WADC TECHNICAL REPORT 52-142 May 1953

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The following correction is applicable to WADC Technical Report 52-142, "Post-Molding Shrinkage Characteristics of Some Thermosetting Plastic Molding Materials", dated May 1953.

Delete the designation: "Bakelite BM-120" on pages 2, 4, 6, 8, 10, 16, 18 and substitute for that designation the following: "Bakelite mica-filled phenolic".

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

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WADC TECHNICAL REPORT 52-142

POST-MOLDING SHRINKAGE CHARACTERISTICS OF SOME THERMOSETTING PLASTIC MOLDING MATERIALS

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Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

McGregor & Werner, Inc., Dayton, O.
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FOREWORD

This report was initiated under Research and Development Order No. 614-12, "Structural Plastics MX 1925", and was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center with Steven T. Marshall, 2/Lt. and Charles P. Ellis, Jr. acting as project engineers.

ABSTRACT

The dimensional stability as to post-molding shrinkage of commercially available melamine, phenolic and polyester plastic molding materials was investigated by means of accelerated conditioning procedures which produced shrinkage corresponding to that obtained on parts in service in long-time aging. It is concluded, that of the materials tested, the polyester mineral filled molding material demonstrated the greatest degree of dimensional stability.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

M. E. SORTE
Colonel, USAF
Chief, Materials Laboratory
Directorate of Research

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INTRODUCTION

Thermosetting plastic molding materials are used in a wide variety of electrical and non-structural applications in aircraft, because of their mechanical, electrical and physical properties and molding characteristics. Although extensive mechanical and electrical test programs on these materials have been carried out in the past, the dimensional stability properties have received little emphasis. However, with the increasing necessity of maintainence of close tolerances in molded parts information on the dimensional stability properties of molded thermosetting plastics is required. In particular, extensive unsatisfactory service has been experienced in aircraft due to dimensional changes of molded plastic parts. These have in some cases been due to expansion from moisture absorption in high humidity exposure, or to shrinkage due to long time aging under conditions in which continuous exposure to this humidity was not involved.

The latter dimensional change is termed post-mold shrinkage because it represents internal changes such as further curing or polymerization occuring over a long period of time. It can be observed in the laboratory as an accelerated test by elevated temperature exposure. This report covers an investigation on this shrinkage problem. An investigation of the exposed dimensional changes of plastic molding material at high humidity will be covered in a supplement to this report.

The present investigation was undertaken to determine, in particular, the dimensional stability of molded dielectric insert materials for use as a dielectric material in AN type multi-pin electrical connectors meeting requirements of Military Specification MIL-C-5015. Commercial resin manufacturers and fabricators submitted samples of experimental and commercially available molding compounds in the form of both AN type connector inserts and standard test bars.

The courtesy of the American Cyanamid Company; American Phenolic Corporation; Bakelite Division, Union Carbide and Carbon Corporation; Cannon Electric Company; Durez Plastics and Chemicals, Incorporated; Monowatt, Incorporated; Monsanto Chemical Company; and the Plaskon Division, Libbey-Owens-Ford Glass Company in furnishing materials for use in this investigation is acknowledged.

MATERIALS

The molding compounds whose properties were investigated in this program are described as follows:

Melmac 592:	Manufactured by the American Cyanamid Company. The material is a brown colored, mineral filled melamine plastic.

Melmac 1500:	Manufactured by the American Cyanamid Company. The material is a brown colored, wood cellulose filled melamine plastic.
Melmac 1502:	Manufactured by the American Cyanamid Company. The material is a brown colored, alpha cellulose filled melamine plastic.
Amphenol 1501:	Manufactured for the American Phenolic Corporation. The material is a blue colored, asbestos filled diallyl phthalate plastic.
Durez 12810:	Manufactured by Durez Plastics and Chemicals, Inc. The material is a yellow brown phenolic plastic.
Bakelite ~~BM-120~~: mica-filled phenolic	Manufactured by the Bakelite Division, Union Carbide and Carbon Company. The material is a black, mica filled phenolic plastic.
Plaskon 422:	Manufactured by the Plaskon Division, Libbey-Owens-Ford Glass Company. The material is a yellow, mineral filled alhyd plastic.
Resimene 803A:	Manufactured by the Monsanto Chemical Company. The material is a light brown colored wood cellulose filled melamine plastic.
Resimene L11284:	Manufactured by the Monsanto Chemical Company. The material is a light brown colored experimental mineral filled melamine plastic.

The materials were submitted as either molded AN type connector insert disks with nominal diameters of 0.77 to 1.83 inches or as standard molded bars (5" x 1/2" x 1/2") or both. The physical appearance of molded inserts are described in Table I and in Military Specification MIL-C-5015 and drawings applicable thereto. The molding data on these inserts are presented in Tables 2, 3, and 4 with data from each fabricator presented in separate tables. Connector fabricators participating in this program are American Phenolic Corp., Cannon Electric Company, and Monowatt Incorporated, Molding data on the standard bars are not available. Since the bars were molded by the resin manufacturer, it is assumed that they were molded under conditions that produce a specimen of optimum over all properties.

DEFINITIONS

The dimensional stability with which this report is concerned is defined as the ability of a thermosetting plastic material to resist shrinkage when that material is subjected to elevated temperature conditioning of such a magnitude and duration as to simulate the affects of prolonged aging and yet not of sufficient magnitude to decompose the resin.

The lack of complete dimensional stability is expressed as shrinkage with all data given as percent of original dimension.

TEST PROCEDURES

Dimensional Stability Tests:

The submitted test specimens of molded AN type connector inserts were tested for elevated temperature dimensional stability as follows: The specimens were first conditioned for a minimum of three days at 23± 1.1°Centigrade and 50 ± 4% relative humidity. This conditioning shall hereinafter be referred to as standard conditioning. Following standard conditioning, the specimen diameter was measured to the nearest 0.0001 inch with micrometer calipers. Two diameter measurements at right angles to each other were taken on each specimen. The specimens were then cycled 8 hours at 125°C. followed by 16 hours at standard conditioning. Diameter measurements were made periodically at the end of a cycle throughout the test period until the completion of 30 cycles. Shrinkage was recorded as percent original diameter. These data appear in Table VI.

The molded 5" x 1/2" x 1/2" standard test bars were first machined so that their ends were smooth and parallel. The specimens were then subjected to standard conditioning for a period of at least three days. The initial length was then measured to the nearest 0.0001 inch over the five inch dimension.

Following this initial conditioning and measurement, the specimens were divided into two groups, the first of which was then cycled 48 hours at 125°C. plus 24 hours at standard conditioning whereas the second group was cycled 48 hours at 100°C. plus 24 hours at standard conditioning. Length measurements were taken of all specimens at the completion of each cycle. The data obtained are shown in Table VII and Figure 2, and Table VIII and Figure 3 for groups 1 and 2 respectively.

In the case of both the insert test specimens and the molded bars, all elevated temperature conditioning was performed in a forced draft oven, with the specimens so distributed that there was a free flow of air past the specimens at all times. The specimens were shielded from the heating elements by asbestos board.

RESULTS AND DISCUSSION

Data on the post-molding shrinkage of AN connector inserts after cycling through periods of 8 hours at 125°C. plus 16 hours at standard conditioning, are presented in Table VI. A representative portion of this data is shown graphically in Figure 1. Data on the post-molding shrinkage of standard 5" x 1/2" x 1/2" test bars after cycling through periods of 48 hours at 125°C. plus 24 hours at standard conditions are given in Table VII. These data are plotted graphically in Figure 2. Data on the shrinkage of standard test bars after cycling through periods of 48 hours at 100°C. plus 24 hours at standard conditions are presented in Table VIII. These data are plotted graphically in Figure 3.

Shrinkage of AN Connector Inserts:

From the data in Table VI, it may be seen that there is no apparent correlation between insert shrinkage for a particular molding material and insert nominal diameter. In addition, a comparison of the insert description in Table I with the corresponding shrinkage data in Table VI shows that for a particular insert nominal diameter and molding material, there is no apparent correlation between shrinkage and the number of holes in the specimen.

From the data presented graphically in Figure 1, it is shown that the shrinkage of the wood cellulose filled melamine molding materials, Melmac 1500 and Resimene 803A, is independent of material fabricator or fabricating technique. All specimens of these materials showed 1.6 to 1.7 percent shrinkage after 30 periods of cycling 8 hours at 125°C. plus 16 hours of standard conditioning. The rate of shrinkage of these materials decreased continuously as the number of cycling periods increased by at the completion of 30 cycles, the material was still shrinking at the rate of 0.03 percent per cycle.

Curve 8 of Figure 1 shows graphically the shrinkage data of sample 4F in Table VI. This sample, molded by Monowatt (Incorporated), of Melmac 1500 was, as shown in Table V, post-mold treated for 18 hours at 105 - 110° C. prior to being subjected to the test cycling. The range of values obtained on the individual specimens shows that one specimen demonstrated unusually high shrinkage (2.76 percent after 30 cycles) and the average of the various test measurements is therefore unusually high. In general, the decrease in post-mold shrinkage of wood flour filled melamic by the postcure treatment as applied by Monowatt Inc. was slight and in one case the shrinkage ran unusually high.

Curve 3 of Figure 1 represents a mineral filled melamine, Melmac 592, which demonstrated a maximum average shrinkage of 0.66% after 30 cycling periods of 8 hours at 125° C. plus 16 hours of standard conditioning.

Curve 4 represents mica filled bakelite, average shrinkage of 0.4% after 30 cycling periods.

Curve 5 represents the shrinkage characteristics of an asbestos filled diallyl phthalate, Amphenol 1-501, whose maximum shrinkage is shown to be 0.2%

Curve 6 represents a phenolic material, Durez 12810, which demonstrates a shrinkage of 0.14% after 30 cycles of temperature conditioning.

Bakelite mica-filled

The materials represented by curves 4, 5 and 6 (BM120, Amphenol 1-501, and Durez 12810) are the only materials tested as molded AN connector insert disks whose shrinkage curves have distinctly leveled out to a negligible rate of shrinkage. In the case of the former material this leveling out occured after 20 cycling periods, whereas the shrinkage curves of the latter two materials leveled out after 14 cycling periods.

Shrinkage of Standard Test Bars:

A. Cycles of 48 hours at 125°C. + 24 hours at standard conditions.-

From curves 1 and 2 of Figure 2, it may be seen that there is little difference in the shrinkage properties of the two wood flour filled melamines, Resimene 803A and Melmac 1500. Both these materials demonstrate shrinkage in the vicinity of 1.2% after seven cycling periods.

Curves 3, 4, and 5 represent mineral filled melamines. Curve 3 represents Resimene L11284 while curves 4 and 5 represent two production runs of Melmac 592. The shrinkage of these materials lie in the range of 0.6 - 0.8% after seven cycling periods. There is a consistent spread of 0.2% shrinkage between the two production runs of Melmac 592.

Curves 6 and 7 represent two production runs of alpha cellulose filled melamine, Melmac 1502. These specimens demonstrated shrinkage properties after seven cycling periods of from 0.26 to 0.42%. There was consistent difference in excess of 0.1% shrinkage between the two separate production runs of the material.

Curves 8 and 9 represent the shrinkage properties of the mineral filled polyester type materials, Amphenol 1-501 and Plaskon 422. These materials demonstrated shrinkage properties in the vicinity of 0.1%.

Of the materials tested under the above conditioning, only those materials represented by curves 8 and 9 of Figure 2, Ampheono 1-501 and Plaskon 422, demonstrate shrinkage rates approaching zero at the completion of seven cycling periods. All other materials tested under these conditions continued to shrink at an appreciable but ever decreasing rates.

B. Cycles of 48 hours at 100°C. + 24 hours at standard conditions.-

As in the previous tests cited the wood flour filled melamine materials, Resimene 803A and Melmac 1500, as represented by Figure 3, curves 1 and 2 respectively, demonstrated the greatest amount of shrinkage. After four cycles of the above conditioning, the shrinkage of these materials was in the vicinity of 0.8%.

The mineral filled melamines, Resimene L11284 and Melmac 592 are represented by curves 3 and 4 respectively of Figure 3. The shrinkage of these materials after four cycling periods at the above conditions is in the vicinity of 0.4%.

Curves 5 and 6 of Figure 3 represent the two production runs of Melmac 1502. A spread of shrinkage properties of nearly 0.2% after four cycling periods exists between the two batches. The average of the shrinkage of these two batches is approximately 0.15% after four cycling periods.

In no case did the rate of shrinkage of the materials tested under the above conditions approach a negligible rate within the four cycling periods.

Correlation of Test Results.-

From a comparison of the data presented in Figures 2 and 3, it may be seen that an alteration of the elevated cycling temperature from 125°C. to 100°C. serves merely to decrease the rate of material shrinkage and does not in any other way serve to alter the shrinkage problem involved.

From a comparison of the data presented in Figures 1 and 2, it may be seen that, for any given total post-curing time at 125°C., the diametrical shrinkage of a round specimen appears to be greater than the longitudinal shrinkage of a bar specimen.

Reproducibility of Test Results.-

From a comparison of the data presented in Tables 6, 7, and 8, it may be seen that the range of test data obtained from standard test bars is far more narrow than the range of test data obtained on molded AN connector inserts. This may be attributed to the fact that accurate, reproducible micrometer readings were difficult to obtain from the insert disks whereas measurements of the standard test bars were made with ease.

CONCLUSIONS

The polyester type molding materials, represented herein by Plaskon 422 and Amphenol 1-501, demonstrate far less post-molding shrinkage than other materials tested. In no case were test bars molded of polyester material observed to shrink in excess of 0.14%. In no case was Plaskon 422 observed to shrink in excess of 0.09%.

The phenolic materials demonstrated varying shrinkage properties; Durez 12810 was found to be comparable to Plaskon 422 whereas the shrinkage of ~~BM120~~ Bakelite mica filled [illegible] was observed to be in the range of 0.4%.

The shrinkage of the melamine materials tested was found to be grouped, in general, in accordance with the filler material employed. Melmac 1502 alphacellulose filled melamine, was observed to shrink in the vicinity of 0.5%. The mineral filled melamines, Melmac 592 and Resimene L11284, demonstrated shrinkage properties approaching 0.8%. The wood flour filled melamines, Melmac 1500 and Resimene 803A, demonstrated, in general, shrinkages of approximately 1.2%. In an isolated case, one of these materials was observed to shrink 2.76%.

It is worthy to note that only the polyester materials indicated that, within the time limits of the test conditioning, the maximum shrinkage of the materials had been reached.

This test program has provided a high temperature - dimensional stability requirement for inclusion in Military Specification MIL-P-4389(USAF) which covers polyester type molding materials that have good dimensional stability and electrical properties.

TABLE I

Test Designation and Description of Molded AN Type Connector Insert Specimens

Test Identification Number	Nominal Diameter	Molders Insert Type Designation	Molder	Number of Holes	Specimen Thickness
1A	.770 inch	9718-3PF	Am. Phenol	2	5/16 inch
1B	" "	9718-8PF	" "	8	" "
1C	" "	18-8PF	Cannon	8	1/8 "
1D	" "	18-SF	"	8	" "
1E	" "	18-4-4	Monowatt	4	3/16 "
2A	1.020 "	9722-2PF	Am. Phenol.	2	5/16 "
2B	" "	9722-14PF	" "	19	" "
2C	" "	22-19PF	Cannon	14	1/8 "
2D	" "	22-19SF	"	14	" "
2E	" "	22-20-4	Monowatt	9	5/16 "
3A	1.365 "	9728-3PF	Am. Phenol.	3	" "
3B	" "	9728-15PF	" "	38	" "
3C	" "	28-15SF	Cannon	38	3/16 "
3D	" "	28-2-4	Monowatt	14	3/16 "
4A	1.830 "	9736-4PF	Am. Phenol.	3	5/16 "
4B	" "	9736-8PF	" "	52	" "
4C	" "	9736-8PF (Molded in Pins)	" "	52	" "
4D	" "	36-1PR	Cannon	22	3/16 "
4E	" "	36-1SR	"	22	15/16 "
4F	" "	36-7-3	Monowatt	52	1/4 "

TABLE 2

Description of Molding Materials

Manufacturer's Material Designation	Resin	Filler	Specimens Submitted	
			Inserts	Bars
Durez 12810	Phenolic	Unknown	x	
~~BM 120~~ Bakelite mica-filled phenolic	Phenolic	Mica	x	
Plaskon 422	Alkyd	Mineral Oxide		x
Amphenol 1-501	Diallyl Phthalate	Asbestos	x	x
Resimene L11284	Melamine	Mineral		x
Resimene 803A	Melamine	Wood-cellulose	x	x
Melmac 592	Melamine	Mineral	x	x
Melmac 1502	Melamine	Alpha-cellulose		x
Melmac 1500	Melamine	Wood-cellulose	x	x

TABLE 3

Molding Data on AN Type Connector Inserts Molded by the American Phenolic Company

Test Identification Number	Ram Pressure	Temp.	Time of Molding Cure	Preheat° Dry	Elec-tronic Preheat	Type of Mold	After Treat-ment	Date of Molding
Material: Amphenol 1-501 American Phenolic Corporation								
1A	100 Ton	320°F- 330°F	2 Min.	Infra Red Lamp	None	Semi-Auto Comp.	None	6-30-51
1B	"	"	"	"	"	"	"	6-30-51
2A	"	"	"	"	"	"	"	6-30-51
2B	"	"	"	"	"	"	"	6-30-51
3A	"	"	"	"	"	"	"	6-30-51
3B	"	"	"	"	"	"	"	6-30-51
4A	51 Ton	290°F- 300°F	2 1/2 Min	Infra Red Lamp	None	Hand Comp.	—	7-5-51
4B	"	290°F- 300°F	2 1/4 Min	Infra Red Lamp	None	Hand Comp.	—	7-5-51
4C	PSI 1400#	290°F	2 1/2 Min	15 Min. at 120°F in oven	15 Sec. at 18° Mill Amp	Hand Trans.	—	7-2-51
Material: Melmac 592 American Cyanamid Company								
1A	100 Ton	290°F- 300°F	4 Min.	Infra Red Lamp	None	Semi-Auto Comp.	None	6-29-51

TABLE 3 (continued)

1B	100 Ton	290°F- 300°F	4 Min.	Infra Red Lamp	None	Semi- Auto Comp.	None	6-30-51
2A	"	"	"	"	"	"	"	6-30-51
2B	"	"	"	"	"	"	"	6-30-51
3A	"	"	"	"	"	"	"	6-30-51
3B	"	"	"	"	"	"	"	6-30-51
4A	NO SAMPLES	MADE						
4B	51 Ton	280°F- 290°F	5 Min.	Infra Red	None	Hand Comp.	None	7-5-51
4C	1400# PSI	290°F- 300°F	2 1/2 Min.	40 Min at 120° F in oven	45 Sec at 170 Mill amps. Med soft	Hand Trans	None	7-2-51

Bakelite mica-filled phenolic

Material: BM120 Bakelite Division - Union Carbide and Carbon

1A	100 Ton	320°F- 330°F	2 Min.	Infra Red Lamp	None	Semi- Auto Comp.	None	6-29-51
1B	"	"	"	"	"	"	"	6-29-51
2A	"	"	"	"	"	"	"	6-29-51
2B	"	"	"	"	"	"	"	6-29-51
3A	"	"	"	"	"	"	"	6-29-51
3B	"	"	"	"	"	"	"	6-29-51
4A	51 Ton	300°F- 310°F	2 1/4 Min.	Infra Red Lamp	None	Hand Comp.	None	6-29-51

TABLE 3(continued)

4B	51 Ton	300°F- 310°F	2 1/4 Min.	Infra Red Lamp	None	Hand Comp.	None	6-29-51
4C	1400# PSI	310°F	2 Min.	25 Min. at 120°F in oven	30 Sec. Med. Soft	Hand Trans.	"	6-29-51
			Material: Melmac 1500 American Cyanamid Company					
1A	100 Ton	320°F- 330°F	2 1/2 Min.	Infra Red Lamp	None	Semi Auto Comp.	"	6-29-51
1B	"	"	"	"	"	"	"	6-29-51
2A	"	"	"	"	"	"	"	6-29-51
2B	"	"	"	"	"	"	"	6-29-51
3A	"	"	"	"	"	"	"	6-29-51
3B	"	"	"	"	"	"	"	6-29-51
4A	51 Ton	310°F	2 1/4 Min.	"	"	Hand Comp.	"	6-30-51
4B	"	"	"	"	"	"	"	6-30-51
4C	1400# PSI	"	2 Min.	30 Min. at 120°F in oven	30 Sec. at 180 Mill amps. Med. soft	Hand Trans	"	6-29-51

TABLE 3 (continued)

Material: Resimene 803A: Monsanto Chemical Company

1A	100 Ton	320°F- 330°F	2 1/4 Min.	Infra Red Lamp	None	Semi-Auto Comp.	None	6-29-51
1B	"	"	"	"	"	"	"	6-29-51
2A	"	"	"	"	"	"	"	6-29-51
2B	"	"	"	"	"	"	"	6-29-51
3A	"	"	"	"	"	"	"	6-29-51
3B	"	"	"	"	"	"	"	6-29-51
4A	51 Ton	305°F- 310°F	"	"	"	Hand Comp.	"	6-30-51
4B	51 Ton	305°F- 310°F	"	"	"	"	"	6-30-51
4C	1400# PSI	310°F- 315°F	2 Min.	1 1/4 Hrs. at 120°F in oven	35 Sec. Med Soft	Hand Trans.	"	6-29-51

Material: Durez 12810

1A	100 Ton	320°F- 330°F	"	Infra Red Lamp	None	Semi-Auto Comp.	"	6-30-51
1B	"	"	"	"	"	"	"	6-30-51
2A	"	"	"	"	"	"	"	6-30-51
2B	"	"	"	"	"	"	"	6-30-51
3A	"	"	"	"	"	"	"	6-30-51
3B	"	"	"	"	"	"	"	6-30-51

TABLE 3 (continued)

4A	51 Ton	290°F- 300°F	2 1/4 Min.	Infra Red Lamp	None	Hand Comp.	None	7-3-51
4B	"	290°F- 300°F	"	"	"	"	"	7-3-51
4C	1400# PSI	300°F- 315°F	2 Min.	40 Min. at 120°F in oven	40 Sec. Med. Soft to 190 millamp.	Hand Trans.	"	6-30-51

TABLE 4

Molding Data on AN Type Connector Inserts Molded by Cannon Electric Company

Test Identification Number	Pressure	Temperature	Cure Time	Material	Mold Type	Pre-Treat	Aft-Treatment
1C	2570 psi	330° F	3 Minutes	803A	Compression	None	
1D	27000 "	300° F	" "	"	Plunger	"	
2D	14000 "	320° F	3 1/2 "	"	"	"	
2C	13500 "	320° F	3 "	"	Compression	"	
3C	23500 "	315° F	3 "	"	Plunger	150° F	
4D	6900 "	320° F	" "	"	Compression	210° F	5 hrs at 225°F
4E	18000 "	325° F	4 "	"	Transfer	None	None

TABLE 5

Molding Data on AN Type Connector Inserts Molded by Monowatt

Test Identification Number	Pressure	Temperature	Cure Time	Material	After Treatment
1E	Unknown	375° F	2 1/2 Minutes	Melmac 1500	18 hrs at 105-110° C
2E	"	"	"	"	"
3D	"	"	"	"	"
4F	"	"	"	"	"

Bakelite mica-filled phenolic

TABLE 6

AVERAGE POST-MOLDING SHRINKAGE DATA OF MOLDED PLASTIC AN TYPE CONNECTOR INSERTS AFTER CYCLING PERIODS OF 8 HOURS AT 125°C PLUS 16 HOURS AT 25°C AND 50% RELATIVE HUMIDITY(1)

Insert Nominal Diameter (inches)	Insert type No.	No. of Cycles	Molded by American Phenolic Corporation(2)												Molded by Cannon Electric Co.(3)				Molded by Monowatt Inc.(4)			
			MATERIAL														MATERIAL				MATERIAL	
			Dures 12810		Amphenol 1-501		~~Bakelite BM-120~~		Melmac 592		Monsanto 803A		Melmac 1500		Insert Type No.	No. of Cycles	Monsanto 803A		Insert Type No.	No. of Cycles	Melmac 1500	
			Avg.%	Range%	Avg.%	Range%	Avg.%	Range%	Avg.%	Range%	Avg.%	Range%	Avg%	Range%			Avg.%	Range%			Avg.%	Range
.770	1A	5	.06	.03 to .10	.08	— —	.22	.22 .25	.56	.46 .64	1.00	.67 1.17		— —	1C	5	2.02	1.87 2.35	1E	5	.91	.72 1.05
		10	.12	.10 to .14	.18	— —	.44	.41 .53	.80	.72 .89	1.37	1.29 1.46	1.23	1.20 1.30								
		30	.10	.10 to .13	—	— —	.34	.29 .41	.81	.76 .88	1.57	1.47 1.68	1.40	1.35 1.50		30	2.04	1.96 2.17		30	1.31	1.22 1.43
.770	1B	5	.08	.00 to .12	.15	.11 .16	.34	.24 .68	—	— —	1.19	1.12 1.24	1.07	.95 1.16	1D	5	1.56	1.44 1.70				
		10	.18	.09 to 27	.28	.25 .32	.60	.52 .68	.71	.64 .81	1.58	1.52 1.63	1.48	1.41 1.58								
		30	—	— —	—	— —	.44	.37 .50	.75	.66 .79	1.61	1.55 1.64	1.54	1.35 1.62		30	1.83	1.71 1.84				
1.020	2A	5	—	— —	—	— —	—	— —	.56	.53 .60	.84	.77 .89	.95	.91 1.02	2C	5	1.71	1.58 1.82	2E	5	1.01	.98 1.04
		10	.16	.07 to .25	.15	.14 .22	.37	.36 .48	.77	.73 .80	1.21	1.17 1.26	1.25	1.20 1.28								
		30	.07	.03 to .12	.05	.01 .07	.36	.34 .38	.81	.79 .90	1.57	1.55 1.61	1.57	1.52 1.61		30	1.85	1.64 2.02		30	1.47	1.42 1.52
1.020	2B	5	--	— —	.09	.02 .18	.37	.33 .41	.55	.42 .70	1.16	1.08 1.31	1.02	.96 1.16	2D	5	1.29	1.12 1.52				
		10	.10	— —	.20	.09 .26	.49	.39 .53	.72	.60 .95	1.47	1.36 1.56	1.43	1.33 1.58								
		30	—	— —	—	— —	.48	.40 .61	.81	.68 .99	1.67	1.54 2.83	1.57	1.45 1.78		30	1.71	1.41 1.88				
1.365	3A	5	.08	.07 to .09	.10	.09 .10	.23	.20 .25	.41	.32 .57	.74	.64 .83	.64	.66 .75	3C	5	1.49	1.40 1.56	3D	5	.84	.70 .92
		10		— —	.23	.21 .25	.40	.37 .43	.62	.44 .85	1.33	1.34 1.45	1.02	1.00 1.03								
		30	.12	.10 to .13	.18	.16 .19	.42	.39 .44	.73	.63 .91	1.45	1.39 1.51	1.33	1.28 1.34		30	2.24	2.18 2.30		30	1.22	1.04 1.48
1.365	3B	5	.08	.07 to .08	.16	.15 .17	.36	.30 .45	.53	.52 .54	1.06	1.02 1.17	1.06	1.03 1.11								
		10	—	— —	.34	.31 .38	—	— —	.74	.69 .78	1.36	1.31 1.41	1.42	1.38 1.52								
		30	.12	.10 to .13	.21	.19 .21	.51	.49 .55	.80	.77 .84	1.60	1.58 1.64	1.57	1.55 1.62								
1.830	4A	5	—	— —	.11	.10 .11	.23	.21 .25	—	— —	.84	.76 1.02	.84	.70 .94	4D	5	1.24	1.05 1.65				
		10	.12	.04 to .18	.22	.18 .24	.35	.30 .44	—	— —	1.17	1.05 1.30	1.15	.96 1.26		26	1.64	1.48 1.74				
		30	.11	.04 to .16		.17 .19	.41	.39 .45	—	— —	[illegible]	1.56 1.91	1.55	1.39 1.66		30	1.68	1.80				
1.830	4B	5	.05	.03 to .06	.13	.12 .15	.24	.21 .28	.39	.29 .49	1.05	.88 1.21	.89	.80 1.04	4E	5	1.14	1.10 1.25	4F	5	1.70	.72 2.13
		10	.14	.12 to .16	.19	.13 .24	.32	.28 .35	.55	.46 [illegible]	1.25	.42 1.42	1.37	1.33 1.39		17	1.46	1.41 1.61		17	1.86	1.19 2.54
		22	.10	.06 to .13	.17	.14 .21	.39	.31 .43	.62	.56 .69	1.58	1.44 1.71	1.55	1.42 1.68		26	1.99	1.54 1.73		26	1.98	1.30 2.67
		30	.12	.10 to .14	.19	.17 .21	.42	.32 .46	.69	.65 .76	1.69	1.54 1.75	1.67	1.57 1.78		30	1.63	1.56 1.80		30	2.09	1.43 2.76
1.830	4C	5	.04	.02 to .07	.10	.09 .10	.29	.28 .32	.41	.31 .49	.68	.65 .72	.68	.56 .67								
		10	—	— —	.19	.14 .26	.48	.45 .51	.58	.43 .81	.97	.94 1.01	.91	.85 1.05								
		30	.11	.10 to .12	.16	.15 .17	.58	.54 .62	.72	.56 .88	1.40	1.40 1.41	1.23	1.18 1.27								

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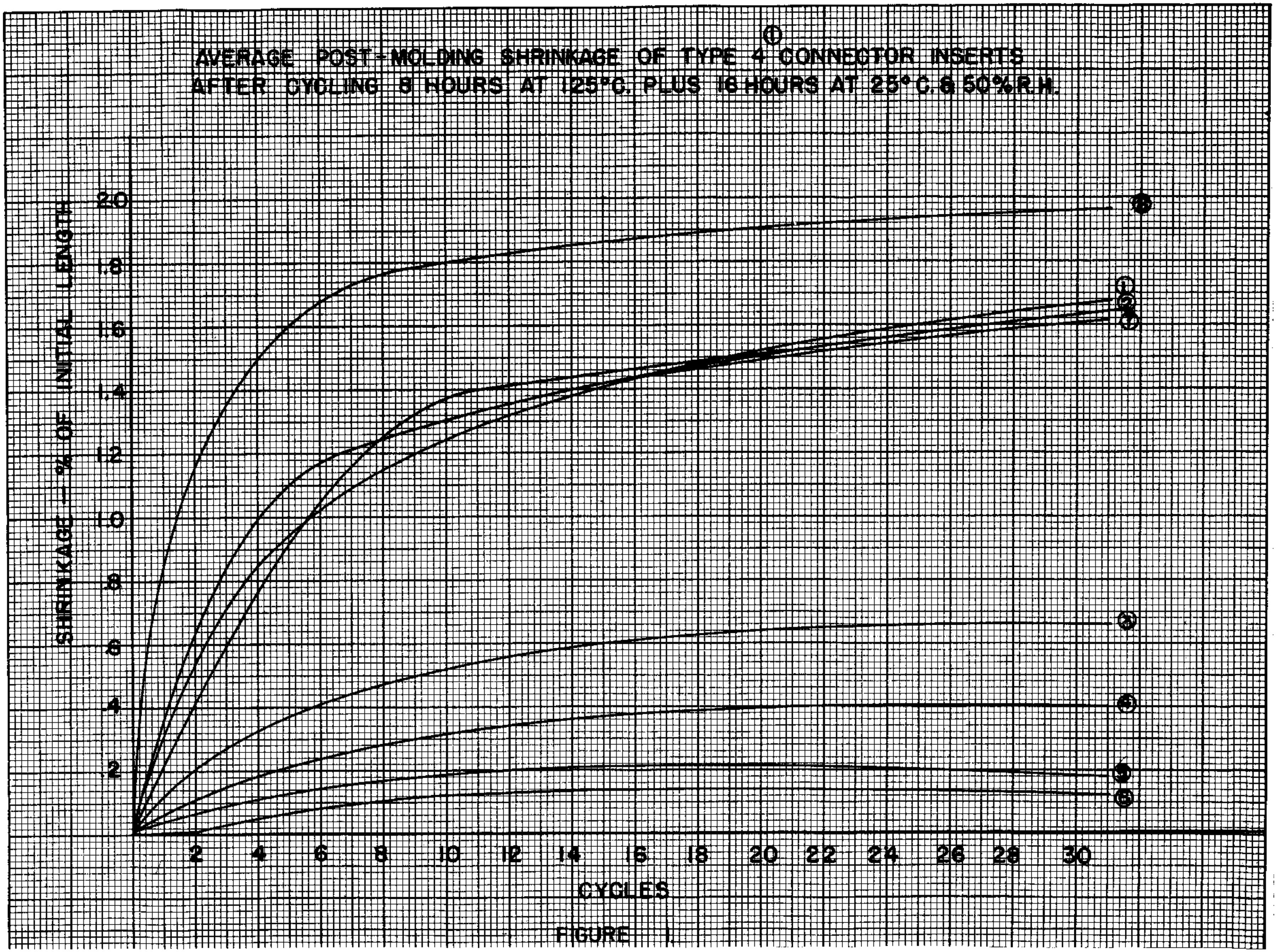
[1] Data are recorded as percent original diameter. The data represnets an average of two measurements on each of three insert specimens.

[2] See Table 3 for molding details.

[3] See Table 4 for mold ng details.

[4] See Table 5 for molding details.



①

AVERAGE POST-MOLDING SHRINKAGE OF TYPE 4 CONNECTOR INSERTS AFTER CYCLING 8 HOURS AT 125°C. PLUS 16 HOURS AT 25°C. & 50% R.H.

FIGURE 1

Materials 2, 3, 4 **Figure 1**

1. Melmac 1500
2. Monsanto 803A
3. Melmac 592 — Molded by American Phenolic Co.
4. ~~Bakelite BM120~~ Bakelite mica-filled phenolic
5. Amphenol 1-501
6. Durez 12810
7. Monsanto 803A — Molded by Cannon Electric Co.
8. Melmac 1500 and after bake — Molded byMonowatt Inc.

Footnotes: Figure 1

1. Nominal Diameter of Type 4 inserts is 1.830 inch.
2. See Table 3 for molding details of 1-6.
3. See Table 4 for molding details of 7.
4. See Table 5 for molding details of 8;

TABLE 7

Average Post-Molding Shrinkage Data[1] of Molded Plastic Bars After Cycling Periods of 48 Hours at 125° C plus 24 Hours at 25° C and 50% Relative Humidity

Material[2]

Cycles	9 Plaskon 422 Avg%	Range%	8 Amphenol 1-501 Avg%	Range %	7 Melmac 1502 Avg%	Range%	6 Melmac 1502 Avg%	Range%	5 Melmac 592 Avg%	Range%	4 Melmac 592 Avg%	Range%	3 Resimene L11284 Avg %	Range%	2 Melmac 1500 Avg%	Range%	1 Resimene 808 A Avg%	Range%
1	.01	.00 to .03	.06	.03 to .07	.01	.00 to .03	.09	.06 to .12	.22	.20 to .25	.39	.35 to .41	.35	.32 to .40	.46	.45 to .47	.50	.48 to .51
2	.02	.01 to .02	.09	.05 to .11	.04	.03 to .06	.20	.15 to .27	.31	.29 to .33	.48	.46 to .52	.47	.43 to .52	.70	.69 to .70	.71	.70 to .71
3	.03	.01 to .05	.12	.10 to .14	.14	.11 to .19	.28	.21 to .34	.37	.34 to .41	.57	.56 to .58	.59	.53 to .66	.90	.89 to .90	.96	.96 to .96
4	.03	.01 to .07	.11	.10 to 114	.17	.15 to .19	.31	.26 to .37	.42	.36 to .48	.62	.60 to .65	.70	.61 to .78	1.02	1.00 to 1.02	1.12	1.10 to 1.13
5	.06	.02 to .07	.13	.10 to .14	.22	.20 to .24	.33	.31 to .38	.46	.39 to .52	.67	.65 .69	—	— —	1.10	1.09 to 1.10	—	— —
6	.07	.04 to .09	.13	.10 to .14	.26	.24 to .29	.39	.35 to .45	.54	.49 to .59	.72	.70 to .77	—	— —	1.19	1.10 to 1.19	—	— —
7	.07	.04 to .09	.12	.10 to .14	.26	.24 to .28	.40	.36 to .45	.56	.54 to .61	.75	.74 to .80	—	— —	1.24	1.23 to 1.25	—	— —

---

[1] Data are recorded as percent original length. The data represents an average of one measurement on each of five specimens. Molded plastics bar dimensions were 5 x 1/2 x 1/2 inches.

[2] Two totally different productions runs of Melmac 1502 and 592 are represented. All materials were molded by the resin manufacturer. No molding data are available.

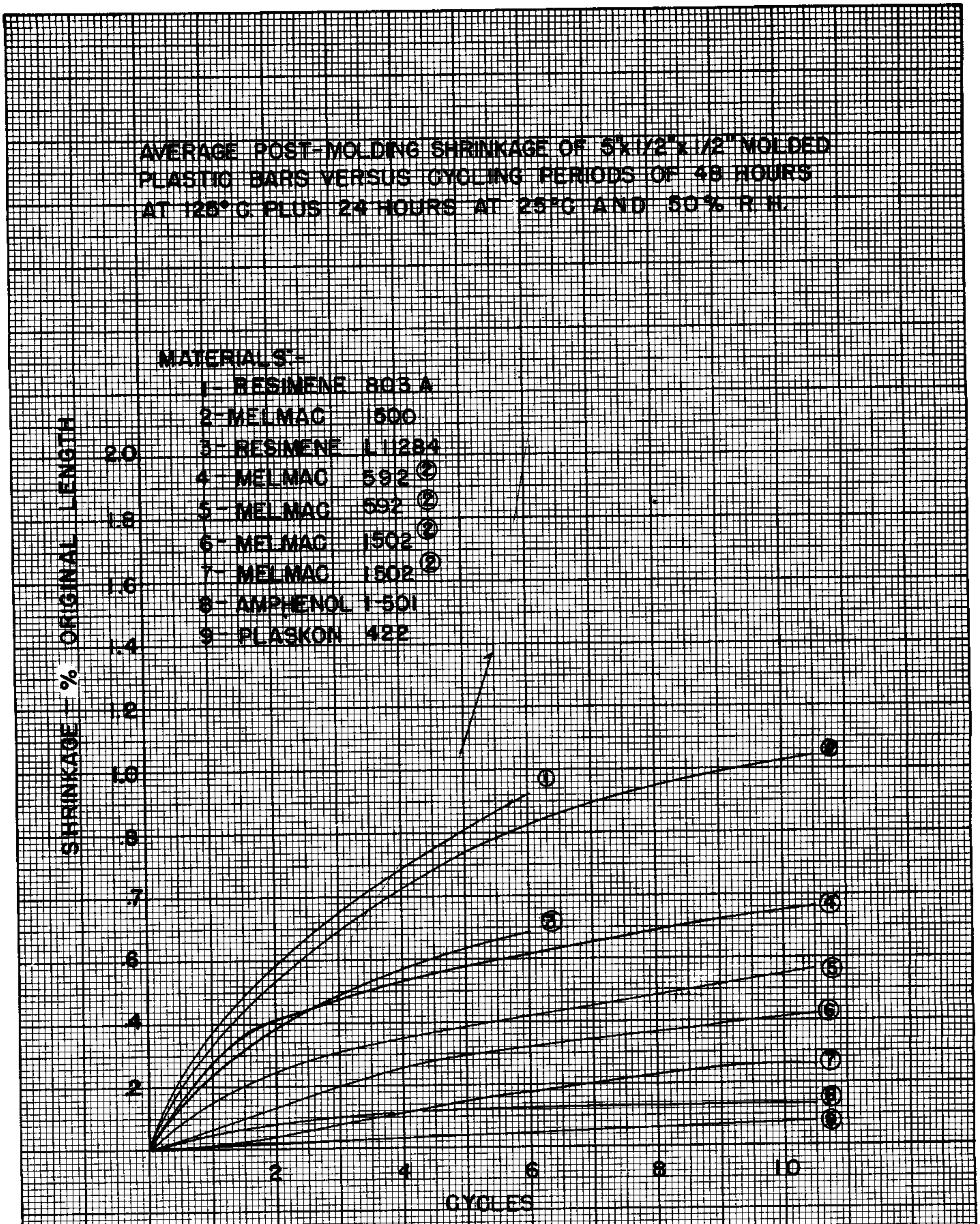

AVERAGE POST-MOLDING SHRINKAGE OF 5"x1/2"x1/2" MOLDED PLASTIC BARS VERSUS CYCLING PERIODS OF 48 HOURS AT 125° C PLUS 24 HOURS AT 25°C AND 50% R.H.
MATERIALS:-
1 - RESIMENE 803 A
2 - MELMAC 1500
3 - RESIMENE L11284
4 - MELMAC 592 ②
5 - MELMAC 592 ②
6 - MELMAC 1502 ②
7 - MELMAC 1502 ②
8 - AMPHENOL 1-501
9 - PLASKON 422
SHRINKAGE - % ORIGINAL LENGTH
2.0
1.8
1.6
1.4
1.2
1.0
.8
.7
.6
.4
.2
2
4
6
8
10
CYCLES
①
③
④
⑤
⑥
⑦
⑧
⑨

FIGURE 2.

Footnotes: Figure 2

1. All materials were molded by the resin manufacturer. No molding data are available.

2. Two production runs of Melmac 592 and 1502 are represented.

TABLE 8

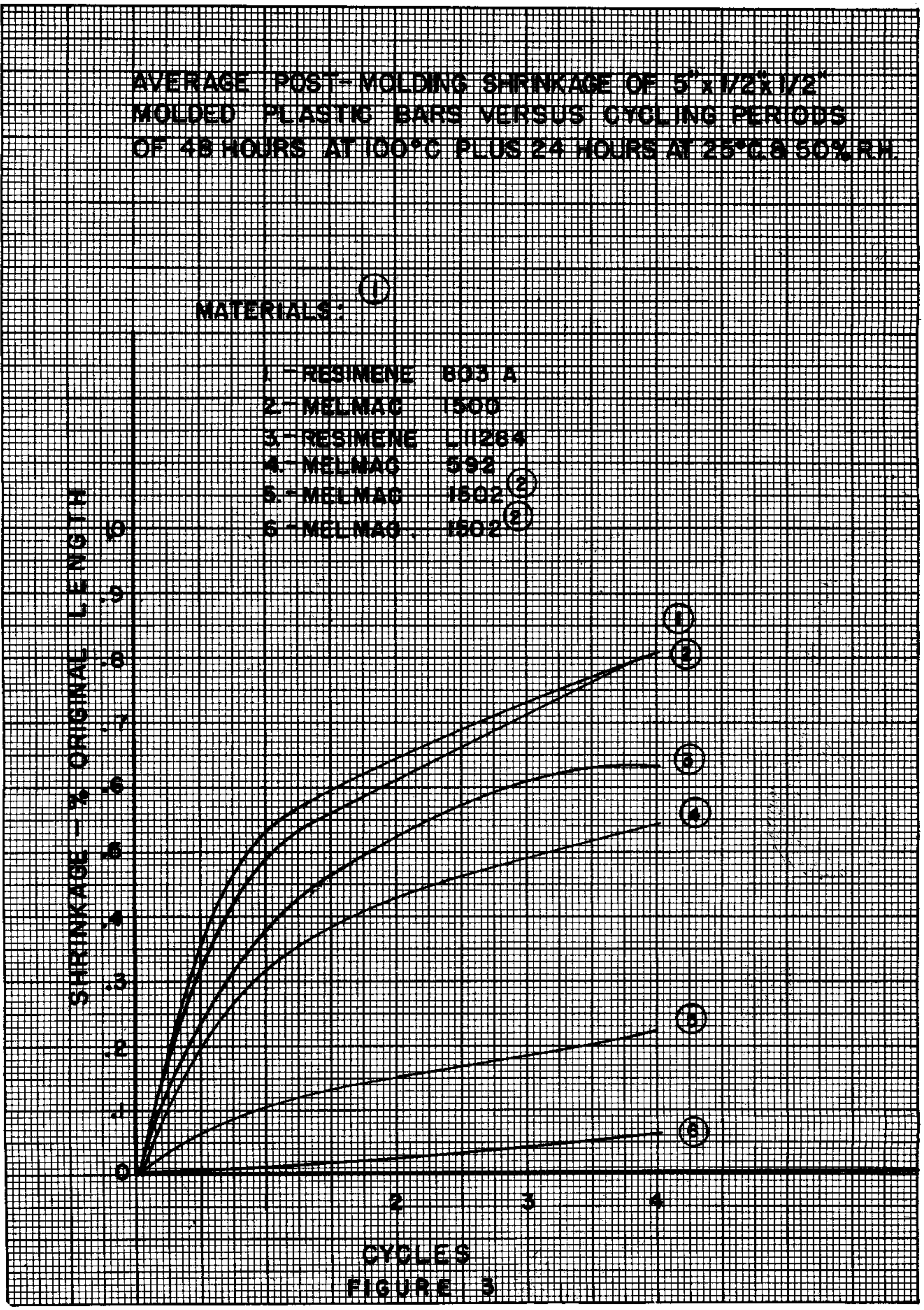
Average[1] Post-Molding Shrinkage Data on Molded Plastic Bars after Cycling Periods of 48 Hours at 100° C Plus 24 Hours at 25° C and 50% Relative Humidity

Cycles	Material[2]											
	Melmac 1502		Melmac 1502		Melmac 592		Resimene 11284		Melmac 1500		Resimene 803A	
	Avg.%	Range%	Avg.%	Range%	Avg.%	Range%	Avg.%	Range%	Avg.%	Range%	Avg.%	Range%
1	—	— —	.12	.11 to .16	—	— —	.36	.26 to .50	.52	.51 to .54	.54	.42 to .70
2	—	— —	.14	.12 to .18	.53	.42 to .74	.41	.29 to .56	.58	.57 to .61	.62	.48 to .77
3	.03	0 to .09	.18	.16 to .22	.61	.50 to .80	.49	.36 to .67	.71	.69 to .72	.73	.58 to .92
4	.07	.01 to .15	.22	.20 to .26	.62	.50 to .83	.55	.41 to .73	.81	.75 to .87	.81	.64 to 1.03

---

[1] Data are recorded as percent original length. The data represents an average of one measurement on each of five specimens. Molded plastic bar dimensions were 5 x 1/2 x 1/2 inches.

[2] Two totally different production runs of Melmac 1502 are represented. All materials were molded by the resin manufacturer. No molding data are available.



AVERAGE POST-MOLDING SHRINKAGE OF 5" x 1/2" x 1/2" MOLDED PLASTIC BARS VERSUS CYCLING PERIODS OF 48 HOURS AT 100°C PLUS 24 HOURS AT 25°C & 50% R.H.

FIGURE 3

Footnotes: Figure 3.

1. All materials were molded by the resin manufacturer. No molding data are available.

2. Two production runs of Melmac 1502 are represented.