X-RAY DEPARTMENT

GENERAL ELECTRIC

COMPANY

GENERAL ELECTRIC COMPANY

TECHNICAL DATA LIBRARY

P. O. BOX 11508

ST. PETERSBURG, FLA. 33733

TECHNICAL INFORMATION SERIES

Title Page

PROPERTY OF U. S. GOVERNMENT

GEPP--97001049

AUTHOR K.E. Creed, Jr.	SUBJECT CLASSIFICATION Materials	NO. R60XF61
		DATE 8/16/61
TITLE POTTING OF MC-1353 MATTA UNITS IN LOCKFOAM BX-105 B-10		
ABSTRACT This program was initiated to develop a more reliable, practical method for potting MC-1353 MATTA units in slow foaming Lockfoam BX-105 B-10. The study included volume determinations, foam density measurements, foam time-temperature relationships and exotherm effects on sub-assemblies.		
G. E. CLASS 4	REPRODUCIBLE COPY FILED AT Technical Data Library P.O. Box 11508 St. Petersburg, Florida	NO. PAGES 37
GOV. CLASS NONE		
CONCLUSIONS Drawing 46A115071 can be utilized in the potting of MC-1353 units with polyurethane foam by employing the following modifications: (1) Utilization of 395 grams of mix. (2) Cementing sub-assemblies to the can bottom to prevent floating. (3) Using 1/8" spacers to position the MATTA. The mixing phase is critical. Pouring should be done when the mix temperature reaches 40°C (100°F) which is approximately three minutes after mixing is initiated. A reinforcing plate on the front of the can is required to prevent bulging. As with epoxy filled units, cover welding causes slight surface scorching of the potted compound. Electrical and environmental tests performed on units which were potted to the above process have been reported in R61XF12.		

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents — drawings, photos, etc., and for distribution see next page.

INFORMATION PREPARED FOR Engineering

TESTS MADE BY K. E. Creed, Jr. *K.E. Creed* Approved by: *Rensien*

COUNTERSIGNED V. T. Burkett *V.T. Burkett* SUBSECTION Materials and Processes Laboratory

DIVISION Industrial Electronics LOCATION St. Petersburg, Florida

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

X-RAY DEPARTMENT
GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
CONTENTS PAGE

CONTENTS OF REPORT

NO. PAGES TEXT 23

NO. CHARTS 5

DRAWING NOS. 46A115071 (3 pages)
46A101674 (3 pages)

PHOTO NOS. 3

DISTRIBUTION

GEXF

J Bension
AF Bischoff
IW Braun
DC Brown
PF Brown
VT Burkett
JS Caven
KE Creed
WH Fenn
CD French
JB Guthrie
CE Jay
DE Lane
AD McGovern
RA Patrick
AF Persons
GP Petersen
Technical Data Library (5)
GL Bodwell (5) Title Page Only

AEC

JH Sund

GEXM

RH Beaton
RR Lackey
WE Johnston
MW Osborn
RS Trautman
RF Wilson

SANDIA

WF Carstens 3423
TS Church 1410
RT DePew 1411
JP Shoup 1413

TABLE OF CONTENTS

	<u>PAGE</u>
I. INTRODUCTION	5 .
II. DEVELOPMENT OF POTTING PROCEDURE	5
III. EXOTHERM EVALUATION	11
IV. CONCLUSIONS	17
V. RECOMMENDATIONS	20
APPENDIX I - Drawing 46A115071: Polyurethane Foam Potting	21-24
APPENDIX II - Method of Volume Determination	25
APPENDIX III - Foam Density Determination	26-29
APPENDIX IV - Typical Potting Defects Observed and Corrected During the MC-1353 MATTA Foam Investigation	30-33
APPENDIX V - Drawing 46A101674 - Polyurethane Foam Potting Procedure for MATTA and MC-1270 Final Units	34-37

LIST OF TABLES AND FIGURES

	<u>PAGE</u>
Figure 1 - Unit #5 Potted 10/21/60 Using 395 g of Foam	9
Figure 2 - Bottom View of Unit #3	9
Figure 3 - View of Can After Unit was Removed	10
Figure 4 - Top View of Unit #6 Showing Cover Weld	10
Figure 5 - Top View of Unit #6 Showing Slight Surface Charring	11
Figure 6 - Time-Temperature Curve for Lockfoam BX-105 B-10	13
Figure 7 - Side View of the Delayed Pour Unit	12
Figure 8 - Temperature and Density Measurement of a Foam Sample	15
Figure 9 - Time-Temperature Relationships of Various Sub-Assemblies Potted in Lockfoam BX-105 B-10	18
Figure 10 - Time-Temperature Relationships of Various Sub-Assemblies Potted to the Optimum Process	19
Figure A - Side View of Standard Mold	27
Figure B - Top View of Standard Mold	28
Figure C - A Top View of MC-1353 Unit #1 Potted	31
Figures D-E - Side View of Castings	32
Figure F - Bottom View of a Unit Illustrating Voids	33
Figure G - Top View of Unit #6 Before Cover Was Welded on	33
Table I - Experimental Variables Studied in Potting the MC-1353	7
Table II - Weights of Foam Ingredients and Densities Utilized With the Standard Mold	29

POTTING OF MC-1027 MATTA UNITS
IN LOCKFOAM BX-105 B-10

I. INTRODUCTION

To meet the varied needs of the customer, the general trend at GEXF has been toward lighter weight, more compact units. One example of efforts in this direction is the recent program to convert the MC-1027 to a foam encased MATTA* unit (MC-1353). One major area of effort in this conversion was the development of a foam potting process.

Past experience had indicated that low shallow forms could be foam filled readily. However, applications requiring a 10" height of foam, as needed in the MC-1027, had not been tried at GEXF. Therefore, a feasibility study was initiated.

Utilizing Drawing 46A115071 (Appendix I) as a model from which the investigation could progress, two main areas were studied: (1) determination of the amount of foam required to provide a firmly filled unit and (2) determination of the amount of exothermic heat the sub-assemblies would encounter. Other objectives included recommendations for drawing changes to incorporate the information and procedures developed; and the potting of dummy, and of live units for further Engineering evaluation.

It was found that only minor changes in Drawing 46A115071 were required to successfully pot the units and that the exotherm did not present a problem. The electrical and environment tests being conducted on units potted to the new procedure, will be reported when tests are completed.

II. DEVELOPMENT OF POTTING PROCEDURE

A. Description of Specimens

Throughout the investigative phase of the program, complete dummy MC-1353 final units were employed in which the normal transformer had been replaced with a MATTA Unit, as illustrated in the following sketch.

* Multiple Application Tube Transformer Assembly

The major components were scrap assemblies which were recovered after each potting to permit increased experimentation with a limited supply of material.

B. Determination of Foam Parameters

Past industrial experience in the utilization of foam materials has resulted in the establishment of a standard procedure for the determination of the amount of foam required to fill a given cavity. This is termed the rule of the 5 "D's" which follows:

- (1) "D" evise the volume of the cavity.
- (2) "D" ecide the foam density.
- (3) "D" erive the amount of material to fill the cavity.
- (4) "D" etermine the excess material and add to (3).
- (5) "D" etail the breakdown of the components by ratio.

The volume and foam density were unknown factors, and thus, emphasis was directed toward determining these parameters.

Volume Determination - In the MC-1353, the sub-assemblies and can are of complex geometry and, therefore, direct calculation of the volumes involved would be extremely difficult. However, by employing the indirect method of water displacement outlined in Appendix II, the volume to be filled by the foam was easily derived. This was found to be 1350 cc.

Foam Density Determination - The urethane foam Drawing 46A115071, indicated that Lockfoam BX 105B-10 produced a density of 10-12 lbs/cu ft. Since there was no indication whether this density was under free blown conditions or in a restricted volume, a standard mold was fabricated in the laboratory so that the density could be determined experimentally. The construction details of the mold and the results of various tests are included in Appendix III. It was ascertained from this series of studies that in order to produce the height of foam required to fill the MC-1353, an average density of 15 lbs/cu ft would be necessary. A 10-12 lb/cu ft density was only realized under free blown conditions. A wide variation in the density of the cast slabs, both from top to bottom and side to side, was noted. The reason for this variation became apparent after the exotherm data was ascertained, and will be discussed under that section.

Application of the Rule of 5 "D's" - As a result of these initial studies, enough information was derived to establish the theoretical amount of foam components to be used.

Applying the rule of 5 "D's" gave the following:

(a)	Volume	1350 cc
(b)	Foam Density	15 lbs/cu ft
(c)	Amount of Material	326.6 g
(d)	Amount of Excess (10%)	32.7 g
	TOTAL	359.3 g
(e)	Amount of Components 61% T	219.2 g
	39% R	140.1 g

Thus, from theoretical considerations 359 g should fill the MC-1027 can. An initial weight of 350 g, however, was chosen because this amount was specified on Drawing 46A115071, and if satisfactory, would permit utilizing this same drawing for both the MC-1027 and MC-1270 Units.

Potting of the MC-1353 Final Units - The initial pour followed Drawing 46A115071 exactly. However, it was quickly established that additional foam would be required to fill the unit. The variations investigated in these studies and the corrective action taken to eliminate the various defects are summarized in Table I.

TABLE I

Experimental Variables Studied in Potting the MC-1353

Unit No.	Amount of Material	Weight of Component		Variable	Remarks
		T	R		
(1)	350 g				Per Dwg. 46A115071; approx. theoretical amount.
(2)	375	228.8	146.2	25 g added; spacers	Spacers added to aid foam distribution.
(3)	385	234.9	150.1	10 g more added; sub-assemblies cemented to can	To eliminate floating
(4)	395	241.0	154.0	10 g more added	Pouring delayed. Had voids.
(5)	395	241.0	154.0	Repeat	Good unit.
(6)	395	241.0	154.0	Repeat	Cover welded on to study effect of this operation on the foam.

Photographs of the typical potting defects noted in Table I are included for reference in Appendix IV.

During this investigation, another potential source of trouble was observed. Where the terminal leads emerge from the foam, a portion is held rigid while the remainder of the lead is flexible. Thus, a pivot point is established which under vibration conditions or in normal flexing might cause fracture of the lead. (See sketch "a" on next page.)

This stress point can be eliminated by incorporating a 1/2" section of Silatube on the lead to act as a cushion as shown in sketch "b" above. Silatubes were tried on two units, and no problems in assembly or potting were encountered.

Finalization of the potting procedure incorporated the various innovations which were employed to rectify the problem areas disclosed during the investigation. It was found that Drawing 46A115071 could be utilized if revised to include the following requirements:

- (a) 395 g of foam mix.
- (b) Use of a restraining fixture on both front and back of the cans to prevent distortion by foam pressure.
- (c) Spacers (1/8" x 1/2" x 1/2"), adhesive, Silatube, and sub-assembly arrangement as indicated in the following sketches.

Typical photographs of the void free casting obtained when employing the preceding features are shown in Figure 1.

Top View

Side View

Figure 1: Unit #5 Potted 10/21/60 Using 395 g of Foam

To eliminate sub-assembly floating Hysol Kit 1-C adhesive was used to cement the components to the bottom of the container. Absence of voids in Figures 2 and 3 demonstrates the effectiveness of this bonding in preventing floating.

Figure 2

Bottom view of Unit #3. Sub-assemblies were cemented to the can to eliminate floating. Bare areas were left in the can when foam was removed.

Figure 3

View of can showing the portions of foam which stuck when the unit was removed. Pieces match bare areas of Figure 2 indicating no void existed.

A cover was welded on one of the foamed units to evaluate this portion of the process. No trouble was encountered in the welding operation. A photograph of the welded unit is shown in Figure 4.

Figure 4

Top view of Unit #6 showing the cover weld.

The effect on the foam of this welding is illustrated in Figure 5.

Figure 5: Top view of Unit #6

Slight surface charring occurred in those areas where the arc was started and stopped. The remainder of the top showed only a slight yellow discoloration. No penetrating effects of the heat were evident, and the scorching was of the same order of magnitude as is experienced with the epoxy filled units.

Scorching was further minimized by the addition of an extra 1/8" thickness to the race of the restraining fixture to further separate the foam from the area of the welding operation.

III. EXOTHERM EVALUATION

A. Exotherm Considerations

Reaction heat evolved during the foaming process is high. Temperatures above 100°C were noted during these experiments. How much of this heat would be transmitted to the sub-assemblies was an unknown factor. To ensure that excessive temperatures would not be a problem, special attention throughout this program was directed toward ascertaining the time-temperature relationships: (1) During the mixing phase, (2) during the foaming reaction, and (3) in and around the various sub-assemblies.

B. Mixing Phase

It was found that while this material is more delayed than most urethane foams, there is still relatively little time in which the mix is pourable. There are two aids, however, which will help to ensure that proper timing is maintained.

First, there is a visible appearance change in the mix. The urethane and foaming agent components are initially clear, but become turbid when mixed. The turbidity lasts for 3 minutes and then clears noticeably. The mix remains relatively clear for 1-2 minutes, but then gradually turns white as active foaming begins.

The other indicator is temperature rise, as the foaming reaction evolves heat. The relationship of these factors is plotted in Figure 6 on the next page. The clearing of the mix occurs as the mix reaches a temperature of 40°C (100°F), which is 3 minutes $\pm$ 15 sec. after mixing is initiated. Pouring should then be started immediately. Within 6 minutes after mixing is started, the foaming viscosity, and temperature of the mix make pouring impractical, as the results of a delayed pour, shown in Figure 7, illustrate.

Figure 7

Side view of the delayed pour unit. Note the large voids where the viscous foam had been unable to flow.

The top of the unit looked satisfactory, but below the surface were large voids where the material had not flowed properly due to its increased viscosity. Thus, if the pour can not be made before 6 minutes after mixing starts, it should be discarded and a new batch prepared.

C. Foaming Reaction

As foaming progressed, the reaction temperature (exotherm) was monitored by a twelve point Minneapolis-Honeywell Brown Elektronik Recorder connected to iron-constantin thermocouples that had been premounted with Hysol 1-C Adhesive at selected locations in the standard mold or MC-1353 can into which the mix had been poured.

From these data, plotted in Figure 8, it appears that two reactions (exotherms) occur simultaneously: (1) A slower exothermic reaction evident at the base of the foam (Thermocouple #5); and (2) a fast hot reaction in the foam head which is illustrated by the rapid temperature rise as the head reaches the various thermocouples (#8 and #10).

In Figure 8 also are shown the density values of the foam block referred to previously in Table II in Appendix III. The area which showed the slow steady heat evolution also had the highest density. The center, which heated up rapidly as the foam head passed, also cooled off quickly and had a lower density. The top proved to have the most heat for the longest time, and had the lowest density. The outer edges of the slab were denser than the center sections because of greater heat loss to the mold in these areas.

Based on these observations, and information available in the literature, it is hypothesized that the initial and slower reaction at the bottom of the mold is predominately a cross-linking reaction, as typified by the following equations.

The urethane can also react with TDI to give a branched polymer.

The heat evolved from these reactions provides the initial temperature rise observed in the mixing phase and also serves to start the second reaction -- foaming. This foaming results from the reaction of the diisocyanate with carboxylic acid and/or water to form anhydrides and carbamic acid respectively which decompose giving off carbon dioxide (CO₂), as follows:

R = Any organic radical or molecule from a methyl group to a complex polyester resin.

As may be seen, with a polyfunctional system such as a hydroxyl rich polyester or polyether resin with toluene diisocyanate, complex cross-linking and branching reactions result as well as various reactions releasing carbon dioxide. Correlating this analysis to the foam temperature-density relationships, at the bottom of the mold the mix starts to cross-link giving off heat in the process. This reaction, in turn, causes decomposition of the anhydrides and carbamic acid groups, which lift a portion of the resin upward in the can. The remainder continues to cross-link and foam, but the rate of CO₂ evolution is slower, probably due to greater heat losses. However, by the time the temperature rises to a point where the CO₂ would evolve rapidly, the polymer is highly cross-linked which would limit expansion, so the higher density area results.

As the foam rises, heat is evolved which in turn accelerates the formation of CO_2 . Thus the density decreases as the foam rises. This reaction is depressed at the outer edges due to greater heat loss to the mold or environment, which gives a denser area. As a consequence of this cooling, a cure or really a post-cure, is necessary to fully cross-link these surface areas and produce a dimensionally stable piece.

Based on the density variations apparent in the standard mold, it follows that similar variations exist in the MC-1353 casting. The amount of foam utilized was based on 15 lb/cu ft plus approximately a 20% excess, and the only area that could be sampled (at the top of the can directly below the terminal cavities) gave readings of 10.6 - 11.8 lb/cu ft. Of necessity, other areas must have values of 18 - 20 lb/cu ft in order to compensate for these lower densities near the top of the can.

D. Sub-Assembly Effects

It was quite apparent from the preceding investigation that temperatures in excess of 100°C (212°F) could be expected in the foam. While the recorders could only follow the exotherm to 100°C , thermometers inserted in the polyurethane during the foaming reaction registered peak temperatures of 163°C (325°F). The effect of these temperatures on the sub-assemblies was unknown. Therefore, thermocouples were positioned on and below the surface of the MATTA and timer control on several units. The typical plot of the temperatures obtained versus time is shown in Figure 9. It is clearly evident that the heat was not transmitted to the assemblies. Previous laboratory investigations had indicated that both Hysol 6608 and Epoxy-Eccosphere castings are poor heat conductors, which is further confirmed by the data from these experiments. The MATTA showed a peak of 63.5°C on the top surface and 62°C one quarter inch below the surface. The timer-control showed 59°C on the surface and 52.5°C inside. These temperatures are appreciably below the 74°C temperature used to post cure the casting.

To confirm previous data in a unit potted to the optimum process, thermocouples were inserted $1/4"$ below the surface of the MATTA, timer control, and capacitor, and in the foam at the top, center and bottom of the can. The time-temperature relationship derived is illustrated in Figure 10. The foam at the top of the can reached temperatures above 100°C (212°F) but the MATTA, which is in that area, reached a maximum of only 66°C . The timer control and capacitor attained 55.5°C and 53°C respectively. Based on these observations, the exothermic heat of the foaming process should produce no deleterious effects on the sub-assemblies.

IV. CONCLUSIONS

MC-1353 final units can be successfully potted employing essentially the procedure outlined in Drawing 46A115071. The modifications necessary to produce a void free casting include:

1. Use of 395 g of mix instead of the 350 g specified.

Figure 10

2. Cementing the sub-assemblies to the can with Hysol 1-C Adhesive or equal, to prevent them from floating.
3. Spacing the MATTA from the can with 1/8" spacers cemented to the MATTA to ensure proper foam coverage.

The foam ingredients should be mixed until the turbidity clears which occurs at a mix temperature of 40°C (100°F) 3 minutes after mixing begins. Pouring should then be conducted immediately. Six minutes after mixing begins the foam has become so viscous that pouring is impractical. Errors in this area could be further reduced by employing commercial foam mixing and dispensing equipment.

The exothermic heat resulting from the foaming reaction rose above 100°C to a peak of 163°C, but temperature monitoring indicated relatively low heat transmission to the sub-assemblies. Maximum temperatures of 62-66°C were observed below the surface of the components. The heat evolved from potting with foam, therefore, should have no deleterious affect on the potted sub-assemblies.

An additional reinforcing plate on the front of the can is needed during the foaming operation to prevent distortion of the can in this area.

The welding operation of the cover to the can presents no problems. Slight surface scorching of the foam results but is of the same order of magnitude as in epoxy filled units. Scorching has been minimized by increasing the thickness of the race on the restraining fixture.

V. RECOMMENDATIONS

Based on the data obtained in this series of investigations the following action is recommended.

- (1) A program should be initiated which would permit the utilization of foam mixing and dispensing equipment in the factory in order to eliminate operator error inherent in hand operations.
- (2) Revise Drawing 46A115071 to conform to the optimum procedure outlined in Appendix V.
- (3) If future emphasis dictates, studies of the curing phase should be made to ascertain whether curing can be effected in less than sixteen hours; when the restraining fixture can be removed without deleterious effect; and when dimensional stability is obtained.
- (4) Additional programs which might be conducted include (a) determination of the water absorption characteristics and, if they appear excessive, (b) desirability of using an epoxy sealant coating.

K. E. Creed
Product Engineer

KEC/mn

APPENDIX I

Drawing 46A115071: Polyurethane Foam Potting

REV NO. 01		TITLE POLYURETHANE FOAM POTTING	
46A115071		FIRST MADE FOR 46C100760 G1	
CONT ON SHEET 2 SH NO. 1			
GROUP NO. AND QUANTITY		PART NO.	NAME
		G1	
		X	1 ASM.
		AR	2 URETHANE 46A115072 P1
		AR	3 FOAMING AGENT 46A115073 P1
		AR	4 MOLD RELEASE 46A100954 P1

1. SCOPE

- 1.1 THIS SPECIFICATION COVERS MATERIAL AND PROCESS REQUIREMENTS FOR EMBEDDING ELECTRICAL COMPONENTS IN A RIGID POLYURETHANE FOAM WITH A DENSITY OF 10-12 POUNDS PER CUBIC FOOT.

2. REQUIREMENTS

- 2.1 FORMULATION. -- THE EMBEDDING COMPOUND SHALL BE FORMULATED AS PER THE MIXTURE SHOWN BELOW AND TAKEN IN THE REQUISITE PROPORTIONS ON A WEIGHT BASIS. THE TOLERANCE ON WEIGHTS OF MATERIALS SHALL BE ± 1 PER CENT.

LOCKFOAM PROPORTIONS:

P2 39 PARTS BY WEIGHT - 136.5 GRAMS
P3 61 PARTS BY WEIGHT - 213.5 GRAMS

3. MOLD PREPARATION

- 3.1 A RESTRAINING OR HOLDING FIXTURE SHALL BE USED DURING FOAMING TO:

- A. PROVIDE A RESTRAINING FORCE ON THE CONTAINER WALLS TO WITHSTAND THE 30 PSI PRESSURE PRODUCED DURING THE FOAMING ACTION.
- B. PROVIDE THE NECESSARY CONFIGURATION TO MAINTAIN THE SPECIFIED OUTSIDE DIMENSION OF THE CONTAINER.
- C. PROVIDE THE SPECIFIED FOAM CONFIGURATION AND FOAM HEIGHT WHERE THE CONTAINER COVER IS MOUNTED

FOR EXPERIMENTAL
USE ONLY

UNLESS OTHERWISE SPECIFIED USE	APPLIED PRACTICES	SURFACES ✓	TOLERANCES ON MACHINED DIMENSIONS		
			FRACTIONS +	DECIMALS +	ANGLES +
DESCRIPTION OF GROUPS		REVISIONS		PRINTS TO	
C/N PENDING 16653 REV 1 TO 2 NAME <u>W</u> DATE 12/30		1 <u>O. Chancey</u> APR 1 1960 CHG. 3, 5, 4, 5, 7, 8		NCN	
MADE BY <u>B. Schnapferling</u> 2/25/60		APPROVALS <u>OK</u> 2/26/60		PINELLAS PENINSULA PLANT	
ISSUED <u>EN 303</u> <u>in name</u> 4-5-60		ST. PETERSBURG, FLORIDA		46A115071	
PRINTED IN U.S.A.		REVIEWED FOR C		CONT ON SHEET 2 SH NO. 1	

REV NO. 01
46A115071
CONT ON SHEET 3 SH NO. 2TITLE
POLYURETHANE FOAM POTTING
FIRST MADE FOR 46C100760 G1

REVISIONS

D. PROVIDE AIR VENTS APPROXIMATELY 1/8 DIAMETER EQUALLY SPACED TO PROVIDE THE ESCAPE OF THE ENTRAPPED AIR AND THE ESCAPE OF EXCESS RESIN, SO THAT ALL AREAS WITHIN THE CASTINGS ARE FILLED WITH FOAM.

E. PROVIDE A HEAT SINK SO THAT THE TEMPERATURE SPECIFIED CAN BE MAINTAINED FOR FOAMING REPEATABILITY.

3.2 APPLY A THIN COAT OF MOLD RELEASE (P4) TO ALL SURFACES OF THE HOLDING FIXTURE. ALLOW TO AIR DRY FOR 30 MINUTES MINIMUM.

3.3 APPLY A THIN COAT OF MOLD RELEASE (P4) TO THE UNIT CONTAINER AT THE INSIDE SURFACE, .25 FROM THE TOP CONTAINER EDGE. ALLOW TO AIR DRY FOR 30 MINUTES MINIMUM.

3.4 ASSEMBLE UNIT INTO THE RETAINING MOLD AND BOLT SECURELY, EXCEPT FOR TOP PLATE.

3.5 PREHEAT UNIT AND RETAINING MOLD TO $100^{\circ}\text{F} \pm 5^{\circ}\text{F}$ (INCLUDING TOP PLATE).

4. MIXING AND POURING

4.1 COMPONENTS SHOULD BE MIXED UNDER A HOOD AS THE FUMES LIBERATED ARE EXTREMELY TOXIC.

4.2 WEIGH OUT 39 PARTS BY WEIGHT, OF P2 AT $75^{\circ}\text{F} \pm 10^{\circ}\text{F}$. RECOMMENDED MASS 136.5 GRAMS.

4.3 WEIGH OUT 61 PARTS BY WEIGHT OF P3 AT $75^{\circ}\text{F} \pm 10^{\circ}\text{F}$. RECOMMENDED MASS 213.5 GRAMS.

4.4 POUR THE PREWEIGHED P3 INTO THE CONTAINER OF P2 AND MIX THOROUGHLY WITH A STAINLESS STEEL SPATULA UNTIL A RESIN TEMPERATURE OF $115-120^{\circ}\text{F}$ IS OBSERVED.

4.5 IMMEDIATELY POUR THE MIXTURE INTO THE CAVITY TO BE FOAM FILLED. (ALL PARTS PRE-HEATED TO $100^{\circ}\text{F} \pm 5^{\circ}\text{F}$. DISTRIBUTE MIXTURE EVENLY.

4.6 ATTACH THE TOP COVER PLATE OF RETAINING MOLD.

4.7 ALLOW THE POURED ASSEMBLY TO STAND AT $75^{\circ}\text{F} \pm 10^{\circ}\text{F}$ FOR 60 MINUTES $\pm$ 10 MINUTES.

4.8 PLACE THE POURED ASSEMBLY IN AN OVEN AT $160^{\circ} \pm 5^{\circ}\text{F}$ FOR 16 HOURS MIN. TO CURE.

FOR EXPERIMENTAL
USE ONLY

PRINTS TO

MADE BY
B. Schupfer 2/25/60
ISSUED
EN303 M. W. 4-5-60 OK 4/5/60

APPROVALS

PINELLAS PENINSULA APPOINTMENT
ST. PETERSBURG, FLORIDA
LOCATION46A115071
CONT ON SHEET 3 SH NO. 2

46A115071
CONT ON SHEET Final SH NO. 3

REV NO. 01

TITLE

POLYURETHANE FOAM POTTING

46A115071

CONT ON SHEET Final SH NO. 3

FIRST MADE FOR 46C100760 G1

REVISIONS

4.9 REMOVE FROM THE OVEN AND DISASSEMBLE THE UNIT FROM THE RETAINING MOLD.

CAUTION: THE FOAM PLASTIC COMPONENTS AND THE GASES EVOLVED DURING FOAMING ARE KNOWN TO BE TOXIC. ADEQUATE VENTILATION AND PROTECTION CLOTHING SHOULD BE PROVIDED TO PREVENT UNDUE EXPOSURE.

FOR EXPERIMENTAL
USE ONLY

I

PRINTS TO

MADE BY <i>B. Schugferling 2/25/60</i>	APPROVALS <i>OK 2/26/60</i>	PINELLAS PENINSULA PLANT ST. PETERSBURG, FLORIDA	46A115071 CONT ON SHEET Final SH NO. 3
ISSUED <i>EN 303 M. W. 4-5-60</i>	<i>OK 4/5/60</i>	LOCATION	

APPENDIX II

METHOD OF VOLUME DETERMINATION

The various sub-assemblies were loaded into an MC-1353 can, and the can filled with a measured volume of water. The can was tapped sharply to dislodge any entrapped air, and additional water was added to restore the original level. The volume of water employed was equal to the volume of the space to be filled by the urethane foam.

APPENDIX III
FOAM DENSITY DETERMINATION

APPENDIX III

FOAM DENSITY DETERMINATION

The mold, constructed of $1/4$ " aluminum plate, had inside measurements of $6" \times 6" \times 1-1/4"$ to give it a capacity of 45 cubic inches. Three (3) holes $1/2"$ in diameter, were drilled in the top for filling and for providing restraint. (Figures A and B)

FIGURE A

Side view of the Standard Mold. The holes on the side were for the insertion of thermocouples to measure the exotherm in various positions of the mold during foaming.

FIGURE B

Top view of the Standard Mold showing the 1/2" diameter holes for filling and restraint.

Using the rule of the 5 "D's", the weights of foam ingredients (urethane, Drawing 46A115072, and foaming agent, Drawing 46A115073) were calculated for a volume of 45 cubic inches assuming densities of 10, 12 and 15 lbs/cu. ft. plus a 10 per cent excess. Samples of foam were prepared following essentially the procedure outlined in Drawing 46A115071. Utilizing the standard mold, test slabs were poured, but the calculated weights based on 10 and 12 lb/cu. ft. foam provided insufficient material to fill the mold. (Samples were also free-blown in 32 ounce paper cups.) A one-cubic-inch sample cut from the center of each of the molded slabs was weighed and found by calculation to have a density of 15.2 lb/cu. ft. and 15.0 lb/cu. ft. respectively. (Slab #1 and 2 of Table II)

Fifteen pounds/cubic foot was then used as the revised density value, and another slab was prepared. This amount of material filled the mold. Twelve one-cubic-inch samples were sectioned from various portions of the slab (Slab #3) and the densities obtained. A summary of these data is tabulated in Tables II and IIA.

TABLE II

Weights of Foam Ingredients and Densities Utilized With the Standard Mold

Slab No.	Volume	Assumed Foam Density	Weight of Foam Compounds + 10% Excess	Weight of R Component Dwg.# 46A115072	Weight of T Component Dwg.# 46A115073	Actual Density Based on 1 cu/in Sample lb/cu. ft.
1	45 cu in	10 lb/cu.ft.	129.7 g	50.6 g	79.1 g	15.2 from center
2	45 cu in	12 lb/cu.ft.	155.6	60.7	94.9	15.0 from center
3	45 cu in	15 lb/cu.ft.	194.6	75.9	118.7	See Table. IIA
4	32 oz. cup (Free blown)	12 lb/cu.ft.	154.7 g	60.3 g	94.4 g	10.8 at center 12.1 at edge

TABLE IIA

Actual Densities (lb/cu.ft.) at Various Locations
in Slab No. 3 Based on 1 cu. in. Samples

14.4	12.2	11.8	12.2
15.6	14.0	14.0	17.1
20.5	17.1	17.1	18.6

APPENDIX IV

TYPICAL POTTING DEFECTS OBSERVED AND CORRECTED
DURING THE MC-1353 MATTA FOAM INVESTIGATION

APPENDIX IV

TYPICAL POTTING DEFECTS OBSERVED AND CORRECTED DURING THE MC-1353 MATIA FOAM INVESTIGATION

- (1) Insufficient material to fill the mold.

FIGURE C

A top view of MC-1353 Unit #1 potted on 10/17/60 using the quantity of foam specified on Drawing 46A115071 (350 g total). The arrows indicate where the foam did not completely fill the mold, and the thermocouple leads.

(2) Insufficient coverage of Sub-Assemblies

FIGURE D

FIGURE E

Side views of castings showing areas where the sub-assemblies were too close to the can to allow the foam to cover them sufficiently.

(3) Floating of Sub-Assemblies

FIGURE F

Bottom view of a unit casting illustrating voids obtained by sub-assemblies lifted from the can by the intrusion of the foam.

(4) Bulging of the Can During Foaming

FIGURE G

Top view of Unit #6 before the cover was welded on. The pressure of the foam bulged the front edge and cover would not fit.

APPENDIX V

DRAWING 46A101674 - POLYURETHANE FOAM POTTING
PROCEDURE FOR MATTA AND MC-1270 FINAL UNITS

REV NO. *1 B-12*TITLE
POLYURETHANE FOAM POTTING

46A101674

CONT ON SHEET 2

SI NO. 1

FIRST MADE FOR

GROUP NO. AND QUANTITY

SEE BELOW

PART
NO.

NAME

DRAWING NO., DESCRIPTION, MATERIAL, WEIGHT

1

ASM

2

PREPOLYMER

46A115072 PI

3

TOLUENE
DIISOCYANATE

46A115073 PI

4

MOLD RELEASE

46A100954 PI

5

LATEX

118A1336 P22

TABLE 1

GROUP NO.	DRAWING NO.	TITLE	P ₂ GRAMS (39 PBW)	P ₃ GRAMS (61 PBW)	TOTAL WT. (GRAMS)
G-1	46D115076 G1	MC-1270 FINAL POTTING	136.5	213.5	350.0
G-2	46A100943 PI	MC-1270 SPACER	175.0	275.0	450.0
G-3	46A100944 PI	MC-1270 SPACER	175.0	275.0	450.0
G-4	46C115212 G1	MC-1314 FINAL POTTING	97.5	152.5	250.0
G-5	46C101383 G1	MC-1353 FINAL POTTING	156.0	244.0	400.0
G-6	46B101630 PI	MC-1353 SPACER	39.0	61.0	100.0
G-7	46C101650 G1	MC-1453 FINAL POTTING	88.0	137.0	225.0
G-8	46D115076 G2	MC-1270 TRAINER	175.0	275.0	450.0

FOR EXPERIMENTAL
USE ONLYUNLESS
OTHERWISE
SPECIFIED
USE

APPLIED PRACTICES

SURFACES

TOLERANCES ON MACHINED DIMENSIONS

FRACTIONS

DECIMALS

ANGLES

+

+

+

DESCRIPTION OF GROUPS

REVISIONS

PRINTS TO

MADE BY

St. Chadwick 5-24-61

ISSUED

APPROVALS

PINELIAS PENINSULA PLANT OR
DEPT
1 PETERSBURG FLORIDA
LOCATION

46A101674

CON. ON SHEET 2

SH NO. 1

REV NO. *ABED*

TITLE
POLYURETHANE
FOAM POTTING

46A101674

CONT ON SHEET 3 SH NO. 2

FIRST MADE FOR

REVISIONS

1. SCOPE - THIS SPECIFICATION COVERS THE MIXING AND PROCESSING REQUIREMENTS FOR EMBEDDING ELECTRICAL COMPONENTS AND FOR THE CASTING OF MOLDED FORMS IN RIGID POLYURETHANE FOAM.

2. REQUIREMENTS

2.1 FORMULATIONS - THE EMBEDDING OR CASTING COMPOUND SHALL BE FORMULATED PER THE MIXTURE SHOWN IN TABLE I AND TAKEN IN THE REQUISITE PROPORTIONS ON A WEIGHT BASIS. THE TOLERANCE ON WEIGHTS OF MATERIALS SHALL BE ± 1 PERCENT. THE QUANTITIES FOR THE POTTING OF A SINGLE UNIT ARE GIVEN IN TABLE I.

3. MOLD PREPARATION

3.1 A RESTRAINING FIXTURE ON ALL SIDES OF THE CONTAINER SHALL BE USED DURING FOAMING TO:

- (A) PROVIDE A RESTRAINING FORCE ON THE CONTAINER WALLS TO WITHSTAND THE 30 PSI PRESSURE PRODUCED DURING THE FOAMING REACTION.
- (B) PROVIDE THE NECESSARY CONFIGURATION TO MAINTAIN THE SPECIFIED OUTSIDE DIMENSIONS OF THE CONTAINER.
- (C) PROVIDE THE SPECIFIED FOAM CONFIGURATION AND FOAM HEIGHT WHERE THE CONTAINER COVER IS MOUNTED.
- (D) PROVIDE AIR VENTS APPROXIMATELY 1/8 INCH DIAMETER EQUALLY SPACED TO ALLOW FOR THE ESCAPE OF THE ENTRAPPED AIR AND EXCESS FOAM TO ENSURE THAT ALL AREAS WITHIN THE CASTING ARE FILLED WITH FOAM.
- (E) PROVIDE A HEAT SINK SO THAT THE TEMPERATURE SPECIFIED CAN BE MAINTAINED FOR FOAM REPEATABILITY.

3.2 FOR CASTING FORMS, A MOLD OF THE PROPER DIMENSIONS SUITABLY RE-INFORCED AND RESTRAINED SHALL BE UTILIZED.

3.3 APPLY A THIN COAT OF MOLD RELEASE (P4) TO ALL SURFACES OF THE HOLDING FIXTURE AND CASTING MOLD.

3.4 APPLY A THIN COAT OF P4 TO THE UNIT CONTAINER ON THE INNER SURFACE, 0.25 INCH FROM THE TOP OF THE CONTAINER EDGE, FOR G1, G5, G7, & G8.

3.5 ALLOW P4 TO AIR DRY FOR THIRTY MINUTES MINIMUM.

3.6 APPLY A THIN COAT OF P5 TO THE G4 UNIT CONTAINER AT THE OUTSIDE SURFACE 0.18 INCH FROM THE TOP CONTAINER EDGE. ALSO, APPLY A THIN COAT TO CONNECTORS AND CONNECTOR MOUNTING SCREWS. ALLOW TO AIR DRY THIRTY MINUTES MINIMUM.

FOR EXPERIMENTAL
USE ONLY

PRINTS TO

MADE BY
St Chadwick 5-24-61
ISSUED

APPROVALS

INILIAS PENINSULA FLA
T. PETERSBURG, FLORIDA
LOCATION

DIV OR
DEPT

46A101674

CONT ON SHEET 3 SH NO. 2

REV NO. *43710*
46A101674
CONT ON SHEET *FINAL* SH NO. *3*

TITLE
POLYURETHANE
FOAM POTTING

FIRST MADE FOR

REVISIONS

FOR EXPERIMENTAL
USE ONLY

- 3.7 ASSEMBLE UNIT INTO THE RETAINING MOLD AND BOLT SECURELY, EXCEPT FOR TOP PLATE.
- 3.8 PRE HEAT UNIT AND RETAINING MOLD TO $125^{\circ} \pm 5^{\circ} \text{F}$ (APPROX. 2 HRS.) INCLUDING TOP PLATE.

4. MIXING AND POURING

4.1 MECHANICAL OPERATION

- 4.1.1 SET MACHINE TO DELIVER THE TOTAL AMOUNT SPECIFIED IN TABLE 1. COMPONENTS TO BE AT $90^{\circ} \pm 10^{\circ} \text{F}$ IN THE STORAGE CONTAINERS. MIX AT THE HEAD SHALL BE AT LEAST 75°F . THE VARIANCE IN THE TOTAL WEIGHT OF FOAM DISPENCED FROM MOLD TO MOLD OR UNIT TO UNIT SHALL NOT EXCEED 10 GRAMS.
- 4.1.2 POSITION UNIT OR MOLD AND ALLOW THE MACHINE TO METER, MIX AND DISPENSE THE REQUIRED QUANTITY OF FOAM INTO THE CAVITY. DISTRIBUTE MIXTURE EVENLY.

4.2 HAND OPERATION

- 4.2.1 COMPONENTS SHOULD BE MIXED UNDER A HOOD AS THE FUMES LIBERATED ARE EXTREMELY TOXIC.
- 4.2.2 WEIGH OUT P2. WEIGHT AS SPECIFIED IN TABLE 1 AT $75^{\circ} \pm 10^{\circ} \text{F}$.
- 4.2.3 WEIGH OUT P3 INTO P2 CONTAINER. WEIGHT AS SPECIFIED IN TABLE 1 AT $75^{\circ} \pm 10^{\circ} \text{F}$.
- 4.2.4 MIX THOROUGHLY WITH A STAINLESS STEEL SPATULA FOR $3 \pm \frac{1}{4}$ MINUTES OR UNTIL A RESIN TEMPERATURE OF $100-105^{\circ} \text{F}$ IS OBSERVED WHICH EVER IS SOONER.
- 4.2.5 IMMEDIATELY POUR THE MIXTURE INTO THE CAVITY TO BE FILLED (PREHEATED TO $125^{\circ} \pm 5^{\circ} \text{F}$). DISTRIBUTE MIXTURE EVENLY. ELAPSED TIME FROM POURING P3 INTO P2 UNTIL COMPLETION OF 4.2.5 TO BE SIX MINUTES MAXIMUM.

5.0 RESTRAINING AND CURING

- 5.1 ATTACH THE TOP COVER PLATE OF THE RETAINING MOLD,
- 5.2 ALLOW THE POURED ASSEMBLY TO STAND AT $75^{\circ} \pm 10^{\circ} \text{F}$ FOR 60 ± 10 MINUTES.
- 5.3 PLACE THE FILLED ASSEMBLY IN AN OVEN AT $160^{\circ} \pm 5^{\circ} \text{F}$ FOR 16-24 HOURS TO CURE.

- 5.4 REMOVE FROM THE OVEN AND DISASSEMBLE THE UNIT OR CASTING FROM THE RETAINING MOLD.

CAUTION: THE FOAM COMPONENTS AND THE GASES ENOLVED DURING FOAMING ARE KNOWN TO BE TOXIC. ADEQUATE VENTILATION AND PROTECTION CLOTHING SHOULD BE PROVIDED TO PREVENT UNDUE EXPOSURE.

PRINTS TO

MADE BY
St. Chadwick 5/24/61
ISSUED

APPROVALS

INELIAS PENINSULA FLORIDA
ST PETERSBURG FLORIDA
LOCATION

46A101674
CONT ON SHEET *FINAL* SH NO. *3*