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STANDARDS PUBLICATION/NO. HP 100.1-1985

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# High Temperature Instrumentation and Control Cables Insulated and Jacketed with FEP Fluorocarbons

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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## Foreword

This Standards Publication for High Temperature Instrumentation and Control Cables Insulated and Jacketed with FEP Fluorocarbons was developed by the High Temperature Insulated Wire and Cable Section of the National Electrical Manufacturers Association.

National Electrical Manufacturers Association standards are adopted in the public interest and designed to eliminate misunderstanding between the manufacturer and the user and to assist the user in selecting and obtaining the proper product for his particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude the manufacture or use of products not conforming to the standard.

Suggestions for improvements gained in the use of this standard will be welcomed. They should be sent to:

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## Scope

This Standards Publication covers specific requirements for multiple-conductor instrumentation and control cables insulated and jacketed with FEP fluorocarbons. It supplements the general requirements and testing procedures contained in NEMA Standards Publication HP 100.



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# HIGH TEMPERATURE INSTRUMENTATION AND CONTROL CABLES INSULATED AND JACKETED WITH FEP FLUOROCARBONS

## Section 1
## REFERENCED STANDARDS AND GENERAL INFORMATION

### 1.1 REFERENCED STANDARDS

American Society for Testing & Materials
1916 Race Street
Philadelphia, PA 19103

ASTM D-2116-83 *FEP-Fluorocarbon Molding and Extrusion Material*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

ANSI/NFPA 70-1984 *National Electrical Code*

National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, DC 20037

NEMA HP 100-1985 *High Temperature Instrumentation and Control Cables*

### 1.2 GENERAL INFORMATION

The requirements in this publication supplement HP 100-1985 and cover specific requirements for multiple-conductor cables, insulated and jacketed with fluorinated ethylene propylene copolymer (FEP) for use in ducts, conduit and trays.

These cables shall be designed to operate continuously at conductor temperatures to 200°C. They shall be suitable for use up to a maximum circuit potential of 1000 volts rms.

These cables are limited to use in dry locations as defined by ANSI/NFPA 70 and are not for direct burial.

FEP cables are for service as shown in 1.3 of NEMA HP 100.



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# Section 2
# REQUIREMENTS

## 2.1 INTRODUCTION

FEP insulated and jacketed cables shall be in accordance with this Standard and NEMA Standards Publication HP 100.

NEMA Standard 6-12-85.

## 2.2 CONDUCTORS

Conductors shall be in accordance with Section 2, NEMA HP 100.

NEMA Standard 6-12-85.

## 2.3 TEMPERATURE RATING

Maximum continuous operating temperatures shall be as follows:

1. 200°C for silver-coated copper, nickel-coated copper conductors for all strand sizes, or uncoated copper conductors with strands of 0.015 inch or greater, and all other thermocouple conductors.
2. 150°C for tin-plated copper conductors, lead or lead-alloy coated conductors or uncoated copper conductors with strands less than 0.015 inch.

NEMA Standard 6-12-85.

## 2.4 INSULATION

Insulation shall be in accordance with Section 3 of NEMA HP 100, Tables 2-1 and 2-2 of this Standard and ASTM D-2116.

NEMA Standard 6-12-85.

### Table 2-1
### PRIMARY INSULATION THICKNESS

| Conductor Size, AWG | CABLE TYPE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Instrumentation | | 300 Volt Control | | 600 Volt Control | | 1000 Volt Control | |
| | Mils | mm | Mils | mm | Mils | mm | Mils | mm |
| 24 | 10 | 0.25 | 12 | 0.31 | . . . | . . . | . . . | . . . |
| 22 | 10 | 0.25 | 12 | 0.31 | . . . | . . . | . . . | . . . |
| 20 | 10 | 0.25 | 12 | 0.31 | 15 | 0.38 | . . . | . . . |
| 18 | 10 | 0.25 | 12 | 0.31 | 15 | 0.38 | . . . | . . . |
| 16 | 10 | 0.25 | 12 | 0.31 | 15 | 0.38 | 18 | 0.46 |
| 14 | . . . | . . . | 12 | 0.31 | 15 | 0.38 | 18 | 0.46 |
| 12 | . . . | . . . | . . . | . . . | 15 | 0.38 | 18 | 0.46 |
| 10 | . . . | . . . | . . . | . . . | 17 | 0.43 | 20 | 0.51 |
| 9 | . . . | . . . | . . . | . . . | 17 | 0.43 | 20 | 0.51 |

### TABLE 2-2
### INSULATION AND JACKET MATERIAL

| Requirements for FEP Fluorocarbon Insulation and Jacket Materials | Test Paragraph[1] | Value |
|---|---|---|
| *Maximum Operating Temperature* | | |
| • Rating, dry locations only, °C[2] | | 200[3] |
| • Maximum emergency overload temperature, °C[4] | | 230 |
| *Physical Requirements* | | |
| Tensile strength, minimum psi | 7.2.3 | 2000 |
| MPa[5] | | 13.8 |
| Elongation at rupture, minimum percent | 7.2.4 | 200 |

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**TABLE 2-2 *(continued)***
**INSULATION AND JACKET MATERIAL**

| Requirements for FEP Fluorocarbon Insulation and Jacket Materials | Test Paragraph | Value |
|---|---|---|
| *Aging Requirements* | | |
| • After air oven test for 168 hours, °C | 7.2.6 | 230 |
| Tensile Strength, minimum percentage of unaged value | | 80 |
| Elongation at rupture, minimum percentage of unaged value | | 80 |
| • After oil immersion at 121°C ± 1°C for 18 hours | 7.2.7 | |
| Tensile strength, minimum percentage of unaged value | | 85 |
| Elongation at rupture, minimum percentage of unaged value | | 85 |
| *Heat Shock* | | |
| Temperature of Test, °C | 7.2.8 | 230 |
| Cracking on mandrel | | no cracking |
| *Heat distortion* at 200°C minimum, percentage | 7.2.9 | 80 |
| *Cold Bend* at −65°C | 7.2.10 | no cracks |
| *Flame Propagation Limit* | 7.3 | pass |
| *Electrical Requirements* | | |
| Voltage Tests | 7.4.1 | Table 7-1 or 5-1 of HP 100 |
| *Insulation Resistance* | 7.4.2 | |
| K Factor | | 5000 |
| Temperature correction coefficient | | 1.00 |
| *Dielectric constant* (SIC) max at 75°C | 7.4.3 | 2.1 |

[1] Unless otherwise listed, the test paragraphs refer to NEMA Standard HP 100.
[2] This insulation and jacket material is suitable for use at conductor and/or installed use temperature not exceeding that shown.
[3] Maximum of 200°C over silver-coated, or nickel coated copper conductors (for all strand sizes) or unplated copper conductors (with strands of 0.015 inch or greater); or a maximum of 150°C over tin-plated copper conductors, lead or lead-alloy coated conductors or unplated copper conductors (with strands less than 0.015).
[4] Operation at these emergency overload temperatures shall not exceed 100 hrs. in any 12 consecutive months nor more than 500 hrs. during the life time of the cable.
[5] 1 Pa ≐ 1 KG/m².

## 2.5 CIRCUIT IDENTIFICATION

Circuit identification of these cables shall be in accordance with Section 4, NEMA HP 100.

## 2.6 ASSEMBLY

Assembly of these cables shall be in accordance with Section 5, NEMA HP 100.

NEMA Standard 6-12-85.

## 2.7 JACKETS

Jackets of these cables shall be in accordance with Section 6 of NEMA HP 100, Tables 2-2 and 2-3 of this Standard and ASTM D-2116.

NEMA Standard 6-12-85.

## 2.8 TEST PROCEDURES

Testing shall be performed in accordance with Section 7, NEMA HP 100.

NEMA Standard 6-12-85.

**Table 2-3**
**OVERALL JACKET THICKNESS**

| Calculated Diameter of Cable Under Jacket | | Jacket Thickness | | | |
|---|---|---|---|---|---|
| | | Normal Duty | | Heavy Duty | |
| Inches | mm | Mils | mm | Mils | mm |
| 0.150 or less | 3.82 or less | 10 | 0.25 | 15 | 0.38 |
| 0.151-0.250 | 3.83-6.36 | 12 | 0.31 | 20 | 0.51 |
| 0.251-0.425 | 6.37-10.80 | 15 | 0.38 | 25 | 0.63 |
| 0.426-0.700 | 10.81-17.77 | 20 | 0.51 | 30 | 0.76 |
| 0.701-1.000 | 17.78-25.40 | 25 | 0.64 | 45 | 1.14 |
| 1.001-1.500 | 25.41-38.10 | 30 | 0.76 | 50 | 1.27 |

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National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

*(Bylaw—Art. V, Sec. 1)*

## Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

*(Bylaw—Art. V, Sec. 2, Subsection A)*

## Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

*(NEMA Policy Memorandum 84-2, dated June 7, 1984)*

## Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

*(Bylaw—Art. V, Sec. 2, Subsection B)*

## Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design.

*(Bylaw—Art. V, Sec. 6, 1st Sentence)*

## Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment and/or approval.

*(Bylaw—Art. V, Sec. 4, Subsection A)*

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Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

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