:

Vice President, Engineering Department
National Electrical Manufacturers Association
1300 North 17th Street
Rosslyn, Virginia 22209

Section approval of this standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time this revision was approved, the Premise Wiring Subcommittee had the following members:

Alcatel Electronics Cable—Elm City, NC
Belden Wire & Cable Company—Richmond, IN
BICC/General—Highland Heights, KY
CommScope Network Cable Division—Claremont, NC
Harbour Industries—Shelburne, VT
Helix/Hi-Temp Cables, Inc.—Franklin, MA
Judd Wire Inc.—Turner Falls, MA
Lucent Technologies—Norcross, GA
Montrose/CDT—Auburn, MA
Southwire Company– Carrolton, GA

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Section 1
GENERAL

1.1 SCOPE

This standard primarily defines minimum electrical performance and allowable conductor sizes, stranding, and shielding for premise wiring cables for voice and data applications. The material and mechanical characteristics for these cables are covered under UL 444/CSA C 22.2 No. 214 where applicable. Definitions and applicable test methods are included herein.

This standard covers Category 3,Category 5, and Category 5e, 100 ohm unshielded and shielded twisted pair, and 150 ohm shielded twisted pair cables for voice and/or data communication systems.

This standard also includes several appendices that were developed for U.S. Government reference.

Requirements for Category 4 cable were removed from this edition as this cable is no longer widely used.

The products covered in this Standard shall conform to the requirements of Part 68 of the FCC rules and regulations, as well as the applicable article(s) of the *National Electrical Code* and/or other national and local codes and safety standards.

The performance requirements contained in this document are for cables as manufactured. The installed cabling system will have different characteristics. The performance of the installed cabling is a function of its components (i.e. cable, connecting hardware, work area, equipment, and patch cords) and installation methods. Requirements for the performance of the installed cabling system are outside the scope of this document.

1.2 REFERENCED STANDARDS

Copies of referenced documents may be obtained from the appropriate sources as follows.

American Society for Testing and Materials (ASTM)
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

ASTM B 3-95	*Soft or Annealed Copper Wire*
ASTM B 8-95	*Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft*
ASTM B 33-94	*Tinned Soft or Annealed Copper Wire for Electrical Purposes*
ASTM B 286-95	*Copper Conductors for Use in Hookup Wire for Electronic Equipment*
ASTM D 4566-98	*Electrical Performance Properties of Insulations and Jackets for Telecommunications Wire & Cable*

Federal Communications Commission (FCC)
1919 M Street, N.W.
Washington, D.C. 20554

Code of Federal Regulations, Title 47, Telecommunications, Chapter 1-FCC, Part 68

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Insulated Cable Engineers Association
P.O. Box 440
South Yarmouth, MA 02644

ANSI/ICEA S-90-661-1997 *Individually Unshielded Twisted Pair Indoor Cables for Use in Communication Wiring Systems*

National Electrical Manufacturers Association (NEMA)
1300 North 17th Street
Rosslyn, VA 22209

ANSI/NEMA WC 61-1992 *Standard for Transfer Impedance Testing*

National Fire Protection Association (NFPA)
Batterymarch Park
Quincy, MA 02269

ANSI/NFPA 70-1999 *National Electrical Code (NEC)*

Telecommunications Industry Association (TIA)
2500 Wilson Blvd.
Arlington, VA 22201

ANSI/TIA/EIA 568A-1995 *Commercial Building Telecommunications Cabling Standard*

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062

Canadian Standards Association
178 Rexdale Blvd.
Etobicoke, ON M9W 1R3
Canada

UL 444/CSA 22.2 NO. 214-94 *Standard for Communications Cables*

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Section 2
PART IDENTIFICATION NUMBER (PIN)

2.1 PART NUMBERING SYSTEM

The part numbers shall be of the following form:
WC 63-(Category)(NEC/CEC)(AWG)(Coating)(Pairs)(Shield[1])(Drain Wire)

Where:

Category	=	Character for NEMA Category as determined in Table 2-1a
NEC/CEC	=	Character for NEC/CEC Type as determined in Table 2-1b
AWG/Stranding	=	Character for conductor gauge size as determined from Table 2-2a
Coating	=	Character for conductor coating; "B" for Bare Copper or "T" for Tin Coated Copper
Pairs	=	Number of pairs in cable (ie: 2, 4, 12, 25, etc.)
Shield	=	Character for type of shield as determined from Table 2-3
Drain Wire	=	Character for drain wire; "D" if present

Table 2-1a
CATEGORY AND TYPE DESIGNATIONS

Category	Description
3	100 Ohm, 24 AWG or 22 AWG, shielded or unshielded, specified at frequencies up to 16 MHz
5	100 Ohm, 24 AWG or 22 AWG, shielded or unshielded, specified at frequencies up to 100 MHz
5e	100 Ohm, 24 AWG or 22 AWG, shielded or unshielded, specified at frequencies up to 100 MHz , with enhanced performance requirements
Type	**Description**
A	150 Ohm, 22 AWG or 26 AWG, shielded, specified at frequencies up to 300 MHz

[1] Shield refers to screen

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Table 2-1b
NEC/CEC TYPES

Character	Cable Types	Description
P	MPP, CMP	Plenum
R	MPR, CMR	Riser
G	MPG, MP, CMG, CM	General Purpose
X	CMX	Limited Use
H	CMH	Limited Use
U	–	Unlisted [2]

Table 2-2a
ALLOWABLE AWG SIZES AND STRANDING IN HORIZONTAL AND BACKBONE CABLE

Character	AWG Size	Stranding
A	22	Solid
B	24	Solid
C[3]	26	Solid

Table 2-2b
ALLOWABLE AWG SIZES FOR STRANDED CONDUCTORS IN PATCH CABLES

Character	AWG Size	Stranding
D	22	7
E	22	19
F	24	7
G	24	19
H	26	7
J	26	19

[2] Not NEC/CEC listed. This type may include cables not for use within a building, where listing is not required. Specific construction requirements shall be mutually agreed upon by the manufacturer and customer.
[3] 26 AWG solid conductors are for Type A Cables only in Table 2-1a.

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Table 2-3
ALLOWABLE SHIELDING OPTIONS

Character	Description
S	Individually shielded pair, foil
K	Individually shielded pair, braid
F	Overall shielded, foil
B	Overall shielded, braid
U	Unshielded

The following are examples of possible part numbers:

WC63-3GBB2U: 100 Ohm, Category 3, general purpose, 24 AWG, solid, bare copper, 2 pair, unshielded.
WC63-5RBB4U: 100 Ohm, Category 5, riser, 24 AWG, solid, bare copper, 4 pair, unshielded
WC63-5GFB4U: 100 Ohm, Category 5, general purpose, 24 AWG, 7 strand, bare copper, 4 pair, unshielded
WC63-5EPBB4U: 100 Ohm, Category 5e, plenum, 24 AWG, solid, bare copper, 4 pair, unshielded
WC63-AGHT2SB: 150 Ohm, Type A, general purpose, 26 AWG, 7 strand, tinned copper, 2 pair, individually foil shielded pairs with an overall braid

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Section 3
MATERIALS AND MECHANICAL REQUIREMENTS

3.1 CONDUCTORS

Conductors shall conform to the requirements of the applicable ASTM document(s) with the exception that the requirements for "Dimensions and Permissible Variations" shall not apply. The minimum dimensions and maximum strand lay shall be in accordance with UL 444/CSA C 22.2 No. 214. Minimum elongation of solid conductors from a finished cable shall be in accordance with ICEA S-90-661.

3.1.1 Bare Copper Wire

Bare copper wire shall conform to soft or annealed wire in accordance with ASTM B 3 except that the requirements for "Dimensions and Permissible Variations" shall not apply.

3.1.2 Tin coated Copper Wire

Tin coated copper wire shall conform to soft or annealed wire in accordance with ASTM B 33 except that the requirements for "Dimensions and Permissible Variations" shall not apply.

3.1.3 Stranded Copper Wire

Stranded bare or tin coated copper wire shall conform to ASTM B 8 or B 286 except the minimum dimensions and maximum strand lay shall be in accordance with UL 444/CSA C 22.2 No. 214. Stranded conductors are used for patch or equipment cords, and as such are intended to be used in short lengths.

3.2 INSULATING MATERIALS

Copper conductors shall be insulated with one or more layers of solid or expanded material. The core, consisting of two or more conductors and other construction components, shall be protected with an overall covering generally referred to as an "outer jacket." The insulation, jacket, and other components such as core wrap, shield, and inner jackets shall conform to the requirements of UL 444/CSA C 22.2 No. 214 where applicable.

3.3 SHIELDS

When a type of shield is specified in the part identification number, that shield shall be constructed as described below.

3.3.1 Individually Shielded Pairs, Foil (When Specified)

The individual pair shield shall be a polymeric/metallic laminated tape, such as polyester/aluminum, electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire shall be provided per Paragraph 3.3.5.

3.3.2 Individually Shielded Pairs, Braid (When Specified)

The individual pair shield shall be a braid, electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5.

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3.3.3 Overall Shielded, Foil

The foil overall shield shall be a polymeric/metallic laminated tape, such as polyester/aluminum, electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s), at the manufacturer's option, shall be provided per Paragraph 3.3.5.

3.3.4 Overall Shielded, Braid

A braid overall shield per Paragraph 3.3.6 shall be applied over the foil shield described in Paragraph 3.3.1.

3.3.5 Drain Wire(s)

One or more drain wire(s) shall be provided when foil shields are specified without a braided shield. The drain wire(s) shall:

- consist of a solid tin coated copper conductor(s) per ASTM B 33 or stranded tin coated copper conductor(s) per ASTM B 286 except that the stranding lay may be 1" maximum,
- be equivalent or larger in gauge size than the twisted pair conductors comprising the core,
- be in contact with the metallic side of the foil tape, and
- be electrically continuous.

3.3.6 Braided Shield

The braided shield shall:

- be tinned copper wires in accordance with ASTM B 33, and
- provide a minimum of 60% coverage.

3.4 MECHANICAL, PHYSICAL, DIMENSIONAL, AND SAFETY CONSIDERATIONS

The cable shall be rated in accordance with NFPA 70 (NEC) and conform to the applicable requirements of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661. These will be determined primarily by the wide variety of insulation and jacket material choices. Additionally, the functional and electrical characteristics as required by this standard will influence cable design parameters.

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Section 4
ELECTRICAL DEFINITIONS

4.1 RESISTANCE

4.1.1 DC Conductor Resistance

The DC resistance of any conductor is defined as:

$$R=V/I$$

Where:

R = DC conductor resistance (in ohms)
V = Applied DC voltage
I = Measured DC current

4.1.2 DC Resistance Unbalance

The DC resistance unbalance between the two conductors of any pair is defined as:

$$R_{ub} = \frac{(R_{max} - R_{min})}{R_{min}} \times 100$$

Where:

R_{ub} = Resistance unbalance (in percent)
R_{max} = The resistance of the conductor with higher resistance value in ohms.
R_{min} = The resistance of the conductor with lower resistance value in ohms.

4.1.3 Insulation Resistance

Insulation resistance is defined as the measured resistance between any single conductor and ground. All other conductors and shields, if present in the cable, are grounded.

4.2 INPUT IMPEDANCE

The input impedance of any pair is defined as:

$$Z_{in} = \sqrt{Z_{open} \times Z_{short}}$$

Where:

Z_{in} = Input impedance in ohms
Z_{open} = Measured open circuit impedance in ohms
Z_{short} = Measured short circuit impedance in ohms

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4.3 CHARACTERISTIC IMPEDANCE

The characteristic impedance is calculated by a least squares function fit of input impedance data as defined in ASTM D 4566 Section 44, Method 3.

4.4 STRUCTURAL RETURN LOSS

The structural return loss of any pair relates the complex input impedance to the complex characteristic impedance. It is defined as:

$$SRL = -20 \log_{10} \left| \frac{Z_{in} - Z_0}{Z_{in} + Z_0} \right|$$

Where:

SRL = Structural return loss in decibels
Z_{in} = Complex input impedance in ohms
Z_0 = Complex characteristic impedance in ohms

4.4.1 Return Loss

The return loss of any pair relates the input impedance to 100 Ohms. It is defined as:

Where:

$$RL = -20 \log_{10} \left| \frac{Z_{in} - 100}{Z_{in} + 100} \right|$$

RL = Return loss in decibels
Z_{in} = Input impedance in ohms

4.5 ATTENUATION

The attenuation of any pair is defined as:

$$\alpha = \left| 10 \log_{10} \frac{P_2}{P_1} \right| = \left| 20 \log_{10} \frac{V_2}{V_1} \right|$$

Where:

α = The attenuation in decibels
P_1 = The input power in watts
P_2 = The output power in watts
V_1 = The input voltage in volts
V_2 = The output voltage in volts

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4.6 CROSSTALK

4.6.1 Near-End Crosstalk (NEXT)

The near-end crosstalk of any pair combination is defined as:

$$NEXT = \left| 10 \log_{10} \frac{P_{2N}}{P_{1N}} \right| = \left| 20 \log_{10} \frac{V_{2N}}{V_{1N}} \right|$$

Where:

NEXT	=	Near-end crosstalk in decibels
P_{1N}	=	The input power of the disturbing pair in watts
P_{2N}	=	The output power of the disturbed pair at the near-end of the cable in watts
V_{1N}	=	The input voltage of the disturbing pair in volts
V_{2N}	=	The output voltage of the disturbed pair at the near-end of the cable in volts

4.6.2 Power Sum Near-End Crosstalk (PSNEXT)

The power sum near-end crosstalk of any disturbed pair is defined as:

$$PSNEXT = \left| 10 \log_{10} \sum_{i=1}^{n} \left| 10^{\left(\frac{-xi}{10}\right)} \right| \right|$$

Where:

PSNEXT	=	Power sum near-end crosstalk in decibels
x_i	=	Measured near-end crosstalk in decibels of the pair combination consisting of the disturbed pair, and the *i*-th disturbing pair
n	=	Number of disturbing pairs (the number of pairs in the cable minus one)
i	=	Disturbing pair number

4.6.3 Far-End Crosstalk (FEXT)/Equal Level Far-End Crosstalk (ELFEXT)

4.6.3.1 Far-End Crosstalk (FEXT)

The FEXT is defined as an input to output crosstalk (the power input to the disturbing pair as compared to the output power coupled into the disturbed pair at the opposite end of the cable from the disturbing source). For a 4 pair cable there will be 12 combinations as indicated in the following example:

Example: FEXT (1-2) Near-end pair 1 to Far-end pair 2
FEXT (2-1) Near-end pair 2 to Far-end pair 1
FEXT (1-3) Near-end pair 1 to Far-end pair 3
FEXT (3-1) Near-end pair 3 to Far-end pair 1, etc.

The first pair is the "Disturbing Pair" and the second pair is the "Disturbed Pair"

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Far-end crosstalk is defined as:

$$FEXT = \left| 20 \log \frac{V_{2F}}{V_{1N}} \right|$$

Where:

FEXT	=	Far-end crosstalk measured in decibels
V_{1N}	=	Disturbing pair input voltage at the near-end
V_{2F}	=	Disturbed pair output voltage at the far-end

4.6.3.2 Equal Level Far-End Crosstalk (ELFEXT)

The ELFEXT is FEXT with the cable attenuation removed to achieve equal-level comparisons (i.e., voltages are compared at the end of the cable opposite the power input).

The ELFEXT is calculated from the 12 FEXT combinations for a 4 pair cable in 4.6.3.1 minus the attenuation of the "Disturbed Pair."

Example: ELFEXT (1-2) = FEXT (1-2) - Attenuation (2)
ELFEXT (2-1) = FEXT (2-1) - Attenuation (1) etc.

4.6.4 Power Sum Equal Level Far-End Crosstalk (PSELFEXT)

The power sum equal level far-end crosstalk of any pair is defined as the power sum of the ELFEXT as

$$PSELFEXT = \left| 10 \log_{10} \sum_{i=1}^{n} \left| 10^{\left(\frac{-x_i}{10}\right)} \right| \right|$$

Where:

PSELFEXT	=	Power sum equal level far-end crosstalk in decibels
x_i	=	Calculated equal level far-end crosstalk in decibels
n	=	Number of disturbing pairs (the number of pairs in the cable minus one)
i	=	Disturbing pair number

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4.7 CAPACITANCE

4.7.1 Mutual Capacitance

Mutual capacitance of any pair is defined as the effective capacitance between the two conductors. The mutual capacitance is defined as:

$$C_m = C_{ab} + \frac{C_{ag} \times C_{bg}}{C_{ag} + C_{bg}}$$

Where:

C_m = Mutual capacitance

C_{ab} = The capacitance between conductor "a" and conductor "b" with all other conductors in the cable and the shield (if present) connected to ground (guarded)

C_{ag} = The capacitance between conductor "a" and all other conductors in the cable and the shield (if present) with conductor "b" connected to ground (guarded)

C_{bg} = The capacitance between conductor "b" and all other conductors in the cable and the shield (if present) with conductor "a" connected to ground (guarded)

4.7.2 Pair-to-Ground Capacitance Unbalance

The pair-to-ground capacitance unbalance of any pair is defined as:

$$C_{upg} = C_{ag} - C_{bg}$$

Where:

C_{upg} = Pair-to-ground capacitance unbalance

C_{ag} = The capacitance between conductor "a" and all other conductors in the cable, the shield (if present) with conductor "b" connected to ground (guarded)

C_{bg} = The capacitance between conductor "b" and all other conductors in the cable, the shield (if present) with conductor "a" connected to ground (guarded)

4.8 TRANSFER IMPEDANCE

The transfer impedance (Z_t) of the shield in an electrically short, longitudinally uniform cable is defined as the ratio of the longitudinal electromotive force induced in the disturbed circuit to the current flowing in the interfering circuit.

4.9 PHASE VELOCITY

Phase velocity of any pair is defined as:

$$v = \frac{\omega}{\beta}$$

Where:

v = Phase velocity in meters/second

ω = Angular frequency in radians/second

β = Phase constant in accordance with Section 39 of ASTM D 4566

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4.10 PHASE DELAY

Phase delay is the reciprocal of the phase velocity.

4.11 PHASE DELAY SKEW

Phase delay skew is defined as the difference in phase delay between any two pairs.

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Section 5
TEST METHODS

5.1 GENERAL

Unless otherwise specified below, measurements shall be in accordance with ASTM D 4566.

The measurements of input impedance, characteristic impedance, SRL, return loss, attenuation, NEXT, and ELFEXT shall be performed on a cable sample of 100 m [328 ft] or greater removed from the reel or package. The test sample shall be laid along a non-conducting surface, loosely coiled or supported in aerial spans. On-reel or packaged cable measurements that satisfy the performance requirements are acceptable. In case of conflict, the aerial span procedure shall be used as the referee method.

For conformance swept frequency testing, a minimum of 100 points per decade shall be sampled. Logarithmic spacing shall be used for referee testing to ensure uniform weighting across the applicable frequency range.

5.2 INPUT IMPEDANCE

Input impedance shall be determined using Section 43, Method 2, Option 1 or Option 2 in ASTM D 4566. Option 1 is the referee method.

5.3 CHARACTERISTIC IMPEDANCE

Characteristic impedance shall be calculated using Section 44, Method 3, in ASTM D 4566.

5.4 STRUCTURAL RETURN LOSS

Structural Return Loss shall be determined per Section 45.2 of ASTM D 4566.

5.4.1 Return Loss

Return Loss shall be determined per Section 45.3 of ASTM D 4566.

5.5 ATTENUATION

The sample length shall exhibit no less than 3 decibels at the lowest frequency tested and no more than 50 decibels for applicable frequencies. More than one length may be required to test a full range of frequencies.

5.6 NEAR-END CROSSTALK (NEXT) AND POWER SUM NEAR-END CROSSTALK (PSNEXT)

NEXT shall be measured and PSNEXT shall be calculated per Section 24 of ASTM D 4566.

5.7 FAR-END CROSSTALK (FEXT), EQUAL LEVEL FAR-END CROSSTALK (ELFEXT), AND POWER SUM EQUAL LEVEL FAR-END CROSSTALK (PSELFEXT)

FEXT shall be measured with a network analyzer per section 4.6.3.1. ELFEXT and PSELFEXT shall be calculated per section 4.6.3.2 and 4.6.4 respectively.

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5.8 TRANSFER IMPEDANCE

The transfer impedance of a shielded cable shall be measured using the method in NEMA WC 61. Note that this test method is only valid to a maximum frequency of 100 MHz.

5.9 PHASE VELOCITY

The phase velocity shall be measured at frequencies of 1, 10, and 100 MHz using the method in Section 41 of ASTM D 4566.

5.10 PHASE DELAY

Phase delay shall be determined from the phase velocity using the following equation:

$$t_d = \frac{100\,L}{V_p C}$$

Where:

t_d = Phase delay in nanoseconds
L = Reference length in meters (usually 100m)
V_p = Phase velocity as a percent of the speed of light in free space
C = 0.3 m/ns

5.11 PHASE DELAY SKEW

The phase delay skew shall be calculated by determining the maximum difference in phase delay between all pairs in a four pair cable. For cables greater than four pair, the phase delay skew shall be calculated by determining the maximum difference in phase delay between any four consecutive pairs.

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Section 6
ELECTRICAL REQUIREMENTS FOR CATEGORY 3, 5, AND 5e CABLES

6.1 GENERAL

The tables in Appendix A are included for reference only.

6.2 RESISTANCE

6.2.1 DC Resistance

The maximum DC resistance corrected to 20°C shall be as follows:

Table 6-1
DC RESISTANCE

AWG	Maximum DC Resistance Ω/100 m(328 ft.)
26	14.8
24	9.38
22	5.91

6.2.2 DC Resistance Unbalance

The maximum DC resistance unbalance of any pair shall be 5%.

6.2.3 Insulation Resistance

The minimum insulation resistance of any insulated conductor corrected to 20°C shall be 1500 MΩ - 100 m (328 ft).

6.3 IMPEDANCE

6.3.1 Characteristic Impedance

The characteristic impedance of any pair shall meet the requirements in Table 6-2.

Table 6-2
CHARACTERISTIC IMPEDANCE

Category	Frequency (MHz)	Characteristic Impedance (Ohms)
3	1 – 16.0	100 ± 15
5/5e	1 – 100.0	100 ± 15

6.4 STRUCTURAL RETURN LOSS

The minimum structural return loss of any pair shall meet or exceed the values determined using Table 6-3 for all frequencies, from 1 MHz to the highest referenced frequency:

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Table 6-3
STRUCTURAL RETURN LOSS

	Structural Return Loss (db)	
Frequency (MHz)	**Category 3**	**Category 5**
1.0–10.0	12	23
>10.0–16.0	$12-10\log_{10}(f/10)$	23
>16.0–20.0	—	23
> 20.0–100.0	—	$23-10\log_{10}(f/20)$

Where:
f = Frequency in MHz

6.4.1 RETURN LOSS

For Category 5e horizontal and patch cables, the minimum return loss of any pair shall meet or exceed the values determined using Table 6-4 for all frequencies, from 1 MHz to the highest referenced frequency.

Table 6-4
RETURN LOSS

	Return Loss (dB)	
Frequency (MHz)	**Category 5e Horizontal**	**Category 5e Patch**
1 to 10	$20+5\log_{10}(f)$	$20+5\log_{10}(f)$
> 10 to 20	25	25
> 20 to 100	$25-7\log_{10}(f/20)$	$25-8.6\log_{10}(f/20)$

Where:
f = Frequency in MHz

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6.5 ATTENUATION

6.5.1 Horizontal and Backbone Cables

The maximum attenuation of any pair, corrected to a temperature of 20°C, shall be less than or equal to the value determined using the following formula rounded to one digit after the decimal point for all frequencies from 0.772 MHz to the highest referenced frequency.

$$\alpha(f) \leq k_1\sqrt{f} + k_2 f + \frac{k_3}{\sqrt{f}}$$

Where:

α = Attenuation in dB/100m (328 ft)
f = Frequency in MHz
k_1 = Constant as defined in Table 6-5, below
k_2 = Constant as defined in Table 6-5, below
k_3 = Constant as defined in Table 6-5, below

Table 6-5
COEFFICIENTS FOR ATTENUATION FORMULA

Coefficient	k_1	k_2	k_3
Category 3	2.320	0.238	0.000
Category 5/Category 5e	1.967	0.023	0.050

The cable attenuation, for Category 5 and Category 5e cables, shall be tested at a temperature of 40°C and 60°C and shall meet the requirements of the formula above after adjusting the formula for temperature. The maximum attenuation determined using the above formula shall be adjusted at elevated temperatures using a factor of 0.4% increase per 1°C.

The tables in Appendix A give attenuation values at specific frequencies of interest for horizontal and backbone cables. These values are for reference only and are derived from the above formula.

6.5.2 Patch (Stranded) Cables

The requirements for attenuation for cables employing 22 to 24 AWG stranded conductors shall be 20% higher than the values determined by the formula in 6.5.1. For stranded conductors sizes smaller than 24 AWG, the requirements shall be 50% higher than the values determined by the formula in 6.5.1 for the applicable cable category.

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6.6 CROSSTALK

6.6.1 Near-End Crosstalk (NEXT)

The minimum near-end crosstalk of any pair combination shall be greater than or equal to the value determined using the following formula for all frequencies from 0.772 MHz to the highest referenced frequency:

$$NEXT(f) \geq NEXT(0.772) - 15\log_{10}\left(\frac{f}{0.772}\right)$$

Where:

NEXT	=	Near-end crosstalk in dB
NEXT(0.772)	=	43 dB for Category 3 cables; 64 dB for Category 5 cables; 67 dB for Category 5e cables
f	=	Frequency in MHz

6.6.2 Power Sum Near-End Crosstalk

The power sum near-end crosstalk of any pair, for all Category 5e cables and in cables employing more than four pairs for Category 3 and Category 5 cables, shall be greater than or equal to the value determined using the following formula for all frequencies from 0.772 MHz to the highest referenced frequency:

$$PSNEXT(f) \geq PSNEXT(0.772) - 15\log10\left(\frac{f}{0.772}\right)$$

Where:

PSNEXT	=	Power sum near-end crosstalk in dB
PSNEXT(0.772)	=	43 dB for Category 3 cables; 64 dB for Category 5 and Category 5e cables
f	=	Frequency in MHz

6.6.2.1 Calculation for Subgroups or Subunits

For Category 3 and Category 5 cables with more than twenty-five pairs, the power sum near end crosstalk may be computed for each pair using only the pair combinations within the twenty-five pair group. In this case, subgroups within any twenty-five pair group shall be considered part of the twenty-five pair group and all twenty-five pairs shall be used in the power sum near end crosstalk computation for that group.

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6.6.3 Equal Level Far-End Crosstalk (ELFEXT)

The minimum equal level far-end crosstalk of any pair combination shall be greater than or equal to the value determined using the following formula for all frequencies from 1 to 100 MHz for Category 5e.

Category 3

No requirement

Category 5

No requirement

Category 5e

$$ELFEXT(f) \geq 66 - 20\log_{10}\left(\frac{f}{0.772}\right)$$

Where:

ELFEXT = Equal level far-end crosstalk in dB
f = Frequency in MHz

6.6.4 Power Sum Equal Level Far-End Crosstalk (PSELFEXT)

The minimum power sum equal level far-end crosstalk of any pair shall be greater than or equal to the value determined using the following formula for all frequencies from 1 to 100 MHz for Category 5e.

Category 3

No requirement

Category 5

No requirement

Category 5e

$$PSELFEXT(f) \geq 63 - 20\log_{10}\left(\frac{f}{0.772}\right)$$

Where:

PSELFEXT = Power sum equal level far-end crosstalk in dB
f = Frequency in MHz

6.7 CAPACITANCE

6.7.1 Mutual Capacitance

Mutual capacitance values are provided for information purposes only. The maximum mutual capacitance, measured at a frequency of 1 kHz, should be 6.6 nF/100 m (328 ft) for Category 3 cables and 5.6 nF/100 m (328 ft) for Category 5 and Category 5e cables.

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6.7.2 Pair-to-Ground Capacitance Unbalance

The pair-to-ground capacitance unbalance of any pair shall not exceed 330 pF/100 m (328 ft) for Category 3, Category 5, and Category 5e cables when measured at a frequency of 1 kHz.

6.8 TRANSFER IMPEDANCE

The common mode transfer impedance for cables that contain individually shielded pairs or overall shield(s) shall be less than or equal to the value determined using the following formula for all frequencies from 0.772 MHz to the highest referenced frequency:

$$Z_t(f) = 37 + 4f + 4\sqrt{f} + 5\sqrt[3]{f}$$

Where:

Z_t = Transfer impedance, in mΩ/m
f = Frequency in MHz

6.9 PHASE VELOCITY

The minimum phase velocity of any pair of a Category 3, Category 5, and Category 5e cable shall be 58.5% for all frequencies from 1 MHz to the highest referenced frequency.

6.10 PHASE DELAY SKEW

6.10.1 Maximum Phase Delay Skew

The maximum phase delay skew at 20°C shall be as follows:

Table 6-6
PHASE DELAY SKEW

Frequency MHz	Category	≤ Four Pairs	> Four Pairs
1.0 – 16.0	3	45	48
1.0 – 100.0	5 and 5e	45	48

6.10.2 Cables Greater Than 4 Pairs

For cables greater than 4 pairs, the maximum phase delay skew between any four consecutive pairs shall be less than 48 ns/100m(ns/328ft).

6.10.3 Environmental Effects

The phase delay skew shall not vary more than 10 ns from the 20°C measurement at each frequency when measured at 40°C and 60°C.

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Section 7
ELECTRICAL REQUIREMENTS FOR 150 Ω TYPE A CABLE

Table A-4 is included for reference only.

7.1 DC RESISTANCE

7.1.1 22 AWG Conductors

The maximum DC resistance of 22 AWG conductors, solid or stranded, shall be 5.6 Ω/100m (328 ft) at, or corrected to, 20°C.

7.1.2 26 AWG Conductors

The maximum DC resistance of 26 AWG conductors, solid or stranded, shall be 14.8 Ω/100 m (328 ft) at, or corrected to, 20°C.

7.2 DC RESISTANCE UNBALANCE

The maximum DC resistance unbalance of any pair shall be 4%.

7.3 INSULATION RESISTANCE

The minimum insulation resistance of any insulated conductor corrected to 20°C shall be 1500 MΩ - 100 m (328 ft).

7.4 CAPACITANCE

7.4.1 Pair-to-Ground Capacitance Unbalance

The pair-to-ground capacitance unbalance of any pair shall not exceed 100 pF/100m (328 ft) when measured at a frequency of 1 kHz.

7.5 CHARACTERISTIC IMPEDANCE

The characteristic impedance of any pair shall meet the requirements in Table 7-1.

Table 7-1
CHARACTERISTIC IMPEDANCE (Ohms)

Frequency (MHz)	22 AWG	26 AWG
0.0096	270 ± 10%	390 ± 15%
0.0384	185 ± 10%	235 ± 15%
3 to 300	150 ± 10%	150 ± 10%

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7.6 STRUCTURAL RETURN LOSS

The minimum structural return loss of any pair shall meet the requirements in Table 7-2 for all frequencies from 3 MHz to the highest referenced frequency.

Table 7-2
STRUCTURAL RETURN LOSS REQUIREMENTS

Frequency (MHz)	Structural Return Loss(dB)
3–20	25
20–300	$25–10 \log_{10} (f/20)$

Where:
f = Frequency in MHz

7.7 RETURN LOSS

TBD

7.8 ATTENUATION

The attenuation of any pair shall not exceed the requirements of the following formulae:

For frequencies between 4 MHz and 20 MHz inclusive:

$$\alpha(f) \leq k_o \sqrt{\frac{f}{4}}$$

Where:
α = Attenuation in dB/100m (328 ft)
k_o = 2.2 for 22 AWG Cables and 3.3 for 26 AWG Cables
f = Frequency between 4 MHz and 20 MHz

For frequencies greater than 20 MHz and up to, and including, 300 MHz:

$$\alpha(f) \leq k_o \sqrt{\frac{f}{62.5}}$$

Where:
α = Attenuation in dB/100m (328 ft)
k_o = 9.75 for 22 AWG cables and 14.75 for 26 AWG cables
f = Frequency greater than 20 MHz and up to, and including, 300 MHz

7.9 NEAR-END CROSSTALK

The near-end crosstalk (NEXT) of any pair combination shall be greater than or equal to the requirements of Table 2-10 for all frequencies from 0.0096 MHz to the highest referenced frequency.

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Table 7-3
NEAR-END CROSSTALK REQUIREMENTS (dB)

Frequency (MHz)	22 AWG	26 AWG
0.0096 – 5	58.0	52.0
5–16	58.0–15 $\log_{10}$ (f/5)	52.0–15 $\log_{10}$ (f/5)
16–300	58.0–15 $\log_{10}$ (f/5)	Not Specified

Where:
f = Frequency in MHz.

7.10 TRANSFER IMPEDANCE

The transfer impedance requirements of 150 Ω, shielded cables are currently under study.

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Appendix A
ELECTRICAL PERFORMANCE REQUIREMENTS AND REFERENCES FOR CATEGORY 3, CATEGORY 5, AND CATEGORY 5e CABLES

Table A-1
ELECTRICAL PERFORMANCE REFERENCE FOR 100 OHM, CATEGORY 3 CABLES

	Category 3*	
	24 AWG	**22 AWG**
Maximum DC Resistance @ 20°C (Ohms/100 m [328 ft])	9.38	5.91
Maximum DC Resistance Unbalance (%)	5	
Minimum Insulation Resistance (MΩ - 100 m [328 ft])	1500	
Maximum Mutual Capacitance of a Pair @ 20±3°C @ 1 kHz (nF/100 m [328 ft])	6.6	
Maximum Pair-to-Ground Capacitance Unbalance @ 20±3°C @ 1 kHz (pF/100 m [328 ft])	330	
Minimum Phase Velocity from 1 to 16 MHz (%)	58.5	
Maximum Phase Delay Skew from 1 to 16 MHz (ns/ 100 m [328 ft])	45	

Frequency (MHz)	Characteristic Impedance (Ohms)	Minimum Structural Return Loss (dB)	Maximum Attenuation** (dB/100m, [328 ft])	Minimum NEXT (dB)	Maximum Transfer Impedance*** (mΩ / m)
0.772	100 ± 15	—	2.2	43	48
1.0	100 ± 15	12	2.6	41	50
4.0	100 ± 15	12	5.6	32	69
8.0	100 ± 15	12	8.5	27	90
10.0	100 ± 15	12	9.7	26	100
16.0	100 ± 15	10	13.1	23	130

* Applies to shielded and unshielded cables.
** Values for stranded conductors are 20% higher than the values shown in the table.
*** Applies to shielded cables only.

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Table A-2
ELECTRICAL PERFORMANCE REFERENCE FOR 100 OHM, CATEGORY 5 CABLES

	Category 5*		
	26 AWG	**24 AWG**	**22 AWG**
Maximum DC Resistance @ 20°C (Ohms/100 m [328 ft])	14.8	9.38	5.91
Maximum DC Resistance Unbalance (%)		5	
Minimum Insulation Resistance (MΩ - 100 m [328 ft])		1500	
Maximum Mutual Capacitance of a Pair @ 20±3°C @ 1 kHz (nF/100 m [328 ft])		5.6	
Maximum Pair to Ground Capacitance Unbalance (@ 20±3°C @ 1 kHz pF/100 m [328 ft])		330	
Minimum Phase Velocity from 1 to 100 MHz (%)		58.5	
Maximum Phase Delay Skew from 1 to 100 MHz (ns/100 m [328 ft])		45	

Frequency (MHz)	**Characteristic Impedance (Ohms)**	**Minimum Structural Return Loss (dB)**	**Maximum Attenuation** (dB/100m, [328 ft])**	**Minimum NEXT (dB)**	**Maximum Transfer Impedance*** (mΩ / m)**
0.772	—	—	1.8	64	48
1.0	100 ± 15	23	2.0	62	50
4.0	100 ± 15	23	4.1	53	69
8.0	100 ± 15	23	5.8	48	90
10.0	100 ± 15	23	6.5	47	100
16.0	100 ± 15	23	8.2	44	130
20.0	100 ± 15	23	9.3	42	149
25.0	100 ± 15	22	10.4	41	172
31.25	100 ± 15	21	11.7	39	200
62.5	100 ± 15	18	17.0	35	339
100	100 ± 15	16	22.0	32	500

* Applies to shielded and unshielded cables.
** Values for 22 and 24 AWG stranded conductors are 20% higher than the values shown in the table. For 26 AWG the values for stranded conductors are 50% higher.
*** Applies to shielded cables only.

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Table A-3
ELECTRICAL PERFORMANCE REFERENCE FOR 100 OHM CATEGORY 5e CABLES

	Category 5e		
	26 AWG	24 AWG	22 AWG
Maximum DC Resistance @ 20°C (Ohms/100 m [328 ft])	14.8	9.38	5.91
Maximum DC Resistance Unbalance (%)		5	
Minimum Insulation Resistance (MΩ - 100 m [328 ft])		1500	
Maximum Mutual Capacitance of a Pair @ 20±3°C @ 1 kHz (nF/100 m [328 ft])		5.6	
Maximum Pair to Ground Capacitance Unbalance (@ 20±3°C @ 1 kHz pF/100 m [328 ft])		330	
Minimum Phase Velocity from 1 to 100 MHz (%)		58.5	
Maximum Phase Delay Skew from 1 to 100 MHz (ns/100 m [328 ft])		45	

Frequency (MHz)	Characteristic Impedance (Ohms)	Return Loss (dB) Minimum*	Attenuation (dB/100m) Maximum*	NEXT (dB) Min.	PSNEXT (dB/100m) Minimum	ELFEXT (dB/100m) Minimum	PSELFEXT (dB/100m) Minimum	Transfer Impedance (mΩ/m) Maximum**
0.772	–	-	1.8	67.0	64.0	-	-	48
1.0	100 ± 15	20.0	2.0	65.3	62.3	63.8	60.8	50
4.0	100 ± 15	23.0	4.1	56.3	53.3	51.7	48.7	69
8.0	100 ± 15	24.5	5.8	51.8	48.8	45.7	42.7	90
10.0	100 ± 15	25.0	6.5	50.3	47.3	43.8	40.8	100
16.0	100 ± 15	25.0	8.2	47.3	44.3	39.7	36.7	130
20.0	100 ± 15	25.0	9.3	45.8	42.8	37.7	34.7	149
25.0	100 ± 15	24.3	10.4	44.3	41.3	35.8	32.8	172
31.25	100 ± 15	23.6	11.7	42.9	39.9	33.9	30.9	200
62.5	100 ± 15	21.5	17.0	38.4	35.4	27.8	24.8	339
100	100 ± 15	20.1	22.0	35.3	32.3	23.8	20.8	500

* Applicable for horizontal and backbone cables only.
** For shielded cable only.

Table A-3a
ELECTRICAL PERFORMANCE REFERENCE FOR 100 OHM CATEGORY 5e PATCH CABLES

Frequency (MHz)	Return Loss (dB) Minimum	22 to 24 AWG Attenuation (dB/100m) Maximum	<24 AWG Attenuation (dB/100m) Minimum
0.772	-	2.2	2.7
1.0	20.0	2.4	3.0
4.0	23.0	4.9	6.2
8.0	24.5	7.0	8.7
10.0	25.0	7.8	9.8
16.0	25.0	9.8	12.3
20.0	25.0	11.2	14.0
25.0	24.2	12.5	15.6
31.25	23.3	14.0	17.6
62.5	20.7	20.4	25.5
100	19.0	26.4	33.0

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Table A-4
ELECTRICAL PERFORMANCE REFERENCE FOR 150 OHM, TYPE A CABLES

	Type A	
	22 AWG	26 AWG
Maximum DC Resistance @ 20°C (Ohms/100 m [328 ft])	5.60	14.8
Maximum DC Resistance Unbalance (%)	4	
Minimum Insulation Resistance (MΩ - 100 m [328 ft])	1500	
Maximum Pair to Ground Capacitance Unbalance @ 20±3°C @ 1 kHz (pF/100 m [328 ft])	150	

Frequency (MHz)	Characteristic Impedance (Ohms)		Minimum Structural Return Loss (dB)	Maximum Attenuation (dB/100m, [328 ft])		Minimum NEXT (dB)	
	22 AWG	26 AWG		22 AWG	26 AWG	22 AWG	26 AWG
0.0096	270 ± 10%	390±15%	—	0.3	0.6	58	52
0.0384	185 ± 10%	235±15%	—	0.5	0.7	58	52
3.0	150 ± 10%		25	—	—	58	52
4.0	150 ± 10%		25	2.2	3.3	58	52
8.0	150 ± 10%		25	3.1	4.7	55	52
10.0	150 ± 10%		25	3.5	5.2	54	48
16.0	150 ± 10%		25	4.4	6.6	50	44
20.0	150 ± 10%		25	4.9	7.4	49	43
25.0	150 ± 10%		24	6.2	9.3	48	42
31.25	150 ± 10%		23	6.9	10.4	46	40
62.5	150 ± 10%		20	9.8	14.8	42	36
100.0	150 ± 10%		18	12.3	18.7	38	33
300.0	150 ± 10%		13	21.4	32.3	31	25

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Appendix B
CABLES, BUILDING, PREMISE, PLENUM, SPECIAL PURPOSE, ELECTRICAL, MULTIPLE TWISTED PAIRS, 24 AWG, UNSHIELDED, INDIVIDUALLY SHIELDED PAIRS, OR OVERSHIELDED, JACKETED CATEGORY 5

B.1 SCOPE

This appendix covers the general requirements for building premise electrical cables used for voice and data signal transmission applications. These cables are intended for use in an air plenum environment, as specified by the National Electrical Code® (NEC) in Article 800 Type CMP/MPP (Plenum) and other applicable local codes.

B.2 SALIENT CHARACTERISTICS

B.2.1 Design And Construction

The cables shall be listed to the NEC designation CMP/MPP (Plenum). Cables shall consist of 24 AWG solid bare copper conductors insulated with one or more layers of solid or expanded material. The conductors shall be twisted into pairs, unshielded or shielded, assembled into a core, with or without overshielding, and protected with an outer jacket. The cables have an impedance of 100 ± 15 ohms, a voltage rating of 300 volts and an operating temperature range of -20°C to +60 °.

B.2.2 Cable Requirements

B.2.2.1 Conductor

The conductors shall be 24 AWG solid, bare copper and meet the requirements of ICEA S-90-661.

B.2.2.2 Conductor Insulation

The conductor insulation shall meet the requirements of Underwriters Laboratory (UL) 444/CSA C 22.2 No. 214.

B.2.2.3 Conductor Insulation Color Code

The conductor insulation shall meet the color code requirements of ICEA S-90-661, Section 3. Solid colors are permissible when all twists are less than 1.5 inches.

B.2.2.4 Individually Shielded Pairs (When specified)

B.2.2.4.1 Individually Foil Shielded Pairs

The individual pair shield shall be a polyester/aluminum laminated tape electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph B.2.2.7.

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B.2.2.5 Core Construction

The core construction shall meet the requirements of ICEA S-90-661, Section 4.

B.2.2.6 Core Overshield (When Specified)

B.2.2.6.1 Foil Overshield

The core overshield shall be a polyester/aluminum laminated tape electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph 2.2.7.

B.2.2.6.2 Braided Overshield (When Specified)

A braided overshield per Paragraph 2.2.8 shall be applied over the foil shield described in Paragraph 2.2.6.1.

B.2.2.7 Drain Wire

One or more drain wire(s)shall be provided when foil shields are specified. When provided, the drain wire(s) shall, at the manufacturer's option:

- consist of a solid tinned copper conductor(s) per ASTM B 33 or
- consist of a stranded tinned copper conductor(s) per ASTM B 286 except that the stranding lay may be 1" maximum,
- be equivalent in gauge size to the twisted pair conductors comprising the core, and
- be contiguous with the aluminum side of the foil tape.

B.2.2.8 Braided Shield

The shield shall be solid tinned copper conductors in accordance with ASTM B 33 and shall:

- provide a minimum of 60% coverage and
- be contiguous with the aluminum side of the foil tape.

B.2.2.9 Jacket

The jacket shall meet the applicable requirements of UL 444/CSA C 22.2 No. 214.

B.2.2.10 Jacket Color

White or natural, unless otherwise specified.

B.2.3 Completed Cable

B.2.3.1 Electrical Requirements

The completed cable shall meet the electrical performance requirements of UL 444/CSA C 22.2 No. 214 and NEMA WC 63.1 for Category 5 cables.

B.2.3.2 Mechanical Requirements

The completed cable shall meet the mechanical requirements of ICEA S-90-661, Section 8.

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B.3 QUALITY ASSURANCE PROVISIONS

The suppliers shall be responsible for those process controls and inspections necessary to supply a product consistently conforming to the requirements of this document. Upon request, the supplier will certify with documented test/inspection evidence, that the part supplied meets the requirements of this document.

B.4 MARKING AND PACKAGING

Identification, marking, and packing shall meet the requirements of ICEA S-90-661, Section 9.

B.5 NOTES

B.5.1 Part Or Identifying Number (PIN)

The PIN for the shall be as shown in the following example:

AAXXXXX	XX	U,I,FS, or BFS	XX
CID Number	Pair Count	Shielding	Jacket Material

Where:

U	= Unshielded, twisted pairs
IF	= Individually foil shielded, twisted pairs
IFB	= Individually foil/braid shielded, twisted pairs
FS	= Overall foil shield
BFS	= Overall foil/braid shield

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Examples of approved Category 5 cables (PINs) are shown in Table B-1.

Table B-1
Standard Constructions[4]

Number of Pairs	Shielding[5]	Jacket Material[6]
04	U	01
25	U	01
04	U	02
04	U	03
25	U	03
04	IF	01
25	IF	01
04	IF	02
04	IF	03
25	IF	03
04	IF	04
25	IF	04
04	IF	05
25	IF	05
04	IF	06
25	IF	06
04	IFB	01
25	IFB	01
04	IFB	02
04	IFB	03
25	IFB	03
04	IFB	04
25	IFB	04
04	IFB	05

Number of Pairs	Shielding[5]	Jacket Material[6]
25	IFB	05
04	IFB	06
25	IFB	06
04	FS	01
25	FS	01
04	FS	02
04	FS	03
25	FS	03
04	FS	04
25	FS	04
04	FS	05
25	FS	05
04	FS	06
25	FS	06
04	BFS	01
25	BFS	01
04	BFS	02
04	BFS	03
25	BFS	03
04	BFS	04
25	BFS	04
04	BFS	05
25	BFS	05
04	BFS	06
25	BFS	06

[5] Where shielding types are defined above Table I.

[6] Where jacket materials are:
01 Polyvinyl Chloride (PVC)
02 Fluorinated Ethylene Propylene (FEP)
03 Ethylene Chloro-Trifluoro Ethylene (ECTFE)
04 Polyvinylidene Fluoride (PVDF)
05 Methyl Fluoroalkoxy (MFA)
06 Perfluoroalkoxy (PFA)

[4] Unless the application requires a specific jacket material, these cables are typically ordered by specifying only pair count and shielding type. Other pair sizes are permissible.

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Appendix C
CABLES, BUILDING, PREMISE, RISER, SPECIAL PURPOSE, ELECTRICAL, MULTIPLE TWISTED PAIRS, 24 AWG, UNSHIELDED, INDIVIDUALLY SHIELDED PAIRS, OR OVERSHIELDED, JACKETED CATEGORY 5

C.1 SCOPE

This appendix covers the general requirements for building premise electrical cables used for voice and data signal transmission applications. These cables are intended for use in vertical or non-plenum horizontal runs as specified by the National Electrical Code® (NEC)in Article 800 for Type CMR and/or MPR, riser or multipurpose, and other applicable local codes.

C.2 SALIENT CHARACTERISTICS

C.2.1 Design And Construction

The cables shall be listed to the NEC designation CMR and/or MPR (Riser). Cables shall consist of 24 AWG solid bare copper conductors insulated with one or more layers of solid or expanded materials. The conductors shall be twisted into pairs, unshielded or shielded, assembled into a core, with or without overshielding, and protected with an outer jacket. The cables have an impedance of 100 ± 15 ohms, a voltage rating of 300 volts and an operating temperature range of -20 °C to +60 °C.

C.2.2 Cable Requirements

C.2.2.1 Conductor.

The conductors shall be 24 AWG solid, bare copper and meet the requirements of ICEA S-90-661.

C.2.2.2 Conductor Insulation

The conductor insulation shall meet the requirements of Underwriters Laboratories UL 444/CSA C 22.2 No. 214.

C.2.2.3 Conductor Insulation Color Code.

The conductor insulation shall meet the color code requirements of ICEA S-90-661, Section 3. Solid colors are permissible when pair lay lengths are less than 1.5 inches.

C.2.2.4 Individually Shielded Pairs (When specified)

An individual pair shield such as polyester/aluminum laminated tape shall be electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph C.2.2.7.

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C.2.2.5 Core Construction

The core construction shall meet the requirements of ICEA S-90-661, Section 4.

C.2.2.6 Core Overshield (When Specified)

C.2.2.6.1 Foil Overshield

The core overshield, such as polyester/aluminum laminated tape, shall be electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph C.2.2.7.

C.2.2.6.2 Braided Overshield (When Specified)

A braided overshield per Paragraph C.2.2.8 shall be applied over the foil shield described in Paragraph C.2.2.6.1.

C.2.2.7 Drain Wire

One or more drain wire(s)shall be provided when foil shields are specified without a braided shield. When provided, the drain wire(s) shall:

- at the manufacturer's option, consist of a solid tinned copper conductor(s) per ASTM B 33, or stranded tinned copper conductor(s) per ASTM B 286 except that the stranding lay may be 1" maximum;
- be equivalent or larger in gage size to the twisted pair conductors comprising the core;
- be in contact with the aluminum side of the foil tape; and
- be continuous.

C.2.2.8 Braided Shield

The braided shield shall:

- be solid tinned copper conductors in accordance with ASTM B 33,
- provide a minimum of 60% coverage, and
- be in contact with the aluminum side of the foil tape.

C.2.2.9 Jacket

The jacket shall meet the applicable requirements of UL 444/CSA C 22.2 No. 214.

C.2.2.10 Jacket Color

White or natural, unless otherwise specified.

C.2.3 Completed Cable

C.2.3.1 Electrical Requirements

The completed cable shall meet the electrical performance requirements of UL 444/CSA C 22.2 No. 214 and NEMA WC 63.1 for Category 5 cables.

C.2.3.2 Mechanical Requirements

The completed cable shall meet the mechanical requirements of ICEA S-90-661, Section 8.

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C.3 QUALITY ASSURANCE PROVISIONS

The suppliers shall be responsible for those process controls and inspections necessary to supply a product consistently conforming to the requirements of this document. Upon request, the supplier will certify, with documented test/inspection evidence, that the part supplied meets the requirements of this document.

C.4 MARKING AND PACKAGING

Identification, marking, and packing shall meet the requirements of ICEA S-90-661, Section 9.

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C.5 NOTES

C.5.1 Part Or Identifying Number (PIN)

The PIN for the cable shall be as shown in the following example:

AARISER	XX	U, IF, FS, IFB or BFS	XX
CID Number	Pair Count	Shielding	Jacket Material

Where:

U = Unshielded, twisted pairs
IF = Individually foil shielded, twisted pairs
FS = Overall foil shield
IFB = Individually foil/overall braided shield, twisted pairs
BFS = Overall foil/braid shield

Examples of Category 5 cables (PINs) are shown in Table C-1.

Table C-1
EXAMPLES OF STANDARD CONSTRUCTIONS[7]

Number of Pairs	Shielding[8]	Jacket Material[9]
04	U	01
25	U	01
04	U	02
25	U	02
04	IF	01
25	IF	01
04	IF	02
25	IF	02
04	IFB	01
25	IFB	01
04	IFB	02
25	IFB	02
04	FS	01
25	FS	01
04	FS	02
25	FS	02
04	BFS	01
25	BFS	01
04	BFS	02
25	BFS	02

[7] Unless the application requires a specific jacket material, these cables are typically ordered by specifying only pair count and shielding type. Other pair counts are permissible.

[8] Where shielding types are defined above Table I.

[9] Where jacket materials are: 01 Polyvinyl Chloride (PVC)
02 Polyolefin

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Appendix D
PATCH CORD CABLES, BUILDING, PREMISE, SPECIAL PURPOSE, ELECTRICAL, 24 AWG, STRANDED CONDUCTORS, MULTIPLE TWISTED PAIRS, UNSHIELDED, INDIVIDUALLY SHIELDED PAIRS, OR OVERSHIELDED, JACKETED CATEGORY 5

D.1 SCOPE

This appendix covers the general requirements for building premise electrical cables used for voice and data signal transmission applications. These cables are designed as patch cords and cross connect jumpers to interconnect telecommunications circuits/links at the cross-connect. They are for applications where Type CM and/or MP cables are specified by the National Electrical Code® (NEC) in Article 800 and other applicable local codes.

D.2 SALIENT CHARACTERISTICS

D.2.1 Design And Construction

The cables shall be listed to the NEC designation CM and/or MP. Cables shall consist of 24 AWG, stranded, bare, or tin coated, copper conductors insulated with one or more layers of solid or expanded materials. The conductors shall be twisted into pairs, unshielded or shielded, assembled into a core, with or without overshielding, and protected with an outer jacket. The cables have an impedance of 100 ± 15 ohms, a voltage rating of 300 volts, and an operating temperature range of -20°C to +60°C.

D.2.2 Cable Requirements

D.2.2.1 Conductor

The conductors shall be 24 AWG, stranded (7X32), bare or tin coated copper, and shall meet the requirements of ASTM B 8 and B 286 except:

- the maximum lay length may be 25 times the calculated diameter per UL 444/CSA C 22.2 No. 214 (approximately 0.625 inches), and
- the direction of lay of the strands may be right or left hand.

D.2.2.2 Conductor Insulation

The conductor insulation shall meet the requirements of Underwriters Laboratories (UL) 444.

D.2.2.3 Conductor Insulation Color Code

The conductor insulation shall meet the color code requirements of ICEA S-90-661, Section 3. Solid colors are permissible when pair lay lengths are less than 1.5 inches.

D.2.2.4 Individually Shielded Pairs (When Specified)

The individual pair shield shall be a polyester/aluminum laminated tape electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph D.2.2.7.

D.2.2.5 Core Construction

The core construction shall meet the requirements of ICEA S-90-661, Section 4.

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D.2.2.6 Core Overshield (When Specified)

D.2.2.6.1 Foil Overshield

The core overshield shall be a polyester/aluminum laminated tape electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph D.2.2.7.

D.2.2.6.2 Braided Overshield (When Specified)

A braided overshield per Paragraph D.2.2.8 shall be applied over the foil shield described in Paragraph D.2.2.6.1.

D.2.2.7 Drain Wire

One or more drain wire(s)shall be provided when foil shields are specified without a braided shield. When provided, the drain wire(s) shall:

- at the manufacturer's option, consist of a solid tinned copper conductor(s) per ASTM B 33, or stranded tinned copper conductor(s) per ASTM B 286 except that the stranding lay may be 1" maximum;
- be equivalent or larger in gage size to the twisted pair conductors comprising the core;
- be in contact with the aluminum side of the foil tape; and
- be continuous.

D.2.2.8 Braided Shield

The braided shield shall be solid tinned copper conductors in accordance with ASTM B 33, and shall:

- provide a minimum of 60% coverage, and
- be in contact with the aluminum side of the foil tape.

D.2.2.9 Jacket

The jacket shall meet the applicable requirements of UL 444/CSA C 22.2 No. 214.

D.2.2.10 Jacket Color

White or natural, unless otherwise specified.

D.2.3 Completed Cable

D.2.3.1 Electrical Requirements

The completed cable shall meet the electrical performance requirements of UL 444/CSA C 22.2 No. 214 and NEMA WC 63.1 for Category 5 cables.

(Note that the maximum attenuation values for stranded conductor cables are 20% higher than solid conductor cables.)

D.2.3.2 Mechanical Requirements

The completed cable shall meet the mechanical requirements of ICEA S-90-661, Section 8.

D.3 QUALITY ASSURANCE PROVISIONS

The suppliers shall be responsible for those process controls and inspections necessary to supply a product consistently conforming to the requirements of this document. Upon request, the supplier will certify, with documented test/inspection evidence, that the part supplied meets the requirements of this document.

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D.4 MARKING AND PACKAGING

Identification, marking, and packing shall meet the requirements of ICEA S-90-661, Section 9.

D.5 NOTES

D.5.1 Part Or Identifying Number (PIN)

The PIN for the cable shall be as shown in the following example:

AAXXSTRD	XX	T or B	U, IF, FS, IFB or BFS	XX
CID Number	Pair Count	Conductors	Shielding	Jacket Material

Where:

T = Tin Coated Copper
B = Bare Copper
U = Unshielded, twisted pairs
IF = Individually foil shielded, twisted pairs
FS = Overall foil shield
IFB = Individually foil/overall braided shield, twisted pairs
BFS = Overall foil/braid shield

Examples of Category 5 patch cords (PINs) are shown in Table D-1.

Table D-1
EXAMPLES OF STANDARD CONSTRUCTIONS[10]

Number of Pairs	Shielding[11]	Jacket Material[12]
04	U	01,02,03
04	IF	01,02
04	FS	01,02
04	IFS	01,02
04	BFS	01,02

[10] Unless the application requires a specific jacket material, these cables are typically ordered by specifying only pair count and shielding type. Other pair counts are permissible.

[11] Where shielding types are defined above Table I.

[12] Where jacket materials are:
01 Polyvinyl Chloride (PVC)
02 Polyolefin
03 Fluoropolymers

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Appendix E
CABLES, BUILDING, PREMISE, PLENUM, SPECIAL PURPOSE, ELECTRICAL, MULTIPLE TWISTED PAIRS, 22 AWG, UNSHIELDED, INDIVIDUALLY SHIELDED PAIRS, OR OVERSHIELDED, JACKETED CATEGORY 5

E.1 SCOPE

This appendix covers the general requirements for building premise electrical cables used for voice and data signal transmission applications. These cables are intended for use in an air plenum environment, as specified by the National Electrical Code® (NEC) in Article 800 Type CMP and/or MPP (Plenum) and other applicable local codes.

E.2 SALIENT CHARACTERISTICS

E.2.1 Design And Construction

The cables shall be listed to the NEC designation CMP and/or MPP (Plenum). Cables shall consist of 22 AWG solid bare copper conductors insulated with one or more layers of solid or expanded material. The conductors shall be twisted into pairs, unshielded or shielded, assembled into a core, with or without overshielding, and protected with an outer jacket. The cables have an impedance of 100 ± 15 ohms, a voltage rating of 300 volts, and an operating temperature range of -20°C to +60°C.

E.2.2 Cable Requirements

E.2.2.1 Conductor

The conductors shall be 22 AWG, solid, bare copper, and meet the requirements of ICEA S-90-661.

E.2.2.2 Conductor Insulation

The conductor insulation shall meet the requirements of UL 444/CSA C 22.2 No. 214.

E.2.2.3 Conductor Insulation Color Code

The conductor insulation shall meet the color code requirements of ICEA S-90-661, Section 3. Solid colors are permissible when pair lay lengths are less than 1.5 inches.

E.2.2.4 Individually Shielded Pairs (When Specified)

The individual pair shield shall be a polyester/aluminum laminated tape electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph E.2.2.7.

E.2.2.5 Core Construction

The core construction shall meet the requirements of ICEA S-90-661, Section 4.

E.2.2.6 Core Overshield (When Specified)

E.2.2.6.1 Foil Overshield

The core overshield shall be a polyester/aluminum laminated tape electrically continuous and satisfy the criteria of UL 444/CSA C 22.2 No. 214 and ICEA S-90-661, Section 5. Drain wire(s) shall be provided per Paragraph E.2.2.7.

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E.2.2.6.2 Braided Overshield (When Specified)

A braided overshield per Paragraph E.2.2.8 shall be applied over the foil shield described in Paragraph E.2.2.6.1.

E.2.2.7 Drain Wire

One or more drain wire(s)shall be provided when foil shields are specified. When provided, the drain wire(s) shall:

- at the manufacturer's option, consist of a solid tinned copper conductor(s) per American Society for Testing and Materials (ASTM) B 33, or stranded tinned copper conductor(s) per ASTM B 286 except that the stranding lay may be 1" maximum;
- be equivalent or larger in gauge size to the twisted pair conductors comprising the core;
- be in contact with the aluminum side of the foil tape; and
- be continuous.

E.2.2.8 Braided Shield

The shield shall be solid tinned copper conductors in accordance with ASTM B 33, and shall

- provide a minimum of 60% coverage and
- be in contact with the aluminum side of the foil tape.

E.2.2.9 Jacket

The jacket shall meet the applicable requirements of UL 444/CSA C 22.2 No. 214.

E.2.2.10 Jacket Color

White or natural, unless otherwise specified.

E.2.3 Completed Cable

E.2.3.1 Electrical Requirements

The completed cable shall meet the electrical performance requirements of UL 444/CSA C 22.2 No. 214 and NEMA WC 63.1 for Category 5 cables.

E.2.3.2 Mechanical Requirements

The completed cable shall meet the mechanical requirements of ICEA S-90-661, Section 8.

E.3 QUALITY ASSURANCE PROVISIONS:

The suppliers shall be responsible for those process controls and inspections necessary to supply a product consistently conforming to the requirements of this document. Upon request, the supplier will certify, with documented test/inspection evidence, that the part supplied meets the requirements of this document.

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E.4 MARKING AND PACKAGING

Identification, Marking, and Packing shall meet the requirements of ICEA S-90-661, Section 9.

E.5 NOTES

E.5.1 Part Or Identifying Number (PIN)

The PIN for the shall be as shown in the following example:

AA22AWG	XX	U,IF, FS, IFS, or BFS	XX
CID Number	Pair Count	Shielding	Jacket Material

Where:

U	= Unshielded, twisted pairs
IF	= Individually foil shielded, twisted pairs
FS	= Overall foil shield
IFB	= Individually foil/overall braided shield, twisted pairs
BFS	= Overall foil/braid shield

Examples of approved Category 5 cables (PIN's) are shown in Table E-1.

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Table E-1
EXAMPLES OF STANDARD CONSTRUCTIONS[13]

Number of Pairs	Shielding[14]	Jacket Material[15]
04	U	01
04	U	02
04	U	03
04	U	04
04	U	05
04	U	06
04	IF	01
04	IF	02
04	IF	03
04	IF	04
04	IF	05
04	IF	06
04	FS	01
04	FS	02
04	FS	03
04	FS	04
04	FS	05
04	FS	06
04	IFB	01
04	IFB	02
04	IFB	03
04	IFB	04
04	IFB	05
04	IFB	06
04	BFS	01
04	BFS	02
04	BFS	03
04	BFS	04
04	BFS	05
04	BFS	06

[13] Unless the application requires a specific jacket material, these cables are typically ordered by specifying only pair count and shielding type. Other pairs sizes are permissible.

[14] Where shielding types are defined above Table I.

[15] Where jacket materials are: 01 Polyvinyl Chloride (PVC)
02 Fluorinated Ethylene Propylene (FEP)
03 Ethylene Chloro Trifluoro Ethylene (ECTFE)
04 Polyvinylidene Fluoride (PVDF)
05 Methry Fluoroalkoxy (MFA)
06 Perfluoroalkoxy (PFA)

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