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## COMPONENTS BULLETIN No. 4

# EFFECT OF THE WIRE DIAMETER ON WIREWOUND RESISTORS RELIABILITY

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*Engineering Department*

**ELECTRONIC INDUSTRIES ASSOCIATION**

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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 <sup>Ω</sup> /cir mil nickel base) | 6                      |
| Class 2 (800 <sup>Ω</sup> /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<br>(Number of units in each group)<br>"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<br>(Number of units in each group)<br>"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<br>(Number of units in each group)<br>"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<br>(Number of units in each group)<br>"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.

# CHARACTERISTIC G

## LOAD LIFE - 100 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.500     | 1.300  | 3.080  |
| Average Maximum Percent                                             | 0.249     | 0.498  | 0.759  |
| Average Algebraic Mean Percent                                      | 0.102     | 0.106  | 0.071  |
| Average Absolute Mean Percent                                       | 0.102     | 0.138  | 0.106  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           |        |        |
| +2.00% to +4.99%                                                    |           |        | 2      |
| +1.00% to +1.99%                                                    |           | 1      |        |
| +0.75% to +0.99%                                                    |           | 1      | 4      |
| +0.50% to +0.74%                                                    | 1         | 7      | 1      |
| +0.25% to +0.49%                                                    | 16        | 56     | 10     |
| +0.10% to +0.24%                                                    | 68        | 12     | 47     |
| 0.00% to +0.09%                                                     | 155       | 163    | 176    |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240    |

## LOAD LIFE - 250 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.510     | 1.860  | 3.080  |
| Average Maximum Percent                                             | 0.318     | 0.805  | 0.781  |
| Average Algebraic Mean Percent                                      | 0.135     | 0.140  | 0.085  |
| Average Absolute Mean Percent                                       | 0.152     | 0.183  | 0.112  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           |        |        |
| +2.00% to +4.99%                                                    |           |        | 1      |
| +1.00% to +1.99%                                                    |           | 3      | 2      |
| +0.75% to +0.99%                                                    |           | 3      | 2      |
| +0.50% to +0.74%                                                    | 1         | 11     | 1      |
| +0.25% to +0.49%                                                    | 39        | 55     | 10     |
| +0.10% to +0.24%                                                    | 98        | 29     | 47     |
| 0.00% to +0.09%                                                     | 102       | 139    | 177    |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240    |

# CHARACTERISTIC G

## LOAD LIFE - 500 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.545     | 1.740  | 3.060  |
| Average Maximum Percent                                             | 0.401     | 0.677  | 0.783  |
| Average Algebraic Mean Percent                                      | 0.191     | 0.167  | 0.098  |
| Average Absolute Mean Percent                                       | 0.191     | 0.208  | 0.123  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           |        |        |
| +2.00% to +4.99%                                                    |           |        | 1      |
| +1.00% to +1.99%                                                    |           | 2      | 2      |
| +0.75% to +0.99%                                                    |           | 7      | 2      |
| +0.50% to +0.74%                                                    | 2         | 13     | 2      |
| +0.25% to +0.49%                                                    | 69        | 51     | 16     |
| +0.10% to +0.24%                                                    | 85        | 63     | 44     |
| 0.00% to +0.09%                                                     | 84        | 104    | 173    |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240    |

## LOAD LIFE - 1000 Hour Measurement

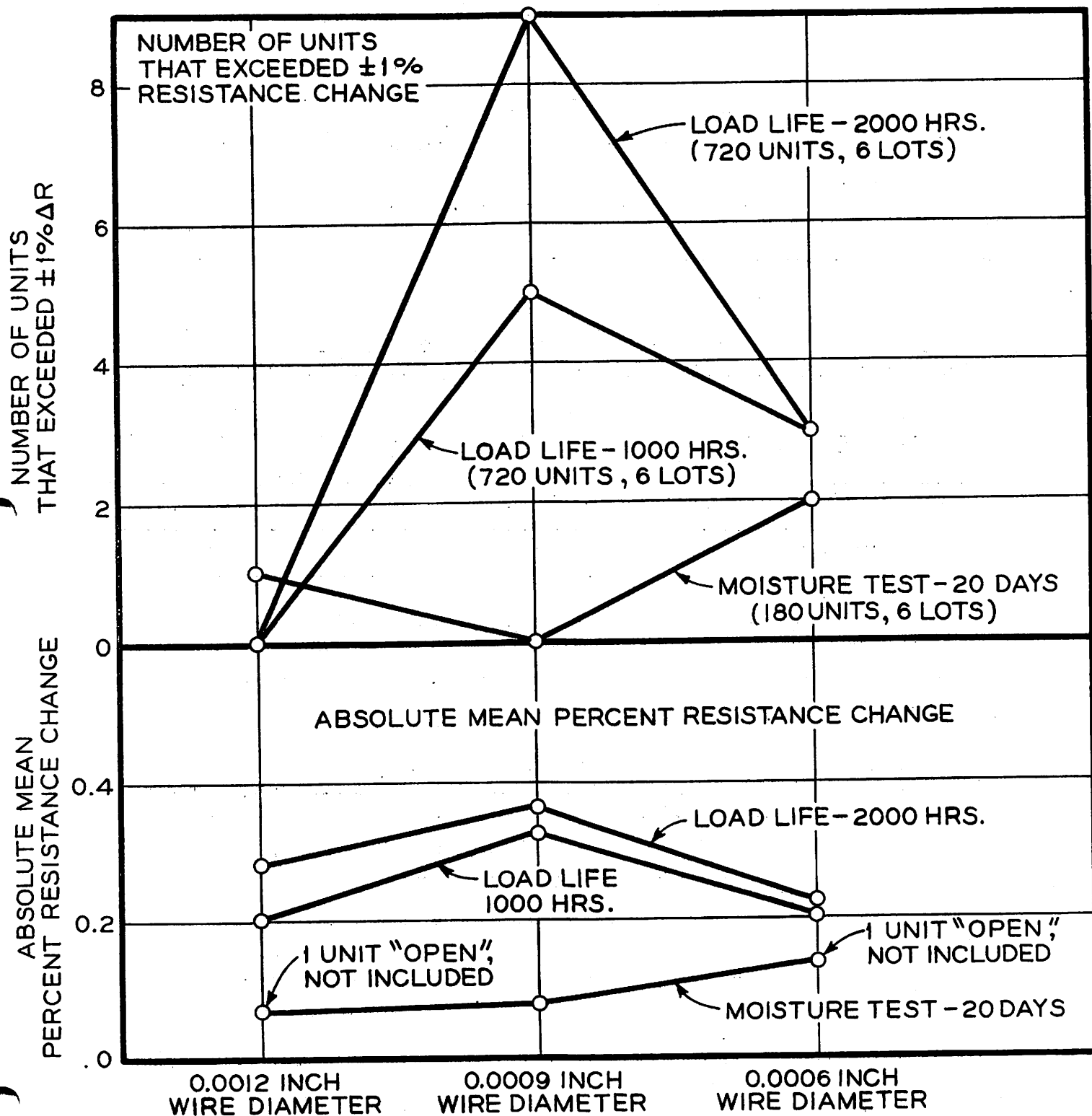
| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.510     | 19.640 | 3.050  |
| Average Maximum Percent                                             | 0.314     | 4.066  | 0.926  |
| Average Algebraic Mean Percent                                      | 0.208     | 0.124  | 0.173  |
| Average Absolute Mean Percent                                       | 0.208     | 0.326  | 0.203  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           | 1      |        |
| +2.00% to +4.99%                                                    |           |        | 1      |
| +1.00% to +1.99%                                                    |           | 4      | 2      |
| +0.75% to +0.99%                                                    |           | 10     | 4      |
| +0.50% to +0.74%                                                    | 1         | 15     | 19     |
| +0.25% to +0.49%                                                    | 103       | 50     | 60     |
| +0.10% to +0.24%                                                    | 80        | 83     | 36     |
| 0.00% to +0.09%                                                     | 56        | 77     | 118    |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240    |

# CHARACTERISTIC G

## LOAD LIFE - 2000 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.880     | 18.105 | 3.010  |
| Average Maximum Percent                                             | 0.501     | 3.811  | 0.944  |
| Average Algebraic Mean Percent                                      | 0.278     | 0.183  | 0.186  |
| Average Absolute Mean Percent                                       | 0.284     | 0.360  | 0.221  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           | 1      |        |
| +2.00% to +4.99%                                                    |           |        | 1      |
| +1.00% to +1.99%                                                    |           | 8      | 2      |
| +0.75% to +0.99%                                                    | 4         | 10     | 5      |
| +0.50% to +0.74%                                                    | 17        | 13     | 19     |
| +0.25% to +0.49%                                                    | 114       | 60     | 65     |
| +0.10% to +0.24%                                                    | 65        | 89     | 53     |
| 0.00% to +0.09%                                                     | 40        | 59     | 95     |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240    |

# EIA FINE WIRE EVALUATION PROGRAM POWER WIREWOUND RESISTORS CHAR. G PER MIL-R-26C



POWER WIREWOUND RESISTOR TYPE  
CHARACTERISTIC V

RESISTOR ENCLOSURE MATERIAL

| Material          | Number of Participants |
|-------------------|------------------------|
| Vitreous Enamel   | 1                      |
| Silicone or Epoxy | 3                      |

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

| Wire Class                                      | Number of Participants |
|-------------------------------------------------|------------------------|
| Class 1 (800 <sup>Ω</sup> /cir mil nickel base) | 3                      |
| Class 2 (800 <sup>Ω</sup> /cir mil iron base)   | -                      |
| Class 3 or 4 (60-80% nickel, 16-20% chrome)     | 1                      |
| 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    | 5,150     | 12,375 | 41,250 |
| Lowest     | 3,600     | 8,500  | 29,000 |

# CHARACTERISTIC V

## THERMAL SHOCK

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.420     | 0.210  | 1.570  |
| Average Maximum Percent                                             | 0.208     | 0.102  | 0.493  |
| Average Algebraic Mean Percent                                      | 0.042     | 0.077  | 0.033  |
| Average Absolute Mean Percent                                       | 0.069     | 0.082  | 0.048  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| ±5.00% but not open                                                 |           |        |        |
| ±2.00% to ±4.99%                                                    |           |        |        |
| ±1.00% to ±1.99%                                                    |           |        | 1      |
| ±0.75% to ±0.99%                                                    |           |        |        |
| ±0.50% to ±0.74%                                                    |           |        | 2      |
| ±0.25% to ±0.49%                                                    | 2         |        | 3      |
| ±0.10% to ±0.24%                                                    | 6         | 18     | 1      |
| 0.00% to ±0.09%                                                     | 32        | 22     | 33     |
| TOTAL UNITS REPORTED                                                | 40        | 40     | 40     |

## MOMENTARY OVERLOAD

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.420     | 0.520  | 15.110 |
| Average Maximum Percent                                             | 0.195     | 0.277  | 3.951  |
| Average Algebraic Mean Percent                                      | 0.031     | 0.025  | 0.445  |
| Average Absolute Mean Percent                                       | 0.050     | 0.053  | 0.490  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| ±5.00% but not open                                                 |           |        | 1      |
| ±2.00% to ±4.99%                                                    |           |        |        |
| ±1.00% to ±1.99%                                                    |           |        |        |
| ±0.75% to ±0.99%                                                    |           |        | 1      |
| ±0.50% to ±0.74%                                                    |           | 1      | 1      |
| ±0.25% to ±0.49%                                                    | 2         | 1      | 5      |
| ±0.10% to ±0.24%                                                    | 7         | 3      | 1      |
| 0.00% to ±0.09%                                                     | 31        | 35     | 31     |
| TOTAL UNITS REPORTED                                                | 40        | 40     | 40     |

# CHARACTERISTIC V

## MOISTURE RESISTANCE - 10 Day Measurement

| Resistance Change                                         | Wire Size |        |        |
|-----------------------------------------------------------|-----------|--------|--------|
|                                                           | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                  | 0.440     | 0.165  | 0.830  |
| Average Maximum Percent                                   | 0.258     | 0.084  | 0.329  |
| Average Algebraic Mean Percent                            | 0.057     | 0.037  | 0.080  |
| Average Absolute Mean Percent                             | 0.069     | 0.039  | 0.097  |
| Frequency Distribution<br>(Number of units in each group) |           |        |        |
| "Open"                                                    |           |        | 2      |
| ±2.00% but not open                                       |           |        |        |
| ±1.00% to ±1.99%                                          |           |        |        |
| ±0.75% to ±0.99%                                          |           |        | 1      |
| ±0.50% to ±0.74%                                          |           |        |        |
| ±0.25% to ±0.49%                                          | 2         |        | 2      |
| ±0.10% to ±0.24%                                          | 7         | 6      | 9      |
| ±0.05% to ±0.09%                                          | 6         | 6      | 4      |
| 0.00% to ±0.04%                                           | 25        | 28     | 22     |
| TOTAL UNITS REPORTED                                      | 40        | 40     | 40     |

## INSULATION RESISTANCE\*

| Resistance | Megohm |
|------------|--------|
| Maximum    | 65,300 |
| Mean       | 16,262 |
| Minimum    | 995    |

\*Based on three companies only.



# CHARACTERISTIC V

## MOISTURE RESISTANCE - 20 Day Measurement

| Resistance Change                                         | Wire Size |        |        |
|-----------------------------------------------------------|-----------|--------|--------|
|                                                           | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                  | 0.960     | 16.630 | 8.660  |
| Average Maximum Percent                                   | 0.353     | 4.234  | 2.314  |
| Average Algebraic Mean Percent                            | 0.041     | 0.462  | 0.374  |
| Average Absolute Mean Percent                             | 0.053     | 0.467  | 0.376  |
| Frequency Distribution<br>(Number of units in each group) |           |        |        |
| "Open"                                                    |           |        | 2      |
| +2.00% but not open                                       |           | 1      | 1      |
| +1.00% to +1.99%                                          | 1         |        |        |
| +0.75% to +0.99%                                          | 1         |        |        |
| +0.50% to +0.74%                                          |           |        | 1      |
| +0.25% to +0.49%                                          | 3         |        | 4      |
| +0.10% to +0.24%                                          | 7         | 7      | 11     |
| +0.05% to +0.09%                                          | 5         | 7      | 1      |
| 0.00% to +0.04%                                           | 23        | 25     | 20     |
| TOTAL UNITS REPORTED                                      | 40        | 40     | 40     |

## INSULATION RESISTANCE\*

| Resistance | Megohm  |
|------------|---------|
| Maximum    | 184,900 |
| Mean       | 62,145  |
| Minimum    | 1,482   |

\*Based on three companies only.

# CHARACTERISTIC V

## LOAD LIFE - 100 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.500     | 1.360  | 14.050 |
| Average Maximum Percent                                             | 0.385     | 0.716  | 3.942  |
| Average Algebraic Mean Percent                                      | 0.304     | 0.235  | 0.225  |
| Average Absolute Mean Percent                                       | 0.304     | 0.280  | 0.328  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           |        | 1      |
| +2.00% to +4.99%                                                    |           |        |        |
| +1.00% to +1.99%                                                    |           | 1      | 5      |
| +0.75% to +0.99%                                                    |           |        | 3      |
| +0.50% to +0.74%                                                    | 1         | 8      | 7      |
| +0.25% to +0.49%                                                    | 111       | 83     | 51     |
| +0.10% to +0.24%                                                    | 7         | 26     | 27     |
| 0.00% to +0.09%                                                     | 41        | 42     | 66     |
| TOTAL UNITS REPORTED                                                | 160       | 160    | 160    |

## LOAD LIFE - 250 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.950     | 6.140  | 27.200 |
| Average Maximum Percent                                             | 0.576     | 1.955  | 7.321  |
| Average Algebraic Mean Percent                                      | 0.422     | 0.259  | 0.330  |
| Average Absolute Mean Percent                                       | 0.422     | 0.387  | 0.429  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           | 1      | 1      |
| +2.00% to +4.99%                                                    |           |        |        |
| +1.00% to +1.99%                                                    |           | 1      | 4      |
| +0.75% to +0.99%                                                    | 1         | 1      | 3      |
| +0.50% to +0.74%                                                    | 72        | 50     | 11     |
| +0.25% to +0.49%                                                    | 46        | 56     | 56     |
| +0.10% to +0.24%                                                    | 1         | 17     | 11     |
| 0.00% to +0.09%                                                     | 40        | 34     | 74     |
| TOTAL UNITS REPORTED                                                | 160       | 160    | 160    |

# CHARACTERISTIC V

## LOAD LIFE - 500 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 1.000     | 5.710  | 26.100 |
| Average Maximum Percent                                             | 0.641     | 1.874  | 7.042  |
| Average Algebraic Mean Percent                                      | 0.512     | 0.327  | 0.268  |
| Average Absolute Mean Percent                                       | 0.512     | 0.439  | 0.442  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           | 1      | 1      |
| +2.00% to +4.99%                                                    |           |        |        |
| +1.00% to +1.99%                                                    | 1         | 1      | 2      |
| +0.75% to +0.99%                                                    | 33        | 12     | 5      |
| +0.50% to +0.74%                                                    | 77        | 59     | 11     |
| +0.25% to +0.49%                                                    | 8         | 40     | 54     |
| +0.10% to +0.24%                                                    | 8         | 12     | 32     |
| 0.00% to +0.09%                                                     | 33        | 35     | 54     |
| TOTAL UNITS REPORTED                                                | 160       | 160    | 160    |

## LOAD LIFE - 1000 Hour Measurement

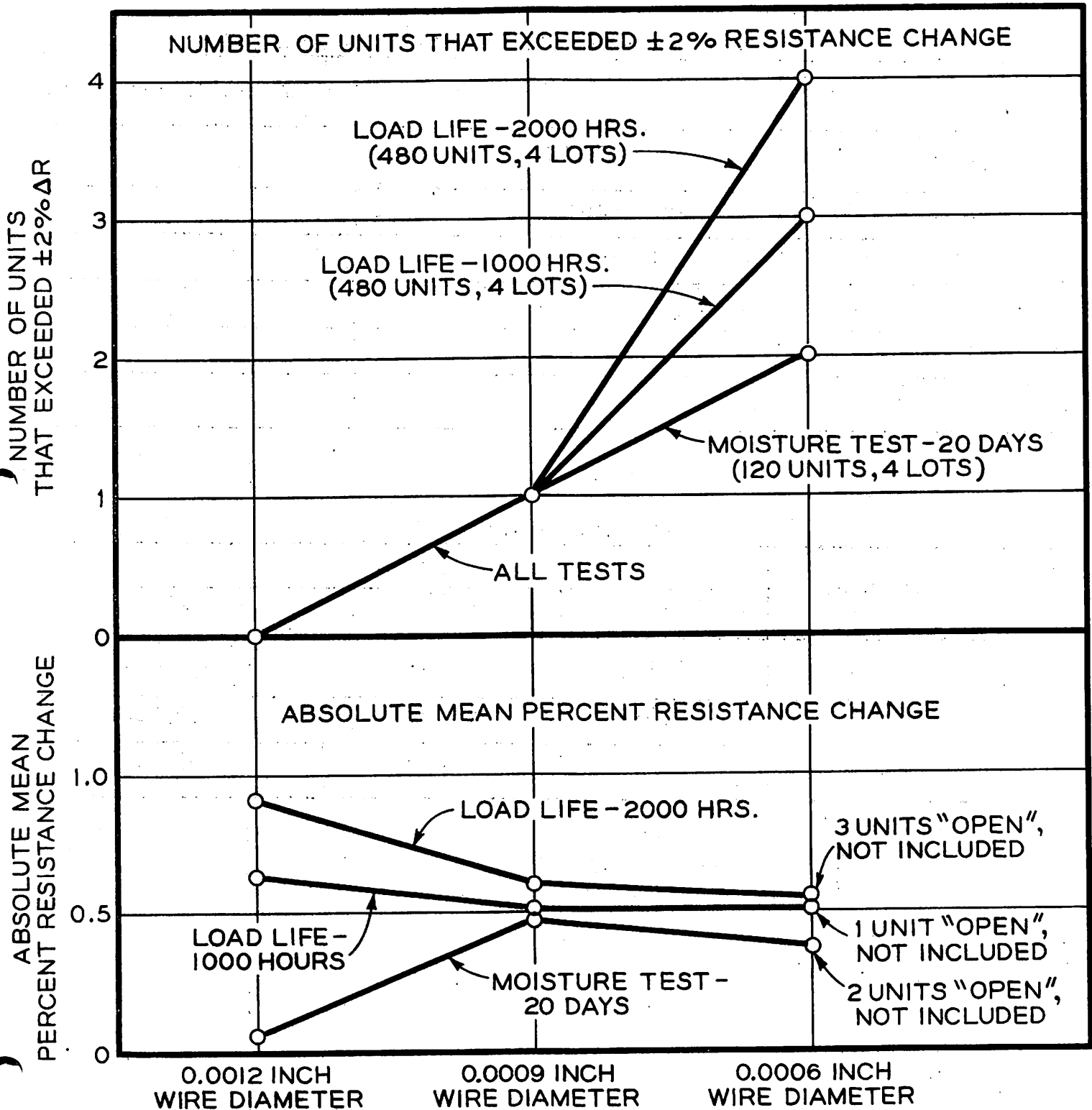
| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 1.400     | 5.460  | 25.520 |
| Average Maximum Percent                                             | 0.791     | 1.863  | 6.912  |
| Average Algebraic Mean Percent                                      | 0.643     | 0.400  | 0.268  |
| Average Absolute Mean Percent                                       | 0.643     | 0.505  | 0.517  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +5.00% but not open                                                 |           | 1      | 1      |
| +2.00% to +4.99%                                                    |           |        |        |
| +1.00% to +1.99%                                                    | 35        | 9      | 2      |
| +0.75% to +0.99%                                                    | 17        | 13     | 5      |
| +0.50% to +0.74%                                                    | 64        | 68     | 41     |
| +0.25% to +0.49%                                                    | 3         | 26     | 28     |
| +0.10% to +0.24%                                                    | 41        | 20     | 55     |
| 0.00% to +0.09%                                                     |           | 23     | 27     |
| TOTAL UNITS REPORTED                                                | 160       | 160    | 160    |

# CHARACTERISTIC V

## LOAD LIFE - 2000 Hour Measurement

| Resistance Change                                         | Wire Size |        |        |
|-----------------------------------------------------------|-----------|--------|--------|
|                                                           | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                  | 1.860     | 4.950  | 24.850 |
| Average Maximum Percent                                   | 1.002     | 1.733  | 6.726  |
| Average Algebraic Mean Percent                            | 0.815     | 0.510  | 0.252  |
| Average Absolute Mean Percent                             | 0.815     | 0.598  | 0.550  |
| Frequency Distribution<br>(Number of units in each group) |           |        |        |
| "Open"                                                    |           |        | 3      |
| +5.00% but not open                                       |           |        | 1      |
| +2.00% to +4.99%                                          |           | 1      |        |
| +1.00% to +1.99%                                          | 39        | 17     | 3      |
| +0.75% to +0.99%                                          | 27        | 20     | 14     |
| +0.50% to +0.74%                                          | 52        | 62     | 50     |
| +0.25% to +0.49%                                          | 26        | 23     | 32     |
| +0.10% to +0.24%                                          | 16        | 36     | 50     |
| 0.00% to +0.09%                                           |           | 1      | 7      |
| TOTAL UNITS REPORTED                                      | 160       | 160    | 160    |

# EIA FINE WIRE EVALUATION PROGRAM POWER WIREWOUND RESISTORS CHAR. V PER MIL-R-26C



PRECISION WIREWOUND RESISTOR TYPE

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

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

RESISTANCE VALUES

| Resistance | Wire Size |         |           |
|------------|-----------|---------|-----------|
|            | 0.0012    | 0.0009  | 0.0006    |
| Highest    | 68,800    | 250,000 | 1,250,000 |
| Average    | 50,633    | 188,500 | 750,000   |
| Lowest     | 30,000    | 100,000 | 300,000   |

# PRECISION WIREWOUND RESISTOR TYPE

## SHORT TIME OVERLOAD

| Resistance Change                                         | Wire Size |        |        |
|-----------------------------------------------------------|-----------|--------|--------|
|                                                           | 0.0012*   | 0.0009 | 0.0006 |
| Absolute Highest Percent                                  | 0.030     | 0.040  | 0.040  |
| Average Maximum Percent                                   | 0.007     | 0.014  | 0.020  |
| Average Algebraic Mean Percent                            | 0.004     | 0.006  | 0.000  |
| Average Absolute Mean Percent                             | 0.004     | 0.008  | 0.011  |
| Frequency Distribution<br>(Number of units in each group) |           |        |        |
| "Open"                                                    |           |        |        |
| +2.00% but not open                                       |           |        |        |
| +1.00% to +1.99%                                          |           |        |        |
| +0.75% to +0.99%                                          |           |        |        |
| +0.50% to +0.74%                                          |           |        |        |
| +0.25% to +0.49%                                          |           |        |        |
| +0.10% to +0.24%                                          |           |        |        |
| +0.05% to +0.09%                                          |           |        |        |
| 0.00% to +0.04%                                           | 59        | 60     | 60     |
| TOTAL UNITS REPORTED                                      | 59        | 60     | 60     |

## TEMPERATURE CYCLING

| Resistance Change                                         | Wire Size |        |        |
|-----------------------------------------------------------|-----------|--------|--------|
|                                                           | 0.0012*   | 0.0009 | 0.0006 |
| Absolute Highest Percent                                  | 0.020     | 0.100  | 0.050  |
| Average Maximum Percent                                   | 0.009     | 0.023  | 0.017  |
| Average Algebraic Mean Percent                            | -0.001    | -0.016 | -0.003 |
| Average Absolute Mean Percent                             | 0.005     | 0.016  | 0.005  |
| Frequency Distribution<br>(Number of units in each group) |           |        |        |
| "Open"                                                    |           |        |        |
| +2.00% but not open                                       |           |        |        |
| +1.00% to +1.99%                                          |           |        |        |
| +0.75% to +0.99%                                          |           |        |        |
| +0.50% to +0.74%                                          |           |        |        |
| +0.25% to +0.49%                                          |           |        |        |
| +0.10% to +0.24%                                          |           |        |        |
| +0.05% to +0.09%                                          |           |        | 1      |
| 0.00% to +0.04%                                           | 59        | 60     | 59     |
| TOTAL UNITS REPORTED                                      | 59        | 60     | 60     |

\*One company tested only nine units.

# PRECISION WIREWOUND RESISTOR TYPE

## MOISTURE RESISTANCE - 10 Day Measurement\*

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.025     | 0.010  | 0.203  |
| Average Maximum Percent                                             | 0.015     | 0.006  | 0.079  |
| Average Algebraic Mean Percent                                      | 0.001     | 0.004  | 0.017  |
| Average Absolute Mean Percent                                       | 0.004     | 0.004  | 0.021  |
| Frequency Distribution<br>(Number of units in each group<br>"Open") |           |        |        |
| +2.00% but not open                                                 |           |        |        |
| +1.00% to +1.99%                                                    |           |        |        |
| +0.75% to +0.99%                                                    |           |        |        |
| +0.50% to +0.74%                                                    |           |        |        |
| +0.25% to +0.49%                                                    |           |        |        |
| +0.10% to +0.24%                                                    |           |        | 2      |
| +0.05% to +0.09%                                                    |           |        | 1      |
| 0.00% to +0.04%                                                     | 30        | 30     | 27     |
| TOTAL UNITS REPORTED                                                | 30        | 30     | 30     |

\*Based on three companies only.

## INSULATION RESISTANCE\*\*

| Resistance | Megohm |
|------------|--------|
| Maximum    | NA     |
| Mean       | NA     |
| Minimum    | NA     |

\*\*Insufficient participation.



# PRECISION WIREWOUND RESISTOR TYPE

## MOISTURE RESISTANCE - 20 Day Measurement\*

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.025     | 0.052  | 0.334  |
| Average Maximum Percent                                             | 0.017     | 0.019  | 0.140  |
| Average Algebraic Mean Percent                                      | 0.002     | 0.005  | 0.010  |
| Average Absolute Mean Percent                                       | 0.004     | 0.007  | 0.039  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +2.00% but not open                                                 |           |        |        |
| +1.00% to +1.99%                                                    |           |        |        |
| +0.75% to +0.99%                                                    |           |        |        |
| +0.50% to +0.74%                                                    |           |        |        |
| +0.25% to +0.49%                                                    |           |        | 1      |
| +0.10% to +0.24%                                                    |           |        | 8      |
| +0.05% to +0.09%                                                    |           | 1      | 1      |
| 0.00% to +0.04%                                                     | 40        | 39     | 30     |
| TOTAL UNITS REPORTED                                                | 40        | 40     | 40     |

\*Based on four companies only.

## INSULATION RESISTANCE\*

| Resistance | Megohm |
|------------|--------|
| Maximum    | 81,666 |
| Mean       | 39,333 |
| Minimum    | 5,200  |

\*Based on four companies only.

# PRECISION WIREWOUND RESISTOR TYPE

## LOAD LIFE - 100 Hour Measurement

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 0.113     | 0.179  | 3.060  |
| Average Maximum Percent                                             | 0.067     | 0.071  | 0.551  |
| Average Algebraic Mean Percent                                      | 0.008     | 0.009  | 0.009  |
| Average Absolute Mean Percent                                       | 0.011     | 0.014  | 0.039  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +2.00% but not open                                                 |           |        | 2      |
| +1.00% to +1.99%                                                    |           |        |        |
| +0.75% to +0.99%                                                    |           |        |        |
| +0.50% to +0.74%                                                    |           |        |        |
| +0.25% to +0.49%                                                    |           |        |        |
| +0.10% to +0.24%                                                    | 5         | 3      | 7      |
| +0.05% to +0.09%                                                    | 5         | 9      | 7      |
| 0.00% to +0.04%                                                     | 230       | 228    | 224    |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240    |

## LOAD LIFE - 250 Hour Measurement

| Resistance Change                                                   | Wire Size |        |             |
|---------------------------------------------------------------------|-----------|--------|-------------|
|                                                                     | 0.0012    | 0.0009 | 0.0006      |
| Absolute Highest Percent                                            | 0.250     | 0.700  | 0.110       |
| Average Maximum Percent                                             | 0.105     | 0.236  | 0.048       |
| Average Algebraic Mean Percent                                      | 0.012     | 0.022  | 0.012       |
| Average Absolute Mean Percent                                       | 0.017     | 0.031  | 0.015       |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        | 1 (Shorted) |
| +2.00% but not open                                                 |           |        |             |
| +1.00% to +1.99%                                                    |           |        |             |
| +0.75% to +0.99%                                                    |           |        |             |
| +0.50% to +0.74%                                                    |           | 1      |             |
| +0.25% to +0.49%                                                    | 1         |        |             |
| +0.10% to +0.24%                                                    | 1         | 8      | 1           |
| +0.05% to +0.09%                                                    | 10        | 39     | 8           |
| 0.00% to +0.04%                                                     | 228       | 192    | 230         |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240         |

# PRECISION WIREWOUND RESISTOR TYPE

## LOAD LIFE - 500 Hour Measurement\*

| Resistance Change                                                   | Wire Size |        |             |
|---------------------------------------------------------------------|-----------|--------|-------------|
|                                                                     | 0.0012    | 0.0009 | 0.0006      |
| Absolute Highest Percent                                            | 0.250     | 0.272  | 3.070       |
| Average Maximum Percent                                             | 0.202     | 0.127  | 0.680       |
| Average Algebraic Mean Percent                                      | 0.015     | 0.026  | -0.028      |
| Average Absolute Mean Percent                                       | 0.017     | 0.032  | 0.042       |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        | 1 (Shorted) |
| +2.00% but not open                                                 |           |        | 2           |
| +1.00% to +1.99%                                                    |           |        |             |
| +0.75% to +0.99%                                                    |           |        |             |
| +0.50% to +0.74%                                                    |           |        |             |
| +0.25% to +0.49%                                                    | 1         | 1      |             |
| +0.10% to +0.24%                                                    | 3         | 13     | 5           |
| +0.05% to +0.09%                                                    | 6         | 33     | 6           |
| 0.00% to +0.04%                                                     | 190       | 153    | 186         |
| TOTAL UNITS REPORTED                                                | 200       | 200    | 200         |

\*Based on five companies only.

## LOAD LIFE - 1000 Hour Measurement

| Resistance Change                                                   | Wire Size |        |             |
|---------------------------------------------------------------------|-----------|--------|-------------|
|                                                                     | 0.0012    | 0.0009 | 0.0006      |
| Absolute Highest Percent                                            | 0.250     | 1.100  | 3.110       |
| Average Maximum Percent                                             | 0.113     | 0.315  | 0.633       |
| Average Algebraic Mean Percent                                      | 0.026     | 0.026  | -0.034      |
| Average Absolute Mean Percent                                       | 0.027     | 0.041  | 0.052       |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        | 2 (Shorted) |
| +2.00% but not open                                                 |           |        | 2           |
| +1.00% to +1.99%                                                    |           | 1      |             |
| +0.75% to +0.99%                                                    |           |        |             |
| +0.50% to +0.74%                                                    |           |        | 1           |
| +0.25% to +0.49%                                                    | 1         | 3      |             |
| +0.10% to +0.24%                                                    | 1         | 16     | 5           |
| +0.05% to +0.09%                                                    | 20        | 42     | 9           |
| 0.00% to +0.04%                                                     | 218       | 178    | 221         |
| TOTAL UNITS REPORTED                                                | 240       | 240    | 240         |

# PRECISION WIREWOUND RESISTOR TYPE

## LOAD LIFE - 2000 Hour Measurement\*

| Resistance Change                                                   | Wire Size |        |        |
|---------------------------------------------------------------------|-----------|--------|--------|
|                                                                     | 0.0012    | 0.0009 | 0.0006 |
| Absolute Highest Percent                                            | 10.800    | 0.412  | 2.390  |
| Average Maximum Percent                                             | 0.310     | 0.181  | 0.507  |
| Average Algebraic Mean Percent                                      | 0.088     | 0.037  | -0.041 |
| Average Absolute Mean Percent                                       | 0.090     | 0.048  | 0.059  |
| Frequency Distribution<br>(Number of units in each group)<br>"Open" |           |        |        |
| +2.00% but not open                                                 | 1         |        | 2      |
| +1.00% to +1.99%                                                    |           |        |        |
| +0.75% to +0.99%                                                    |           |        |        |
| +0.50% to +0.74%                                                    |           |        |        |
| +0.25% to +0.49%                                                    | 1         | 6      |        |
| +0.10% to +0.24%                                                    | 1         | 25     | 34     |
| +0.05% to +0.09%                                                    | 58        | 33     | 9      |
| 0.00% to +0.04%                                                     | 139       | 136    | 155    |
| TOTAL UNITS REPORTED                                                | 200       | 200    | 200    |

\*Based on five companies only.

**EIA FINE WIRE EVALUATION PROGRAM  
PRECISION WIREWOUND RESISTORS  
PER MIL-R-93C**

