NEMA STANDARDS PUBLICATION NO. LI 1-1998

Industrial Laminating Thermosetting Products

Published by

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

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Foreword

This standard deals with Industrial Unclad Laminates only. The standards for Industrial Laminates used in circuitry applications are now found in LI-2, which will be published shortly.

Most of the materials in this publication have been developed over a period of years in close coordination with user needs. New and improved grades have been developed to satisfy military and industrial requirements particularly in the aerospace, electronic, and computer industries. In most cases, these standards are the same as military specifications.

NEMA standards for polyester-glass laminates were developed initially as a joint activity with the Society of the Plastics Industry, and a number of standards for laminates for printed circuits and multilayer circuits were developed jointly with the Institute for Interconnecting and Packaging Electronic Circuits (IPC). Both of these groups represent user interest in their memberships.

In addition to cooperative work with the users on mechanical and electrical properties, much work has been carried on for Underwriters Laboratories, Inc. with regard to safety aspects of laminates, particularly the effect of heat, flammability, and ignition from electrical sources.

User comments and recommendations are solicited on all aspects of these standards. They should be addressed to:

Vice President
Engineering Department
National Electrical Manufacturers Association
1300 N. 17th Street
Suite 1847
Rosslyn, VA 22209

This Standards Publication was developed by the Laminates Section. 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 Group/Section was composed of the following members:

Accurate Plastics, Inc.—Yonkers, New York
Current, Inc.—East Haven, Connecticut
GE Electromaterials—Coshocton, Ohio
Glastic Corporation—Cleveland, Ohio
Haysite Reinforced Plastic Company—Erie, Pennsylvania
ILNorplex, Inc.—Postville, Iowa
Industrial Dielectric, Inc.—Noblesville, Indiana
International Paper Company, Decorative Product Div.—Hampton, South Carolina
Iten Industries—Ashtabula, Ohio
NVF Company—Yorklyn, Delaware
Spaulding Composites Company—Tonawanda, New York

Section 1
GENERAL

1.1 SCOPE

The Scope of this Standards Publication includes information concerning the manufacture, testing, and performance of laminated thermosetting products in the form of sheets, rods, and tubes.

A new format for the Industrial Laminate (Unclad) Standard has been established in which the requirements for the physical and electrical properties of the individual NEMA Grades have been consolidated and placed on individual specification sheets. With this format, all of the information on an individual material will be found in one place.

1.2 REFERENCED STANDARDS

The titles of standards to which reference is made in this publication are as follows. Copies are available from the sources indicated.

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

D 150-87	*Tests for A-C Loss Characteristics and Dielectric Constant (Permittivity) of Solid Electrical Insulating Materials*
D 229-86	*Testing Rigid Sheet and Plate Materials Used for Electrical Insulation*
D 256-88	*Test for Impact Resistance of Plastics and Electrical Insulating Materials*
D 257-78 (R 1983)	*Test for D-C Resistance or Conductance of Insulating Materials*
D 348-89	*Testing Laminated Tubes Used for Electrical Insulation*
D 349-87	*Testing Laminated Round Rods Used for Electrical Insulation*
D 459-84	*Tests for High-Voltage, Low-Current Arc Resistance of Solid Electrical Insulating Materials*
D 570-81 (R 1988)	*Test for Water Absorption of Plastics*
D 621-64 (R 1988)	*Test for Deformation of Plastics Under Load*
D 709-87	*Specifications for Laminated Thermosetting Materials*
D 790-86	*Test for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulation Materials*
D 877-87	*Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes*
D 1180-57 (R 1978)	*Test for Bursting Strength of Round Rigid Plastic Tubing*
D 2303-85	*Test for Liquid-Contaminant, Inclined-Plane tracking and Erosion of Insulating Materials*

Institute of Electrical and Electronics Engineers
445 Hoes Lane
Piscataway, NJ 08855-1331

1-1986.1	*General Principles for Temperature Limits in the Ratings of Electric Equipment and for the Evaluation of Electric Insulation*
98-1984	*Guide for the Preparation of Test Procedures for the Thermal Evaluation of Solid Electrical Insulating Systems for Electric Equipment*
99-1980	*Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electrical Equipment*
101-1972 (R 1987)	*Guide for Statistical Analysis of Test Data*

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LI 6-1993 *Relative Temperature Indices of Industrial Thermosetting Laminates*

LI 1-1989 (R 1995) *Industrial Laminate Thermosetting Products*

International Electrotechnical Commission
Geneva, Switzerland

IEC 893 *Specifications for Industrial Rigid Laminated Sheets Based on Thermosetting Resins for Electrical Purposes – Sheets*

PF CP 203
PF CP 205
PF CP 206
PF CP 207
PF CP 208

IEC 1212 *Industrial Rigid Round Laminated Tubes and Rods Based on Thermosetting Resins for Electrical Purposes – Sheets*

PF CC 11	
PF CC 13	
PF CC 21	(Rolled Tubes)
PF CC 23	(Rolled Tubes)
PF CC 33	(Molded Tubes)
PF CC 43	(Molded Rods)
EP CG 22	(Rolled Tubes)
EP GC 202	
EP GC 32	
EP GC 42	
EP GC 202	
SI GC 21	(Rolled Tubes)
SI GC 202	

Underwriters Laboratories
Northbrook, IL

UL 94 *Test for Flammability of Plastic Materials for Parts in Devices and Appliances*

Department of Defense, Navy Sea Systems Command
Washington, DC

MILSPEC I *Insulation Plastics, Laminated Thermosetting ... :*

-24768/1	...Glass-Cloth, Melamine-Resin (GME)
-24768/2	...Glass-Cloth, Epoxy-Resin (GEE)
-24768/3	...Glass-Cloth, Epoxy-Resin (GEB)
-24768/4	...Glass-Mat, Polyester-Resin (GPO-N-1)
-24768/5	...Glass-Mat, Polyester-Resin (GPO N-2)
-24768/6	...Glass-Mat, Polyester-Resin (GPO N-2)
-24768/8	...Glass-Cloth, Melamine-Resin (GMG)
-24768/9	...Nylon-Fabric Base, Phenolic-Resin (NPG)
-24768/10	...Paper-Base, Phenolic-Resin (PBE)
-24768/11	...Paper-Base, Phenolic-Resin (PBG)
-24768/12	...Paper-Base, Phenolic-Resin (PBM)
-24768/13	...Cotton-Fabric-Base, Phenolic-Resin (FBE)
-24768/14	...Cotton-Fabric-Base, Phenolic-Resin (FBG)
-24768/15	...Cotton-Fabric-Base, Phenolic-Resin (FBI)
-24768/16	...Cotton-Fabric-Base, Phenolic-Resin (FBM)
-24768/17	...Glass-Cloth, Silicone-Resin (GSG)
-24768/18	...Glass-Cloth, Phenolic-Resin (GPG)
-24768/19	...Paper-Base, Phenolic-Resin (PBM-P)
-24768/20	...Paper-Base, Phenolic-Resin (PBM-C)
-24768/21	...Paper-Base, Phenolic-Resin (PBG-P)
-24768/22	...Paper-Base, Phenolic-Resin (PBE-P)
-24768/23	...Paper-Base, Phenolic-Resin (PBE-PC)
-24768/24	...Paper-Base, Phenolic-Resin (PBM-PF)
-24768/25	...Paper-Base, Phenolic-Resin (PBE-PCF)
-24768/26	...Paper-Base, Epoxy-Resin (PEE)
-24768/27	...Glass-Cloth, Epoxy-Resin (GEB-F)
-24768/28	...Glass-Cloth, Epoxy-Resin (GEB-F)
-24768/29	...Continuous Filament, Glass-Cloth, Epoxy-Resin (CEM-1)
-24768/30	...Continuous Filament, Glass-Cloth, Epoxy-Resin (CEM-3)
-24768/31	...Glass-Mat, Polyester-Resin (GPO-N-1P)
-24768/32	...Glass-Mat, Polyester-Resin (GPO-N-28)
-24768/33	...Glass-Mat, Polyester-Resin (GPO-N-38)

1.3 MIL SPEC CROSS-REFERENCES

MIL SPEC	LI 1 Specification Sheet:
24768/1	Reference LI 1/20 – G9
24768/2	Reference LI 1/21 – G10
24768/3	Reference LI 1/22 – G11
24768/4	Reference LI 1/31 – GPO-1
24768/5	Reference LI 1/32 – GPO-2
24768/6	Reference LI 1/33 – GPO-3
24768/8	Reference LI 1/18 – G5
24768/9	Reference LI 1/23 – N-1
24768/10	Reference LI 1/06 – XXX
24768/11	Reference LI 1/04 – XX
24768/12	Reference LI 1/01 – X
24768/13	Reference LI 1/16 – LE
24768/14	Reference LI 1/13 – CE
24768/15	Reference LI 1/15 – L
24768/16	Reference LI 1/12 – C
24768/17	Reference LI 1/19 – G-7
24768/18	Reference LI 1/17 – G-3
24768/19	Reference LI 1/02 – XP
24768/20	Reference LI 1/03 – XPC
24768/21	Reference LI 1/05 – XXP
24768/22	Reference LI 1/07 – XXXP
24768/23	Reference LI 1/08 – XXXPC
24768/24	Reference LI 1/24 – FR-1
24768/25	Reference LI 1/25 – FR-2
24768/26	Reference LI 1/26 – FR-3
24768/27	Reference LI 1/27 – FR-4
24768/28	Reference LI 1/28 – FR-5
24768/29	Reference LI 1/29 – CEM-1
24768/30	Reference LI 1/30 – CEM-3
24768/31	Reference LI 1/34 – GPO-1P
24768/32	Reference LI 1/35 – GPO-2P
24768/33	Reference LI 1/36 – GPO-3P

1.4 HISTORY OF LAMINATED MATERIALS STANDARDS

These standards and authorized engineering information provide practical information concerning the manufacture, testing, and performance of laminated thermosetting sheets, tubes, and rods used in the manufacture of electrical apparatus and supplies. They represent general practice in the industry, promote production economies and assist users in the proper selection of laminated thermosetting products.

Standards on laminated thermosetting material were originally developed by the Associated Manufacturers of Electrical Supplies. That Association became the Supply Division of NEMA in 1926, at which time the NEMA Handbook of Supply Standards dated October 1927 was published, containing four pages of standards on laminated thermosetting material. Those four pages covered thickness and tolerances of the following types of laminated phenolic sheet:

a. Pieces cut and punched from sheet and blanks cut from sheet
b. Heavy-weave fabric base material
c. Pieces cut or punched from sheet
    1. Paper-based laminates
    2. Asbestos-base laminates
    3. Fine-weave fabric base laminates