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EFFECT OF THE WIRE DIAMETER ON WIREWOUND RESISTORS RELIABILITY

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 manufacturerd 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 erractic 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 (800Ω /cir mil nickel base)	6
Class 2 (800Ω /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.

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 (Number of units in each group) "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 (Number of units in each group) "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 (Number of units in each group) "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

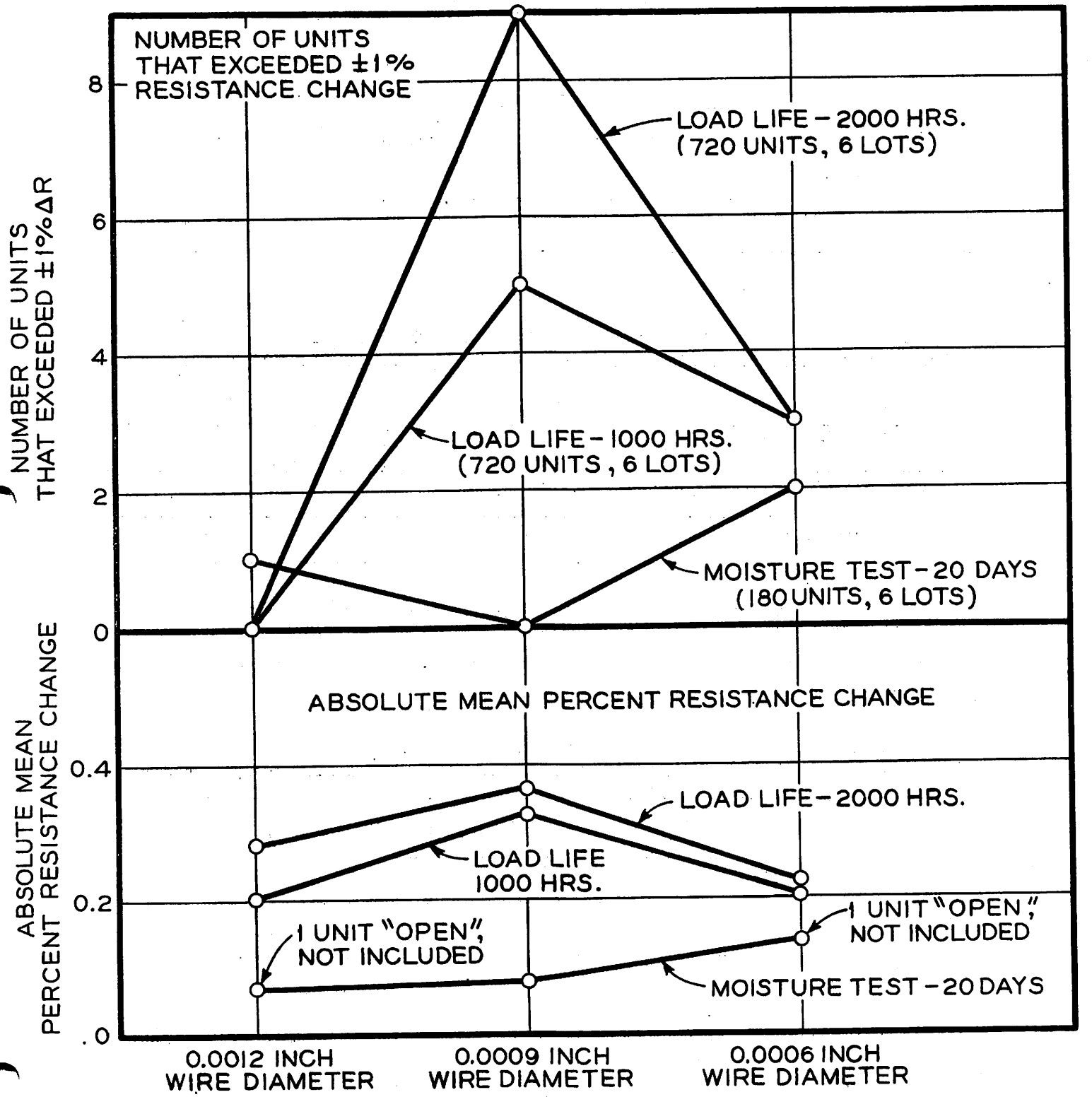
Resistance Change	Wire Size		
	0.0012	0.0009	0.0006
Absolute Highest Percent	0.510	19.640	3.050
Average Maximum Percent	0.314	4.066	0.926
Average Algebraic Mean Percent	0.208	0.124	0.173
Average Absolute Mean Percent	0.208	0.326	0.203
Frequency Distribution (Number of units in each group) "Open"			
±5.00% 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 (Number of units in each group) "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 (800Ω /cir mil nickel base)	3
Class 2 (800Ω /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 (Number of units in each group) "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 (Number of units in each group) "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 (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 (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 (Number of units in each group) "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 (Number of units in each group) "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 (Number of units in each group) "Open"			1
±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

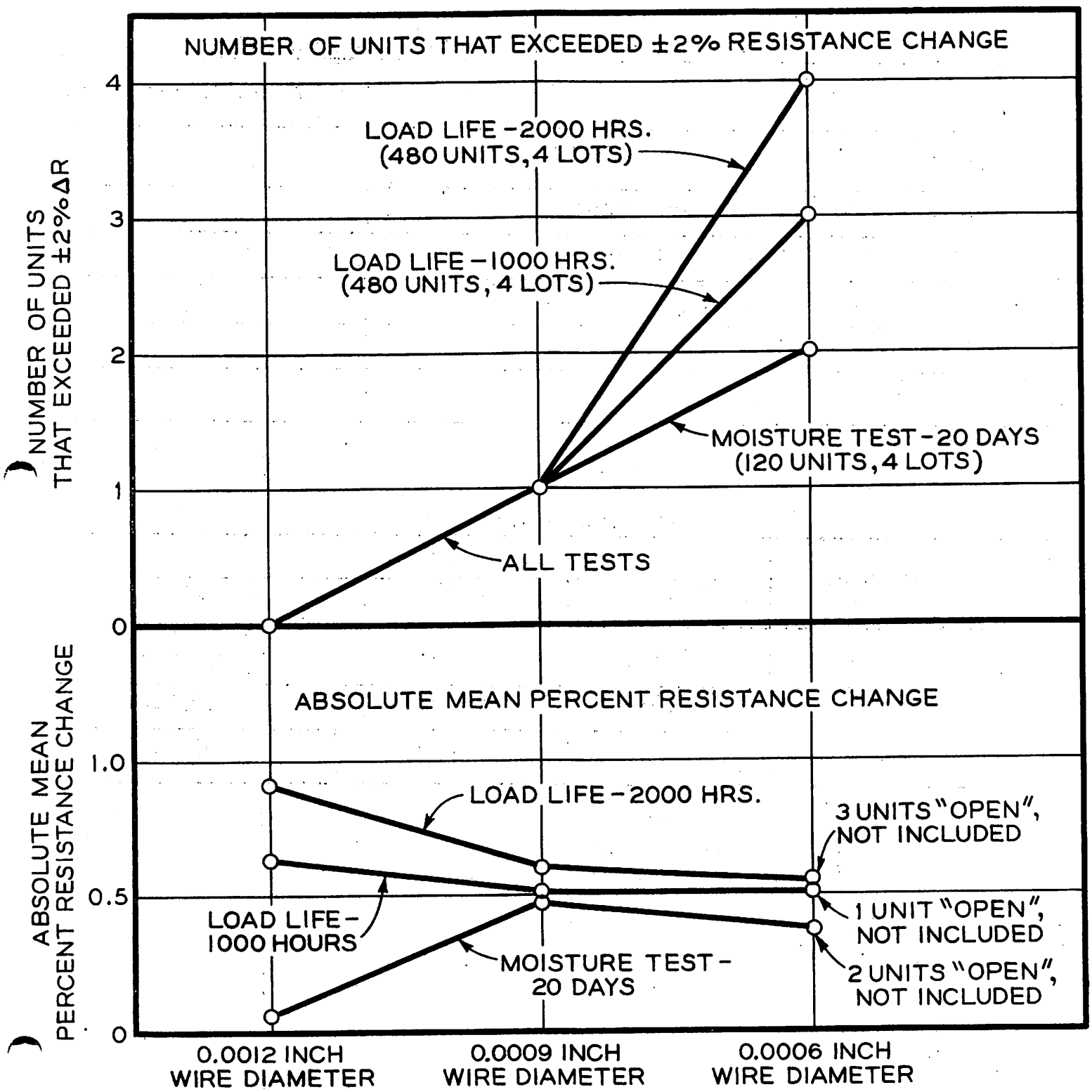
Resistance Change	Wire Size		
	0.0012	0.0009	0.0006
Absolute Highest Percent	1.400	5.460	25.520
Average Maximum Percent	0.791	1.863	6.912
Average Algebraic Mean Percent	0.643	0.400	0.268
Average Absolute Mean Percent	0.643	0.505	0.517
Frequency Distribution (Number of units in each group) "Open"			1
±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 (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 (800Ω /cir mil nickel base)	5
Class 2 (800Ω /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 (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 (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 (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%			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 (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%			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 (Number of units in each group) "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 (Number of units in each group) "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 (Number of units in each group) "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 (Number of units in each group) "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

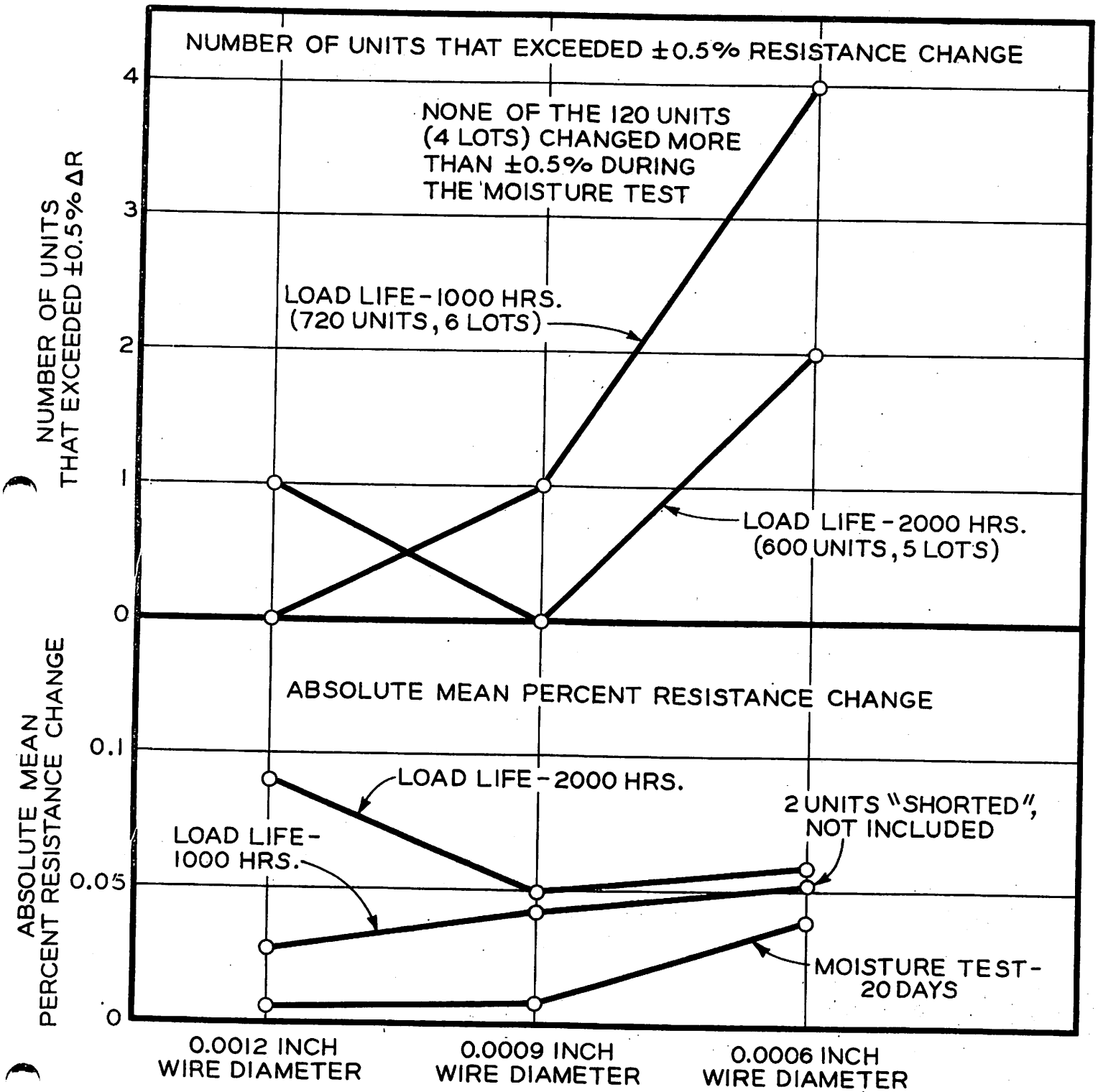
PRECISION WIREWOUND RESISTOR TYPE

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 (Number of units in each group) "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

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