

# SPECIFICATION CONTROL DRAWING

TITLE

HIGH TEMPERATURE HOOKUP WIRE, RADIATION-CROSSLINKED, MODIFIED ETFE-INSULATED, 600 VOLT

The complete requirements for procuring the wire described herein shall consist of this document and the issue in effect Raychem Specification WCD 3106, UL Subject 758, Style 3557, File E303150 and carries UL labels to this effect.

CONDUCTOR - TIN-COATED COPPER

INSULATION - RADIATION-CROSSLINKED  
MODIFIED ETFE

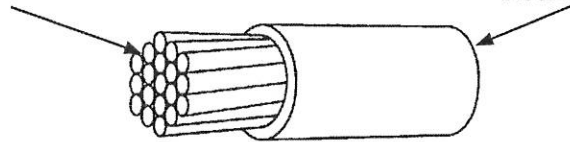


TABLE I. CONSTRUCTION DETAILS

PART NUMBER 1/	WIRE SIZE (AWG)	CONDUCTOR STRANDING (number x AWG) or (number x SEOD) (inch) (mm)	NOMINAL CONDUCTOR DIAMETER (inch) (mm)	FINISHED WIRE			
				MAXIMUM RESISTANCE AT 20°C (ohms/1000 ft.) (ohms/km)	DIAMETER (inch) (mm)		
					MINIMUM	NOMINAL	MAXIMUM
FLHTB0311-18-*	18	7 x 26	.047 (1.19)	7.06 (23.2)	.0584 (1.48)	.0601 (1.53)	.0618 (1.5)
FLHTB0311-16-*	16	7 x 24	.060 (1.52)	4.45 (14.6)	.0731 (1.86)	.0750 (1.91)	.0769 (1.9)
FLHTB0311-14-*	14	7 x .0242 (.615)	.073 (1.85)	2.90 (9.51)	.0865 (2.20)	.0886 (2.25)	.0907 (2.3)
FLHTC0311-26-*	26	19 x 38	.019 (.483)	45.8 (150.)	.0301 (.765)	.0315 (.800)	.0329 (.83)
FLHTC0311-24-*	24	19 x 36	.024 (.610)	28.7 (94.2)	.0351 (.892)	.0365 (.927)	.0379 (.96)
FLHTC0311-22-*	22	19 x 34	.030 (.762)	18.1 (59.4)	.0411 (1.04)	.0425 (1.08)	.0439 (1.1)
FLHTC0311-20-*	20	19 x 32	.038 (.965)	11.4 (37.4)	.0491 (1.25)	.0505 (1.28)	.0519 (1.3)
FLHTC0311-18-*	18	19 x 30	.047 (1.19)	7.15 (23.5)	.0583 (1.48)	.0600 (1.52)	.0617 (1.5)
FLHTC0311-16-*	16	19 x 29	.053 (1.35)	4.82 (15.8)	.0656 (1.67)	.0675 (1.71)	.0694 (1.7)
FLHTC0311-14-*	14	19 x 27	.066 (1.68)	3.05 (10.0)	.0799 (2.03)	.0820 (2.08)	.0841 (2.1)
FLHTC0311-12-*	12	19 x 25	.090 (2.29)	1.92 (6.30)	.1035 (2.63)	.1060 (2.69)	.1085 (2.7)
FLHTD0311-14-*	14	37 x 30	.068 (1.73)	3.22 (10.6)	.0819 (2.08)	.0840 (2.13)	.0861 (2.1)
FLHTD0311-12-*	12	37 x 28	.085 (2.16)	2.01 (6.59)	.0984 (2.50)	.1010 (2.57)	.1036 (2.6)
FLHTD0311-10-*	10	37 x 26	.107 (2.72)	1.26 (4.13)	.121 (3.07)	.125 (3.18)	.129 (3.2)
FLHTE0311-8-*	8	133 x 29	.160 (4.06)	.701 (2.30)	.175 (4.45)	.180 (4.57)	.185 (4.7)

Due to UL limitations on the usage of small strand bare and tin plated conductors, products with conductor strand diameters less than .015 inch (.381) For wet locations, other UL recognized products are available.

Users should evaluate the suitability of this product for their application. Specifications are subject to change without notice.  
Tyco Electronics Corporation also reserves the right to make changes in materials or processing, which do not affect compliance with any specification, without notification.

1/ COLORS AND COLOR CODE DESIGNATORS SHALL BE IN ACCORDANCE WITH MIL-STD-681. OTHER CODES AND SUFFIXES MAY BE ADDED TO THE PART NUMBER, AS NECESSARY, TO CAPTURE ANY ADDITIONAL REQUIREMENTS IMPOSED BY THE PURCHASE ORDER.

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Raychem, TE Connectivity, TE connectivity (logo), and TE (logo) are trademarks.

DIMENSIONS ARE IN INCHES AND, UNLESS OTHERWISE DESIGNATED, ARE NOMINAL.

THIS SPECIFICATION SHEET TAKES PRECEDENCE OVER DOCUMENTS REFERENCED HEREIN.  
REFERENCED DOCUMENTS SHALL BE OF THE ISSUE IN EFFECT ON DATE OF INVITATION FOR BID.

TABLE II. PERFORMANCE DETAILS		
PART NUMBER <i>1/</i>	BEND TESTING	
	MANDREL DIAMETER (inch) (mm) (± 3%)	WEIGHT (lb) (kg) (± 3%)
	CROSSLINK VERIFICATION	CROSSLINK VERIFICATION
FLHTB0311-18-*	.500 (12.7)	1.00 (.454)
FLHTB0311-16-*	.750 (19.1)	1.50 (.680)
FLHTB0311-14-*	1.00 (25.4)	2.00 (.907)
FLHTC0311-26-*	.375 (9.53)	.125 (.057)
FLHTC0311-24-*	.375 (9.53)	.500 (.227)
FLHTC0311-22-*	.500 (12.7)	.750 (.340)
FLHTC0311-20-*	.500 (12.7)	1.00 (.454)
FLHTC0311-18-*	.500 (12.7)	1.00 (.454)
FLHTC0311-16-*	.750 (19.1)	1.50 (.680)
FLHTC0311-14-*	1.00 (25.4)	2.00 (.907)
FLHTC0311-12-*	1.50 (38.1)	3.00 (1.36)
FLHTD0311-14-*	1.00 (25.4)	2.00 (.907)
FLHTD0311-12-*	1.50 (38.1)	3.00 (1.36)
FLHTD0311-10-*	2.00 (50.8)	3.00 (1.36)
FLHTE0311-8-*	3.00 (76.2)	4.00 (1.81)

### WIRE RATINGS AND ADDITIONAL REQUIREMENTS

TEMPERATURE RATING: 200°C  
 VOLTAGE RATING: 600 volts (rms) at sea level  
 CROSSLINK VERIFICATION: 300 ± 3°C for 1 hour  
 FLAME RATING: VW-1

**INSULATION ELONGATION AND TENSILE STRENGTH:**

Elongation, 100% (minimum)  
 Tensile Strength, 5470 lbf/in<sup>2</sup> (minimum)

**INSULATION FLAWS:**

Spark Test, 6.0 kV (rms)  
 Impulse Dielectric Test, 8.0 kV (peak)

**INSULATION THICKNESS:**

AWG 26-16: .0055 inch (.140 mm) (minimum), .006 inch (.152 mm) (minimum average)  
 AWG 14: .006 inch (.152 mm) (minimum), .0065 inch (.165 mm) (minimum average)  
 AWG 12: .0065 inch (.165 mm) (minimum), .007 inch (.178 mm) (minimum average)  
 AWG 10: .007 inch (.178 mm) (minimum), .0075 inch (.191 mm) (minimum average)  
 AWG 8: .0075 inch (.191 mm) (minimum), .008 inch (.203 mm) (minimum average)

SHRINKAGE: 200°C for 1 hour, 0.125 inch (3.18 mm)  
 THERMAL STABILITY: 232°C for 168 hours,  
 Elongation, 60% (minimum)  
 Tensile Strength, 5000 lbf/in<sup>2</sup> (minimum)  
 VOLTAGE WITHSTAND (Post Environmental): 2500 v

SPOOL LABEL: All spool/reel labels containing conductor diameter shall include "Fo" and "C" and "D" shall include ".015 inch (.381 mm)

**1/ PART NUMBER:**

The "+" in the part number in the upper right hand corner with a letter designator to define conductor stranding  
 B = 7 Strands C = 19 Strands D = 37 Strands

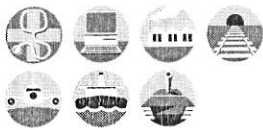
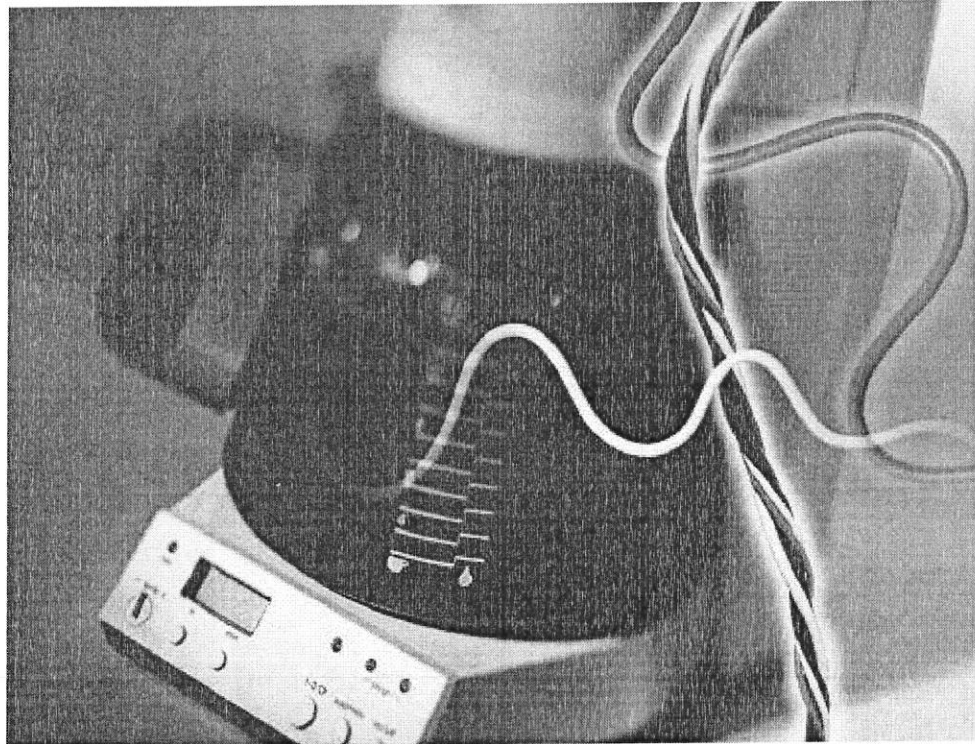
The "\*" in the part numbers in Tables I and II shall be  
 Example: AWG 18, 19 strands, white: FLHTC0311-1  
 AWG 18, 19 strands, white with a black stripe: FLHTC0311-1\*

1/ See footer section on page 1

**High-Temperature Hookup Wire**

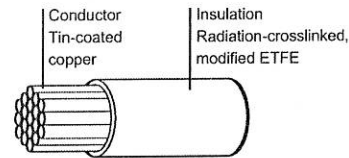
**Product Facts**

- UL rated operating temperature to 200°C [392°F]
- Exceptional chemical resistance
- Thin-wall, for size and weight savings
- Tough fluoropolymer insulation material
- Excellent stripping and handling
- Variety of constructions and colors
- Crosslinked to minimize cold flow
- VW-1 flammability rating
- 600 V rating



**Applications**

FlexLite HT (FLHT) wire is the product of choice for high-temperature applications. It offers shop-handling advantages over silicone/ fiberglass constructions (SF1/SF2) and is cost-competitive with other fluoropolymer wire. Applications include halogen lights and small high-end appliances where space and temperature are issues.



Available in:	Americas	Europe	Asia Pacific
	■	■	■



**FlexLite HT (Continued)**

**Specifications/Approvals**

Series	UL	CUR	CSA	Raychem
HT	Style 3557 Flammability VW-1 Temperature rating 200°C [392°F]	Recognized	Certified AWMIA/B	WCD-3106

**Construction Details**

Part No.	Wire Size (AWG)	Conductor Stranding (No. x AWG)	Nominal Diameter mm [inch]	Finished Wire Maximum Resistance at 20°C (68°F) Ω/km [Ω /1000 ft]	Diameter			Nominal Weight in kg/km [lb/1000 ft]
					Minimum mm [inch]	Nominal mm [inch]	Maximum mm [inch]	
FLHTC0311-26-*	26	19 x 38	.470 [.0185]	132 [40.1]	.765 [.0301]	.800 [.0315]	.836 [.0329]	1.89 [1.27]
FLHTC0311-24-*	24	19 x 36	.597 [.0235]	83.3 [25.4]	.892 [.0351]	.927 [.0365]	.963 [.0379]	2.75 [1.85]
FLHTC0311-22-*	22	19 x 34	.749 [.0295]	52.2 [15.9]	1.04 [.0411]	1.08 [.0425]	1.12 [.0439]	4.08 [2.74]
FLHTC0311-20-*	20	19 x 32	.953 [.0375]	32.0 [9.76]	1.25 [.0491]	1.28 [.0505]	1.32 [.0519]	6.21 [4.17]
FLHTC0311-18-*	18	19 x 30	1.18 [.0465]	20.4 [6.22]	1.48 [.0583]	1.52 [.0600]	1.57 [.0617]	9.43 [6.34]
FLHTC0311-16-*	16	19 x 29	1.33 [.0525]	15.8 [4.82]	1.67 [.0656]	1.71 [.0675]	1.76 [.0694]	12.0 [8.09]
FLHTC0311-14-*	14	19 x 27	1.68 [.0660]	10.0 [3.05]	2.03 [.0799]	2.08 [.0820]	2.14 [.0841]	18.6 [12.5]
FLHTD0311-12-*	12	37 x 28	2.16 [.0850]	6.59 [2.01]	2.50 [.0984]	2.57 [.1010]	2.63 [.1036]	28.7 [19.3]

**Construction Details**

Part No.	Nominal CSA (mm²)	Conductor Stranding No/Dia. (mm)	Diameter		Finished Wire Maximum Resistance at 20°C (68°F) (ohms/km)	Diameter			Nominal Weight (kg/km)
			(min.) mm [inch]	(max.) mm [inch]		Lower Spec. Limit mm [inch]	Target Value mm [inch]	Upper Spec. Limit mm [inch]	
FLHTC0311-0.25-*	0.25	19/0.127	0.55 [.022]	0.63 [.025]	84.3	0.96 [.038]	1.00 [.039]	1.03 [.041]	2.95
FLHTC0311-0.35-*	0.35	19/0.15	0.74 [.029]	0.76 [.030]	56.1	1.12 [.044]	1.16 [.046]	1.19 [.047]	4.22
FLHTC0311-0.50-*	0.50	19/0.19	0.86 [.034]	0.88 [.035]	40.1	1.24 [.049]	1.27 [.050]	1.31 [.052]	5.59
FLHTC0311-0.75-*	0.75	19/0.23	1.05 [.041]	1.08 [.043]	24.7	1.43 [.056]	1.47 [.058]	1.51 [.059]	7.95
FLHTC0311-1.00-*	1.00	19/0.25	1.17 [.046]	1.26 [.050]	20.0	1.58 [.062]	1.62 [.064]	1.66 [.065]	9.85
FLHTC0311-1.50-*	1.50	19/0.32	1.35 [.053]	1.58 [.062]	13.7	1.82 [.072]	1.87 [.074]	1.92 [.076]	15.69
FLHTC0311-2.00-*	2.00	19/0.36	1.66 [.065]	1.79 [.070]	9.7	2.05 [.081]	2.10 [.083]	2.16 [.085]	18.67
FLHTC0311-2.50-	2.50	19/0.41	1.85 [.073]	2.01 [.080]	8.2	2.24 [.088]	2.31 [.091]	2.38 [.094]	24.62

\* Replace asterisk with color code designator:  
 0 = Black    3 = Orange    6 = Blue    9 = White  
 1 = Brown    4 = Yellow    7 = Violet  
 2 = Red    5 = Green    8 = Gray  
 For example: FLHTC0311-22-9 = AWG 22, white.  
 FLHTC0311-0.50-9 = Size 0.50mm², white.

For product requiring CUR (Canadian UL) or CSA marking in 14-10 AWG, 19 strand conductors only, the part numbering descriptions above **DO NOT** apply. Please contact Tyco Electronics for further information.

## WIRE AND CABLE, ELECTRIC, INSULATED COPPER

### 1. SCOPE

#### 1.1 SCOPE

This specification defines wire, unshielded-unjacketed cables, and shielded-unjacketed cables for general commercial electronics where an Underwriters Laboratories Inc. recognized construction is required. Some wire types of DW, HT, TW and TX defined herein may also be used in markets where certification to Canadian Standards Association CSA C22.2 No. 210 is required.

#### 1.2 CLASSIFICATION

Products in accordance with this specification shall be of the following types, as specified in the applicable specification sheet.

**Finished Wire:** A single conductor, insulated as specified in the applicable specification sheet.

**Finished Cable:** Any construction other than finished wire, utilizing a wire or wires with or without shielding.

##### 1.2.1 Temperature Rating

Products in accordance with this specification have a temperature rating as shown in the specification sheet as defined by the Underwriters Laboratories' temperature rating practices, and where applicable, the Canadian Standards Association's practices.

### 2. APPLICABLE DOCUMENTS

#### 2.1 GOVERNMENT-FURNISHED DOCUMENTS

The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

### 2.1.1 Department of Defense

MIL-STD-104 Limits for Electrical Insulation Color

(Copies of Department of Defense documents may be obtained from the Naval Publications and Forms Center, Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094; or at <http://assist.daps.dla.mil/quicksearch/>.)

### 2.2 OTHER PUBLICATIONS

The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

#### 2.2.1 American Society for Testing and Materials (ASTM)

B 1 Standard Specification for Hard Drawn Copper Wire  
 B 3 Standard Specification for Soft or Annealed Copper Wire  
 B 33 Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes  
 B 263 Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors  
 D 3032 Standard Test Methods for Hookup Wire Insulation

(Copies of ASTM documents may be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959; or at [www.astm.org](http://www.astm.org).)

#### 2.2.2 Canadian Standards Association (CSA)

C22.2 No. 210 Appliance Wiring Material Products

(Copies of CSA documents may be obtained from the Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6; or at [www.shopcsa.ca](http://www.shopcsa.ca).)

#### 2.2.3 National Electrical Manufacturers Association (NEMA)

WC 27500 Standard for Aerospace and Industrial Electrical Cable

(Copies of NEMA documents may be obtained from the National Electrical Manufacturers Association, 1300 North 17th Street, Rosslyn, Virginia 22209; or at [www.nema.org](http://www.nema.org).)

#### 2.2.4 Underwriters Laboratories Inc.

UL 758 Standard for Appliance Wiring Material  
 UL Subject 758 Section General for Appliance Wiring Material (AWM)  
 UL 1581 Reference Standard for Electrical Wires, Cables and Flexible Cords  
 UL 2556 Wire and Cable Test Methods

(Copies of UL documents may be obtained from Underwriters Laboratories Inc., 1655 Scott Boulevard, Santa Clara, CA 95050-4169; or at [www.ul.com](http://www.ul.com).)

### 3. REQUIREMENTS

#### 3.1 SPECIFICATION SHEETS

The requirements for the individual wires and cables furnished under this specification shall be as specified herein and in accordance with the applicable specification sheet. In the event of a conflict, the requirements of the specification sheet shall govern.

#### 3.2 MATERIALS

Materials not specifically designated herein shall be of the quality and form best suited for the purpose intended. Unless otherwise specified, the materials shall meet the following requirements:

##### 3.2.1 Conductor Materials

Conductor materials shall be hard drawn copper in accordance with ASTM B 1, bare annealed copper in accordance with ASTM B 3, or tinned annealed copper in accordance with ASTM B 33, or as specified in the applicable specification sheet.

##### 3.2.2 Insulating Materials

The extruded insulation shall be one of the following types:

- DW = Dual Wall, Radiation-Crosslinked, Modified PVDF/Polyalkene
- HT = High Temperature, Radiation-Crosslinked, Modified ETFE
- MT = Medium Temperature, Modified ETFE
- TW = Thin Wall, Modified Polyester
- TX = Thin Wall, Extra High Temperature Fluoropolymer

##### 3.2.3 Shield Materials

Shield materials shall conform to the requirements of WC 27500 and the applicable specification sheet.

#### 3.3 CONSTRUCTION

##### 3.3.1 Conductor Construction

###### 3.3.1.1 Stranding

The conductors shall be constructed as specified in the applicable specification sheet and UL 758 or UL Subject 758, as required by the applicable specification sheet. When CSA is required by the specification sheet, the conductor shall also be constructed to meet the requirements of CSA C22.2 No. 210.

###### 3.3.1.2 Joints

Joints shall be in accordance with UL 758 and CSA C22.2 No. 210.

### 3.3.2 Insulation Construction

The insulation shall be constructed as specified in the applicable specification sheet. When stranded conductors are used in the construction of the finished wire, there shall be no insulation under any of the strands of the conductor.

## 3.4 FINISHED WIRE AND CABLE

### 3.4.1 Finished Wire

Finished wire shall conform to the requirements of Table 1 and to those of the applicable specification sheet.

### 3.4.2 Finished Cable

Finished cable shall conform to the requirements of Table 2 and to those of the applicable specification sheet. Component wires used in the cable shall conform to the requirements of 3.4.1, prior to cabling.

### 3.4.3 Cabling

The required number of wires for multiconductor constructions shall be cabled with a left hand lay. The lay of the individual wires shall not be less than eight nor more than sixteen times the outside diameter of the unshielded, unjacketed cable. Fillers and binders shall be used as required.

### 3.4.4 Cold Bend

When the finished wire is subjected to the cold bend test of ASTM D 3032, Section 26, at a temperature of  $-55 \pm 2^{\circ}\text{C}$ , the insulation shall not crack or fail dielectrically. Wires shall be tested on mandrels with a diameter of 15 to 20 times the nominal diameter of the finished wire. Test weights shall be sufficient to keep the finished wire in contact with the mandrel.

### 3.4.5 Color

Finished wire insulation color code designators shall be as specified in Table 3. Colors for DW finished wires shall be in accordance with MIL-STD-104, Class 1. Colors for HT and TX finished wires shall be in accordance with MIL-STD-104, Class 1 or 2. Colors for TW finished wires shall be in accordance with Table 4.

### 3.4.6 Conductor and Shield Continuity

Prior to shipment, one hundred percent of all finished wire and cable shall be tested for continuity in accordance with 4.5.2. There shall be no indication of discontinuity in any of the conductors or shields, as applicable.

### 3.4.7 Crosslink Verification

When finished wire is tested in accordance with 4.5.3, the insulation must not crack or fail dielectrically within 5 minutes of electrification.



**TABLE 1. PROPERTIES OF FINISHED WIRE**

Examination or Test	Requirement	Test Method	*Inspection Class				
			DW	HT	MT	TW	TX
Cold Bend	3.4.4	ASTM D 3032, Section 26	P	Q	Q	Q	Q
Color	3.4.5	4.5.5	P	P	P	P	P
Conductor Continuity	3.4.6	4.5.2	100%	100%	100%	100%	100%
Conductor Joints	3.3.1.2	4.5.5	V	V	V	V	V
Conductor Material	Specification Sheet and 3.2.1	4.5.5	V	V	V	V	V
Conductor Resistance	Specification Sheet	UL 1581	P	P	P	P	P
Conductor Stranding	Specification Sheet and 3.3.1.1	4.5.5	V	V	V	V	V
Crosslink Verification	Specification Sheet and 3.4.7	4.5.3	P	P	--	--	--
Dimensions	Specification Sheet	ASTM D 3032, Section 15	P	P	P	P	P
Flammability	Specification Sheet and 3.4.8	UL 1581	P	P	P	--	--
Identification Durability: Unaged specimen	3.4.9	4.5.6	P	P	P	P	P
Aged specimen	3.4.9	4.5.6	Q	Q	Q	Q	Q
Insulation Concentricity	3.4.10	ASTM D 3032, Section 16	P	P	P	P	P
Insulation Construction	Specification Sheet and 3.3.2	4.5.5	P	P	P	P	P
Insulation Elongation and Tensile Strength	Specification Sheet	4.5.7	P	P	P	P	P
Insulation Flaws	Specification Sheet and 3.4.11	4.5.8	100%	100%	100%	100%	100%
Insulation Thickness	Specification Sheet	4.5.9	P	P	P	P	P
Removability of Insulation	3.4.12	4.5.5	P	P	P	P	P
Shrinkage	3.4.13	4.5.10	P	P	P	P	P
Thermal Stability	Specification Sheet	4.5.11	Q	Q	Q	Q	Q
Weight	Specification Sheet	4.5.13	P	P	P	P	P
Workmanship	3.4.14	4.5.5	P	P	P	P	P

\*Inspection Class (see 4.2): P = In-Process or Lot Test V = Vendor Test  
 100% = 100% Finished Product Test -- = Not applicable to product  
 Q = Qualification Test

**TABLE 2. PROPERTIES OF FINISHED CABLE**

Examination or Test	Requirement	Test Method	*Inspection Class
Cabling	Specification Sheet and 3.4.3	4.5.5	P
Conductor and Shield Continuity	3.4.6	4.5.2	100%
Dielectric Withstand	Specification Sheet	4.5.4	100%
Dimensions	Specification Sheet	ASTM D 3032, Section 15	P
Insulation Elongation and Tensile Strength	Specification Sheet	4.5.7	P
Insulation Flaws	Specification Sheet and 3.4.11	4.5.8	100%
Shield Coverage	Specification Sheet	WC 27500	P
Shield Material and Construction	Specification Sheet and 3.2.3	WC 27500	P
Weight	Specification Sheet	4.5.13	P
Workmanship	3.4.14	4.5.5	P

\*Inspection Class (see 4.2): P = In-Process or Lot Test  
 100% = 100% Finished Product Test

**NOTE: ANY PRINTED COPY OF THIS DOCUMENT IS AN UNCONTROLLED COPY.**

**TABLE 3. FINISHED WIRE COLOR CODE DESIGNATORS**

Color Code	Solid Color
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Purple
8	Gray
9	White

**TABLE 4. TW FINISHED WIRE COLORS**

Color Code	Light	Central	Dark
0	N3	N 2.25	N/A
1	10R/3.5/1.0	0.8YR/3.0/1.0	4.6YR/2.5/1.0
2	2.5R/4.2/11.2	3.3R/3.8/11.0	4.4R/3.4/10.4
3	8.75R/6.0/11.5	8.75R/5.75/12.5	8.75R/5.5/13.5
4	8.4Y/8.5/8.3	8.2Y/8.5/9.8	8Y/8.5/11.2
5	0.5G/6.25/6.3	0.5G/5.6/7.0	0.5G/5.1/7.5
6	9B/5.4/5.0	9B/5.0/5.0	9B/4.7/5.0
7	4.4P/3.9/6.7	3.9P/3.4/6.7	3.4P/2.8/6.7
8	N6.3/(10GY,0.2)	N5.7/(10GY,0.2)	N5.2/(10GY,0.2)
9	N/A	5Y/9/1	5Y/8.5/1

**3.4.8 Flammability**

When finished wire is tested in accordance with UL 1581, Section 1080, the finished wire shall not cause more than 25 percent of the indicator flag to burn or char, nor cause the cotton to ignite, nor continue to burn more than 60 seconds after any flame application.

**3.4.9 Identification Durability**

When finished wire is tested in accordance with 4.5.6, the printed product identification shall remain legible and there shall be no discontinuity of the identification mark.

**3.4.10 Insulation Concentricity**

When finished wire is tested in accordance with ASTM D 3032, Section 16, the concentricity of the total wire insulation shall be not less than 70 percent.

### 3.4.11 Insulation Flaws

One hundred percent of finished wire and unshielded, unjacketed cable shall pass the impulse dielectric test specified in ASTM D 3032, Section 13, or the spark test specified in 4.5.8 using the voltage specified in the applicable specification sheet. Testing shall be performed during the final winding of the wire or cable on shipment spools or reels.

### 3.4.12 Removability of Insulation

For finished wire, 0.25 inch (6.4 mm) of insulation shall be readily removable using conventional, hand operated, wire strippers with properly-sized blades for the construction. The insulation slug shall not bunch, nor shall any conductor strands break during the removal process.

### 3.4.13 Shrinkage

The insulation shrinkage, at either end of the finished wire specimen, shall not exceed that specified in the applicable specification sheet after a 1-hour oven exposure at the specified temperature when tested in accordance with 4.5.10.

### 3.4.14 Workmanship

All details of workmanship shall be in accordance with high grade wire and cable manufacturing practices. The insulation shall be free of cracks, splits, irregularities, and imbedded foreign material.

## 4. **QUALITY ASSURANCE PROVISIONS**

### 4.1 **RESPONSIBILITY FOR INSPECTION**

The supplier is responsible for the performance of all the inspection tests specified herein. The supplier may utilize his own or any other inspection facility and services acceptable to the buyer. Inspection records of the examinations and tests shall be kept complete and available to the buyer as required.

### 4.2 **INSPECTION CLASSIFICATION**

- a. Vendor Control (V): Requirements for raw materials such as conductor and insulation materials over which the vendor has control and responsibility.
- b. Process Control (P): Inspections performed on samples taken from the lots of wire or cable. Inspections may be performed on finished wire and cable or after the process which establishes the specified characteristic. The Quality Control Plan establishes the frequency of inspection based on process control data.
- c. One Hundred Percent (100%): Tests performed on the total length of each wire or cable. Tests may be performed on the finished product or "in process", as applicable.
- d. Qualification (Q): Tests performed only at the time of initial qualification or requalification.

### 4.3 QUALIFICATION INSPECTION

Qualification inspection shall consist of all tests listed in Table 1 for primary wire and Table 2 for cable. Requalification testing shall be performed by Tyco Electronics and Underwriters Laboratories Inc., as required, any time changes in materials occur that are deemed to have the potential for significantly altering the form, fit, function, or appearance of the product.

#### 4.3.1 Sampling for Qualification Inspection

Samples of wire or cable for qualification inspection shall be taken from production lots which have been manufactured under the most current Quality Control Plan.

### 4.4 QUALITY CONFORMANCE INSPECTION

Quality conformance inspection consists of a series of tests and inspections that assure that raw materials and manufacturing processes are consistent and result in products that conform to specification requirements. Quality conformance tests and inspections are listed in Table 1, designated as "P", "V", or "100%", and shall be performed on every lot of wire or cable procured under this specification.

#### 4.4.1 Nonconforming Inspection Lots

All lots found unacceptable under initial quality conformance inspections shall be reviewed and reworked in accordance with established internal procedures.

### 4.5 TEST METHODS

#### 4.5.1 Bend Test (Post Environmental)

At a temperature maintained between 20 and 25°C and using the mandrel and weight specified in the applicable specification sheet, attach one end of a finished wire specimen to the mandrel and the other end to the weight. The mandrel shall be rotated until the full length of the specimen is wrapped around the mandrel and is under the specified tension with adjoining turns in contact. The mandrel shall then be rotated in the reverse direction until the full length of the specimen which was outside during the first wrapping is now next to the mandrel. This procedure shall be repeated until two bends in each direction have been formed in the same section of the specimen. The specimen shall then be examined for cracking of the insulation.

#### 4.5.2 Conductor and Shield Continuity

To establish continuity, 25 volts DC, maximum, shall be applied to both ends of each conductor and shield of the wire or cable, as applicable, through an appropriate indicator, such as an ohmmeter, light or buzzer. For finished cable, the test voltage may be applied to the conductors and shields individually, or in a series.

#### 4.5.3 Crosslink Verification

When required, finished wire specimens, prepared in accordance with 4.5.3.1, shall be conditioned in an air-circulating oven for the time and temperature specified in the applicable specification sheet. The velocity of air passing the specimens (measured at room temperature) shall be between 100 and 200 feet (30 to 61 m) per minute. After conditioning, the oven shall be shut off, the door opened, and the specimens allowed to cool in the oven for at least 1 hour. When cool, the finished wire specimens shall be freed from tension, removed from the mandrel, and straightened. The finished wire specimens shall then be subjected to the bend test (4.5.1) followed by the voltage withstand test (4.5.12).

##### 4.5.3.1 Finished Wire Preparation

Two inches (51 mm) of insulation shall be removed from each end of a 24-inch (610-mm) specimen of finished wire. The central portion of the specimen shall then be bent at least halfway around a horizontally positioned smooth stainless steel mandrel of the diameter specified in the applicable specification sheet. To prevent sticking of the specimen to the mandrel, the mandrel shall be covered with polytetrafluoroethylene in the form of either a dispersion coating (preferred) or wrapped tape, provided that the diameter of the mandrel still conforms to the specification sheet. Each end of the conductor shall be loaded with the weight specified in the applicable specification sheet, so that the portion of the insulation between the conductor and mandrel is under compression while the conductor is under tension. For smaller wires, both conductor ends may be tied together and loaded with a single weight that is twice the weight specified in the applicable specification sheet. This specimen, so prepared on the mandrel, shall be conditioned and tested as specified above.

#### 4.5.4 Dielectric Withstand

The voltage specified in the applicable specification sheet shall be applied between each component wire and shield, if any, for a period of 1 minute. The test potential shall be supplied from a suitable 2 kVA or larger test transformer. There shall be no dielectric breakdown.

#### 4.5.5 Examination of Product

All samples shall be examined carefully to determine conformance to this specification and to the applicable specification sheet with regard to requirements not covered by specific test methods.

#### 4.5.6 Identification Durability

Finished wire shall be tested in accordance with the Durability of ink printing in UL 2556. The unaged specimen shall be tested at room temperature. The aged specimen shall be conditioned in an air-circulating oven at  $60 \pm 2^\circ\text{C}$  for 168 hours.

#### 4.5.7 Insulation Elongation and Tensile Strength

Specimens of the insulation shall be carefully removed from all component or finished wire, as applicable, and tested for tensile strength and elongation in accordance with ASTM D 3032, Section 17, using 1-inch (25-mm) bench marks and 1.5-inch (38-mm) initial jaw separation, with the conditions and exceptions as shown in Table 5.

**TABLE 5. CROSSHEAD SPEED**

Construction	Crosshead Speed (per minute)	
	Qualification	Process Control
DW (primary insulation only)	2 inches (51 mm)	20 inches (508 mm)
HT	2 inches (51 mm)	2 inches (51 mm)
MT	2 inches (51 mm)	2 inches (51 mm)
TW	2 inches (51 mm)	20 inches (508 mm)
TX	20 inches (508 mm)	20 inches (508 mm)

In the event of a failure of a DW or TW finished wire under the process control conditions, a referee test shall be performed to the qualification crosshead speed of 2 inches (51 mm) per minute and these results shall take precedence over the process control results.

#### 4.5.8 Insulation Flaws - Spark Test

Finished wire or cable shall be passed through a chain electrode spark test device using the voltage specified in the applicable specification sheet at a frequency of 60 or 3000 Hz. The conductor shall be grounded at one or both ends. The electrode shall be of a suitable bead chain or fine mesh construction that will give intimate metallic contact with practically all of the wire or cable surface. Electrode length and speed of specimen movement shall be such that the wire or cable is subjected to the test voltage for a minimum of 0.2 second. Any portion showing breakdown shall be cut out, including at least 2 inches (51 mm) of insulation on each side of the failure.

#### 4.5.9 Insulation Thickness

##### 4.5.9.1 UL

##### 4.5.9.1.1 9 AWG and Smaller

The minimum insulation wall thickness shall be measured on one 5-foot (1.5-m) specimen using cross-sections taken at the 10, 20, 30, 40 and 50 inch (254, 508, 762, 1016 and 1270 mm) points along the specimen. The minimum wall thickness shall be the smallest of the five measurements. The minimum average wall thickness shall be the average of the five measurements.

##### 4.5.9.1.2 8 AWG and Larger

The minimum insulation wall thickness shall be measured on one 24-inch (610-mm) specimen using cross-sections taken at the 4, 8, 12, 16 and 20 inch (102, 203, 305, 406 and 508 mm) points along the specimen. The minimum wall thickness shall be the smallest of the five measurements. The minimum average wall thickness shall be the average of the five measurements.

#### 4.5.9.2 CSA

When CSA is required by the specification sheet, the minimum insulation wall thickness shall be as specified in the applicable specification sheet. The average wall thickness shall be determined by measuring the wall thickness at three locations spaced 2 inches (50 mm) apart. The minimum average wall thickness shall be the average of the three measurements.

#### 4.5.10 Shrinkage

A 12 inch (305 mm) specimen of finished wire, with flush cut ends, shall be placed in an air-circulating oven at the temperature specified in the applicable specification sheet for one hour. The specimen shall then be removed from the oven and allowed to cool to room temperature. The difference between the ends of the insulation and conductor shall be measured at each end of the specimen. The maximum amount of shrinkage at either end shall not exceed the value specified in the applicable specification sheet.

#### 4.5.11 Thermal Stability

A minimum of three tensile specimens shall be prepared in accordance with ASTM D 3032. The specimens shall be aged in an air-circulating oven for the time and temperature specified in the applicable specification sheet. Upon removal from the aging oven, the specimens shall be conditioned at  $20 \pm 5^\circ\text{C}$  for a minimum of four hours, and then tested for elongation and tensile strength per 4.5.7.

#### 4.5.12 Voltage Withstand (Post Environmental)

The uninsulated ends of the specimen shall be attached to an electrical lead. The specimen shall be immersed in a 5-percent, by weight, solution of sodium chloride in water at 20 to  $25^\circ\text{C}$ , except that the uninsulated ends and 1.5 inches (38 mm) of insulated wire at each end of the specimen shall protrude above the surface of the solution. After immersion for 1 hour, the voltage specified in the applicable specification sheet at 60 Hz shall be applied between the conductor and the water bath which shall be grounded. The voltage shall be gradually increased at a uniform rate from zero to the specified voltage in 0.5 minute, maintained at that voltage for a period of 5 minutes, and then gradually reduced to zero in 0.5 minute.

#### 4.5.13 Weight

The weight of each lot of finished wire or cable shall be determined by Procedure I (4.5.13.1). Lots failing to meet the weight requirement of the applicable specification sheet when tested in accordance with Procedure I shall be subjected to Procedure II (4.5.13.2). All spools or reels failing to meet the requirements of the applicable specification sheet when tested to Procedure II shall be rejected.

##### 4.5.13.1 Procedure I

A length of wire or cable, sufficient to produce a measured weight to at least 3 significant figures, shall be weighed and converted to the weight per unit length shown on the applicable specification sheet.

#### 4.5.13.2 Procedure II

The net weight of the finished wire or cable on each spool or reel shall be obtained by subtracting the tare weight of the spool or reel from the gross weight of the spool or reel containing the finished wire or cable. The net weight of the wire or cable on each spool or reel shall be divided by the accurately determined length of finished wire or cable on that spool or reel and the resultant figure converted to the weight per unit length shown on the applicable specification sheet. When wood or other moisture absorbent materials are used for spool or reel construction, weight determinations shall be made under substantially uniform conditions of relative humidity.

### 5. STANDARD PACKAGING

Unless otherwise specified (see 6.1), the following shall define the standard spooling and labeling requirements for wire and cable furnished under this specification. Standard shipping tolerance on ordered quantity, for both wire and cable, shall be  $\pm 10$  percent.

#### 5.1 SPOOLING REQUIREMENTS

All layers of wire and cable shall be wound on spools or reels (see 5.1.3) with sufficient tension to prevent shifting of layers and creation of crossovers within layers.

##### 5.1.1 Finished Wire

Finished wire lengths shall be wound on spools or reels with the ends spliced together to provide one mechanically and electrically continuous length. Unless otherwise specified, the minimum continuous length between splices shall be in accordance with Table 6.

**TABLE 6. FINISHED WIRE LENGTHS**

Wire Size Range		Minimum Length
(AWG)	( $mm^2$ )	
30 through 10	0.057 through 4.74	100 feet (30 m)
8 and larger	8.60 and larger	50 feet (15 m)

(NOTE: Metric lengths specified above apply only to those orders placed in metric.)

##### 5.1.2 Finished Cable

Finished cable lengths shall be wound on spools or reels with all ends exposed. There shall be no more than 5 lengths per spool or reel and no length shall be less than 50 feet (15 m).

##### 5.1.3 Spools and Reels

Spools and reels shall be of a non-returnable type. Each spool and reel shall have an appropriate diameter for the respective wire or cable size. In no case shall the barrel of the spool or reel have a diameter less than 3.5 inches (89 mm). Spools and reels shall be suitably finished to prevent corrosion under typical storage and handling conditions. Loaded plastic spools shall not exceed 50 pounds (23 kg). Loaded wooden reels shall have no weight restriction.



#### 5.1.4 Containers

Unless otherwise specified (see 6.1), finished wire and cable shall be delivered in standard commercial containers so constructed as to ensure acceptance by common or other carrier for safe transportation at the lowest rate to the point of delivery.

#### 5.2 LABELING REQUIREMENTS

All spools and reels shall be identified with a manufacturer's label, UL labels, and when required by the specification sheet, CSA labels as specified herein.

##### 5.2.1 Manufacturer's Label

The manufacturer's label shall include the following information:

Manufacturer's Part Number  
 Lot Number  
 Quantity in Feet *(or Meters)*  
 Name of Manufacturer

##### 5.2.2 UL Labels

###### 5.2.2.1 UL Non-denominational label

###### 5.2.2.2 UL Style Label

The UL Style label shall include the following information:

UL STYLE # *(as applicable)*  
 AWM SUITABLE FOR *(applicable "Use" as stated on style sheet)*  
 Insulation Material and Average Wall Thickness *(of each layer, if applicable)*  
*(example for DW: XLPE 6 mils / XLPVDF 3 mils)*  
 Number of Conductors/Size (AWG or mm<sup>2</sup>) *(example: 2/24 AWG)*  
 Max Temperature Rating *(as stated on style sheet)*  
 Max Voltage Rating \_\_\_\_\_ *(as stated on style sheet)*  
 Flame Rating VW-1 *(only if tested per 3.4.8)*  
 Manufacturer E303150 *(or other applicable File Number if manufactured in another country)*  
 Month & Year *(of manufacturing)*

When required by the specification sheet, the following additional information shall also be included, as applicable:

FOR DRY LOCATIONS ONLY  
 REINFORCED INSULATION

5.2.3 CSA Labels

When CSA is required by the specification sheet, all spools and reels shall include CSA footage labels and a CSA identification label as specified herein.

5.2.3.1 CSA Footage Label

An applicable number of brown CSA labels shall be attached to each spool or reel that represents the applicable quantity on each spool or reel.

5.2.3.2 CSA Identification Label

The CSA identification label shall include the following information:

Manufacturer LL33902  
 Date of Manufacture *(month and year)*  
 xx AWG, One Conductor  
 Insulation Wall Thickness   \* Min  
 I *(for Class I)*  
 "A", "B", or "A/B" *(for Group A, Group B, or Groups A and B, as applicable)*  
 Temperature Rating *(example: "150°C")*  
 Voltage Rating *(example: "600V")*  
 LIMITED USE FOR INTERNAL WIRING OF ELECTRONIC  
 EQUIPMENT AND APPLICANCES

Where: xx = Applicable AWG Size  
       \* = Actual minimum value measured

6. **NOTES**

6.1 ORDERING DATA

Procurement documents should specify the following:

- a. Title, number, and date of this specification
- b. Applicable specification sheet part number
- c. Quantity
- d. Special preparation for delivery requirements, if applicable (see Section 5)

6.2 METRIC UNITS

Metric units (where shown in parentheses) are for information only.

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