



ANSI/NEMA MW 1000-2015

American National Standard for Magnet Wire





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American National Standard

Magnet Wire

Secretariat:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

Approved: February 12, 2015
Published: March 31, 2015

American National Standards Institute, Inc.

www.nema.org

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FOREWORD

ANSI/NEMA MW 1000-2015 supersedes NEMA MW 1000-2014 and all subsequent revisions. It has been approved as an American National Standard.

This standard is periodically reviewed by the NEMA Magnet Wire Section for revisions considered to be necessary to keep it up to date with changes in technology and regulations. See <http://www.nema.org/Products/Pages/MW-1000.aspx> for additional information.

Proposed or recommended revisions should be submitted to:

Senior Vice President, Operations
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MW 1000 was developed by the Magnet Wire Section of NEMA, working closely with representatives of various industries that use magnet wire. At the time this edition was approved, the Magnet Wire Section had the following members:

Alconex Specialty Products, Inc.
Bridgeport Insulated Wire Company
CONDUMEX
Elektrisola, Inc.
Essex Group, Inc.
Magnekón
MWS Wire Industries
Rea Magnet Wire Company, Inc.

Fort Wayne, IN
Bridgeport, CT
México, D.F., México
Boscawen, NH
Fort Wayne, IN
San Nicolas, NL, México
Westlake Village, CA
Fort Wayne, IN

How to Use This Publication

First, review Part 1 for general information. Then in Part 2, locate the specification for the type of insulation and conductor of interest. Part 2 is arranged in numerical order as shown beginning on page 14. The dimensions for each Part 2 MW type are provided in Part 1, beginning with Table 1. The specification in Part 2 will indicate the requirements to be met and will refer to the test procedures and corresponding test values to be attained in Part 3.

Part 1 of this publication deals with information common to all types of magnet wire: ordering information, general material requirements, general test conditions, definitions, and manufacturing data in support of thermal rating. This part also includes dimensions with metric equivalents for all bare, minimum insulation increase, and overall dimensions for all Part 2 MW specification requirements.

Part 2 consists of product specifications requirements (other than dimensions) for magnet wire with different types of coatings and/or coverings. Insofar as possible, the product specifications are complete on one sheet, since they are arranged to include only one insulation or covering per sheet. The title on each sheet identifies the product. Example: MW 15-C, Polyvinyl Acetal Round Copper Magnet Wire. MW 15-A covers the aluminum version of the same generic product.

Part 3 contains the test procedures to be followed and corresponding tables of specific test values to be attained in determining compliance with the requirements given in Part 2. The requirements are consolidated with the test procedures and testing parameters for a given property. An index of the main test paragraphs is provided, beginning on page 14, Part 3 Test Procedures, in the Table of Contents.

Annex A provides a cross reference between test procedures in this standards publication and those published by the American Society for Testing and Materials (ASTM).

Annex B consists of definitions, requirements, and recommended test procedures for reusable magnet wire packaging, standardized dimensions for spools and reels, and formatting for the labeling of magnet wire products.

Annex C provides a cross reference between NEMA and IEC magnet wire specifications.

Annex D provides the formulas for determining dimensional requirements of round film-insulated magnet wire and dielectric breakdown, as well as cross-sectional area and resistance calculations.

Annex E provides the dimensional criteria for ranges of sizes of rectangular bare, film, and fabric magnet wire products, setting the general rules and guidelines for various traditional yet non-standard rectangular magnet wire products.

Annex F provides properties of selected refrigerants determined as suitable alternatives to refrigerant R22 in the Refrigerant Extraction Test, clause 3.55.

Annex G provides recommended winding tensions for round copper and aluminum magnet wire to ensure that wire, as it is de-reeled, is not stretched beyond end user requirements.

Annex H provides the test methods and requirements for fully insulated winding wire (FIW) referenced in specification MW 85-C in Part 2.

Summary of Revisions

Introductory Material

Updated Tables of Contents	7-17
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1.2 revised with additional references to IEC 60317-56 and UL 7146B	19
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1.6.7.3 revised for editorial reorganization	28
Table 1 revised with adjusted Single Build maximum overall diameters for 9.5-13.5 AWG	31, 34
Table 1 revised to reword the Note **	33, 36
Table 8 revised to correct the reference for square sizes	48, 49
Table 8 revised to modify thickness and width ranges having radii of 0.031 in. (0.79 mm)	48, 49

Part 2

MW 15-A, 15-C, 28-A, 31-A, 31-C, 35-A, 35-C, 37-C, 41-C, 44-C, 45-C, 47-C, 50-C, 51-C, 74-A, 74-C, 75-C, 77-C, 78-C, 80-A, 80-C, 81-C, 130-C, 131-C, 132-C, 135-C, 136-C, 137-C revised to assign half-AWG sizes to wire size ranges for applicable tests.....	Per MW No.
MW 15-A, 15-C, 18-A, 18-C revised to reference Transformer Oil Resistance Test methods according to the appropriate wire size range.	75, 76, 78, 79
MW 16-C revised to remove references to Quad dimensions, now in Table 1, and to add requirements for hermetic applications when applicable	77
MW 26-C, 27-C revised to be declared obsolete	84, 85
MW 61-A revised to delete Coverage requirement.....	113
MW 64-A, 65-A added as new specifications	115, 117
MW 64-C, 65-C revised to replace FEP as the adhesive layer with a generic description.....	116, 118
MW 85-C added as a new specification.....	136

Part 3

3.13.1 revised to transition notes on lead-free solder to normative text and to add a note advising of the greater likelihood of copper corrosion when using lead-free solder	168
Table 30 revised to add new MW 64 to the appropriate column headers and to indicate that elongation requirements for film-insulated square and rectangular wire also apply to bare wire.	149
Table 31 revised to indicate that elongation requirements for film-insulated round wire also apply to bare wire.	150

Summary of Revisions, Continued

Annex C

Revised to remain current with NEMA and IEC standards activities through 2014..... C-1

Annex D

Revised to add the formula for deriving Dielectric Breakdown Voltage for MW 16-C Quad D-2

Annex E

Revised to correct the rounding of mm values for certain Table E-1 nominal widths.....E-1

Annex H

Added to provide test methods and requirements for FIW, referenced in new MW 85-C H-1

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Part 2 PROPERTIES AND REQUIREMENTS

Specification Number		Thermal Class	Round	Rectangular and Square	Page No.
MW 5-C	Polyester (Single and Heavy)	155	X	—	74
MW 15-A	Polyvinyl Acetal (Single and Heavy)	105	X	—	75
MW 15-C	Polyvinyl Acetal (Single, Heavy, Triple, Quad)	105	X	—	76
MW 16-C	Polyimide (Single, Heavy, Triple, Quad)	240	X	—	77
MW 18-A	Polyvinyl Acetal (Heavy and Quad)	105	—	X	78
MW 18-C	Polyvinyl Acetal (Heavy and Quad)	105	—	X	79
MW 19-C	Polyvinyl Acetal with Self-bonding Overcoat (Types 1, 2, and 3)	105	X	—	80
MW 20-C	Polyimide (Heavy and Quad)	240	—	X	81
MW 24-A	Polyester (amide)(imide) Overcoated with Polyamide (Single and Heavy)	155	X	—	82
MW 24-C	Polyester (amide)(imide) Overcoated with Polyamide (Single, Heavy, Triple)	155	X	—	83
MW 26-C	Polyester (imide) for Solderable Applications (Single and Heavy) OBSOLETE EFFECTIVE DEC. 31, 2014	155	X	—	84
MW 27-C	Polyester (imide) Overcoated with Polyamide for Solderable Applications (Single and Heavy) OBSOLETE EFFECTIVE DEC. 31, 2014	155	X	—	85
MW 28-A	Polyurethane Overcoated with Polyamide for Solderable Applications (Single and Heavy)	130	X	—	86
MW 28-C	Polyurethane Overcoated with Polyamide for Solderable Applications (Single and Heavy)	130	X	—	87
MW 30-C	Polyester (amide)(imide) (Single, Heavy, Triple)	180	X	—	88
MW 31-A	Paper Covered	90 or 105	X		89
MW 31-C	Paper Covered	90 or 105	X	—	90
MW 33-A	Paper Covered Bare Rectangular and Square	90 or 105	—	X	91
MW 33-C	Paper Covered Bare Rectangular and Square	90 or 105	—	X	92
MW 35-A	Polyester (amide)(imide) Overcoated with Polyamideimide (Single and Heavy)	220	X	—	93
MW 35-C	Polyester (amide)(imide) Overcoated with Polyamideimide (Single, Heavy, Triple, Quad)	200	X	—	94
MW 36-A	Polyester (amide)(imide) Overcoated with Polyamideimide (Heavy and Quad)	220	—	X	95
MW 36-C	Polyester (amide)(imide) Overcoated with Polyamideimide (Heavy and Quad)	200	—	X	96
MW 37-C	Polyester (amide)(imide) Overcoated with Polyamideimide (Single, Heavy, Triple)	220	X	—	97

Table continued on next page

Part 2 PROPERTIES AND REQUIREMENTS, Continued

Specification Number		Thermal Class	Round	Rectangular and Square	Page No.
MW 38-C	Polyester (amide)(imide) Overcoated with Polyamideimide (Heavy and Quad)	220	—	X	98
MW 41-C	Glass Fiber Covered (Single and Double)	155	X	—	99
MW 42-C	Glass Fiber Covered (Single and Double)	155	—	X	100
MW 43-C	Glass Fiber Covered Silicone Treated (Single and Double)	200	—	X	101
MW 44-C	Glass Fiber Covered Silicone Treated (Single and Double)	200	X	—	102
MW 45-C	Polyester Glass Fiber Covered (Single and Double)	155	X	—	103
MW 46-C	Polyester Glass Fiber Covered (Single and Double)	155	—	X	104
MW 47-C	Polyester Glass Fiber Covered Silicone Treated (Single and Double)	200	X	—	105
MW 48-C	Polyester Glass Fiber Covered Silicone Treated (Single and Double)	200	—	X	106
MW 50-C	Glass Fiber Covered, High-Temperature Organic Varnish Treated (Single and Double)	180	X	—	107
MW 51-C	Polyester Glass Fiber Covered, High-Temperature Organic Varnish Treated (Single and Double)	180	X	—	118
MW 52-C	Glass Fiber Covered, High-Temperature Organic Varnish Treated (Single or Double)	180	—	X	119
MW 53-C	Polyester Glass Fiber Covered, High-Temperature Organic Varnish Treated (Single and Double)	180	—	X	110
MW 60-A	Aromatic Polyamide Paper Covered (Paper)	220	—	X	111
MW 60-C	Aromatic Polyamide Paper Covered (Paper)	220	—	X	112
MW 61-A	Aromatic Polyamide Paper Covered (Paper)	220	X	—	113
MW 61-C	Aromatic Polyamide Paper Covered (Paper)	220	X	—	114
MW 64-A	Aromatic Polyimide Tape Covered	240	—	X	115
MW 64-C	Aromatic Polyimide Tape Covered	240	—	X	116
MW 65-A	Aromatic Polyimide Tape Covered	240	X	—	117
MW 65-C	Aromatic Polyimide Tape Covered	240	X	—	118
MW 72-C	Polyester (amide)(imide) for Hermetic Applications (Heavy)	180	X	—	119
MW 73-A	Polyester (amide)(imide) Overcoated with Polyamideimide for Hermetic Applications (Heavy)	220	X	—	120
MW 73-C	Polyester (amide)(imide) Overcoated with Polyamideimide for Hermetic Applications (Heavy, Triple, Quad)	200	X	—	121
MW 74-A	Polyester (amide)(imide) (Single and Heavy)	220	X	—	122

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Part 2
PROPERTIES AND REQUIREMENTS, Continued

Specification Number		Thermal Class	Round	Rectangular and Square	Page No.
MW 74-C	Polyester (amide)(imide) (Single and Heavy)	200	X	—	123
MW 75-C	Polyurethane for Solderable Applications (Single and Heavy)	130	X	—	124
MW 76-A	Polyester (amide)(imide) Overcoated with Polyamide (Single and Heavy)	180	X	—	125
MW 76-C	Polyester (amide)(imide) Overcoated with Polyamide (Single, Heavy, Triple)	180	X	—	126
MW 77-C	Polyester (imide) for Solderable Applications (Single and Heavy)	180	X	—	127
MW 78-C	Polyester (imide) Overcoated with Polyamide for Solderable Applications (Single and Heavy)	180	X	—	128
MW 79-C	Polyurethane for Solderable Applications (Single, Heavy, Triple)	155	X	—	129
MW 80-A	Polyurethane Overcoated with Polyamide for Solderable Applications (Single and Heavy)	155	X	—	130
MW 80-C	Polyurethane Overcoated with Polyamide for Solderable Applications (Single, Heavy, Triple)	155	X	—	131
MW 81-C	Polyamideimide (Single and Heavy)	220	X	—	132
MW 82-C	Polyurethane for Solderable Applications (Single, Heavy, Triple)	180	X	—	133
MW 83-C	Polyurethane Overcoated with Polyamide for Solderable Applications (Single, Heavy, Triple)	180	X	—	134
MW 84-C	Polyamideimide Rectangular and Square	220		X	135
MW 85-C	Polyurethane Fully Insulated FIW Zero-Defect Insulated Round Copper Wire for Solderable Applications	180	X	—	136
MW 102-A	Polyester (amide)(imide) Overcoated with Polyamideimide and Self-bonding Overcoat (Type 1 and Type 2)	180	X	—	137
MW 102-C	Polyester (amide)(imide) Overcoated with Polyamideimide and Self-bonding Overcoat (Type 1 and Type 2)	180	X	—	138
MW 130-C	Polyurethane with Self-bonding Overcoat (Type 1 and Type 2)	130	X	—	139
MW 131-C	Polyurethane with Self-bonding Overcoat (Type 1 and Type 2)	155	X	—	140
MW 132-C	Solderable Polyurethane with Self-bonding Overcoat	180	X		141
MW 135-C	Polyurethane Overcoated with Polyamide and Self-bonding Overcoat (Type 1 and Type 2)	130	X	—	142
MW 136-C	Polyurethane Overcoated with Polyamide and Self-bonding Overcoat (Type 1 and Type 2)	155	X	—	143
MW 137-C	Solderable Polyurethane Overcoated with Polyamide and Self-bonding Overcoat	180	X		144

Part 2

PROPERTIES AND REQUIREMENTS LISTING BY THERMAL CLASS, FILM INSULATION, COATING, COVERING AND FORM

Thermal Class	Film Insulation, Coating, Covering, and Form	See Part 2, Specification No.		
		Aluminum	Copper	Page No.
FILM-INSULATED ROUND MAGNET WIRE				
105	Polyvinyl Acetal	MW 15-A	MW 15-C	75, 76
105	Polyvinyl Acetal and Self-bonding Overcoat	-	MW 19-C	80
130 Solderable	Polyurethane Overcoated with Polyamide	MW 28-A	MW 28-C	86, 87
130 Solderable	Polyurethane	-	MW 75-C	124
130 Solderable	Polyurethane with Self-bonding Overcoat	-	MW 130-C	139
130 Solderable	Polyurethane Overcoated with Polyamide and Self-bonding Overcoat	-	MW 135-C	142
155	Polyester	-	MW 5-C	74
155	Polyester (amide)(imide) Overcoated with Polyamide	MW 24-A	MW 24-C	82, 83
155 Solderable	Polyester (imide) OBSOLETE EFFECTIVE DEC. 31, 2014	-	MW 26-C	84
155 Solderable	Polyester (imide) Overcoated with Polyamide OBSOLETE EFFECTIVE DEC. 31, 2014	-	MW 27-C	85
155 Solderable	Polyurethane	-	MW 79-C	129
155 Solderable	Polyurethane Overcoated with Polyamide	MW 80-A	MW 80-C	130, 131
155 Solderable	Polyurethane with Self-bonding Overcoat	-	MW 131-C	140
155 Solderable	Polyurethane Overcoated with Polyamide and Self-bonding Overcoat	-	MW 136-C	143
180	Polyester (amide)(imide)	-	MW 30-C	88
180	Polyester (amide)(imide) Overcoated with Polyamide	MW 76-A	MW 76-C	125, 126
180	Polyester (amide)(imide) Overcoated with Polyamideimide and Self-bonding Overcoat	MW 102-A	MW 102-C	137, 138
180 Solderable	Polyester (imide)	-	MW 77-C	127
180 Solderable	Polyester (imide) Overcoated with Polyamide	-	MW 78-C	128
180 Hermetic	Polyester (amide) (imide)	-	MW 72-C	119
180 Solderable	Polyurethane	-	MW 82-C	133
180 Solderable	Polyurethane Overcoated with Polyamide	-	MW 83-C	134
180 Solderable	Polyurethane Fully Insulated FIW Zero-Defect Insulated Round Copper Wire for Solderable Applications	-	MW 85-C	136
180 Solderable	Solderable Polyurethane with Self-bonding Overcoat	-	MW 132-C	141
180 Solderable	Solderable Polyurethane Overcoated with Polyamide and Self-bonding Overcoat	-	MW 137-C	144
200	Polyester (amide) (imide) Overcoated with Polyamideimide	-	MW 35-C	94
200	Polyester (amide)(imide)	-	MW 74-C	123
220	Polyester (amide)(imide) Overcoated with Polyamideimide	-	MW 37-C	97

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Part 2
PROPERTIES AND REQUIREMENTS LISTING BY THERMAL CLASS,
FILM INSULATION, COATING, COVERING, AND FORM, Continued

Thermal Class	Film Insulation, Coating, Covering, and Form	See Part 2, Specification No.		
		Aluminum	Copper	Page No.
220	Polyester (amide)(imide)	MW 74-A	-	122
220 Hermetic	Polyester (amide)(imide) Overcoated with Polyamideimide	MW 73-A	-	120
220	Polyamideimide		MW 81-C	132
240 Hermetic	Polyimide	-	MW 16-C	77
FILM-INSULATED RECTANGULAR AND SQUARE WIRE				
105	Polyvinyl Acetal	MW 18-A	MW 18-C	78, 79
200	Polyester (amide)(imide) Overcoated with Polyamideimide	-	MW 36-C	96
220	Polyester (amide)(imide) Overcoated with Polyamideimide	MW 36-A	-	95
220	Polyester (amide)(imide) Overcoated with Polyamideimide	-	MW 38-C	98
220	Polyamideimide		MW 84-C	135
240	Polyimide	-	MW 20-C	81
FIBROUS COVERED ROUND MAGNET WIRE				
90 or 105	Paper Covered	MW 31-A	MW 31-C	89, 90
155	Glass Fiber Covered	-	MW 41-C	99
155	Polyester Glass Fiber Covered	-	MW 45-C	103
180	Glass Fiber Covered, High-Temperature Organic Varnish Treated	-	MW 50-C	107
180	Polyester Glass Fiber Covered, High-Temperature Organic Varnish Treated	-	MW 51-C	108
200	Glass Fiber Covered, Silicone Treated	-	MW 44-C	102
200	Polyester Glass Fiber Covered, Silicone Treated	-	MW 47-C	105
220	Aromatic Polyamide Paper Covered	MW 61-A	MW 61-C	113, 114
240	Aromatic Polyimide Tape Covered	MW 65-A	MW 65-C	117, 118
FIBROUS COVERED RECTANGULAR & SQUARE MAGNET WIRE				
90 or 105	Paper Covered	MW 33-A	MW 33-C	91, 92
155	Glass Fiber Covered	-	MW 42-C	100
155	Polyester Glass Fiber Covered	-	MW 46-C	104
180	Glass Fiber Covered, High-Temperature Organic Varnish Treated	-	MW 52-C	109
180	Polyester Glass Fiber Covered, High-Temperature Organic Varnish Treated	-	MW 53-C	110
200	Glass Fiber Covered, Silicone Treated	-	MW 43-C	101
200	Polyester Glass Fiber Covered, Silicone Treated	-	MW 48-C	106
220	Aromatic Polyamide Paper Covered	MW 60-A	MW 60-C	111, 112
240	Aromatic Polyimide Tape Covered	MW 64-A	MW 64-C	115, 116

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Part 1 GENERAL

1.1 SCOPE

This publication is designed to present in concise and convenient form all existing NEMA standards for magnet wire. It contains standards for round, rectangular, and square film-insulated and/or fibrous-covered copper and aluminum magnet wire for use in electrical apparatus. Included are the definitions, type designations, dimensions, constructions, performance, and test methods for magnet wire generally used in the winding of coils for electrical apparatus. Unless otherwise stated, a revision to a product specification in this standards publication does not affect compliance of product manufactured during the time a previous version of that specification was in effect.

1.2 NORMATIVE REFERENCES AND AUTHORIZED ENGINEERING INFORMATION (AEI)

The following references apply to Parts 1, 2, and 3 only. Reference is made to the current revision of each of the standards or Authorized Engineering Information (AEI) listed below:

**American Society for Testing Materials
100 Barr Harbor Drive
West Conshohocken, PA 19428**

ASTM B 3	<i>Standard Specification for Soft or Annealed Copper Wire</i>
ASTM B 32	<i>Standard Specification for Solder Metal</i>
ASTM B 48	<i>Standard Specification for Soft Rectangular and Square Bare Copper Wire for Electrical Conductors</i>
ASTM D 149	<i>Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies</i>
ASTM B 193	<i>Standard Test Method for Resistivity of Electrical Conductor Materials</i>
ASTM B 258	<i>Standard Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors</i>
ASTM D 1676	<i>Standard Methods for Testing Film-Insulated Magnet Wire</i>
ASTM D 1711	<i>Standard Terminology Relating to Electrical Insulation</i>
ASTM D 1932	<i>Standard Test Method for Thermal Endurance of Flexible Electrical Insulating Varnishes</i>
ASTM D 2307	<i>Standard Test Method for Relative Thermal Endurance of Film-Insulated Round Magnet Wire</i>
ASTM D 3353	<i>Standard Methods for Testing Fibrous-Insulated Magnet Wire</i>
ASTM D 5423	<i>Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation</i>
ASTM E 29	<i>Standard Recommended Practice for Indicating Which Places of Figures Are to Be Considered Significant in Specified Limiting Values</i>
ASTM E 8	<i>Standard Methods of Tension Testing of Metallic Materials</i>

**International Electrotechnical Commission
3, rue de Varembe
Case postale 131
CH-1211 Geneva 20**

IEC 60317-0-1	<i>Specifications for particular types of winding wires—Part 0-1 General requirements—Enamelled round copper wire</i>
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