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Electrical and Electronic PTFE (Polytetrafluoroethylene) Insulated High Temperature Hook-Up Wire; Types ET (250 Volts), E (600 Volts), and EE (1000 Volts)

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FOREWORD

This standard publication was developed by the NEMA High Performance Wire and Cable Section. It was developed to assure that these types of hook-up wire can be procured and that they will meet requirements associated with high reliability commercial electrical and electronic equipment in which it is used. Compliance with provisions of this Standards Publication is strictly voluntary and any certification of compliance is left to the discretion of the buyer and seller.

This Standards Publication was designed as a non-government standard for replacement of MIL-W-16878 PTFE insulated wire slash sheets (/4, /5, /6, /20 through /27, /34, and /35).

This Standards Publication was developed by the High Performance Wire and Cable Section of NEMA. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Section was composed of the following members:

Alcatel/Nexans—Elm City, NC
General Cable—Willimantic, CT
Cable USA Inc.—Naples, FL
Furon Company/Dekron Division—Akron, OH
Judd Wire Inc.—Turner Falls, MA
Quirk Wire Company Inc.—West Brookfield, MA
Radix Wire Company—Cleveland, OH
Raychem/Tyco Corporation—Menlo Park, CA
Rockbestos/Surprenant Cable Corp.—Clinton, MA

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Section 1
GENERAL

1.1 SCOPE

This Standards Publication covers specific requirements for PTFE (polytetrafluoroethylene) insulated solid and stranded wire, designed for the internal wiring of high reliability electrical and electronic equipment. This Standards Publication addresses 250 volt (Type ET), 600 volt (Type E), and 1000 volt (Type EE) wire and permits continuous conductor temperature ratings of -65°C to +200°C with silver-coated conductors and -65°C to +260°C with nickel-coated conductors. These types of hook-up wire are used when the following properties are called for:

- High temperature resistance
- Low temperature resistance
- Low dielectric constant
- Solder iron resistance
- Resistance to cleaning solutions or a variety of chemicals that may come in contact with either the wire or the equipment
- Good flexibility and flex life when stranded conductors are used

1.2 REFERENCED STANDARDS AND SPECIFICATIONS

The following publications are adopted in part, by reference in this publication, and are available from the organizations below.

American Society For Testing and Materials
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

B 3-95	*Soft or Annealed Copper Wire*
B 286-95	*Copper Conductors for Use in Hook-up Wire for Electronic Equipment*
B 298-99	*Silver-Coated Soft or Annealed Copper Wire*
B 355-95	*Nickel-Coated Soft or Annealed Copper Wire*
B 452-93	*Copper Clad Steel Wire for Electronic Applications*
B 501-99	*Silver-Coated Copper-Clad Steel Wire for Electronic Applications*
B 559-93	*Nickel-Coated Copper-Clad Steel Wire for Electronic Applications*
B 624-99	*High-Strength, High Conductivity Copper-Alloy Wire for Electronic Application*
D 3032-98	*Hook-up Wire Insulation*
D 4895-98	*PTFE Resin Produced from Dispersion*

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American Society for Quality Control
611 E. Wisconsin Ave.
Milwaukee, WI 53202

ANSI/ASQC Z1.4 *Sampling Procedures and Tables for Inspection by Attributes*

Electronic Industries Association
2500 Wilson Blvd.
Arlington, VA 22201

EIA-359 *EIA Standard Colors for Color Identification and Coding*

DODISS-Customer Service
Bldg. 4D
700 Robbins Ave.
Philadelphia, PA 19111-5094

MIL-STD-2223 *Test Methods for Insulated Electric Wire*

National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

WC 52-1991 *High Temperature and Electronic Insulated Wire-Impulse Dielectric Testing*

WC 56-1993 (R2000) *3.0 kHz Insulation Continuity Proof Testing of Hook Up Wire*

1.3 RECOMMENDED USES OF WIRE TYPES

1.3.1 Type ET

Type ET wire is intended for use in low voltage, high temperature applications. It is considered suitable for use up to a maximum of 250 volts RMS (root mean square) and/or for high frequency circuitry.

Wires having ET thin wall insulation are relatively fragile and can be damaged. They should not be used where mechanical stress or an abrasive environment may exist.

1.3.2 Type E

Type E is intended for high temperature applications and is considered suitable for use at a maximum of 600 volts RMS and/or for high frequency circuitry.

1.3.3 Type EE

Type EE is intended for high temperature applications and is considered suitable for use at a maximum of 1000 volts RMS and/or for high frequency circuitry.

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1.4 Part Identification Number (PIN)

The PIN shall be of the following form:

HP3-(TYPE)(CONSTRUCTION)(CONDUCTOR MATERIAL)(AWG)(NUMBER OF STRANDS)(COLOR)

NEMA STANDARD
for PTFE

NEMA TYPE E, EE, ET
as described above

CONSTRUCTION
Wrapped (W) Extruded (X)

Example:

HP3-EXBGE9

PTFE ,Type E, Extruded, Silver Coated Copper, 20 AWG, 19 Strands, White

Table 1-1
CONDUCTOR MATERIAL AND COATING

Letter	Conductor Material & Coating	Letter	Conductor Coating & material
B	Silver-coated Copper (SCC)	E	Nickel-coated high-strength copper alloy (NCA)
C	Nickel-Coated Copper	F	Silver-coated copper clad steel (SCCCS)
D	Silver-coated high-strength copper alloy (SCA)	G	Nickel coated copper clad steel (NCCCS)

Table 1-2
AWG NOMINAL CONDUCTOR SIZE

AWG	Letter	AWG	Letter	AWG	Letter	AWG	Letter
32	A	20	G	8	N	2/0	W
30	B	18	H	6	P	3/0	Y
28	C	16	J	4	R	4/0	Z
26	D	14	K	2	S		
24	E	12	L	1	T		
22	F	10	M	1/0	U		

Table 1-3
NUMBER OF STRANDS

Letter	Number of Strands	Letter	Number of Strands	Letter	Number of Strands	Letter	Number of Strands
A	1	G	37	R	817	V	1665
B	7	L	133	S	1045	W	2109
E	19	P	665	T	1330		

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Table 1-4
COLOR

Color (see para. 4.1)	Number Designator	Color	Number Designator
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet (Purple)	7
Orange	3	Gray (Slate)	8
Yellow	4	White	9

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Section 2
CONDUCTORS

2.1 CONDUCTOR MATERIALS

The base conductor material shall be composed of soft or annealed copper conforming to ASTM B 3, or copper-clad steel conforming to ASTM B 452, Class 40A, or a copper alloy conforming to ASTM B 624. Conductor strands shall be individually coated. The addition of the coating material after stranding shall not be permitted.

2.2 CONDUCTOR COATINGS

2.2.1 Silver-Coated Conductors

Silver-coated conductors shall be employed for applications up to conductor temperatures of 200°C. The silver coating shall be commercially pure silver and not less than 40 microinches in thickness for copper and copper alloys and not less than 50 microinches for copper-clad steel. The conductor shall be tested prior to stranding for continuity of coating and coating thickness in accordance with ASTM B 298 for silver-coated copper and copper alloy or ASTM B 501 for silver-coated copper-clad steel.

2.2.2 Nickel-Coated Conductors

Nickel-coated conductors shall be employed for applications up to conductor temperatures of 260°C. The nickel coating shall be commercially pure nickel and not less than 50 microinches in thickness. The conductor shall be tested prior to stranding for continuity of coating and coating thickness in accordance with ASTM B 355 for nickel-coated copper and copper alloy or ASTM B 559 for nickel-coated copper-clad steel.

2.3 STRANDING

Stranding shall be in accordance with Table 2. The lay length of the outer layer shall be 8 to 16 times the maximum conductor diameter. All requirements for stranded conductors, not specified in Table 2, shall be in accordance with the applicable requirements of ASTM B 286.

2.4 MINIMUM CONDUCTOR DIAMETER

The minimum conductor diameter shall be controlled by maximum dc resistance per Table 2.

2.5 CONDUCTOR SPLICES

Splices shall not be made in a stranded conductor as a whole: however, individual strands and solid conductors may be spliced. Splices shall be made by electro welding or brazing with silver composition solder.

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Table 2-1
DETAILS OF CONDUCTORS

Size (AWG)	Stranding	Single End Strand Dia. Nominal (inches)	Nominal CMA	Conductor Diameter Nominal (inches)	Conductor Diameter Maximum (inches)	Maximum DC Resistance of Finished Wire (Ohms/1000 Ft. at 20 °C) SCC	NCC	SCA	NCA	SCCCS	NCCCS	Alloy Breaking Strength Minimum (Lbs.)
32	1 X 32	0.0080	64	0.0080	0.0083	166	177	196	210	424	433	2.94
	7 X 40	0.0031	67	0.0093	0.0102	170	186	199	223	433	449	2.97
	19 X 44	0.0020	76	0.0094	0.0115	157	179	185	215	401	423	3.23
30	1 X 30	0.0100	100	0.0100	0.0103	106	110	124	131	270	273	4.62
	7 X 38	0.0040	112	0.0120	0.0129	100	110	118	132	256	265	5.02
	19 X 42	0.0025	119	0.0118	0.0140	98.6	112	116	135	251	265	5.16
28	1 X 28	0.0126	159	0.0126	0.0130	66.7	69.4	78.4	82.3	170	172	7.33
	7 X 36	0.0050	175	0.0150	0.0159	63.6	67.6	74.8	80.5	162	166	7.92
	19 X 40	0.0031	183	0.0146	0.0170	63.1	69.3	74.2	83.0	161	167	8.06
26	1 X 26	0.0159	253	0.0159	0.0164	41.9	43.6	49.2	51.7	107	108	11.7
	7 X 34	0.0063	278	0.0189	0.0198	39.7	42.2	46.7	50.3	101	103	12.7
	19 X 38	0.0040	304	0.0188	0.0215	37.3	41.0	43.9	49.1	95.2	98.7	13.6
24	1 X 24	0.0201	404	0.0201	0.0207	26.2	27.3	30.8	32.3	66.8	67.5	18.7
	7 X 32	0.0080	448	0.0240	0.0249	24.5	26.0	28.8	31.0	62.4	63.7	20.6
	19 X 36	0.0050	475	0.0235	0.0265	23.6	25.2	27.8	29.9	60.3	61.6	21.5
22	1 X 22	0.0253	640	0.0253	0.0261	16.5	17.2	19.4	20.4	42.2	42.6	29.6
	7 X 30	0.0100	700	0.0300	0.0309	15.6	16.2	18.3	19.2	39.7	40.1	32.3
	19 X 34	0.0063	754	0.0296	0.0330	14.8	15.7	17.4	18.7	37.7	38.5	34.4
20	1 X 20	0.0320	1024	0.0320	0.0330	10.3	10.8	12.2	12.8	26.4	26.6	47.3
	7 X 28	0.0126	1111	0.0378	0.0389	9.81	10.2	11.5	12.1	25.0	25.3	51.3
	19 X 32	0.0080	1216	0.0376	0.0415	9.10	9.68	10.7	11.5	23.2	23.7	55.9
18	1 X 18	0.0403	1624	0.0403	0.0415	6.52	6.79	7.67	8.04	16.6	16.8	75.0
	7 X 26	0.0159	1770	0.0477	0.0491	6.16	6.42	7.25	7.60	15.7	15.9	81.7
	19 X 30	0.0100	1900	0.0470	0.0515	5.79	6.03	6.81	7.15	14.8	14.9	87.8
16	1 X 16	0.0508	2581	0.0508	0.0523	4.10	4.27	4.82	5.06	10.5	10.6	112
	19 X 29	0.0113	2426	0.0531	0.0582	4.54	4.73	5.34	5.60	11.6	11.7	119
14	19 X 27	0.0142	3831	0.0667	0.0731	2.87	2.99					
12	19 X 25	0.0179	6088	0.0841	0.0922	1.81	1.88					
	37 X 28	0.0126	5874	0.0858	0.0908	1.89	1.97					
10	37 X 26	0.0159	9354	0.108	0.115	1.19	1.24					
8	133 X 29	0.0113	16983	0.161	0.175	0.661	0.688					
6	133 X 27	0.0142	26818	0.202	0.219	0.418	0.436					
4	133 X 25	0.0179	42615	0.266	0.277	0.263	0.274					
2	665 X 30	0.0100	66500	0.335	0.342	0.170	0.177					
1	817 X 30	0.0100	81700	0.378	0.382	0.139	0.144					
1/0[1]	1045 X 30	0.0100	104500	0.410	0.431	0.108	0.113					
2/0[2]	1330 X 30	0.0100	133000	0.477	0.486	0.085	0.0887					
3/0[3]	1665 X 30	0.0100	166500	0.535	0.545	0.067	0.0705					
4/0[4]	2109 X 30	0.0100	210900	0.601	0.635	0.053	0.0559					

CMA – Circular Mil Area
SCC – Silver-coated copper
NCC – Nickel-coated copper
SCA – Silver-coated high-strength copper alloy
NCA – Nickel-coated high-strength copper alloy
SCCCS – Silver-coated copper-clad steel
NCCCS - Nickel-coated copper-clad steel

[1] Can also be referenced as 01
[2] Can also be referenced as 02
[3] Can also be referenced as 03
[4] Can also be referenced as 04

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Section 3
INSULATION

3.1 GENERAL

The insulating material shall be a PTFE resin conforming to ASTM D 4895.

3.2 PTFE INSULATION

A continuous coating of extruded or tape-wrapped PTFE insulation shall be added over the conductor and shall be processed to meet the requirements listed herein. Sizes AWG 2 and larger shall be tape-wrapped only. Only the extruded insulations are required to meet the concentricity requirements specified herein.

The diameter of the insulated conductors shall be in accordance with Table 3-1 and as measured in accordance with paragraph 6.1.4

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Table 3-1
DIAMETERS OF INSULATED CONDUCTORS
(TYPES ET, E, EE)
(All Dimensions in Inches)

			Insulated Conductor Diameter	
AWG	**Type**	**Stranding**	**(Minimum)**	**(Maximum)**
32	ET	1x32	0.016	0.022
	ET	7x40	0.020	0.024
	ET	19x44	0.020	0.024
	E	1x32	0.025	0.033
	E	7x40	0.026	0.034
	E	19x44	0.026	0.034
	EE	1x32	0.034	0.042
	EE	7x40	0.036	0.044
	EE	19x44	0.036	0.044
30	ET	1x30	0.020	0.024
	ET	7x38	0.022	0.026
	ET	19x42	0.022	0.026
	E	1x30	0.026	0.034
	E	7x38	0.028	0.036
	E	19x42	0.028	0.036
	EE	1x30	0.036	0.044
	EE	7x38	0.038	0.046
	EE	19x42	0.038	0.046
28	ET	1x28	0.023	0.027
	ET	7x36	0.025	0.029
	ET	19x40	0.025	0.029
	E	1x28	0.029	0.037
	E	7x36	0.031	0.039
	E	19x40	0.031	0.039
	EE	1x28	0.039	0.047
	EE	7x36	0.041	0.049
	EE	19x40	0.041	0.049

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Table 3-1 (Continued)
DIAMETERS OF INSULATED CONDUCTORS
(TYPES ET, E, EE)
(All Dimensions in Inches)

			Insulated Conductor Size Diameter	
AWG	**Type**	**Stranding**	**(Minimum)**	**(Maximum)**
26	ET	1x26	0.026	0.030
	ET	7x34	0.029	0.033
	ET	19x38	0.029	0.034
	E	1x26	0.032	0.040
	E	7x34	0.035	0.043
	E	19x38	0.035	0.044
	EE	1x26	0.042	0.050
	EE	7x34	0.045	0.053
	EE	19x38	0.045	0.054
24	ET	1x24	0.030	0.034
	ET	7x32	0.034	0.038
	ET	19x36	0.034	0.039
	E	1x24	0.036	0.044
	E	7x32	0.040	0.048
	E	19x36	0.040	0.049
	EE	1x24	0.046	0.054
	EE	7x32	0.050	0.058
	EE	19x36	0.050	0.059
22	ET	1x22	0.035	0.040
	ET	7x30	0.040	0.044
	ET	19x34	0.040	0.046
	E	1x22	0.041	0.049
	E	7x30	0.046	0.054
	E	19x34	0.046	0.056
	EE	1x22	0.051	0.060
	EE	7x30	0.056	0.064
	EE	19x34	0.056	0.066

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Table 3-1 (Continued)
DIAMETERS OF INSULATED CONDUCTORS
(TYPES ET, E, EE)
(All Dimensions in Inches)

			Insulated Conductor Size Diameter	
AWG	**Type**	**Stranding**	**(Minimum)**	**(Maximum)**
20	ET	1x20	0.042	0.046
	ET	7x28	0.048	0.052
	ET	19x32	0.048	0.052
	E	1x20	0.048	0.056
	E	7x28	0.054	0.062
	E	19x32	0.054	0.062
	EE	1x20	0.058	0.066
	EE	7x28	0.064	0.072
	EE	19x32	0.064	0.072
18	E	1x18	0.056	0.066
	E	7x26	0.064	0.074
	E	19x30	0.064	0.074
	EE	1x18	0.066	0.076
	EE	7x26	0.074	0.084
	EE	19x30	0.074	0.084
16	E	1x16	0.067	0.081
	E	19x29	0.073	0.087
	EE	1x16	0.077	0.089
	EE	19x29	0.083	0.095
14	E	19x27	0.088	0.102
	EE	19x27	0.098	0.114
12	E	19x25	0.107	0.121
	E	37x28	0.105	0.119
	EE	19x25	0.117	0.133
	EE	37x28	0.115	0.131

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Table 3-1 (Continued)
DIAMETERS OF INSULATED CONDUCTORS
(TYPES ET, E, EE)
(All Dimensions in Inches)

			Insulated Conductor Size Diameter	
AWG	**Type**	**Stranding**	**(Minimum)**	**(Maximum)**
10	E	37x26	0.127	0.141
	EE	37x26	0.137	0.153
8	EE	133x29	0.199	0.219
6	EE	133x27	0.286	0.301
4	EE	133x25	0.349	0.369
2	EE	665x30	0.395	0.415
1	EE	817x30	0.475	0.495
1/0	EE	1045x30	0.504	0.524
2/0	EE	1330x30	0.553	0.577
3/0	EE	1665x30	0.633	0.657
4/0	EE	2109x30	0.703	0.727

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Section 4
WIRE IDENTIFICATION

4.1 CIRCUIT IDENTIFICATION

Circuit identification if required shall be accomplished by use of an insulation color in accordance with EIA-359-A-85 (R 1985). Colored stripe or band tracers on the insulation, and/or printed numbers or letters shall be permitted, in addition to the colored insulation.

4.1.1 Lay of Stripes

The length of lay of colored stripes shall conform to Table 4-1.

Table 4-1
LENGTH OF LAY OF STRIPES

Diameter Over Finished Wire (inch)	Length of Lay (inches, maximum)
0.000 to 0.083	1.00
0.084 to 0.110	1.50
0.111 and larger	2.00

4.2 IDENTIFICATION BY PRINTING

Identification by printing on the wire is available for Types E and EE wire for conductor sizes 22 AWG and larger. Print should be clear, legible, and of a contrasting color to the insulation. Printing on Type ET wire is not recommended due to the thin wall construction. PIN printed on wire shall not include color designation. Identification marks shall not be applied by hot stamp marking or other methods which significantly penetrate the insulation.

4.2.1 Identification of Product

When specified, the printed identification shall be marked at intervals of 9 to 60 inches measured from the beginning of one complete marking to the beginning of the succeeding marking. Per paragraph 1.4, the identification shall consist of:

a. NEMA Standard for PTFE (HP 3)
b. NEMA Type
c. Construction
d. Conductor material and coating AWG
e. Number of strands
f. Conductor material and coating
g. Color
h. Manufacturer's identification ("CAGE code")

Example:
HP3-EXBGE 12345

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Section 5
PHYSICAL AND ELECTRICAL REQUIREMENTS

5.1 GENERAL

The physical and electrical requirements for Types ET, E, and EE wire shall be in accordance with this Section and Tables 2-1, 3-1, and 5-1. Testing shall be conducted in accordance with Section 6.

5.2 QUALITY CONFORMANCE INSPECTION OF FINISHED PRODUCT

5.2.1 Definitions

5.2.1.1. Inspection Lot

An inspection lot shall consist of all wire of the same part number, produced under essentially the same conditions, and presented for inspection at one time.

5.2.1.2 Unit of Product

The unit of product for determining lot size for sampling shall be the quantity of wire offered for inspection on one coil, one reel, or one spool, as applicable.

5.2.2 Sampling Inspection

All other tests shall use a sampling plan in accordance with special inspection level S-2 in ANSI/ASQC Z1.4.

5.3 WORKMANSHIP

The insulated wire shall be free of kinks, abrasions, and cracked or peeled surfaces. The wire should be a uniform and consistent product and should be free from defects which will adversely affect the serviceability of the product for the intended use, as described in Section 1.2.

5.4 MATERIALS CERTIFICATION

Suppliers shall maintain certifications that all materials used conform to the requirements in Section 2 and Section 3.

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Table 5-1
PHYSICAL AND ELECTRICAL REQUIREMENTS FOR TYPE ET, E, AND EE WIRES

Test	Requirements		
	ET	E	EE
Conductor Resistance (See 6.2.1)	See Table 2	See Table 2	See Table 2
High-Frequency Spark Test Voltage or Impulse Spark Test Voltage (See 6.2.2)	2.9 kV 4.0 kV	4.6 kV 6.5 kV	5.7 kV 8.0 kV
Insulation Tensile Strength (See 6.1.3)	4000 psi (Minimum)	4000 psi (Minimum)	4000 psi (Minimum)
Insulation Elongation (See 6.1.3)	200 percent (Minimum)	200 percent (Minimum)	200 percent (Minimum)
Wrapback Test & Dielectric Strength Peak Voltage (See 6.1.2 and 6.2.3)	1.5 kV	2.0 kV	3.0 kV
Dimensional Inspection (See 6.1.4.1 and 6.1.4.2)	See Tables 2 and 3	See Tables 2 and 3	See Tables 2 and 3
Concentricity for Extruded Insulations (See 6.1.4.3)	70% (Minimum)	70% (Minimum)	70% (Minimum)
Shrinkage (See 6.1.5)	0.125” (Maximum)	0.125” (Maximum)	0.125” (Maximum)
Marking and Stripe Durability (See 6.1.6)	125 cycles (Minimum)	125 cycles (Minimum)	125 cycles (Minimum)

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Section 6
TEST PROCEDURES

6.1 PHYSICAL TESTS

Physical test on the conductor and insulated wire shall be made in accordance with the following procedures:

6.1.1 Test Temperature

Unless otherwise specified, physical tests shall be performed at a room temperature of 23°C ± 2°C. The test specimens shall be kept at room temperature for not less than 30 minutes prior to the tests.

6.1.2 Wrapback Test

This test shall be used only for 10 AWG and smaller wires.

The center portion of a 12-inch minimum length specimen of finished PTFE insulated wire shall be tightly wound back on itself for a total of four close turns as shown in Figure 6-1. The specimen shall then be placed in an oven and heated for two hours at 307°C ± 5°C. At the end of this period, the specimen shall be visually examined for cracks with the unaided eye and subjected to the dielectric strength test in 6.2.3 without unwinding.

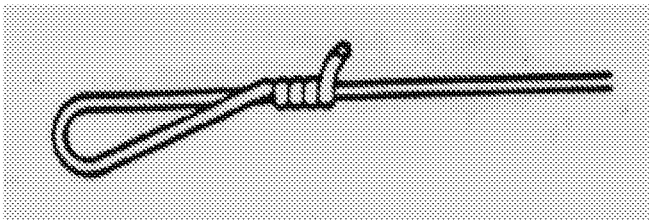


Figure 6-1
WRAP BACK TEST

6.1.3 Insulation Tensile Strength and Elongation

The insulation tensile strength and elongation test shall be conducted in accordance with, ASTM D 3032, Section 17, except that the rate of travel of the jaws shall be 2 inches minimum and 20 inches maximum per minute. Determination of insulation tensile strength for tape-wrapped constructions shall use the optical method for insulated wire in ASTM D 3032 Section 15 to measure wall thickness.

6.1.4 Dimensional Inspection

Using a micrometer or equivalent device capable of measuring to the nearest 0.0001 inch, determine the diameters of the conductor and insulation as described below.

6.1.4.1 Conductor Diameter

Remove the insulation for the specimen without damaging or distorting the conductor. Measure the outer diameter in at least three locations along the length of the stripped conductor. Each measurement shall consist of two micrometer readings taken 90 degrees from each other. For sizes 8 and larger, a circumferential measuring tape may be used. Report the average of the readings.

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6.1.4.2 Insulation Diameter

Measure the outer diameter of the insulated wire in at least three locations along a 12 inch length of the specimen. Each measurement shall consist of two readings taken 90 degrees from each other. For sizes 8 and larger, a circumferential measuring tape may be used. Report the average of the readings.

6.1.4.3 Concentricity

The concentricity of the insulation shall be measured on a cross section of the finished wire at 10 X magnification. In making the determination, the minimum thickness of the insulation shall be located and measured in the cross section. The maximum thickness of the insulation wall shall be located and measured in the same cross section. The percent concentricity is 100 times the ratio of the minimum measurement to the corresponding maximum measurement. Three cross sections shall be measured in each specimen. The failure of the concentricity of any cross section shall constitute failure of the entire specimen.

6.1.5 Shrinkage

Shrinkage of the insulation shall be measured using a 12-inch specimen with ends cut flush. Specimen shall be placed in an air-circulating oven at 285 ± 3C for one hour. At the end of the conditioning period, allow specimen to cool to room temperature. Measure shrinkage on both ends. The maximum values shall not exceed the requirements in Table 5.

6.1.6 Marking and Stripe Durability

6.1.6.1 Specimen

The specimen shall consist of a piece of finished wire which shall have sufficient length for use in the test as specified in 6.1.6.3.

6.1.6.2 Special Apparatus

Apparatus shall include an abrading machine which shall support and secure the specimen such that it is straight and horizontal, and which shall abrade the specimen printed identification by means of a motor driven, transversely reciprocating steel pin. this steel pin shall have a diameter of 0.025 ± 0.001 inch where it abrades the specimen. The steel pin shall be horizontal and perpendicular to the specimen axis, shall ride along the top of the specimen and shall be weighted to bear down on the specimen with a force of 1 plus 1/16, minus 0 pound for wire size number 24 or larger, and 1/2 plus 1/8, minus 0 for wire size 26 and smaller. The pin shall be reciprocated at a rate of 60 ± 2 cycles per minute, such that the pin is drawn along the specimen for a distance of 3/8 plus 1/16, minus 0 inch in each direction (3/4 inch minimum total excursion) during each cycle. The abrading machine shall incorporate an automatic counter to total the number of cycles (a cycle is defined as one stroke forward and one stroke backwards across the specimen) the specimen is abraded by the steel pin during the test.

6.1.6.3 Procedure

The specimen shall be wiped with a clean, dry cloth to remove any lubricant or dirt, and shall be secured in the abrading machine with the specimen printed identification facing upwards, where it is to be abraded by the steel pin. The automatic counter shall be set initially to zero. The abrading machine motor shall then be turned on, allowing the steel pin to reciprocate and abrade the specimen printed identification until 125 cycles have been completed. This test shall next be repeated four more times (five times total), subjecting a fresh portion of the specimen printed identification to abrasion each time.

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6.1.6.4 Observation

Specimen failure shall be construed if two or more abraded sites exhibit a complete line of obliteration.

6.2 ELECTRICAL TESTS

Electrical tests on the insulated conductors shall be made in accordance with the following procedures:

6.2.1 Conductor Resistance

The dc resistance of the finished insulated wire shall be measured in accordance with MIL-STD-2223 Method 5003.

6.2.2 High-Frequency or Impulse Spark Test

High-frequency spark testing or impulse spark testing shall be conducted on 100 percent of all lengths of insulated wire in accordance with NEMA WC 52 or NEMA WC 56 at the voltages specified in the requirements of Table 5-1.

6.2.3 Dielectric Strength

One inch of insulation shall be removed from each end of the specimen and the conductor shall be attached to an electric lead. The specimen shall be immersed in tap water at 23°C ± 5°C, except for the uninsulated ends. After immersion for 1 hour, the voltage specified (see Table 5-1) at 60 Hz shall be applied between the conductor and an electrode in contact with liquid. The applied voltage shall be uniformly increased from zero to the specified peak voltage in 30 seconds, maintained at the voltage for a period of 1 minute, and uniformly reduced to zero in 30 seconds.

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Section 7
PACKAGING

7.1 PACKAGING REQUIREMENTS

Spools, reels, and packaging material(s) shall be sufficient to afford adequate protection against physical damage during shipment from the supply source to the customer. Any special packaging requirements must be specified in the ordering data.

7.2 LABELING

HP3 PIN
Date (month, day, and year) of manufacture and inspection
Manufacturer's name or trademark

7.3 LENGTHS

Table 7-1 specifies the minimum lengths and quantity of lengths per spool or reel that are acceptable unless otherwise specified.

Table 7-1
MINIMUM LENGTHS FOR PTFE WIRE CONSTRUCTIONS

AWG size	Percentage of Order	Length (feet) One Continuous length	Max. no. of lengths (per spool or reel)	
			500-1000 ft.	1001-1500 ft.
32 to 22	25	50-75	3	5
	25	75-300		
	50	301 or more		
20 to 16	Unacceptable	Under 75	4	6
	20	75-100		
	50	101-300		
	30	301 or more		
14-10	Unacceptable	Under 50	5	7
	40	50-100		
	50	101-300		
	10	301 or more		
8 and larger	10	25-50	6	8
	70	51-100		
	20	101 or more		

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Section 8
ORDERING DATA

8.1 ORDERING INFORMATION

Purchasing documents should specify the following information:

a. Part identification number (PIN). See paragraph 1.4
b. Packaging Requirements
c. Length Requirements
d. Quantity
e. Optional Identification (stripes, bands, tracers, printing, lot coding)

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Appendix A
MEASUREMENT AND CALCULATION DATA FOR TABLE 2

Minimum alloy breaking strength calculated based on the minimum diameter and tensile strength per ASTM B 624

Nominal CMA based on the square of the nominal single end diameter in mils times the number of ends.

Nominal conductor diameter based on nominal single end diameter per ASTM B 3, B 298, B 355, B 501, and B 559 which are all the same.
3 times the nominal single end diameter for 7 strand and 4.7 times for 19 strand was used. The OD for 19 strand was based on the unilay construction which is the most commonly used.

Maximum conductor diameter based on maximum single end diameters for nickel coated copper per ASTM B 355. Three times the maximum single end diameter for 7 strand, 5 times for 19 strand, and 7 times for 37 strand was used. A true concentric construction which represents the largest possible 19 and 37 strand diameter was used. A 19 X 7 true concentric rope which represents the largest diameter was used. Rope Stranding using bunched members maximum diameter is per ASTM B 286.

Maximum DC

SCC and NCC
— DC resistance based on formula in ASTM B 286 Note 2.

SCA
— DC resistance based on formula in ASTM B 286 Note 2 using a conductivity of 85% IACS minimum per ASTM B 624

NCA
— DC resistance based on formula in ASTM B 286 Note 2 using a base conductivity of 85% IACS minimum per ASTM B 624 minus the effect of nickel per ASTM B 286.

Class 2: .0100" diameter and larger	81% IACS
Class 4: .0099" to .0050"	79% IACS
Class 7: .0049" to .0031"	76% IACS
Class 10: .0030" to .0020"	73% IACS

SCCCA
— DC resistance based on formula in ASTM B 286 Note 2 using a minimum conductivity of 39.2% IACS for type 40A per ASTM B 501

NCCCS
— DC resistance based on formula in ASTM B 286 Note 2 using the minimum conductivity for type 40A per ASTM B 559

Class 2: .0100" diameter and larger	38.2% IACS
Class 4: .0099" to .0050"	38.4% IACS
Class 7: .0049" to .0031"	37.8% IACS
Class 10: .0030" to .0020"	37.2% IACS

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