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EFFECT OF THE WIRE DIAMETER

ON

WIREWOUND RESISTORS

RELIABILITY

Engineering Department

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EFFECT OF THE WIRE DIAMETER
ON WIREWOUND RESISTOR RELIABILITY
AS JUDGED BY
ENVIRONMENTAL AND LIFE TEST RESULTS

INTRODUCTION

For many years the question of the minimum wire size which could be safely used for wirewound resistors has been debated. In Military specifications the minimum wire diameter has been specified which indicated that below that diameter unsatisfactory operation could be expected. Many hours have been spent discussing whether the minimum should be 0.00175", 0.0015", 0.001", 0.0008", or some other size. Opinions on this requirement have varied greatly between wirewound resistor manufacturers, and between persons who have conducted tests to obtain an answer to the problem.

To obtain an Industry-wide solution, the EIA Working Group P-1.4 on Wirewound Resistors has conducted an Industry-wide testing program. A total of eight wirewound resistor manufacturers participated and a total of 2400 resistors were tested.

Three types of resistors were included in the test. The companies participating for each type are shown below.

POWER WIREWOUND RESISTOR
Characteristic G per Mil-R-26C

Dale Electronics, Inc.
International Resistance Co.
P.R. Mallory & Co., Inc.
Mepco, Inc.
Ward Leonard Electric Co. (submitted
2 reports)

POWER WIREWOUND RESISTOR
Characteristic V per Mil-R-26C

Dale Electronics, Inc.
International Resistance Co.
P.R. Mallory & Co., Inc.
Ward Leonard Electric Co.

PRECISION WIREWOUND RESISTOR
per Mil-R-93C

Dale Electronics, Inc.
International Resistance Co.
The Daven Corp.
Mepco, Inc.
Resistance Products Co.
Shallcross Manufacturing Co.



The evaluation was conducted on the basis of comparative tests on resistor units made from three different wire sizes.

The 0.0012 inch diameter wire represented the largest wire size (this size is generally accepted as satisfactory by nearly all users and the Military Services).

The 0.0009 inch diameter wire represented the medium size, and is in the area that is presently being specified as a minimum by most customers and the Military specifications.

The 0.0006 inch diameter wire was tested as representing the very fine wire and what is being used by the more advanced manufacturers where high values are required.

Manufacturers were instructed to make standard Military specification resistors (RW-67 for the Power Wirewound and RB-55 for the Precision Resistors) with no special care or handling. The resistance values were to be whatever best represented the normal manufacturing procedures for each specific wire size. Fifty units were manufactured by each participant for testing of each wire size for each style.

From each group of 50 resistors, 10 units were tested on environmental tests and 40 units were tested on a 2000 hour load life test. For the Precision resistors, the environmental tests consisted of short time overload, temperature cycling, and a 20 day moisture resistance test with a measurement after 10 days. For the Power resistors, the environmental tests were thermal shock, momentary overload, and a 20 day moisture resistance test with a measurement after 10 days. In all cases, testing procedures were set up to follow Military specifications as closely as possible.

Tests were conducted by each manufacturer on his own product and a summary of the test results, along with the raw data, was submitted to the EIA Marketing Services Office where it was handled in a completely confidential manner. The results from the various participating companies were then combined to obtain over-all averages as well as distribution figures for the group. The original raw data are available for additional statistical work if required.

The over-all results of the program indicate that there is no one distinct wire diameter, below which units are satisfactory and above which all units are satisfactory. The tests on the units wound with 0.0006 inch diameter wire show that although the average resistance change may be even less than that shown by the larger wire, there is a tendency to have a greater number of erratic units or catastrophic failures. These erratic units

can be understood, since there is closer control required in the fine wire manufacturing, and manufacturing errors cause more effect on the end unit test results.

There was a surprisingly high number of failures in all sizes of wire, including the 0.0012 inch diameter which Industry has accepted as being satisfactory and reliable.

The overload and thermal tests provided little indicated difference between the wire sizes. A graph is attached showing the results of the 20 day moisture test and the 1000 and 2000 hour load life tests for each style.

A conclusion from the program might be that the use of a wire diameter down to 0.0009 is as safe as any other minimum which could be specified. The use of smaller wire diameters down to 0.0006 will depend on the users confidence in the ability of the manufacturer to process units without the introduction of "sports" or non-homogeneous parts.

The test strongly indicates the need for a more extensive program with closer control.

G. Carter
Chairman
EIA Working Group P-1.4
on Wirewound Resistors

INDUSTRY SUMMARY
OF
EIA WORKING GROUP P-1.4 ON
FINE WIRE EVALUATION PROGRAM
FOR
POWER WIREWOUND RESISTOR TYPE
CHARACTERISTIC G

RESISTOR ENCLOSURE MATERIAL

Material	Number of Participants
Vitreous Enamel	1
Silicone or Epoxy	5

WIRE CLASS USED IN WINDING (per ASTM-B-267-60T)

Wire Class	Number of Participants
Class 1 (800 ^Ω /cir mil nickel base)	6
Class 2 (800 ^Ω /cir mil iron base)	-
Class 3 or 4 (60-80% nickel, 16-20% chrome)	-
Class 5 (55% copper, 45% nickel)	-
Class 6 (Manganin)	-
Other	-

RESISTANCE VALUES

Resistance	Wire Size		
	0.0012	0.0009	0.0006
Highest	5,800	14,500	48,000
Average	5,167	12,000	39,667
Lowest	4,500	10,000	30,000

CHARACTERISTIC G

THERMAL SHOCK

Resistance Change	Wire Size		
	0.0012	0.0009	0.0006
Absolute Highest Percent	0.820	0.510	2.130
Average Maximum Percent	0.180	0.141	0.045
Average Algebraic Mean Percent	0.014	0.039	0.096
Average Absolute Mean Percent	0.047	0.047	0.114
Frequency Distribution (Number of units in each group) "Open"			
+2.00% but not open			1
+1.00% to +1.99%			
+0.75% to +0.99%	1		1
+0.50% to +0.74%			1
+0.25% to +0.49%			5
+0.10% to +0.24%	10	12	10
+0.05% to +0.09%	1	2	3
0.00% to +0.04%	48	46	39
TOTAL UNITS REPORTED	60	60	60

MOMENTARY OVERLOAD

Resistance Change	Wire Size		
	0.0012	0.0009	0.0006
Absolute Highest Percent	0.826	0.580	4.420
Average Maximum Percent	0.205	0.121	0.832
Average Algebraic Mean Percent	0.011	0.033	0.106
Average Absolute Mean Percent	0.046	0.043	0.139
Frequency Distribution (Number of units in each group) "Open"			
+2.00% but not open			1
+1.00% to +1.99%			
+0.75% to +0.99%	1		1
+0.50% to +0.74%			
+0.25% to +0.49%			4
+0.10% to +0.24%	10	12	11
+0.05% to +0.09%	1	4	3
0.00% to +0.04%	48	44	40
TOTAL UNITS REPORTED	60	60	60

CHARACTERISTIC G

MOISTURE RESISTANCE - 10 Day Measurement

Resistance Change	Wire Size		
	0.0012	0.0009	0.0006
Absolute Highest Percent	1.640	0.890	1.100
Average Maximum Percent	0.469	0.229	0.542
Average Algebraic Mean Percent	-0.003	0.040	0.109
Average Absolute Mean Percent	0.083	0.060	0.135
Frequency Distribution (Number of units in each group) "Open"	1		
+2.00% but not open			
+1.00% to +1.99%	1		1
+0.75% to +0.99%	1	1	2
+0.50% to +0.74%			3
+0.25% to +0.49%	2		3
+0.10% to +0.24%	7	13	9
+0.05% to +0.09%	2	3	9
+0.00% to +0.04%	46	43	33
TOTAL UNITS REPORTED	60	60	60

INSULATION RESISTANCE*

Resistance	Megohm
Maximum	127,875
Mean	18,310
Minimum	730

*Based on four companies only.

CHARACTERISTIC G

MOISTURE RESISTANCE - 20 Day Measurement

Resistance Change	Wire Size		
	0.0012	0.0009	0.0006
Absolute Highest Percent	0.810	0.770	1.200
Average Maximum Percent	0.281	0.215	0.503
Average Algebraic Mean Percent	0.037	0.054	0.071
Average Absolute Mean Percent	0.067	0.076	0.136
Frequency Distribution (Number of units in each group) "Open"	1		1
+2.00% but not open			
+1.00% to +1.99%			1
+0.75% to +0.99%	1	1	2
+0.50% to +0.74%			3
+0.25% to +0.49%	3		4
+0.10% to +0.24%	7	11	9
+0.05% to +0.09%	6	10	7
0.00% to +0.04%	42	38	33
TOTAL UNITS REPORTED	60	60	60

INSULATION RESISTANCE*

Resistance	Megohm
Maximum	93,650
Mean	25,592
Minimum	535

*Based on four companies only.