NEMA MW 785-2021

Simulated Insertion Force Test for
Film Insulated Round Magnet Wire

Published by

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

www.nema.org

NOTICE AND DISCLAIMER

The information in this publication was considered technically sound by the consensus of persons engaged in the development and approval of the document at the time it was developed. Consensus does not necessarily mean that there is unanimous agreement among every person participating in the development of this document.

NEMA Standards and guideline publications, of which the document contained herein is one, are developed through a voluntary consensus Standards development process. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. While NEMA administers the process and establishes rules to promote fairness in the development of consensus, it does not write the document and it does not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its Standards and guideline publications. NEMA disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document.

NEMA disclaims and makes no guaranty or warranty, express or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. NEMA does not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this Standard or guide.

In publishing and making this document available, NEMA is not undertaking to render professional or other services for or on behalf of any person or entity, nor is NEMA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. Information and other Standards on the topic covered by this publication may be available from other sources, which the user may wish to consult for additional views or information not covered by this publication.

NEMA has no power, nor does it undertake to police or enforce compliance with the contents of this document. NEMA does not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of compliance with any health or safety–related information in this document shall not be attributable to NEMA and is solely the responsibility of the certifier or maker of the statement.

CONTENTS

Figures

Tables

< This page intentionally left blank. >

Foreword

This Standards publication was prepared by the NEMA Magnet Wire Section Technical Committee and reflects the input of various industries that use magnet wire. All information in this publication is Authorized Engineering Information.

NEMA magnet wire publications are periodically reviewed by the NEMA Magnet Wire Section and revised as necessary to keep them current with technological changes. Proposed revisions should be submitted to:

NEMA Technical Operations Department
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, VA 22209

This Standards publication was developed by the Magnet Wire 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 Magnet Wire Section was composed of the following Members:

CONDUMEX—Mexico City, Mexico
Elektrisola, Inc.—Boscawen, NH
Essex Group, Inc.—Fort Wayne, IN
Magnekón—San Nicolas de los Garza, NL, Mexico
MWS Wire Industries—Westlake Village, CA
New England Wire Technologies Corporation—Lisbon, NH
Rea Magnet Wire Company, Inc.—Fort Wayne, IN
Rubadue Wire Company, Inc. —Loveland, CO
Virginia Insulated Products—Saltville, VA
Zeus Wire—Orangeburg, SC

Introduction

As magnet wire is used to manufacture various electrical devices, particularly electric motors, it is quite often wound on a coil preform and then inserted into the proper stator slot through the use of various kinds of coil injection equipment, which provides the mechanical force to place the coil in its final position. The insertion force required to place the coil in its proper position can have a dramatic effect on the quality of the finished electrical device. Excessive insertion forces may be related to excessive magnet wire insulation damage, which can lead to electrical failures.

Past investigation into the factors related to the coil insertion force have shown that it depends upon the dimensions of the magnet wire, the softness or formability of the conductor, and the coefficient of friction and/or the smoothness of the outside surface of the film insulation.

History

Various devices and test methods have been used to measure some of the magnet wire characteristics that affect the coil insertion force independent of one another. Round film coated magnet wire dimensions can be determined using NEMA MW 1000 Test Procedure 3.2.1.1, listed on page 1 of Part 3. The softness characteristics of various round film-coated magnet wire samples (sizes 14–30 AWG) can be compared using NEMA MW 1000 Springback Test Procedure 3.7.1, listed on page 5 of Part 3. The coefficient of friction of various film insulated magnet wire samples (sizes 14-44 AWG) can be compared using the Dynamic Coefficient Test method as described in MW 750.

However, the correlation of the various magnet wire test results with manufacturing performance to predict acceptably low coil insertion forces in motor manufacturing operations is difficult and has not always been successful. Also, it is relatively expensive and inconvenient to evaluate various wires on production motor manufacturing equipment.

In a paper presented at the 1984 International Coil Winders Association (ICWA) Conference, Schmidt and Knoll described a Simulated Insertion Force Test (SIFT) for magnet wire that identified differences between various film insulated magnet wires in their ability to be inserted into stators and in the forces associated with this insertion (See 1.6, Ref. No. 4). Test results using the method described were shown to correlate with actual measured coil insertion forces on production motor manufacturing equipment.

In a paper presented at the 1985 ICWA Conference, Schmidt and Knoll further explored the effects of test parameters and magnet wire characteristics on SIFT results (See 1.6, Ref. No. 5). Additional test results using the method over a broader range of sizes and types of magnet wire were shown to correlate with measured coil insertion forces while producing several sizes of motors.

As a result of the aforementioned presentations, several Members of the NEMA Magnet Wire Technical Committee became interested in the test procedure, and in 1986 the committee decided to conduct a round-robin test series among four technical committee Member companies to determine if the SIFT was capable of differentiating magnet wire construction in terms of insertion force. The results of the round-robin testing were published in a paper presented by Schmidt and Scherrer at the 1987 Electrical/Electronic Insulation Conference (E/EIC) (See 1.6, Ref. No. 6). At that time, it was determined that the SIFT could indeed differentiate between wire samples, but there were differences in the level of test values between different test fixtures that could be attributed to dimensional or other design characteristic differences between test fixtures.

In an effort to resolve previously mentioned differences in simulated insertion force between test fixtures, a series of four test fixtures were produced in one machine shop. The results of this testing were published in a paper by Schmidt and Scherrer presented at the 1989 E/EIC (See 1.6, Ref. No. 7). It was concluded that three of the four test fixtures showed no significant difference in test results when testing like wire samples. Furthermore, it was also demonstrated that the statistically higher SIFT values attributed to the one test

fixture of the four that did not agree with the others could be attributed to a slightly smaller dimensional opening in the test fixture exit hole.

The 1989 paper also presented some test data showing differences in simulated insertion force between several different kinds of slot liner material. The test results from this paper and previous papers illustrated how the SIFT can evaluate the effects that various characteristics of magnet wire have on insertion forces. Because of these unique capabilities, the NEMA Magnet Wire Section Technical Committee decided to publish the test procedure as NEMA Authorized Engineering Information. As a result of the rather rigorous test program that was followed in developing and evaluating the SIFT,a great deal of information is available concerning the test procedure itself and the various wire test properties and other factors that affect the results. The primary advantage of this particular test is its ability to predict acceptable coil insertion performance once acceptable SIFT Standards have been determined for a given stator coil injection process.

< This page intentionally left blank. >

1 General

1.1 Scope

This Standards publication describes a method and the equipment used to determine the simulated insertion force of film insulated round magnet wire, wire sizes 14-28 AWG.