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Test Procedure
for
EVALUATION of the THERMAL STABILITY
of
ENAMELED WIRE in AIR

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INTRODUCTION

Purpose

The purpose of this test procedure is to establish a test method for determining the relative thermal life of enameled magnet wire used in electric equipment operated in air. In evaluating the usefulness of materials applied as insulating films to magnet wire, such physical and chemical properties as hardness, solvent resistance and thermoplastic flow are equally important. The evaluation of these properties, however, is not within the scope of this test method. They must be evaluated separately by recognized test methods.

This test procedure is intended for use in the preliminary temperature classification and the selection of enameled wire for use in the more comprehensive system testing. This test procedure is intended to supplement rather than displace the functional testing of actual equipment or model insulation systems.¹

Experience has shown that this procedure can be used to evaluate the thermal stability of most types of magnet wire enamels. However, some types of enamels cannot be evaluated using this method. When obviously unrealistic results are obtained other methods of evaluation must be used.

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This Test Procedure was prepared by the following men, comprising a Working Group on Enameled Magnet Wire of the Thermal Evaluation Subcommittee of the Electrical Insulation Committee.

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AIEE TEST PROCEDURE FOR EVALUATION OF THE THERMAL STABILITY OF ENAMELED WIRE IN AIR

Part I. Round Enameled Magnet Wire

SECTION I

Insulation Test Specimens

1-1 Scope.—Part 1 of this Test Procedure is a method for the evaluation of the useful life of round, enameled or film insulated magnet wire. It is not applicable to round or rectangular magnet wire insulated with fibrous insulations such as cotton or glass fiber. The evaluation of fibrous insulated round and rectangular wires will be covered by subsequent Test Procedures. Enameled and film insulated magnet wire having bare, uninsulated wire diameters ranging from 0.0072 to 0.1285 inch inclusive can be evaluated as described herein. However, because of the fragility of the test specimens, it is recommended that wire with diameters larger than 0.0099 inch be used in this method. Furthermore, the purpose of this Test Procedure is to evaluate the thermal stability of the enamel or insulating film rather than its stability as it may be affected by wire diameter. Wire sizes from 0.032 inch through 0.057 inch are generally recommended as being the most convenient to handle and test.

1-2 Test Specimens.—The test specimen consists of two strands of the insulated wire twisted together as described in Section 1-3. This sample has been selected because of its simplicity and convenience. Furthermore, the twisted pair of enameled wire simulates to some extent the actual use of enameled wires in electric equipment.

1-3 Preparation of Test Specimens.—The test specimens are prepared as follows:

a. Two pieces of enameled wire shall be twisted together for a distance of 4.75 inches. The tension on the wires while being twisted and the number of twists are given in Table I. This test specimen is the standard electric strength sample made in accordance with American Standard C9.5-1955.

TABLE I

Bare Wire Diameter, Inch	Approximate AWG Range	Total Tension on Wires, English Units	Total Number of Twists
0.0050-0.0071	36-33	1.5 oz	24
0.0072-0.0113	32-29	4.0 oz	20
0.0114-0.0179	28-25	12.0 oz	16
0.0180-0.0285	24-21	1.0 lb	12
0.0286-0.0508	20-16	3.0 lbs	9
0.0509-0.0808	15-12	9.0 lbs	6
0.0809-0.1285	11-8	15.0 lbs	3

A specimen is formed by symmetrically twisting one wire around the mating wire. Any device

capable of forming the twisted wires in accordance with this specification can be used. A typical device used to form the twisted samples is shown in Figure 1. In using this device a single length of wire approximately 18 inches long is looped around the spindle of the device and the appropriate weight is hung on the two ends after they pass over the sheaves. A test specimen being twisted is shown in Figure 1.

b. Prepare spacers as shown in Figure 2. The spacers are constructed of an insulating material with thermal stability comparable to or better than the wire under test. A silicone resin-fibrous glass laminate approximately 0.030 inch thick is satisfactory for this use. The spacers are marked with a suitable identifying letter or number. Small strips of aluminum foil properly marked folded around the spacer are convenient for identification purposes.

c. The twisted test specimens may be shaped in a jig, an engineering drawing of which is shown in Figure 3. A specimen is placed in the jig and a spacer, placed on the parallel leads of the wires, is brought up to the face of the jig as shown in Figure 4. The leads are then bent parallel to hold the spacer in position. The purpose of the forming jig is to provide more uniform test specimens. The use of the jig is optional, but experience indicates that more consistent results are obtained when the jig is used.

d. The loop at the opposite end of the twist is cut in two places as shown in Figure 5. The loop should not be cut in one place and the ends separated as this may injure the wire where it enters the twisted section.

1-4 Varnish Impregnation.—Experience has shown that combinations of enameled magnet wire and electrical insulating varnishes react with one another during the thermal aging process. The interaction with varnish may increase or decrease the relative thermal life of the varnished and enameled wire combination compared with the life of the enameled wire tested without varnish. Therefore, this test procedure may be used to determine the relative thermal life of insulating varnishes and enameled magnet wire combinations.

When varnish is used the test specimens are dipped to cover the spacer in the varnish for approximately five seconds. They are then slowly withdrawn from the varnish. The varnish should be diluted to dipping viscosity and it may be cured in accordance with the manufacturer's recommendations. The dip and bake operation may

also simulate actual processing schedules. A single dip in varnish is usually satisfactory although additional dips may be used to determine the effect of varnish thickness. When more than one dip is used, it is recommended that the ends of the test specimen be reversed for each dip.

In some cases it may be advisable to anneal the twisted specimens prior to varnish dipping. When annealing is desirable, it is recommended that the specimens be subjected to the baking temperature specified for the varnish for one hour.

1-5 Effect of Wire Metal.—The wire metal and surface treatment of the wire will also affect the thermal life of enameled magnet wire.⁴ This test procedure may be used to determine the relative thermal life of magnet wire enamel coated on various kinds of wire.

1-6 Number of Test Specimens.—The accuracy of the test results depends largely upon the number of test specimens exposed at each temperature. A greater number of test specimens is required to achieve an acceptable degree of accuracy if there is a broad spread in failure time among the specimens exposed at each temperature. The number of test specimens at each exposure temperature must, therefore, be determined by a statistical analysis of the failure times and the degree of accuracy that is desired in determining the average life.

When the proof voltage test method is used, experience has shown that a minimum of twenty unvarnished test specimens should be exposed at each exposure temperature. If varnished specimens are tested, a minimum of ten specimens may be used.

1-7 Quality Control.—All specimens should be proof tested prior to starting the aging. Voltages given in Table III are recommended.

SECTION II

Test Exposures

2-1 Scope.—Recommended exposures to which the test specimens are subjected are given in this Section. These exposures represent the cumulative deteriorating effects that may cause the failure of enameled magnet wire in service.

A major factor affecting the life of enameled magnet wire is thermal degradation. Other factors such as moisture, chemical contamination, and mechanical stresses, or vibration usually do not in themselves cause failure, but are factors that may result in failure after the enameled wire has been weakened by thermal deterioration. For this reason exposure to high temperature is the primary deteriorating influence considered in this Test Procedure.²

2-2 Temperature Exposure.—In Table II the temperature and time of exposure in each cycle are given for materials that are to be evaluated for use within anticipated limiting insulation temperature ranges. A test cycle consists of exposure to a high temperature and testing at room temperature. (20 to 30C)

TABLE II

Suggested Temperatures and Exposure Times in Days per Cycle

Exposure Temperature, Centigrade	Estimated Limiting Insulation Temperature				
	105C	130C	155C	180C	220C
300					1
290					2
280					4
270					7
260					14
250				1	28
240				2	49
230				4	
220			1	7	
210			2	14	
200		1	4	28	
190		2	7	49	
180	1	4	14		
170	2	7	28		
160	4	14	49		
150	7	28			
140	14	49			
130	28				
120	49				

The exposure times given in Table II are selected to subject the test specimens to approximately 10 cycles at each temperature before the average endpoint (life) is reached.

The temperature of the specimens should be kept within a range of plus or minus 2 degrees Centigrade. Care should be taken to prevent damage in handling the specimens.

The life of the specimens will be affected by the number of cycles. Thermal life values obtained from test specimens subjected to an average of less than 8 or to more than 20 cycles at the exposure temperature may not be reliable and should not be used to predict the temperature rating of the enameled wire. Therefore, the cycle times may be increased or decreased during the aging, to assure that the average number of cycles to failure fall within this range. For example, if a set of test specimens has been exposed for 8 cycles and less than half have failed, the exposure time should be increased to the next longer time given in the vertical columns of Table II.

Test specimens should be exposed to a minimum of three temperatures when the results are used