GENERAL PLASTICS MFG. COMPANY
3481 South 35th Street
Tacoma, Washington

FINAL REPORT

SUBJECT: DEVELOPMENT OF LOW DENSITY RIGID POLYURETHANE FOAM FOR USE ON S-1C FLIGHT VEHICLES

COMPLETION DATE: 22 OCTOBER 1964

CONTRACT NUMBER: NAS8-11688

ATTENTION: PR-RC

This completes the requirements of Phase I, Phase II, Phase III and Phase IV of Contract NAS8-11688 and Modification I.

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GENERAL PLASTICS MFG. COMPANY
3481 South 35th Street
Tacoma, Washington 98409

SUMMARY

CONTRACT NAS8-11688

Contract NAS8-11688 entitled "The development of a low density rigid polyurethane foam for use in the S-1C Flight Vehicle", consists of four phases, each with a specific objective. This report consists of four separate sections, which corresponds to the four Contract phases.

Phase I comprises the development of a 3 to 4#/cu.ft. density polyurethane foam. This foam is required to meet four specific compression requirements and must be capable of large (2' x 5' x 6') single pour castings.

Phase II is comprised of developing a foam system which will have similar physical properties but is capable of closed moldings. A specific closed mold has been supplied by the Government and sample parts are to be molded and furnished to the Government.

Phase III requires the fabrication of sixteen (16) blocks of the foam developed in Phase I. The dimensions of these blocks are 24" high x 60" wide x 72" long. These blocks require X-ray examination to assure the internal quality of the foam.

Phase IV requires the development of a repair technique for damaged blocks. The required technique should restore the damaged material to the physical requirements spelled out in the Phase I development.

GENERAL PLASTICS MFG. COMPANY
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Tacoma, Washington

FINAL REPORT

PHASE I

SUBJECT: FORMULATION DEVELOPMENT

COMPLETION DATE: 22 OCTOBER 1964

CONTRACT NUMBER: NAS8-11688

ATTENTION: PR-RC

2 OCTOBER 1964
Contract NAS8-11688
General Plastics Mfg. Company

SUMMARY - PHASE I

Phase I consisted of developing a low density foam formulation which would pass the creep and compression requirements spelled out in Contract NAS8-11688. This was accomplished by screening foam formulations for their physical and casting properties. From these formulations three promising formulations were then cast into test blocks measuring sixty inches in diameter and twenty-five inches thick. Test samples were again taken from these large castings and a single formulation, designated R4803.5, was chosen for further testing. This formula was cast into a 30" x 66" x 78" block and samples were again subjected to the property requirements of this contract. This formula proved to meet all the property requirements and to cast satisfactorily in the large pour. This formula was later used in Phase III to produce the sixteen fabricated blocks.

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Company

DESCRIPTION OF PHASE I

The following methods were used in obtaining formulation R4803.5 to comply with the Phase I requirements:

Bench Formulations:

A series of twenty-two foam formulations utilizing various basic raw materials were established and samples of each formulation were cast. These samples were poured in one-gallon paper containers utilizing approximately 400 grams of total foam ingredients. These formulations were designed to determine which raw materials would be capable of not only the physical requirements, spelled out in Phase I, but also would be capable of large volume castings. These cup samples were then subjected to preliminary screening to determine the compliance with these requirements. This screening consisted primarily of subjecting samples to the Section A Phase I test (1 hr. cyclic loading at 60 psi) which indicated the properties which could be expected from each formulation.

Box Formulations:

Three formulations obtained from the bench formulations were cast in approximately four cubic foot boxes to determine the feasibility of large volume castings. No major disadvantage was found to any of these castings, and upon dissecting the foam, all samples were found to be sound. Since much larger castings were necessary to complete the Phase III requirement, it was felt that a larger casting would be necessary to achieve the final formulation.

Half-size Casting:

The three box formulations were then cast in 220 pound pours which measured 60" in diameter and approximately 25" thick. This size casting was chosen to minimize the material requirement and yet provide the same internal exotherm which could be expected in the Phase III production blocks. Each of these 60" diameter castings were allowed to cure two days before being removed from the mold and an additional two days before the castings were dissected. The castings were then split directly in half and samples were taken from various heights throughout the blocks

DESCRIPTION OF PHASE I
(Continued)

Half-size Casting (Cont'd)

to determine their physical properties. The remainder of the blocks were cut into small pieces to establish the consistency and quality of the internal foam. Because of undesirable molding characteristics, two of the three formulations were discarded at this point and only formula R4803.5 was considered for the Phase III production.

Block Casting:

Formula R4803.5 was cast into the 30" x 68" x 78" block mold utilizing 420 pounds of foam. This block was allowed to cure two days in the mold and two days prior to fabrication. Samples for testing were then obtained from this block and the block was X-rayed. This formulation was found to be satisfactory for the production of the Phase III blocks.

Testing:

Samples obtained during this development procedure were subjected to the tests described in Phase I of this Contract. Where a definite indication of failure, or a definite conclusion could be drawn from the Section A requirement, no further testing was performed. In this way it was possible to screen the numerous formulations mentioned above and still meet the time requirements of the Contract.

In Appendix I of this Phase are the progressive creep curves which were obtained from the various steps performed on formulation R4803.5.

DISCUSSION OF TEST RESULTS

The creep and compression tests were run on samples measuring 2" x 2" x 2" (Figure 1). The loading in all cases were applied to the direction of the foam rise. On the test data, included with this report, the test No. 1 coincides with Requirement A of the Phase I Contract tests. Correspondingly, Test No. 2 corresponds with Contract test (b), Test No. 3 corresponds with Contract test (c) and Test No. 4 corresponds with Contract test (d). Also our creep test equipment is built so as the thickness measurement during the tests includes a 1" thickness of metal plate. This accounts for the recorded values always being 1" greater than the plotted graph values.

The first creep sample was taken from box sample N1014-62 and was obtained from the sample of the box casting as shown in Figure 2. Because this was a preliminary sample, only the Section "a" sixty pound creep test was run on this block. From the results of this sixty pound creep test, it was felt that a larger casting would be necessary in order to make a final decision on this foam formulation.

Four test samples were taken from the one-half size pour, Sample No. N1017-69 from the position shown in Figure 3. As would be expected, the density of this pour decreased from the bottom of the pour to the top. Also, as would be expected, the creep became greater as the density decreased. From this sample it was concluded that the minimum acceptability production density for a Phase III block would be 3.5 pounds per cubic foot. This conclusion was drawn from Sample 1 which had a density of 3.41 pounds per cubic foot and a maximum creep of 4.65%. Since our maximum allowable creep was 5%, it seemed inadvisable to approach this limit by reducing the minimum density of any point in a casting below 3.4 pound per cubic foot. The creep samples were then subjected to the compression test and this data shows a minimum compressive strength of 75 psi at 6% deflection on the 3.41 pound per cubic foot sample. From these combined results it was concluded that formula R4803.5 would be satisfactory for the Phase III production blocks.

To further prove its acceptability, a full size casting measuring 30" x 66" x 78" was cast and additional creep samples were taken from this block. Samples #1, #2 and #3 were taken from the extreme end slice of this block and subjected to the creep requirements. Although the creep values obtained from these end samples did not correspond in increasing order to their decreasing density, all the samples did pass the Phase I

DISCUSSION OF TEST RESULTS
(Cont'd)

requirement. This inconsistency can be explained by the fact that these samples were obtained very close to the mold wall and consequently their cell structure is not ideal as in those samples taken closer to the center of the block. Sample #4 taken from the center of the block passed creep easily and all testing to this point indicated that formula R4803.5 could be used in the Phase III production.

Block N1019-615 was then submitted for X-ray evaluation. The X-rays obtained from this block showed that this material could be cast in this size casting and produced the required internal foam quality.

RECOMMENDATIONS

Based on the formulation work carried out in Phase I, the following specific recommendations can be made:

1. The minimum average density which will pass the Phase I physical property requirements is 3.5 pounds per cubic foot.

2. The two-foot x 5-foot x 6-foot casting approaches the maximum practical single casting size for this foam formulation.

3. A minimum size pour of approximately four-cubic feet must also be applied to this formulation if no heat cure is applied. Should a smaller casting, such as an Exclusion Riser Rim, be attempted from this formulation, a heat cure requirement which was not established in this program would definitely be necessary.

22 OCTOBER 1964
Contract NAS8-11688
General Plastics Mfg. Company

PHASE I

Foam Formulation:

R-4803.5

R-4803.5 Part A

Polyether Resin	(510 OH#)	80
Tcluene Diisocyanate	(80-20 Isomer)	298
Benzoyl Chloride		0.2
Silicone Glycol Copolymer	(DC 201)	3.9

R-4803.5 Part B

Polyether Resin	(500 OH#)	75
Flourocarbon 11		14
Silicones Glycol Copolymer	(DC 201)	1.0
Triethylenediamine		0.1
Dipropylene Glycol		0.2

To Obtain Foam:

These components are combined in a ratio of 110 parts by weight Part A to 100 parts by weight Part B.

CREEP & COMPRESSION SAMPLE

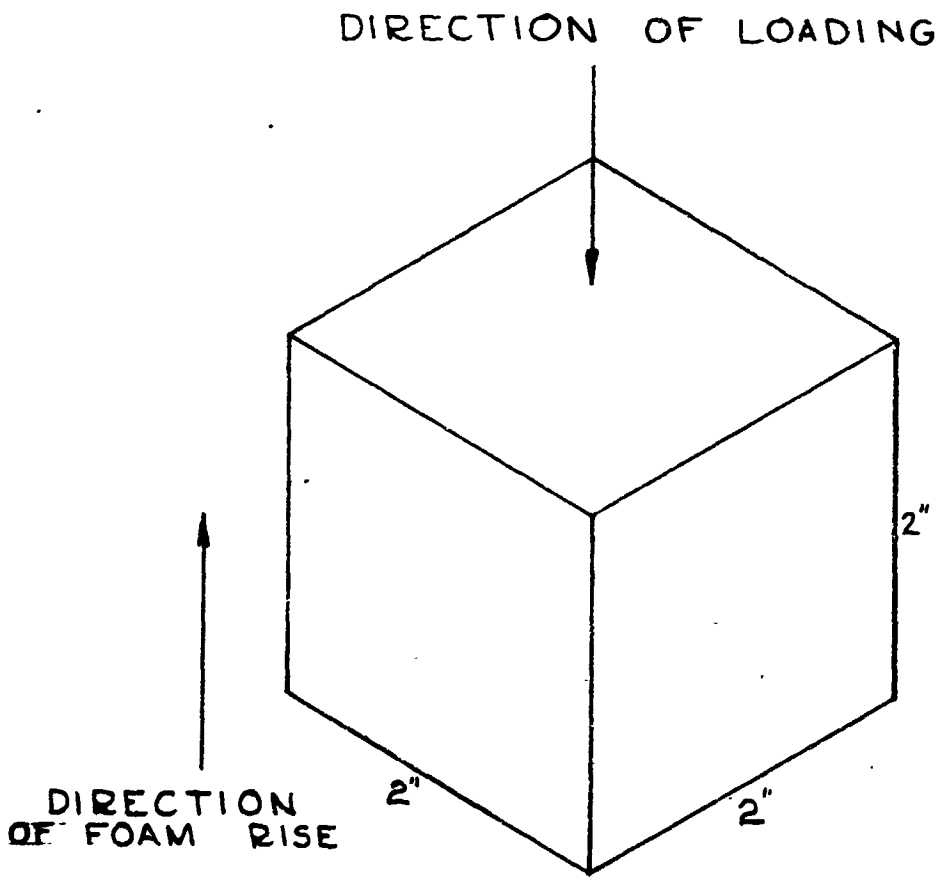
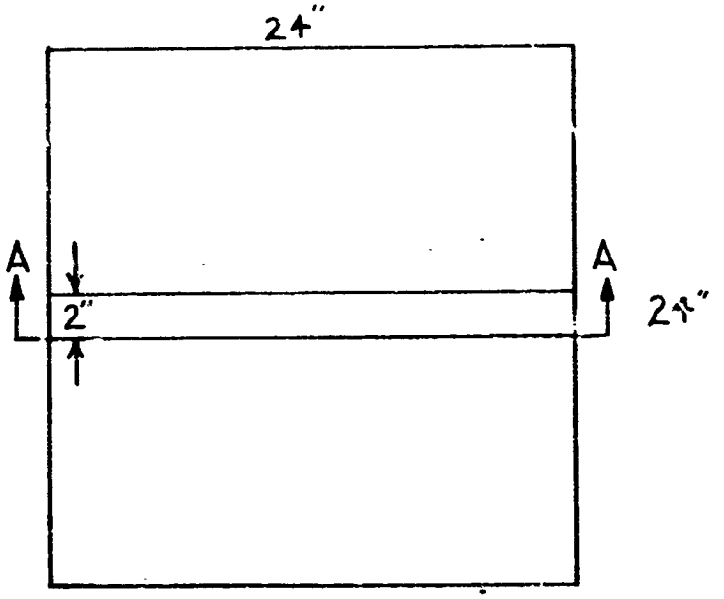
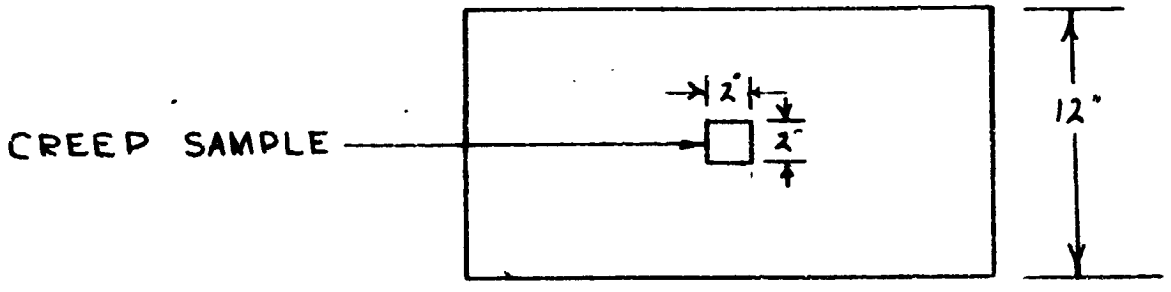


FIGURE 1

BOX SAMPLE
SERIAL No. N 1014-62



TOP VIEW



SECTION A-A

SAMPLE BLOCK DENSITY 3.58 #/CU. FT. MAX. CREEP 3.60%

FIGURE 2

CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No. APP 7A 100-527 BATCH B ~~Date Tested~~ N-9 N110-64

Date Poured JUNE 2ND Date Tested JUNE 5TH & 6TH

SERIAL No. N 1014-62

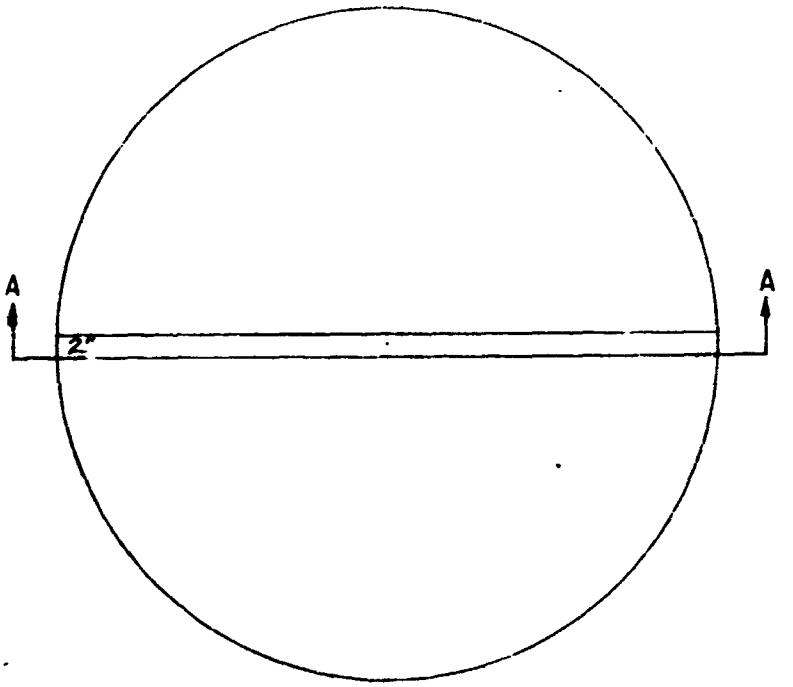
TEST #1

	Time	Height	Deflection	
Initial 5TH	12:10	3.017		
Loaded t = 0m	12:10	2.974		
t = 60m	1:10	2.958		
Unloaded t = 60m	1:10	2.995		
t = 120m	2:10	3.007		
Loaded t = 120m	2:10	2.966		
t = 180m	3:10	2.950		
Unloaded t = 180m	3:10	2.994		
6TH t = 240m	7:40	3.012		
Loaded t = 240m	7:40	2.965		
t = 300m	8:40	2.945		
Unloaded t = 360m	8:40	2.991		

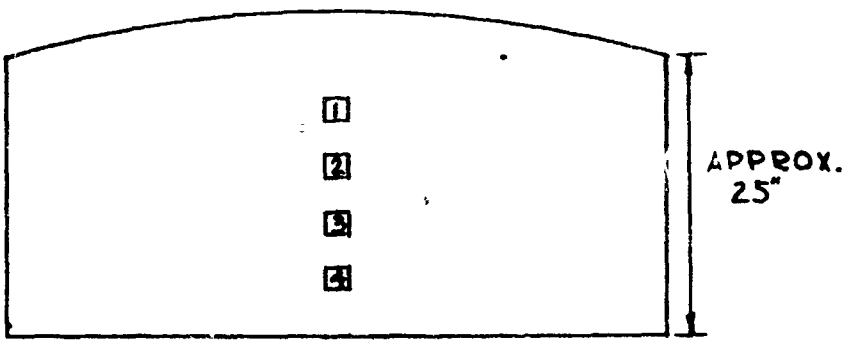
TEST #3

	Time	Height	Deflection	
Initial				
Loaded t = 0 hr				
t = 1 hr				
t = 24 hr				
t = 48 hr				
t = 60 hr				
Loaded t = 72 hr				
Unloaded t = 72 hr				

ONE HALF SIZE POUR
SERIAL No. N 1017-69



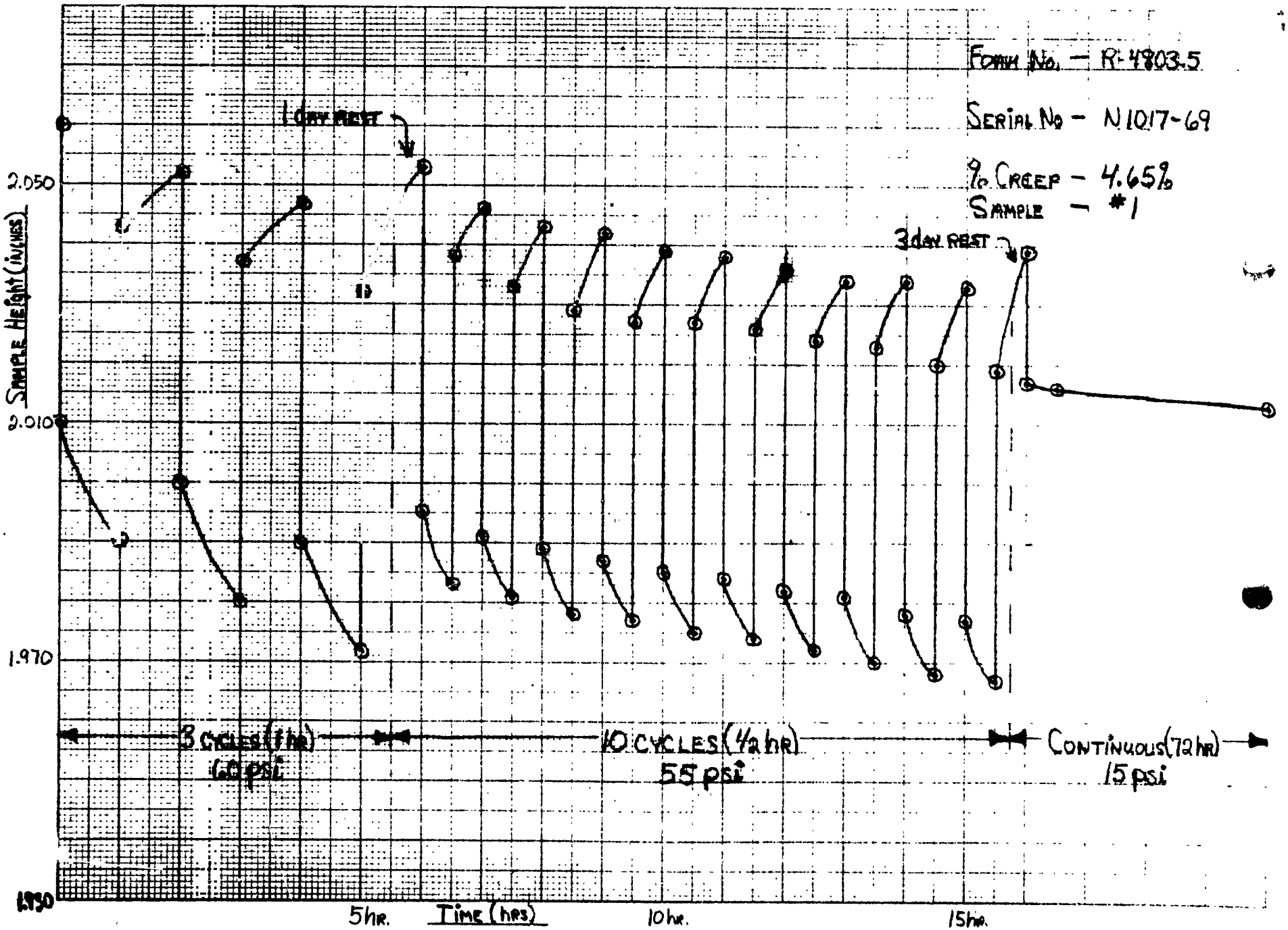
60" DIAMETER POUR



SECTION A-A

SAMPLE	#1	DENSITY	3.41#/cu. ft.	MAX. CREEP	4.65%
"	#2	"	3.47#/cu. ft.	"	3.75 %
"	#3	"	3.52#/cu. ft.	"	3.1 %
"	#4	"	3.62#/cu. ft.	"	2.75 %

FIGURE 3


KEUFFEL & ESSER CO
FORM NO. — R-4803.5
SERIAL NO — N1017-69
% CREEP — 4.65%
SAMPLE — #1
1 DAY REST
3 DAY REST
2.050
2.010
1.970
1.930
SAMPLE HEIGHT (INCHES)
3 CYCLES (1 hr) 60 psi
10 CYCLES (½ hr) 55 psi
CONTINUOUS (72 hr) 15 psi
5hr.
Time (hrs)
10hr.
15hr.

CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No. APP-7A 100-527 Batch No. B N110-64

Date Poured JUNE 9TH Date Tested JUNE 12TH SAMPLE

Serial No. N1017-69

TEST #1

	Time	Height	Deflection	
Initial	9:40	3.060		
Loaded t = 0m	9:40	3.010		
t = 60m	10:40	2.990		
Unloaded t = 60m	10:40	3.043		
t = 120m	11:40	3.052		
Loaded t = 120m	11:40	3.000		
t = 180m	1:00	2.980		
Unloaded t = 180m	1:00	3.037		
t = 240m	2:00	3.047		
Loaded t = 240m	2:00	2.090		
t = 300m	3:00	2.972		
Unloaded t = 360m	3:00	3.032		

JUNE 15TH - 18TH

TEST #3

	Time	Height	Deflection	
Initial	8:30	3.039		
Loaded t = 0 hr	8:30	3.017		
t = 1 hr	9:30	3.016		
t = 24 hr	8:30	3.015		
t = 48 hr	8:30	3.014		
t = 60 hr	4:00	3.014		
Loaded t = 72 hr	8:30	3.013		
Unloaded t = 72 hr				

CREEP TEST #2

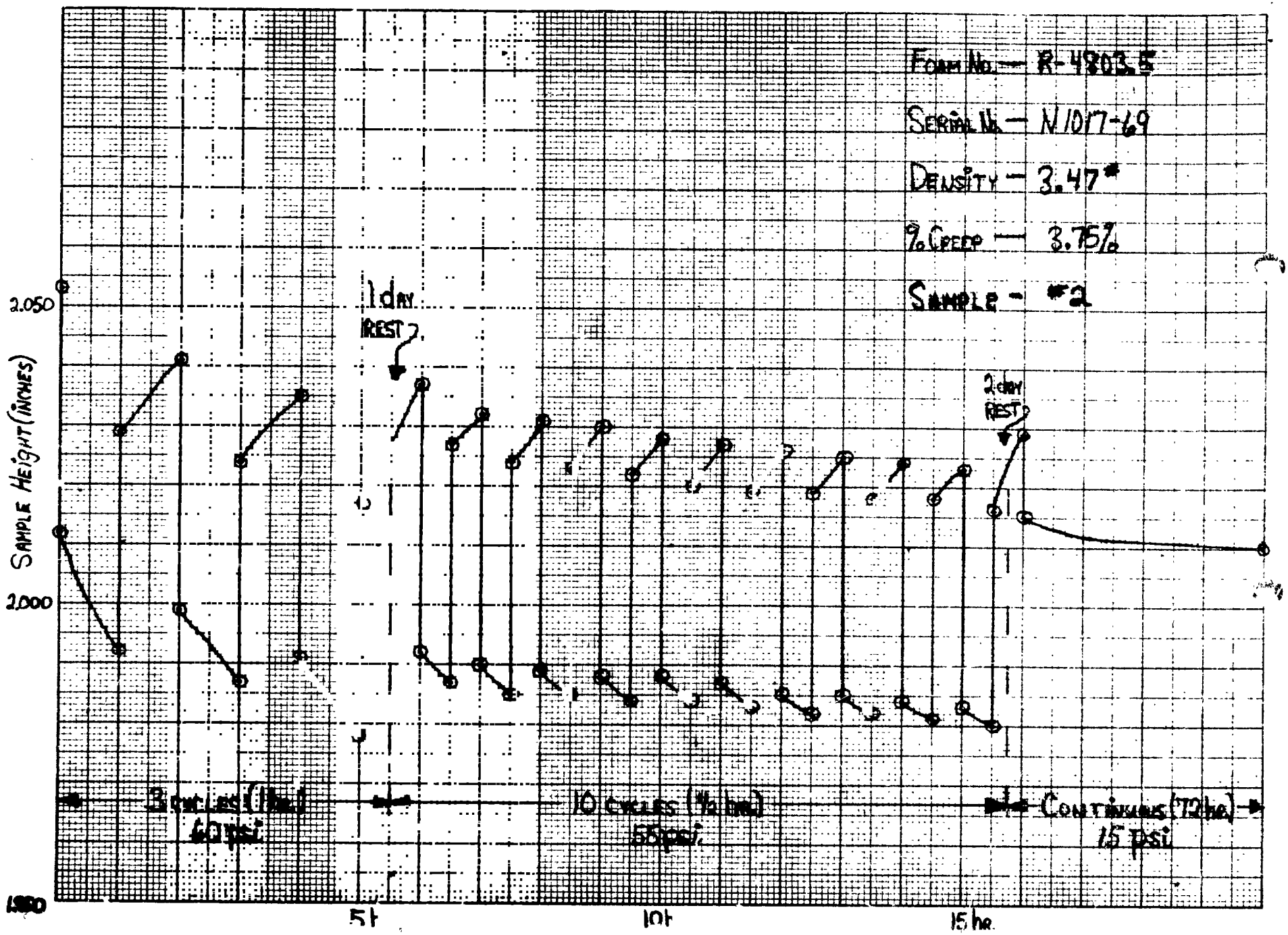
Foam No. R-4803.5 Batch No. A PP-7M 100-527 Batch No. B N110-64

Date Poured JUNE 9TH Date Tested JUNE 13TH

TEST #2 Serial No N1017-69 SAMPLE #1

	Time	Height		Time	Height
Initial	7:30	3.053			
Loaded t = 0m	7:30	2.995	t = 300	12:30	2.984
t = 30m	8:00	2.983	t = 330	1:00	2.974
Unloaded t = 30m	8:00	3.038	t = 330	1:00	3.926
t = 60m	8:30	3.046	t = 360	1:30	3.036
Loaded t = 60m	8:30	2.991	t = 360	1:30	2.982
t = 90m	9:00	2.981	t = 390	2:00	2.972
Unloaded t = 90m	9:00	3.933	t = 390	2:00	3.024
t = 120m	9:30	3.043	t = 420	2:30	3.034
Loaded t = 120m	9:30	2.989	t = 420	2:30	2.981
t = 150m	10:00	2.978	t = 450	3:00	2.970
Unloaded t = 150m	10:00	3.029	t = 450	3:00	3.023
t = 180m	10:30	3.042	t = 480	3:30	3.034
Loaded t = 180m	10:30	2.987	t = 480	3:30	2.978
t = 210m	11:00	2.977	t = 510	4:00	2.968
Unloaded t = 210m	11:00	3.027	t = 510	4:00	3.020
t = 240m	11:30	3.039	t = 540	4:30	3.033
Loaded t = 240m	11:30	2.985	t = 540	4:30	2.977
t = 270m	12:06	2.075	t = 570	5:00	2.967
Unloaded t = 270m	12:00	3.027	t = 570	5:00	3.019
t = 300m	12:30	3.038	t = 600		

K-E 10 X 10 TO THE ½ INCH KEUFFEL & ESSER CO 358-12 MADE IN U.S.A.



CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No. A PP-7A 102-527 Batch No. B N110-64

Date Poured JUNE 9, 1964 Date Tested JUNE 17TH

Serial No. N1017-69 SAMPLE #2

TEST #1

	Time	Height	Deflection	
Initial 17TH	11:25	3.053		
Loaded t = 0m	11:25	3.012		
t = 60m	12:25	2.992		
Unloaded t = 60m	12:25	3.029		
t = 120m	1:25	3.041		
Loaded t = 120m	1:25	2.999		
t = 180m	2:25	2.987		
Unloaded t = 180m	2:25	3.024		
t = 240m	3:25	3.035		
Loaded t = 240m	3:25	2.991		
t = 300m	4:25	2.978		
Unloaded t = 360m	4:25	3.017		

TEST #3 JUNE 20-23

	Time	Height	Deflection	
Initial 20TH	10:00	3.029		
Loaded 20TH t = 0 hr	10:00	3.015		
20TH t = 1 hr	11:00	3.014		
SUNDAY t = 24 hr	—	—		
22ND t = 48 hr	10:00	3.011		
22ND t = 55/60 hr	5:00	3.011		
Loaded t = 72 hr	10:00	3.010		
Unloaded t = 72 hr				

CREEP TEST #2

Foam No. R-4803.5 Batch No. A PP-7A 100-527 Batch No. B N110-64

Date Poured _____ Date Tested JUNE 18TH

TEST #2 SERIAL No. N1017-69 SAMPLE #2

	Time	Height		Time	Height
Initial	7:30	3.037			
Loaded t = 0m	7:30	2.992	t = 300	12:30	2.987
t = 30m	8:00	2.987	t = 330	1:00	2.983
Unloaded t = 30m	8:00	3.027	t = 330	1:00	3.019
t = 60m	8:30	3.032	t = 360	1:30	3.026
Loaded t = 60m	8:30	2.990	t = 360	1:30	2.985
t = 90m	9:00	2.985	t = 390	2:00	2.982
Unloaded t = 90m	9:00	3.024	t = 390	2:00	3.019
t = 120m	9:30	3.031	t = 420	2:30	3.025
Loaded t = 120m	9:30	2.989	t = 420	2:30	2.985
t = 150m	10:00	2.985	t = 450	3:00	2.982
Unloaded t = 150m	10:00	3.023	t = 450	3:00	3.018
t = 180m	10:30	3.030	t = 480	3:30	3.024
Loaded t = 180m	10:30	2.988	t = 480	3:30	2.984
t = 210m	11:00	2.984	t = 510	4:00	2.981
Unloaded t = 210m	11:00	3.022	t = 510	4:00	3.018
t = 240m	11:30	3.028	t = 540	4:30	3.023
Loaded t = 240m	11:30	2.988	t = 540	4:30	2.983
t = 270m	12:00	2.984	t = 570	5:00	2.980
Unloaded t = 270m	12:00	3.020	t = 570	5:00	3.015
t = 300m	12:30	3.027	t = 600		

CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No. APP-7A 100-527 Batch No. B N110-64

Date Poured JUNE 9, 1964 Date Tested JUNE 18TH

Serial No. N-1017-69 SAMPLE #3

TEST #1

	Time	Height	Deflection	
Initial	9:30	3.014		
Loaded t = 0m	9:30	2.978		
t = 60m	10:30	2.964		
Unloaded t = 60m	10:30	2.993		
t = 120m	11:30	3.002		
Loaded t = 120m	11:30	2.968		
t = 180m	12:30	2.957		
Unloaded t = 180m	12:30	2.988		
t = 240m	1:30	2.997		
Loaded t = 240m	1:30	2.962		
t = 300m	2:30	2.953		
Unloaded t = 360m	2:30	2.985		

TEST #3

	Time	Height	Deflection	
Initial				
Loaded t = 0 hr				
t = 1 hr				
t = 24 hr				
t = 48 hr				
t = 60 hr				
Loaded t = 72 hr				
Unloaded t = 72 hr				

CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No. A PP-TA 100-507 Batch No. B N110-64

Date Poured JUNE 9, 1964 Date Tested JUNE 18TH

Serial No. N107-69

SAMPLE #1

TEST #1

	Time	Height	Deflection	
Initial	10:30	2.994		
Loaded t = 0m	10:30	2.962		
t = 60m	11:30	2.950		
Unloaded t = 60m	11:30	2.978		
t = 120m	12:30	2.985		
Loaded t = 120m	12:30	2.954		
t = 180m	1:30	2.943		
Unloaded t = 180m	1:30	2.972		
t = 240m	2:30	2.981		
Loaded t = 240m	2:30	2.948		
t = 300m	3:30	2.959		
Unloaded t = 360m	3:30	2.968		

TEST #3

	Time	Height	Deflection	
Initial				
Loaded t = 0 hr				
t = 1 hr				
t = 24 hr				
t = 48 hr				
t = 60 hr				
Loaded t = 72 hr				
Unloaded. t = 72 hr				

Compression Test #4

Sample No. #1
Sample Density 3.41*

Strain in/in	% Deflection	Stress (psi)
.005	.5	10
.010	1.0	22
.020	2.0	47
.030	3.0	62
.040	4.0	69
.050	5.0	73
.060	6.0	75
.070	7.0	75

Sample No. #2
Sample Density 3.47*

Strain in/in	% Deflection	Stress (psi)
.005	.5	11
.010	1.0	23
.020	2.0	52
.030	3.0	66
.040	4.0	73
.050	5.0	76
.060	6.0	78
.070	7.0	78

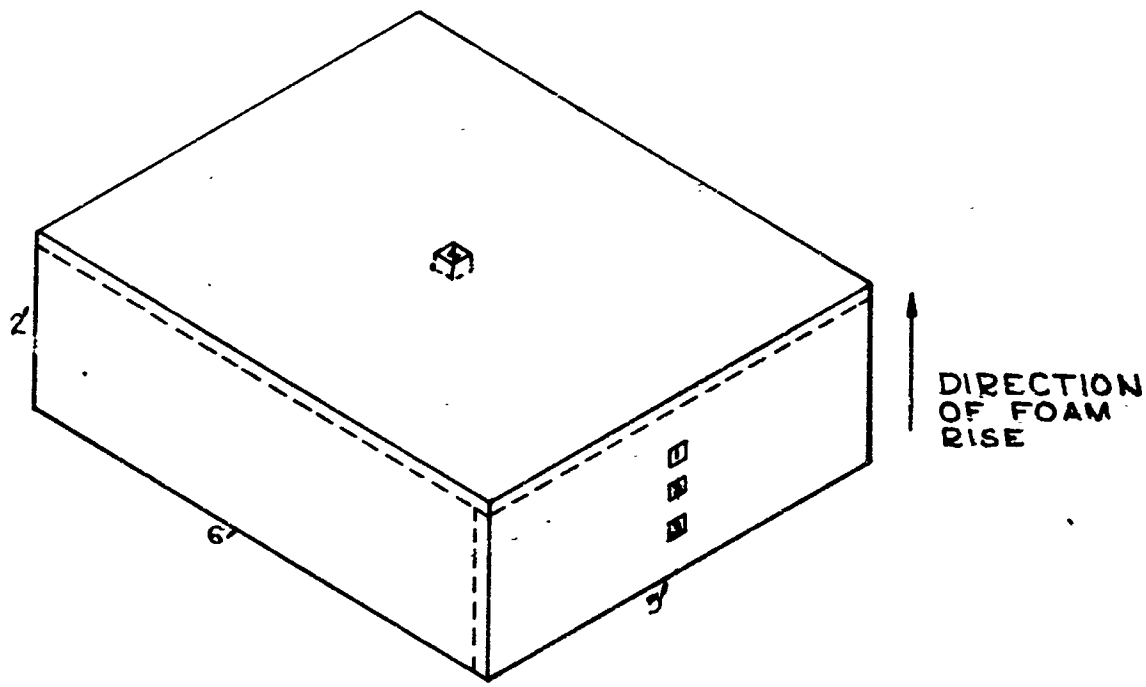
Sample No. #3
Sample Density 3.52*

Strain in/in	% Deflection	Stress (psi)
.005	.5	11
.010	1.0	23.5
.020	2.0	54
.030	3.0	68
.040	4.0	75
.050	5.0	80
.060	6.0	81
.070	7.0	81

Sample No. #4
Sample Density 3.62*

Strain in/in	% Deflection	Stress (psi)
.005	.5	11
.010	1.0	22
.020	2.0	53
.030	3.0	72
.040	4.0	79
.050	5.0	83
.060	6.0	85
.070	7.0	85

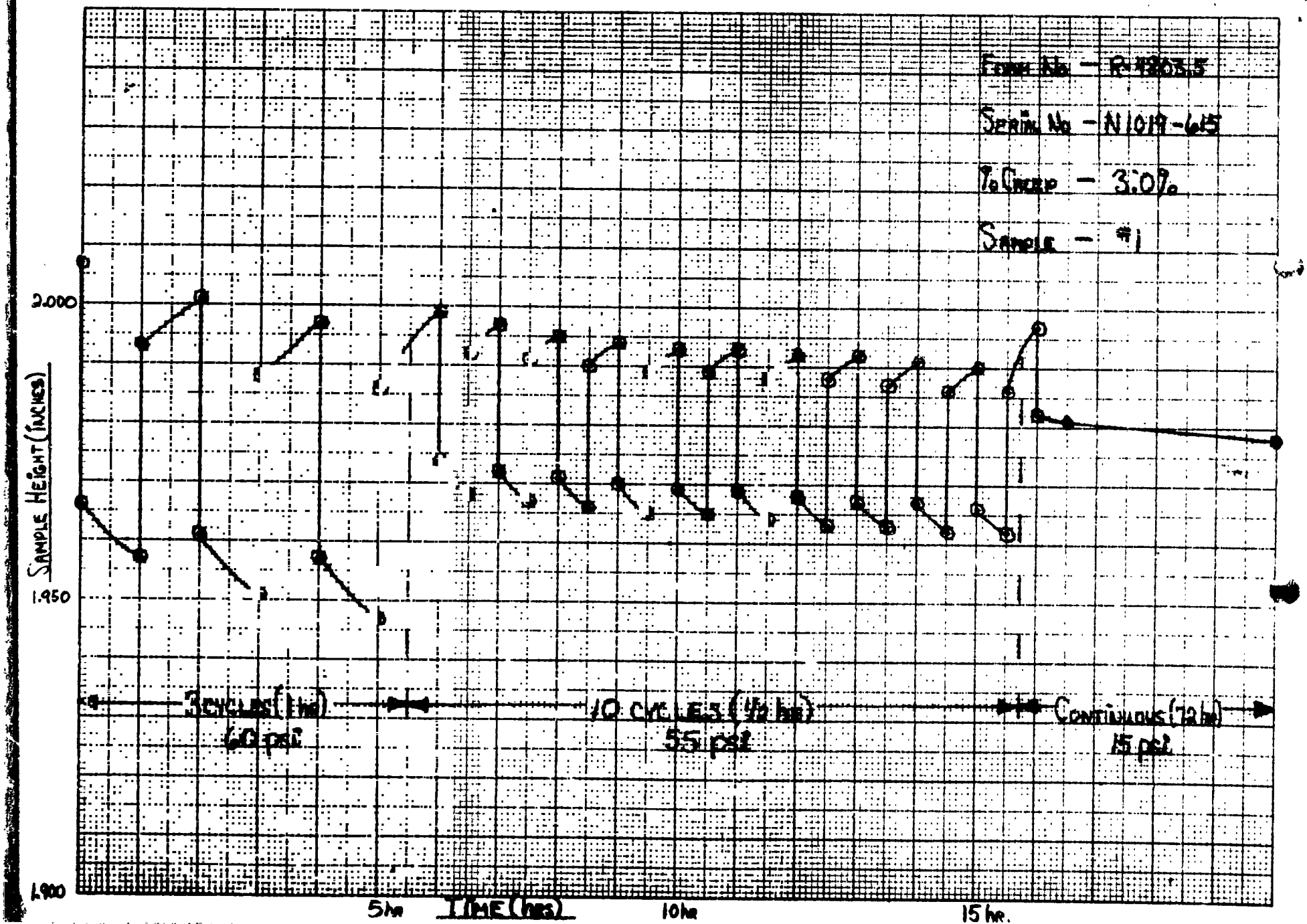
BLOCK CASTING
SERIAL No. N 1019-615



SAMPLE	# 1	DENSITY	3.59 #/cu. ft.	MAX. CREEP	3.0%
"	# 2	"	3.62#/cu. ft.	"	3.65%
"	# 3	"	3.66#/cu. ft.	"	4.35%
"	# 4	"	3.64#/cu.ft.	"	3.25%

FIGURE 4

KEUFFEL & ESSER CO.



CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No. A 102-611 Batch No. B N 114-613

Date Poured JUNE 15 19- Date Tested JUNE 19TH

Serial No. N 1019-615 SAMPLE

TEST #1

	Time	Height	Deflection	
Initial 19TH	11:05	3.007		
Loaded t = 0m	11:05	2.966		
t = 60m	12:05	2.957		
Unloaded t = 60m	12:05	2.993		
t = 120m	1:05	3.001		
Loaded t = 120m	1:05	2.961		
t = 180m	2:05	2.951		
Unloaded t = 180m	2:05	2.988		
t = 240m	3:05	2.997		
Loaded t = 240m	3:05	2.957		
t = 300m	4:05	2.947		
Unloaded t = 360m	4:05	2.986		

JUNE 22 - 25TH

TEST #3

	Time	Height	Deflection	
Initial	8:00	2.997		
Loaded t = 0 hr	8:00	2.982		
t = 1 hr	9:00	2.981		
t = 24 hr	8:00	2.980		
t = 48 hr	8:00	2.979		
t = 60 hr	4:30	2.979		
Loaded t = 72 hr	8:00	2.978		
Unloaded t = 72 hr				

CREEP TEST #2

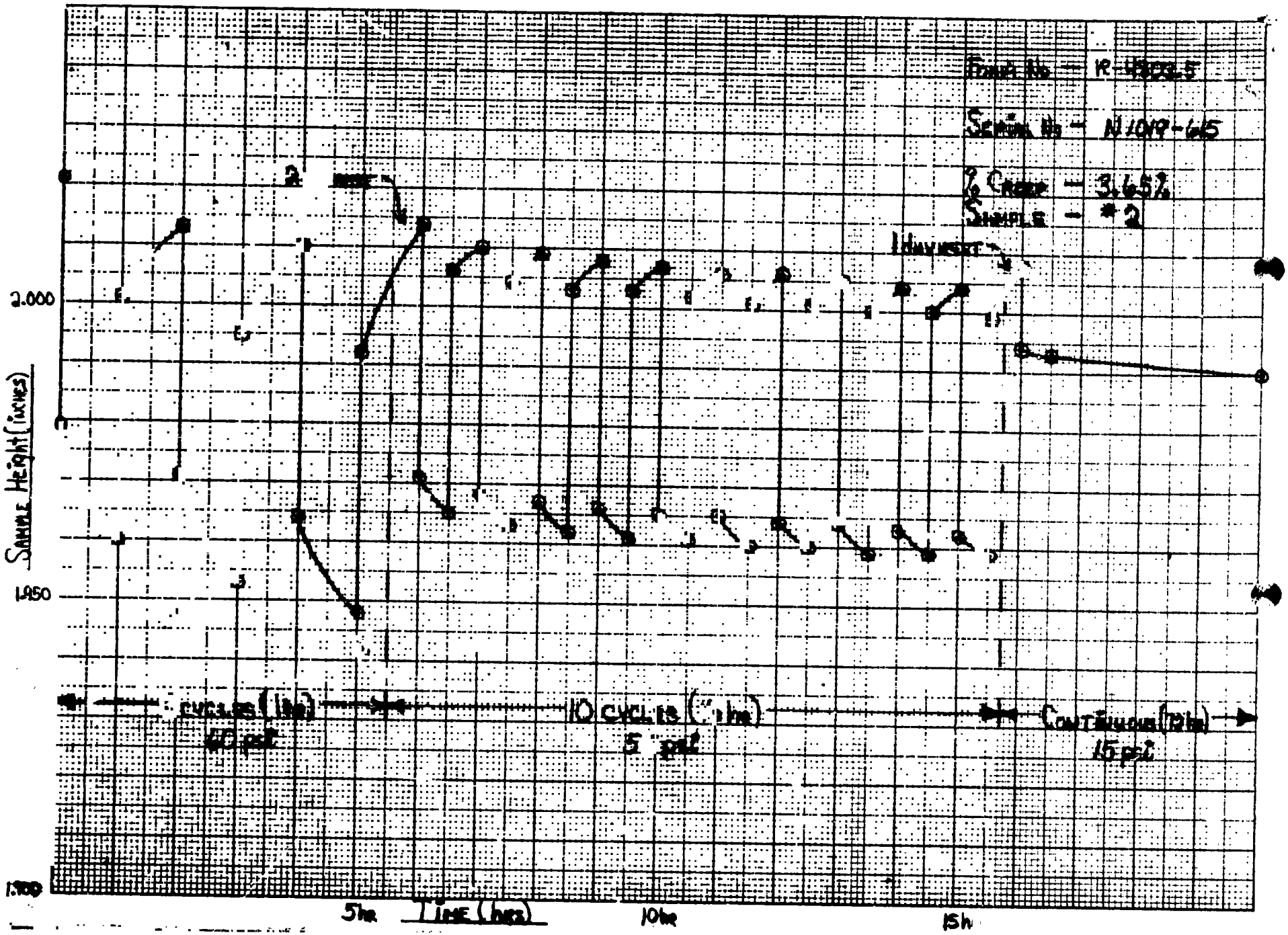
Foam No. R-4803.5 Batch No. A 102-611 Batch No. B N114-613

Date Poured _____ Date Tested JUNE 20, '64

TEST #2 Serial No. N 1019-615 SAMPLE #1

		Time	Height		Time	Height
Initial		7:30	2.999			
Loaded	t = 0m	7:30	2.974	t = 300	12:30	2.969
	t = 30m	8:00	2.968	t = 330	1:00	2.964
Unloaded	t = 30m	8:00	2.992	t = 330	1:00	2.988
	t = 60m	8:30	2.997	t = 360	1:30	2.992
Loaded	t = 60m	8:30	2.972	t = 360	1:30	2.968
	t = 90m	9:00	2.967	t = 390	2:00	2.963
Unloaded	t = 90m	9:00	2.991	t = 390	2:00	2.988
	t = 120m	9:30	2.995	t = 420	2:30	2.992
Loaded	t = 120m	9:30	2.971	t = 420	2:30	2.967
	t = 150m	10:00	2.966	t = 450	3:00	2.963
Unloaded	t = 150m	10:00	2.990	t = 450	3:00	2.987
	t = 180m	10:30	2.994	t = 480	3:30	2.991
Loaded	t = 180m	10:30	2.970	t = 480	3:30	2.967
	t = 210m	11:00	2.965	t = 510	4:00	2.962
Unloaded	t = 210m	11:00	2.989	t = 510	4:00	2.986
	t = 240m	11:30	2.993	t = 540	4:30	2.990
Loaded	t = 240m	11:30	2.969	t = 540	4:30	2.966
	t = 270m	12:00	2.965	t = 570	5:00	2.962
Unloaded	t = 270m	12:00	2.989	t = 570	5:00	2.986
	t = 300m	12:30	2.993	t = 600		

K·E 10 X 10 TO THE ½ INCH KEUFFEL & ESSER CO. 358-12 MADE IN U.S.A.



CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No A 102-611 Batch No. B N 114-613

Date Poured JUNE 15, 1964 Date Tested JUNE 20TH

Serial No. N-1019-615 SAMPLE #2

TEST #1

	Time	Height	Deflection	
Initial 20TH	8:15	3.021		
Loaded t = 0m	8:15	2.979		
t = 60m	9:15	2.960		
Unloaded t = 60m	9:15	3.001		
t = 120m	10:15	3.013		
Loaded t = 120m	10:15	2.971		
t = 180m	11:15	2.953		
Unloaded t = 180m	11:15	2.995		
t = 240m	12:15	3.010		
Loaded t = 240m	12:15	2.964		
t = 300m	1:15	2.948		
Unloaded t = 360m	1:15	2.992		

JUNE 23-26TH

TEST #3

	Time	Height	Deflection	
Initial	7:45	3.008		
Loaded t = 0 hr	7:45	2.994		
t = 1 hr	8:45	2.993		
t = 24 hr	7:45	2.992		
t = 48 hr	7:45	2.991		
t = 60 hr	4:00	2.991		
Loaded t = 72 hr	7:45	2.990		
Unloaded t = 72 hr				

CREEP TEST #2

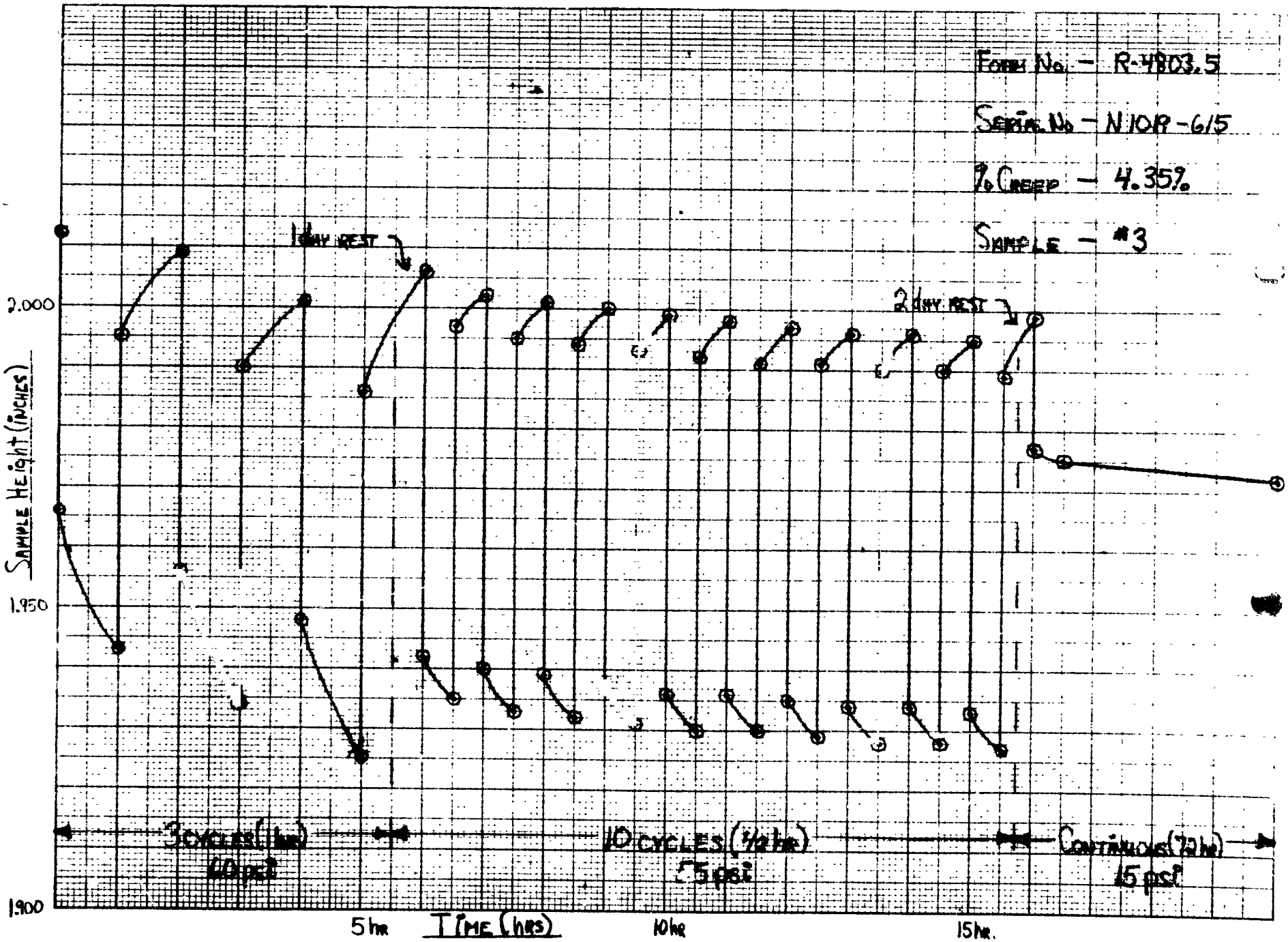
Foam No. R-4803.5 Batch No. A 102-611 Batch No. B N 114-613

Date Poured June 15 1964 Date Tested June 22nd '64

TEST #2 Serial No. N 1019-615 SAMPLE #2

		Time	Height		Time	Height
Initial		7:30	3.014			
Loaded	t = 0m	7:30	2.971	t = 300	12:30	2.965
	t = 30m	8:00	2.965	t = 330	1:00	2.960
Unloaded	t = 30m	8:00	3.006	t = 330	1:00	3.001
	t = 60m	8:30	3.010	t = 360	1:30	3.006
Loaded	t = 60m	8:30	2.968	t = 360	1:30	2.964
	t = 90m	9:00	2.963	t = 390	2:00	2.960
Unloaded	t = 90m	9:00	3.004	t = 390	2:00	3.001
	t = 120m	9:30	3.009	t = 420	2:30	3.005
Loaded	t = 120m	9:30	2.967	t = 420	2:30	2.964
	t = 150m	10:00	2.962	t = 450	3:00	2.959
Unloaded	t = 150m	10:00	3.003	t = 450	3:00	3.000
	t = 180m	10:30	3.008	t = 480	3:30	3.004
Loaded	t = 180m	10:30	2.966	t = 480	3:30	2.963
	t = 210m	11:00	2.961	t = 510	4:00	2.959
Unloaded	t = 210m	11:00	3.003	t = 510	4:00	3.000
	t = 240m	11:30	3.007	t = 540	4:30	3.004
Loaded	t = 240m	11:30	2.965	t = 540	4:30	2.962
	t = 270m	12:00	2.961	t = 570	5:00	2.959
Unloaded	t = 270m	12:00	3.002	t = 570	5:00	2.999
	t = 300m	12:30	3.006	t = 600		

KEUFFEL & ESSER CO MADE IN U.S.A.



CREEP TEST #1 and #3

Foam No. R-4803.5 Batch No. A 102-611 Batch No. B N 114-613

Date Poured JUNE 15, 1964 Date Tested JUNE 19TH

Serial No. N 1019-615 SAMPLE

TEST #1

	Time	Height	Deflection	
Inicial	12:05	3.012		
Loaded t = 0m	12:05	2.966		
t = 60m	1:05	2.943		
Unloaded t = 60m	1:05	2.995		
t = 120m	2:05	3.009		
Loaded t = 120m	2:05	2.956		
t = 180m	3:15	2.934		
Unloaded t = 180m	3:15	2.990		
t = 240m	4:15	3.001		
Loaded t = 240m	4:15	2.948		
t = 300m	5:15	2.925		
Unloaded t = 360m	5:15	2.986		

JUNE 22-25TH

TEST #3

	Time	Height	Deflection	
Initial	10:30	2.999		
Loaded t = 0 hr	10:30	2.977		
t = 1 hr	11:30	2.975		
t = 24 hr	10:30	2.974		
t = 48 hr	10:30	2.973		
t = 60 hr	4:30	2.973		
Loaded t = 72 hr	10:30	2.972		
Unloaded t = 72 hr				

CREEP TEST #2

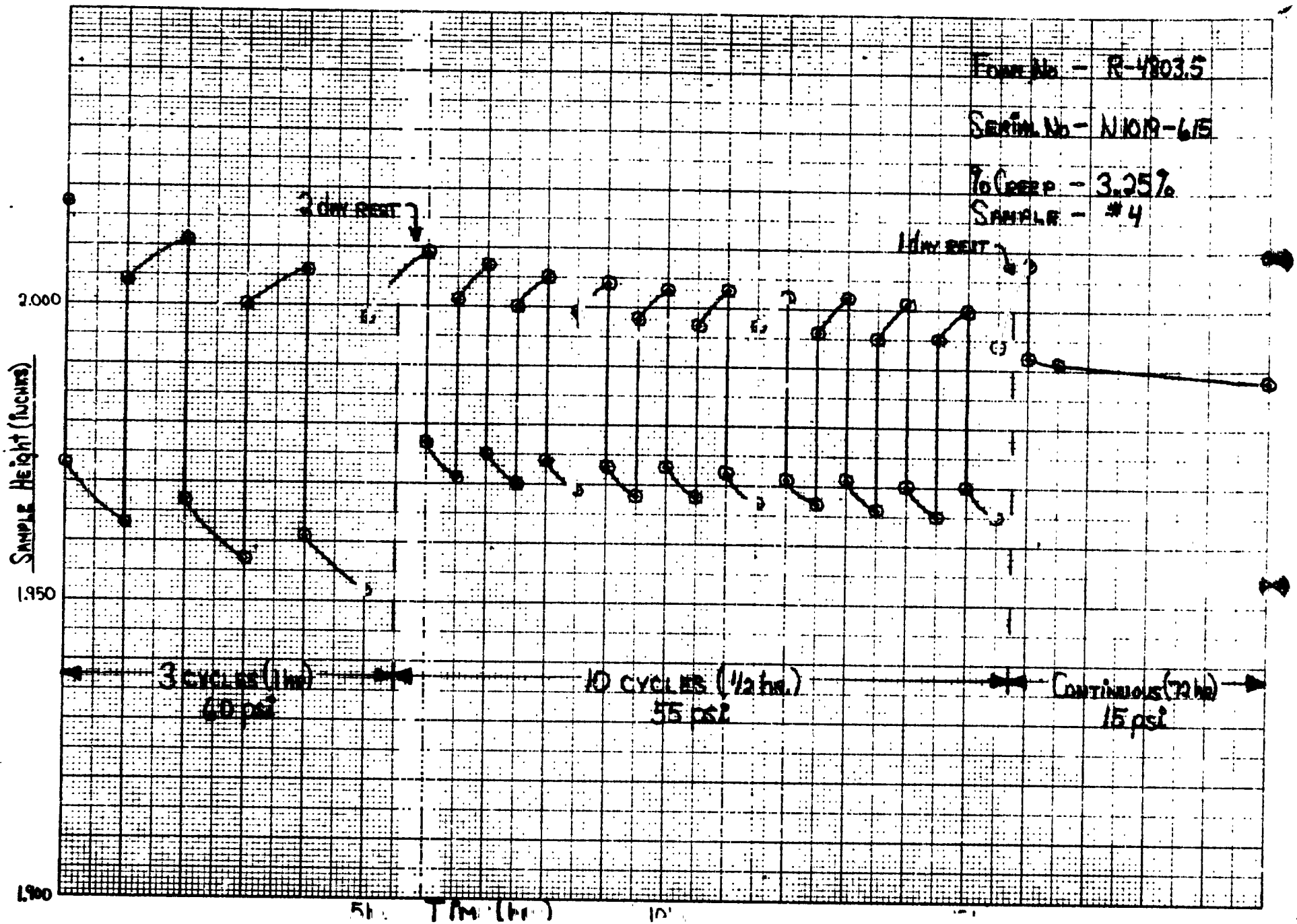
Foam No. R-4803.5 Batch No. A 102-611 Batch No. B N 114-613

Date Poured JUNE 15, 1964 Date Tested JUNE 20, '64

TEST #2 Serial No. N 1019-615 SAMPLE #3

		Time	Height		Time	Height	
Initial		7:30	3.006				
Loaded	t = 0m	7:30	2.942	t = 300	12:30	2.936	
	t = 30m	8:00	2.935	t = 330	1:00	2.930	
Unloaded	t = 30m	8:00	2.997	t = 330	1:00	2.991	
	t = 60m	8:30	3.002	t = 360	1:30	2.997	
Loaded	t = 60m	8:30	2.940	t = 360	1:30	2.935	
	t = 90m	9:00	2.933	t = 390	2:00	2.929	
Unloaded	t = 90m	9:00	2.995	t = 390	2:00	2.991	
	t = 120m	9:30	3.001	t = 420	2:30	2.996	
Loaded	t = 120m	9:30	2.939	t = 420	2:30	2.934	
	t = 150m	10:00	2.932	t = 450	3:00	2.928	
Unloaded	t = 150m	10:00	2.994	t = 450	3:00	2.990	
	t = 180m	10:30	3.000	t = 480	3:30	2.996	
Loaded	t = 180m	10:30	2.937	t = 480	3:30	2.934	
	t = 210m	11:00	2.931	t = 510	4:00	2.928	
Unloaded	t = 210m	11:00	2.993	t = 510	4:00	2.990	
	t = 240m	11:30	2.999	t = 540	4:30	2.995	
Loaded	t = 240m	11:30	2.936	t = 540	4:30	2.933	
	t = 270m	12:00	2.930	t = 570	5:00	2.927	
Unloaded	t = 270m	12:00	2.992	t = 570	5:00	2.989	
	t = 300m	12:30	2.998	t = 600			

K-E 10 X 10 TO THE ½ INCH KEUFFEL & ESSER CO 358-12



CREEP TEST #1 and #3

Foam No R-4803.5 Batch No A 102-611 Batch No. B N114-613

Date Poured June 15 Date [illegible] JUNE 23RD

Serial No. N1019-615 SAMPLE #4

TEST #1

	Time	Height	Notation
Initial	8:30	3.017	
Loaded t = 0m	8:30	2.973	
t = 60m	9:20	2.963	
Unloaded t = 60m	9:30	3.004	
t = 120m	10:30	3.011	
Loaded t = 120m	10:30	2.967	
t = 180m	11:30	2.957	
Unloaded t = 180m	11:30	3.000	
t = 240m	12:30	3.006	
Loaded t = 240m	12:30	2.961	
t = 300m	1:30	2.952	
Unloaded t = 360m	1:30	2.998	

JUNE 26TH - 29TH

TEST #3

	Time		Notation
Initial	11:15	3.008	
Loaded t = 0 hr	11:15	2.992	
t = 1 hr	12:15	2.991	
t = 24 hr	11:15	2.990	
t = 48 hr	SUNDAY	—	
t = 60 hr	SUNDAY	—	
Loaded t = 72 hr	11:15	2.988	
Unloaded t = 72 hr			

CREEP TEST #2

Foam No. R-4803.5 Batch No. A 102-611 Batch No. B N 114-613

Date Poured June 15, 1964 Date Tested June 25, '64

SAMPLE #4

TEST #2 Serial No. N 1019-615

		Time	Height		Time	Height	
Initial		7:30	3.009				
Loaded	t = 0m	7:30	2.977	t = 300	12:30	2.972	
	t = 30m	8:00	2.971	t = 330	1:00	2.967	
Unloaded	t = 30m	8:00	3.001	t = 330	1:00	2.997	
	t = 60m	8:30	3.007	t = 360	1:30	3.002	
Loaded	t = 60m	8:30	2.975	t = 360	1:30	2.971	
	t = 90m	9:00	2.970	t = 390	2:00	2.967	
Unloaded	t = 90m	9:00	3.000	t = 390	2:00	2.996	
	t = 120m	9:30	3.005	t = 420	2:30	3.002	
Loaded	t = 120m	9:30	2.974	t = 420	2:30	2.971	
	t = 150m	10:00	2.969	t = 450	3:00	2.966	
Unloaded	t = 150m	10:00	2.999	t = 450	3:00	2.995	
	t = 180m	10:30	3.004	t = 480	3:30	3.001	
Loaded	t = 180m	10:30	2.973	t = 480	3:30	2.970	
	t = 210m	11:00	2.968	t = 510	4:00	2.965	
Unloaded	t = 210m	11:00	2.998	t = 510	4:00	2.995	
	t = 240m	11:30	3.003	t = 540	4:30	3.000	
Loaded	t = 240m	11:30	2.973	t = 540	4:30	2.970	
	t = 270m	12:00	2.968	t = 570	5:00	2.965	
Unloaded	t = 270m	12:00	2.997	t = 570	5:00	2.994	
	t = 300m	12:30	3.003	t = 600			

Compression Test #4

Sample No. #4

Sample Density 3.64*

Strain in/in	% Deflection	Stress (psi)
.005	.5	10
.010	1.0	21
.020	2.0	53
.030	3.0	71
.040	4.0	78
.050	5.0	81
.060	6.0	82
.070	7.0	82

GENERAL PLASTICS MFG. COMPANY
3481 South 35th Street
Tacoma, Washington

FINAL REPORT

PHASE II

SUBJECT: MOLDING FORMULATION

CONTRACT: NAS8-11688

DATE OF COMPLETION: 22 OCTOBER 1964

ATTENTION: PR-RC

REVIEWED AND APPROVED:

Karl J. Eckman, COR

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Company

SUMMARY - PHASE II

Phase II requires the development of a low density urethane foam which could be cast into the Plastic Exclusion Riser mold to obtain a casting of a density comparable to the Phase I foam. A series of formulations was established and from this experimental work a formula designated R-4603 was established. This formula was then used to cast a series of experimental Rim Sections. Four of these sections are being forwarded to the George C. Marshall Space Flight Center for their evaluation.

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Company

DESCRIPTION OF PHASE II

Bench Formulations:

A series of bench formulations similar to those in Phase I were established and cup samples were cast. Based on the Testing done in Phase I and on these samples, box samples measuring 15" x 20" x 12" deep were molded from three of the promising bench formulations. Creep data from formula R-4603 at two different densities are included with this report. Since all of these formulations passed the creep requirement, the only efficient screening method was to utilize the Government supplied Exclusion Riser mold.

Closed Molding:

These three formulations were then cast into the Exclusion Riser Mold. From these samples it was apparent that formula R-4603 would best fulfill the molding requirement. Eight additional Rim moldings were then made using this foam formulation.

In order to approach the described four pound per cubic foot density, it was necessary to warm the mold to 110° - 120°F. This was done on all of the closed molded samples. In attempting to increase the skin density slightly, a mold temperature of 90 to 100°F. was used on the open mold samples.

22 October 1964
Contract NAS8-11688
General Plastics Mfg.Co.

PHASE II

MOLDED SAMPLES:

Four molded samples utilizing formula R-4603 have been forwarded to the George C. Marshall Space Flight Center for evaluation.

1. N-31-1 - Closed Molded Rim Section:

This sample was cast using the supplied mold without the fuel line insert. The top surface shows some porosity due to both the mold design and the attempt to minimise the part density.

Part weight - 6.73 pounds

2. N-31-2 - Closed Molded Rim Section:

This sample was cast using the supplied mold including the fuel line insert. A strip of fiberglass cloth was also placed in the mold along the feathered edge after several castings had been unsuccessful because of chips. This fiberglass can readily be seen in the casting but it did supply the necessary reinforcement to assure a satisfactory edge. From the excess material obtained at the end of the part, the creep sample was obtained and the creep curves are included with this report.

Part weight - 3.60 pounds
Maximum Creep- 2.6%

3. N-31-6 - Open Molded Rim Section:

This sample represents a Rim Section without the fuel line insert. It was molded utilizing only the bottom face of the supplied mold and the foam was allowed to free blow away from this surface. The excess foam rise was then machined away, resulting in a casting of superior quality to those obtained in the closed molding.

Part weight - 6.7 pounds

PHASE II

MOLDED SAMPLES: (Cont'd)

4. N-31-7 - Open Molded Rim Section:

This sample represents an open molded casting including the fuel line insert. The feather edge contains numerous defects which could be eliminated by re-designing the present mold configuration. The overall quality of the molding is superior to those obtained in the completely closed mold. This casting was also allowed to free rise and the excess foam was machined resulting in a standard size Rim Section. A creep sample was obtained from the excess rise of this material.

Part weight - 3.44 pounds

Maximum Creep 3.4%

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Corp.

Phase II

Conclusions:

After examining the castings and the related test data, there are two very definite areas which must be considered in obtaining high quality molded Rim Sections. These two points are: (1) the skin density; (2) the cell structure orientation.

The purpose of molded skins in this application is to create a part with greater foam integrity than can be obtained by simply machining a block of cast foam. The molded skin has the detrimental effect of raising the overall part density because by its very nature it is a high density foam. In evaluating a 1/8" thickness of molded skin it was found that from a cold mold this reduced thickness was actually a twenty pound per cubic foot density foam. Since this added density was too great to still allow a four pound density casting, the mold was heated which did reduce this skin effect. In doing this, however, the toughness and purpose for which the skin was intended was reduced substantially as can be seen from the moldings supplied.

The advantages of this molded skin must therefore be weighed against the added weight it contributes to the part. It must also be recognized that the skin density can be reduced but when this is accomplished, the skin does not have the same strengthening effect that is created when a high density cold molded skin is allowed on the part.

The second obvious effect which is noticed in the closed molded parts is the non-uniform orientation of the cell structure. This contributes to an unpredictable strength pattern throughout the castings and although sections of the castings can be found which meet the established creep requirements, there are sections which because of this cell orientation are unable to withstand this requirement. Since our testing was done on two-inch cubes, our results primarily show the sections where cell orientation is most uniform. The thinner sections by outward appearance appear not to be this same strength.

22 OCTOBER 1964
Contract NAS8-11688
General Plastics Mfg.Compan

RECOMMENDATIONS - PHASE II

The following recommendations are made in the hope of establishing a method of producing Rim Sections with the required compression properties, density and integrity to fulfill its design requirement. To accomplish this, we would recommend one of the following three production methods:

1. Rim Section - Closed Moldings:

A completely closed molded Rim Section could be made but we feel the following items, or requirements, would be necessary. A specific closed mold for each Rim Section configuration should be made to improve the molding characteristics. The insert type mold as was used in this development work is not satisfactory for producing high quality parts. An overall density, including skins of five to seven pound per cubic foot, would be necessary to assure that all sections of the casting would meet the creep requirement spelled out in Phase I.

2. Molded Rim Sections with one skin only:

Rim Sections with a top molded skin only can be made of superior quality to the closed mold castings. To assure the strength requirements, an overall density, including skins of five to six pounds per cubic foot would be necessary. It would be also necessary to have individual molds for each configuration of Rim Sections.

3. Machined Rim Sections:

Rim Sections can be manufactured by machining the configuration from oversize blocks of a material similar to that developed in Phase I. This would assure the physical properties requirements. In order to increase the integrity of these parts, a false skin, such as an epoxy and Dacron cloth lay-up could be applied. The overall density of this part would be four to five pounds per cubic foot and the quality would exceed both of those obtained by the first two methods.

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Company

PHASE II

Molding Formulation:

R-4603

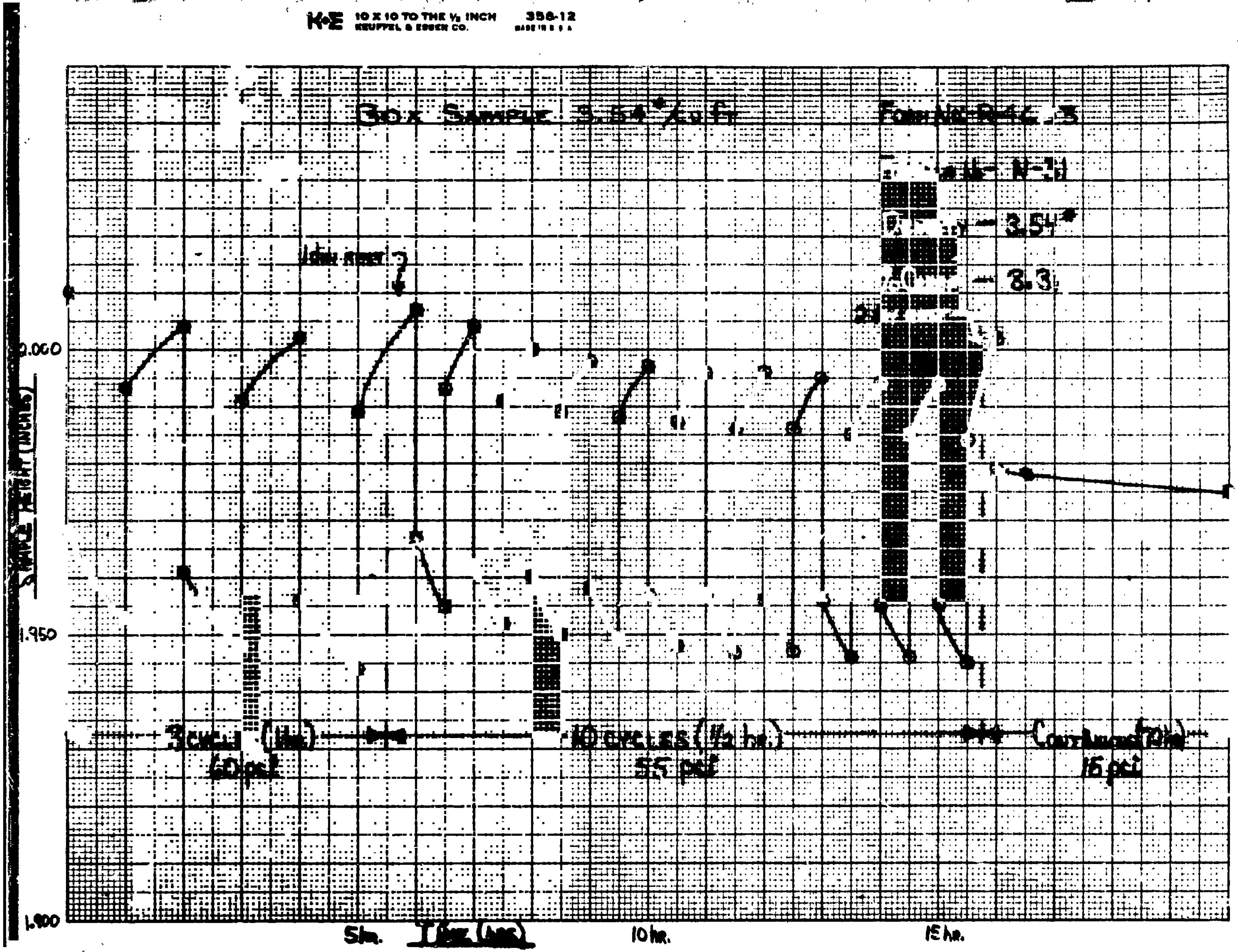
R-4603 Part A

Polyether Resin	(510 OH#)	80
Toluene Diisocyanate	(80-20 Isomer)	298
Benzoyl Chloride		0.2
Silicone Glycol Copolymer	(DC 201)	3.9

R-4603 Part B

Polyether Glycol (540 OH#)	65
Tetrakis (2-hydroxypropyl) ethylenediamine	8
Fluorocarbon 11 (stabilized)	12
Silicone Glycol Copolymer DC-201	2
Triethylenediamine	0.17
Dipropylene Glycol	0.34
Water	0.50

To obtain foam these ingredients must be mixed in a ratio of 100 parts by weight Part A to 75 parts by weight Part B.


K&E 10 X 10 TO THE ½ INCH 358-12
KEUFFEL & ESSER CO.
1.950
1.900
Sample Height (inches)
3.54
3.3
60 psi
55 psi
15 psi
5hr.
10hr.
15hr.
Time (hrs)

CREEP TEST #1 and #3

Foam No._____ Batch No A_____ Batch No. B_____

Date Poured_____ Date Tested SEPT. 23 '64

FORMULA No. N-31 (NASA RIM MATERIAL)

TEST #1

DEN 3.54*

	Time	Height	Deflection	
Initial	4:30	3.010		
Loaded t = 0m	4:30	2.968		
t = 60m	5:30	2.953		
Unloaded t = 60m	5:30	2.993		
t = 120m	6:30	3.004		
Loaded t = 120m	6:30	2.961		
t = 180m	7:30	2.948		
Unloaded t = 180m	7:30	2.991		
t = 240m	8:30	3.002		
Loaded t = 240m	8:30	2.956		
t = 300m	9:30	2.944		
Unloaded t = 360m	9:30	2.989		

SEPT. 26-29

TEST #3

	Time	H	Deflection	
Initial	8:30	3.002		
Loaded t = 0 hr	8:30	2.779		
t = 1 hr	9:30	2.778		
t = 24 hr	SUNDAY	—		
t = 48 hr	8:30	2.776		
t = 60 hr	4:00	2.776		
Loaded t = 72 hr	8:30	2.775		
Unloaded t = 72 hr				

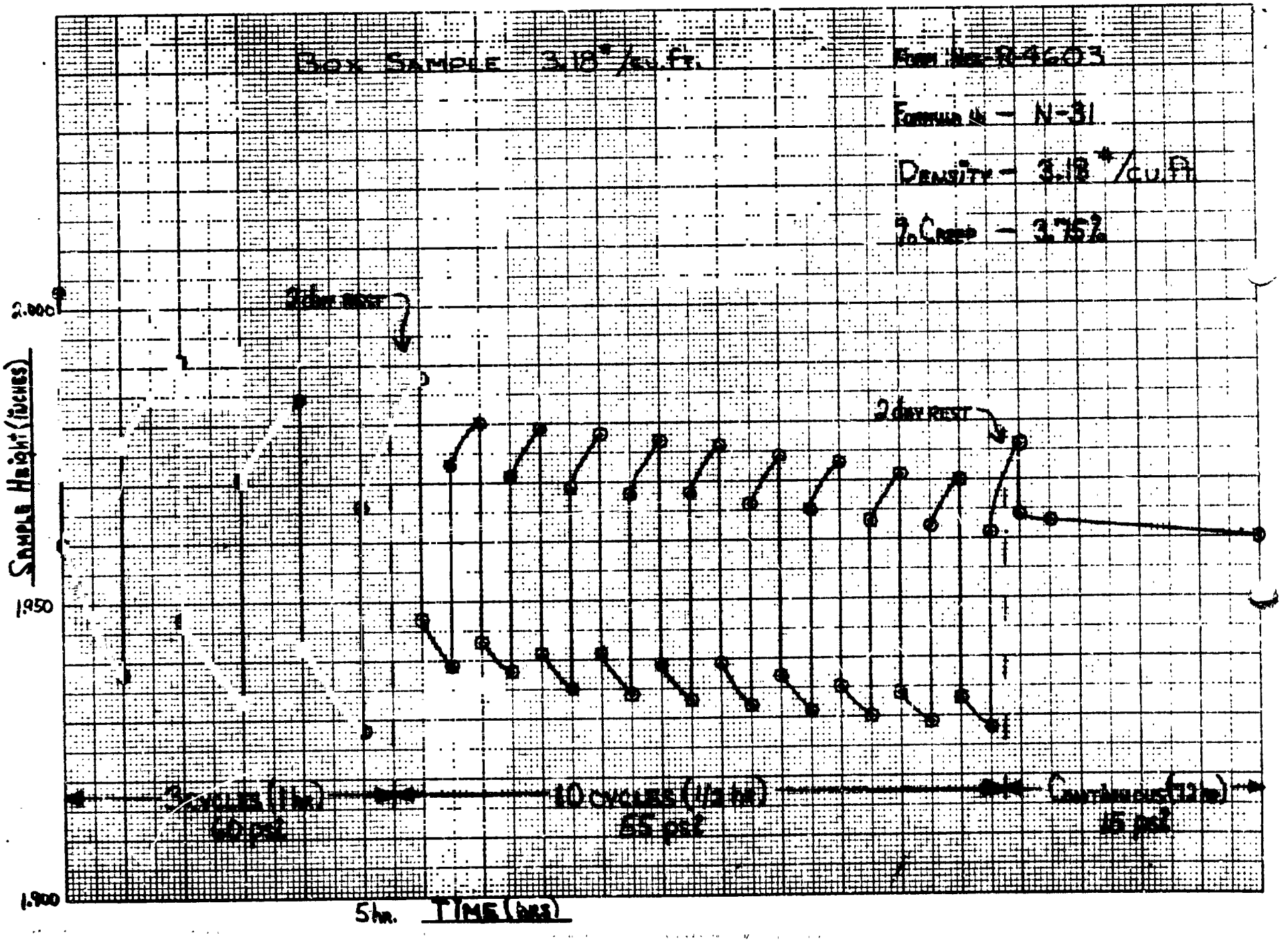
CREEP TEST #2

Foam No._____ Batch No. A_____ Batch No. B_____

Date Poured_____ Date Tested SEPT. 24, '64

TEST #2 Serial No. N-31 (NASA RIM MATERIAL

	Time	Height		Time	Height
Initial	1:00	3.007			
Loaded t = 0m	1:00	2.967	t = 300	6:00	2.957
t = 30m	1:30	2.955	t = 330	6:30	2.947
Unloaded t = 30m	1:30	2.993	t = 330	6:30	2.98[illegible]
t = 60m	2:00	3.004	t = 360	7:00	2.99[illegible]
Loaded t = 60m	2:00	2.962	t = 360	7:00	2.956
t = 90m	2:30	2.952	t = 390	7:30	2.947
Unloaded t = 90m	2:30	2.991	t = 390	7:30	2.986
t = 120m	3:00	3.000	t = 420	8:00	2.995
Loaded t = 120m	3:00	2.960	t = 420	8:00	2.956
t = 150m	3:30	2.950	t = 450	8:30	2.946
Unloaded t = 150m	3:30	2.989	t = 450	8:30	2.985
t = 180m	4:00	2.998	t = 480	9:00	2.994
Loaded t = 180m	4:00	2.958	t = 480	9:00	2.955
t = 210m	4:30	2.949	t = 510	9:30	2.946
Unloaded t = 210m	4:30	2.988	t = 510	9:30	2.985
t = 240m	5:00	2.997	t = 540	10:00	2.994
Loaded t = 240m	5:00	2.957	t = 540	10:00	2.955
t = 270m	5:30	2.948	t = 570	10:30	2.945
Unloaded t = 270m	5:30	2.987	t = 570	10:30	2.984
t = 300m	6:00	2.996	t = 600		


Box Sample 3.18 #/cu.ft.
Form No. 8-4603
Formula # - N-31
Density - 3.18 #/cu ft
% Creep - 3.75%
2 day rest
2 day rest
2.000
1.950
1.900
Sample Height (Inches)
5 hr.
Time (hrs)
10 cycles (1/2 hr)
60 psi
10 cycles (1/2 hr)
65 psi
Continuous (12 hr)
65 psi

CREEP TEST #1 and #3

Foam No._____ Batch No A_____ Batch No. B_____

Date Poured_____ Date Tested Oct. 1, '64

FORMULA No. N-31 (NASA RIM MATERIAL)

DEN 3.18*

TEST #1

	Time	Height	Deflection	
Initial	3:05	3.003		
Loaded t = 0m	3:05	2.960		
t = 60m	4:05	2.938		
Unloaded t = 60m	4:05	2.977		
t = 120m	5:05	2.991		
Loaded t = 120m	5:05	2.947		
t = 180m	6:05	2.933		
Unloaded t = 180m	6:05	2.971		
t = 240m	7:05	2.984		
Loaded t = 240m	7:05	2.942		
t = 300m	8:05	2.928		
Unloaded t = 360m	8:05	2.966		

TEST #3

	Time	[illegible]	Deflection	
Initial	8:15	2.976		
Loaded t = 0 hr	8:15	2.964		
t = 1 hr	9:15	2.963		
t = 24 hr	8:15	2.962		
t = 48 hr	8:15	2.961		
t = 60 hr	8:15	2.961		
Loaded t = 72 hr	8:15	2.960		
Unloaded t = 72 hr				

CREEP TEST #2

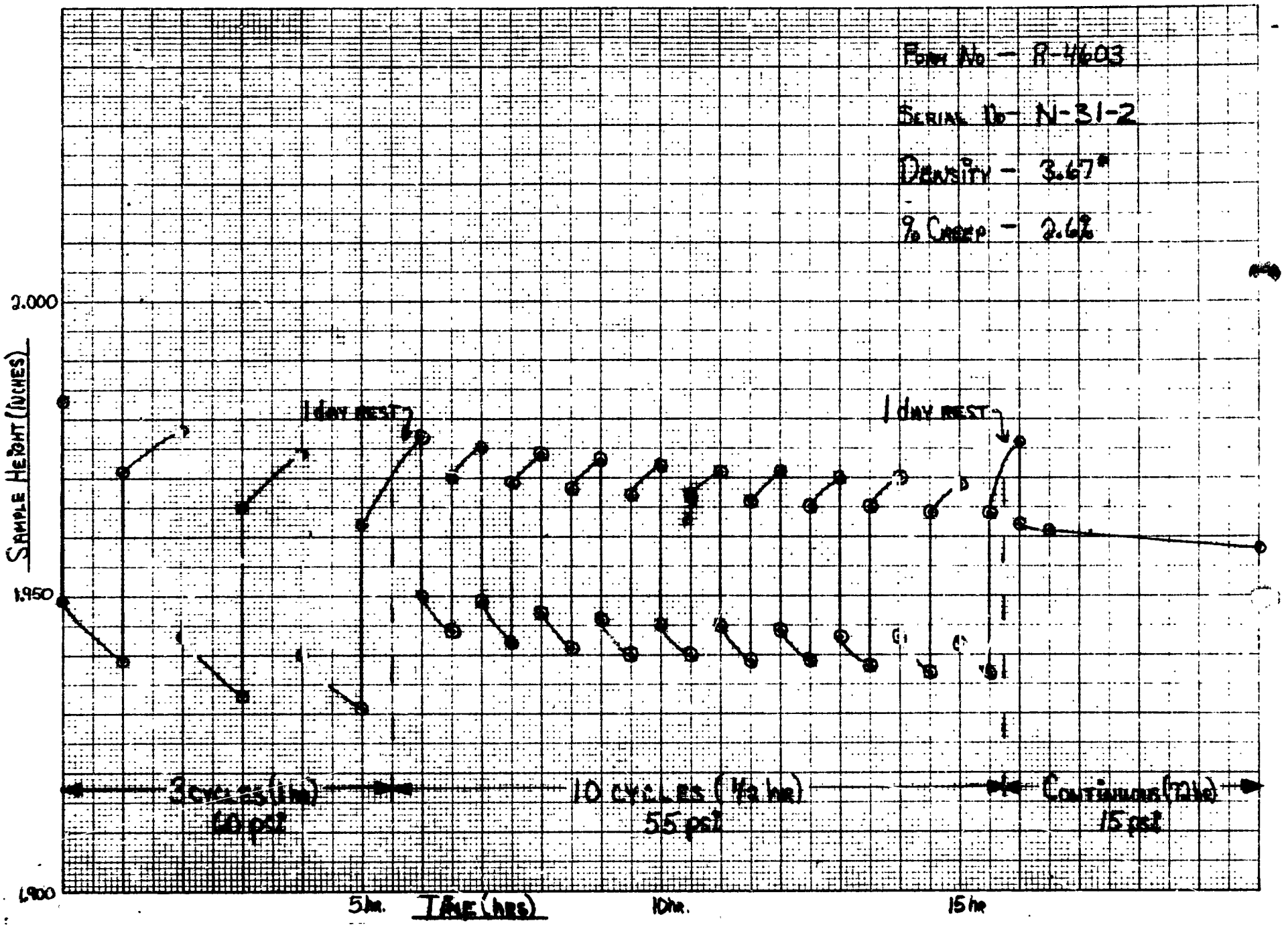
Foam No._____ Batch No. A_____ Batch No. B_____

Date Poured_____ Date Tested Oct. 3, '64

TEST #2 FORMULA No. N-31 DEN 3.18

		Time	Height		Time	Height
Initial		7:30	2.988			
Loaded	t = 0m	7:30	2.947	t = 300	12:30	2.939
	t = 30m	8:00	2.939	t = 330	1:00	2.932
Unloaded	t = 30m	8:00	2.973	t = 330	1:00	2.966
	t = 60m	8:30	2.980	t = 360	1:30	2.974
Loaded	t = 60m	8:30	2.943	t = 360	1:30	2.937
	t = 90m	9:00	2.937	t = 390	2:00	2.931
Unloaded	t = 90m	9:00	2.971	t = 390	2:00	2.965
	t = 120m	9:30	2.979	t = 420	2:30	2.973
Loaded	t = 120m	9:30	2.941	t = 420	2:30	2.935
	t = 150m	10:00	2.935	t = 450	3:00	2.930
Unloaded	t = 150m	10:00	2.969	t = 450	3:00	2.963
	t = 180m	10:30	2.978	t = 480	3:30	2.971
Loaded	t = 180m	10:30	2.941	t = 480	3:30	2.934
	t = 210m	11:00	2.934	t = 510	4:00	2.929
Unloaded	t = 210m	11:00	2.968	t = 510	4:00	2.962
	t = 240m	11:30	2.977	t = 540	4:30	2.970
Loaded	t = 240m	11:30	2.939	t = 540	4:30	2.933
	t = 270m	12:00	2.933	t = 570	5:00	2.928
Unloaded	t = 270m	12:00	2.968	t = 570	5:00	2.961
	t = 300m	12:30	2.974	t = 600		

K•E 10 X 10 TO THE ½ INCH 358-12
KEUFFEL & ESSER CO



CREEP TEST #1 and #3

Foam No. R-4603 Batch No. A Batch No. B

Date Poured Date Tested Aug. 19, '64

FORMULA No. N-31-2 (NASA RIM MATERIAL)

DEN 3.67

TEST #1

	Time	Height	Deflection	
itial	8:00	2.983		
oaded t = 0m	8:00	2.949		
t = 60m	9:00	2.939		
nloaded t = 60m	9:00	2.971		
t = 120m	10:00	2.978		
oaded t = 120m	10:00	2.943		
t = 180m	11:00	2.933		
nloaded t = 180m	11:00	2.965		
t = 240m	12:00	2.974		
oaded t = 240m	12:00	2.940		
t = 300m	1:00	2.931		
nloaded t = 360m	1:00	2.962		

Aug 21-24

TEST #3

	Time	Height	Deflection	
nitial	9:00	2.976		
oaded t = 0 hr	9:00	2.962		
t = 1 hr	10:00	2.961		
t = 24 hr	9:00	2.960		
t = 48 hr	SUNDAY	—		
t = 60 hr	SUNDAY	—		
oaded t = 72 hr	9:00	2.958		
nloaded t = 72 hr				

CREEP TEST #2

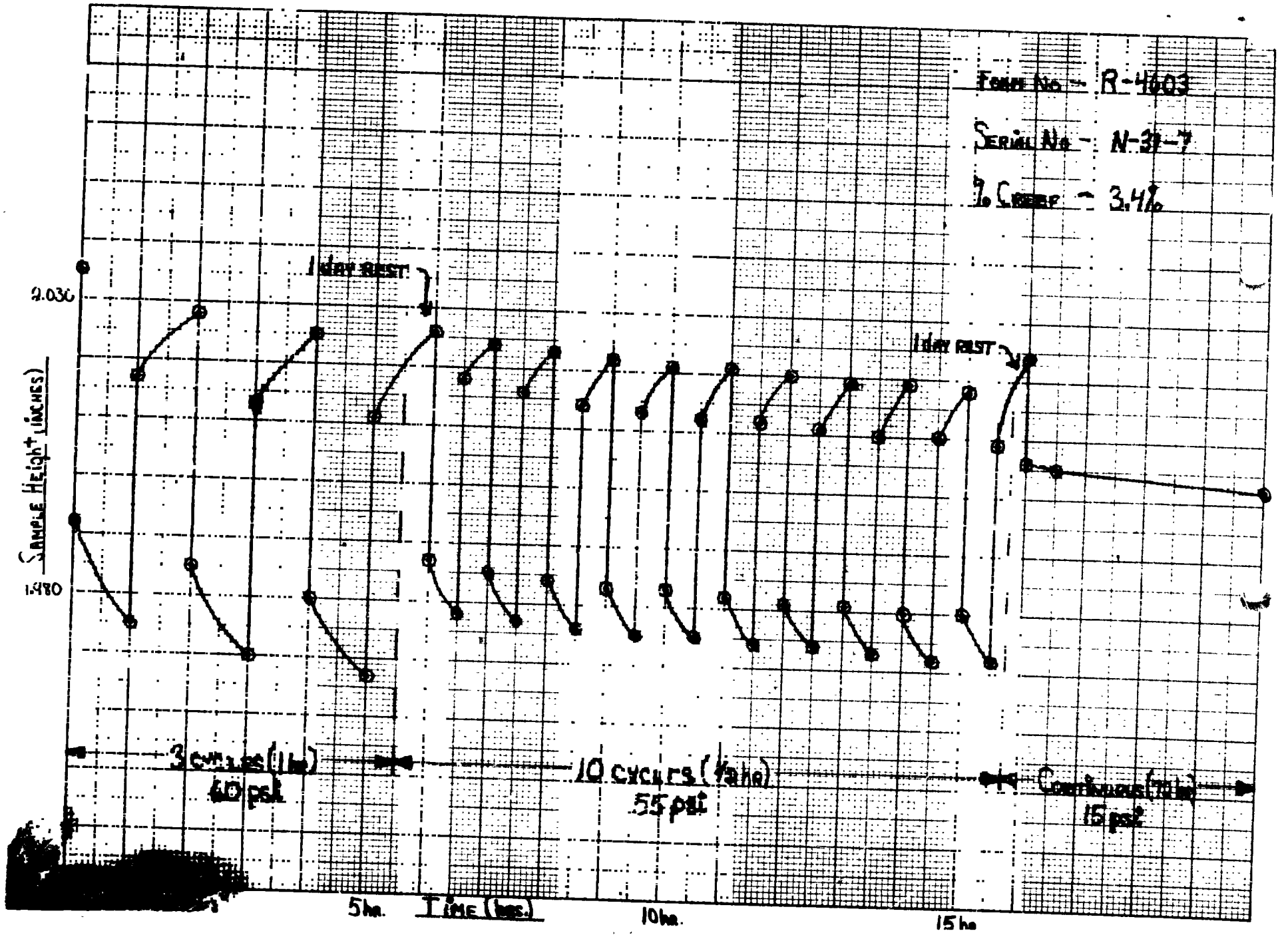
Foam No. R-4603 Batch No. A_____ Batch No. B_____

Date Poured_____ Date Tested Aug 20, '64

TEST #2 Serial No. N-31-2

	Time	Height		Time	Height
Initial	7:30	2.977			
Loaded t = 0m	7:30	2.950	t = 300	12:30	2.945
t = 30m	8:00	2.944	t = 330	1:00	2.939
Unloaded t = 30m	8:00	2.970	t = 330	1:00	2.966
t = 60m	8:30	2.975	t = 360	1:30	2.971
Loaded t = 60m	8:30	2.949	t = 360	1:30	2.944
t = 90m	9:00	2.942	t = 390	2:00	2.939
Unloaded t = 90m	9:00	2.969	t = 390	2:00	2.965
t = 120m	9:30	2.974	t = 420	2:30	2.970
Loaded t = 120m	9:30	2.947	t = 420	2:30	2.943
t = 150m	10:00	2.941	t = 450	3:00	2.938
Unloaded t = 150m	10:00	2.968	t = 450	3:00	2.965
t = 180m	10:30	2.973	t = 480	3:30	2.970
Loaded t = 180m	10:30	2.946	t = 480	3:30	2.943
t = 210m	11:00	2.940	t = 510	4:08	2.937
Unloaded t = 210m	11:00	2.967	t = 510	4:00	2.964
t = 240m	11:30	2.972	t = 540	4:30	2.969
Loaded t = 240m	11:30	2.945	t = 540	4:30	2.943
t = 270m	12:00	2.940	t = 570	5:00	2.937
Unloaded t = 270m	12:00	2.967	t = 570	5:00	2.964
t = 300m	12:30	2.971	t = 600		

KEUFFEL & ESSER CO.



CREEP TEST #1 and #2

Foam No R-4603 Batch No. R

Date Poured Date Tested Oct. 14, '64.

Serial No. N-31-7 VERTICAL CELL

TEST #1

	Time	Height	Deflection
Initial	8:50	3.035	
Loaded t = 0m	8:50	2.992	
t = 60m	9:50	2.975	
Unloaded t = 60m	9:50	3.017	
t = 120m	10:50	3.028	
Loaded t = 120m	10:50	2.985	
t = 180m	11:50	2.970	
Unloaded t = 180m	11:50	3.013	
t = 240m	12:50	3.025	
Loaded t = 240m	12:50	2.980	
t = 300m	1:50	2.967	
Unloaded t = 360m	1:50	3.018	

Oct. 16 - 19th

TEST #3

	Time		Deflection
Initial	5:00	3.024	
Loaded t = 0 hr	5:00	3.006	
t = 1 hr	6:00	3.005	
t = 24 hr	5:00	3.004	
t = 48 hr	SUNDAY	—	
t = 60 hr	SUNDAY	—	
Loaded t = 72 hr	5:00	3.002	
Unloaded t = 72 hr			

CREEP TEST #2

Foam No. R-4603 Batch No. A_____ Batch No. B_____

Date Poured_____ Date Tested Oct. 15, '64

TEST #2 Serial No. N-31-7 VERTICAL CELL

		Time	Height		Time	Height
Initial		7:30	3.026			
Loaded	t = 0m	7:30	2.987	t = 300	12:30	3.082
	t = 30m	8:00	2.978	t = 330	1:00	2.974
Unloaded	t = 30m	8:00	3.018	t = 330	1:00	3.012
	t = 60m	8:30	3.024	t = 360	1:30	3.020
Loaded	t = 60m	8:30	2.985	t = 360	1:30	3.081
	t = 90m	9:00	2.977	t = 390	2:00	2.974
Unloaded	t = 90m	9:00	3.016	t = 390	2:00	3.011
	t = 120m	9:30	3.023	t = 420	2:30	3.019
Loaded	t = 120m	9:30	2.984	t = 420	2:30	3.081
	t = 150m	10:00	2.976	t = 450	3:00	2.973
Unloaded	t = 150m	10:00	3.014	t = 450	3:00	3.010
	t = 180m	10:30	3.022	t = 480	3:30	3.019
Loaded	t = 180m	10:30	2.983	t = 480	3:30	3.080
	t = 210m	11:00	2.975	t = 510	4:00	2.972
Unloaded	t = 210m	11:00	3.013	t = 510	4:00	3.010
	t = 240m	11:30	3.021	t = 540	4:30	3.018
Loaded	t = 240m	11:30	3.083	t = 540	4:30	3.080
	t = 270m	12:00	2.975	t = 570	5:00	2.972
Unloaded	t = 270m	12:00	3.012	t = 570	5:00	3.009
	t = 300m	12:30	3.021	t = 600		

GENERAL PLASTICS MFG. COMPANY
3481 South 35th Street
Tacoma, Washington

FINAL REPORT

PHASE III

SUBJECT: BLOCK FABRICATION

COMPLETION DATE: 22 OCTOBER 1964

CONTRACT NUMBER: NAS8-11688

ATTENTION: PR-RC

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Company

SUMMARY - PHASE III

Sixteen (16) blocks measuring 24" x 60" x 72" were fabricated from formulation R-4803.5 which was developed in Phase I. The first fourteen (14) blocks were cast using a standard casting technique. The remaining two (2) blocks were cast using a modified casting technique in an attempt to obtain better cell structure and cell orientation. All the blocks were cast in an oversized mold measuring 30" deep, 66" wide and 78" long. The cast blocks were then rough trimmed and completely X-rayed to determine the internal quality of the foam. Although not a specific requirement of this Contract, samples from the excess material of each block were tested as required in Phase I, Section A and some samples were tested for all sections of Phase I. This testing verified the properties which were spelled out in the Phase I requirement.

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Co.

DESCRIPTION OF PHASE III

The following sections described the method used in producing the sixteen (16) Phase III blocks:

Mold:

The mold used in producing the Phase III blocks measured 30" high x 66" wide x 78" long and was made of plywood reinforced with steel structural members. The mold was waxed prior to every casting with Johnson's Paste Wax.

Mix Procedure:

Each casting required the mixing of 420 pounds of raw material. Because of the size of these batches, they were mixed in two separate containers of 210 pounds each using identical mixers and mix procedures. The foam was mixed for a total of 130 seconds and immediately poured into the mold.

The first fourteen (14) blocks were free rise castings where no mold top was utilized. The fifteenth block, bearing Serial No. N1034-107 was cast in an identical manner but immediately upon pouring the mixed liquid ingredients into the mold, a 3/4" plywood panel, covered with polyethylene film, was laid on the unfoamed liquid. This plywood cover was then allowed to rise as the foam expanded. No additional weight was applied to this cover and a normal foam expansion took place which pushed this cover to the top of the mold.

Block No. Sixteen (16), bearing the Serial Number N1035-109 was cast in an identical manner to the first fourteen (14) blocks. It was mixed using a different mix procedure. This procedure kept the mix blades completely submerged in the material at all times and therefore reduced the amount of trapped air which was normally mixed in during the standard mix procedure.

Cure Cycle:

After the castings were completed, the blocks were allowed to stand in the mold for forty-eight (48) hours. The sides of the mold were then released and the blocks removed. The blocks were then allowed to stand an additional forty-eight (48) hours before the trim operation was initiated.

DESCRIPTION OF PHASE III
(Continued)

Rough Trim:

The blocks now measuring approximately 30" x 66" x 78" were rough trimmed to approximately 25" x 62"x 74". The excess material was left to protect the blocks during the handling which was necessary during the X-ray inspection. In obtaining the 25" height dimension, a slab, approximately 1" thick, was removed from the bottom of the block and a 4" slab was removed from the top of the block. A creep sample was then taken from each of the slabs. This top slab is the lowest density and therefore the weakest link in the entire casting, and by submitting this sample to creep testing, a positive indication for the structural value of each block could be obtained. The results of these creep samples are included in this report.

Creep Testing:

The samples taken from the top sample of each production casting were subject to creep testing. In some cases this testing consisted of all the physical tests spelled out in Phase I and in other cases just the Section A test of Phase I were accomplished. Throughout this Contract it became apparent that the Section A test was the most severe requirement and if the blocks passed this test with a reasonable creep value, they would have no difficulty in passing the remaining required tests. It must also be remembered that this testing was not a Phase III Contract requirement, but it was felt that continued control testing would assure the quality of the production castings.

X-ray Testing:

X-ray examination of the entire block was required to assure the absence of any detrimental flaws. X-rays were taken through both the two-foot and the five-foot dimensions. In the five-foot dimension X-ray films were taken from both sides of the block. The X-ray procedure is described in a letter with this report.

Final Trimming:

The blocks were then trimmed to the final production dimensions (24" x 60" x 72") and the blocks were weighed to the nearest one-half pound. From the actual measured dimensions, the density of each block was obtained. A listing of the creep data, density and shipping information is enclosed with this phase.

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Company

PHASE III RECOMMENDATIONS

Although all sixteen (16) blocks passed the requirements of Phase I, there was a noticeable improvement in foam quality and creep data when the floating mold top (Block N1034-107) and the alternate mix technique (Block N1035-109) were employed. Should further castings of this nature be required, both of these methods should be utilized.

The mold top increased the top density slightly and noticeably helped to orient the cell structure in a more completely vertical direction. The reduced air mixing procedure resulted in less entrapped bubbles throughout the foam as can be noted in the X-rays.

22 October 1964
Contract NAS8-11688
General Plastics Mfg.Company

	Block Serial Number	Density	Creep	Shipping Date	Shipment Number
#1	N1020-622	3.74	3.10%*	9 July 1964	#3320
#2	N1021-625	3.68	3.55%*	9 July 1964	#3320
#3	N1022-627	3.65	3.00%	9 July 1964	#3320
#4	N1023-76	3.64	4.10%*	28 July 1964	#3346
#5	N1024-78	3.63	3.15%*	28 July 1964	#3346
#6	N1025-710	3.56	3.7%*	28 July 1964	#3346
#7	N1026-713	3.63	3.25%*	18 Sept 1964	#3433
#8	N1027-715	3.66	2.85%*	6 Aug 1964	#3363
#9	N1028-717	3.72	3.2%	6 Aug 1964	#3363
#10	N1029-720	3.66	3.5%*	6 Aug 1964	#3363
#11	N1030-722	3.70	3.7%*	19 Aug 1964	#3379
#12	N1031-724	3.74	3.0%*	19 Aug 1964	#3379
#13	N1032-727	3.72	3.35%	19 Aug 1964	#3379
#14	N1033-729	3.71	3.4%	18 Sept 1964	#3433
#15	N1034-107	3.78	2.3%	21 Oct. 1964	#3501
#16	N1035-109	3.77	2.7%	21 Oct. 1964	#3501

* Results of Phase I Section (a) creep only.

INDUSTRIAL X-RAY ENGINEERS

DIVISION OF AUTOMATION INDUSTRIES, INC. · 6561 SIXTH AVENUE S., SEATTLE, WASHINGTON 98108 · AREA CODE 206 · PA 2-6878

8 July 1964

Mr. Tom Brazier
General Plastics
3481 South 35th St.
Tacoma, Washington

Subject: Radiography Technique of NASA Blocks

Dear Mr. Brazier:

The cellular foam material being radiographed for NASA measures approximately 2' thick in the form of a rectangle, 5'x6'. The equipment used are x-ray machines manufactured by the Ind-X Division of Automation Industries.

The 2' thickness sections are radiographed using a beryllium window tube Ind-X Unit at 6' focal film distances, at from 60 to 70 KVP for 16 milliampere minutes on Eastman type M film for the density of 2.3 H&D. The beryllium window tube used has a focal spot size of 1.3 mm. The blocks are marked in one foot squares at the source side so that each 14x17 film covers one square foot of block area. The identification is placed on the film area beyond the one foot square.

The 5' dimension of the block is radiographed from each side with the squares being marked as per the enclosed diagram. The enclosed diagram also shows the identification system used.

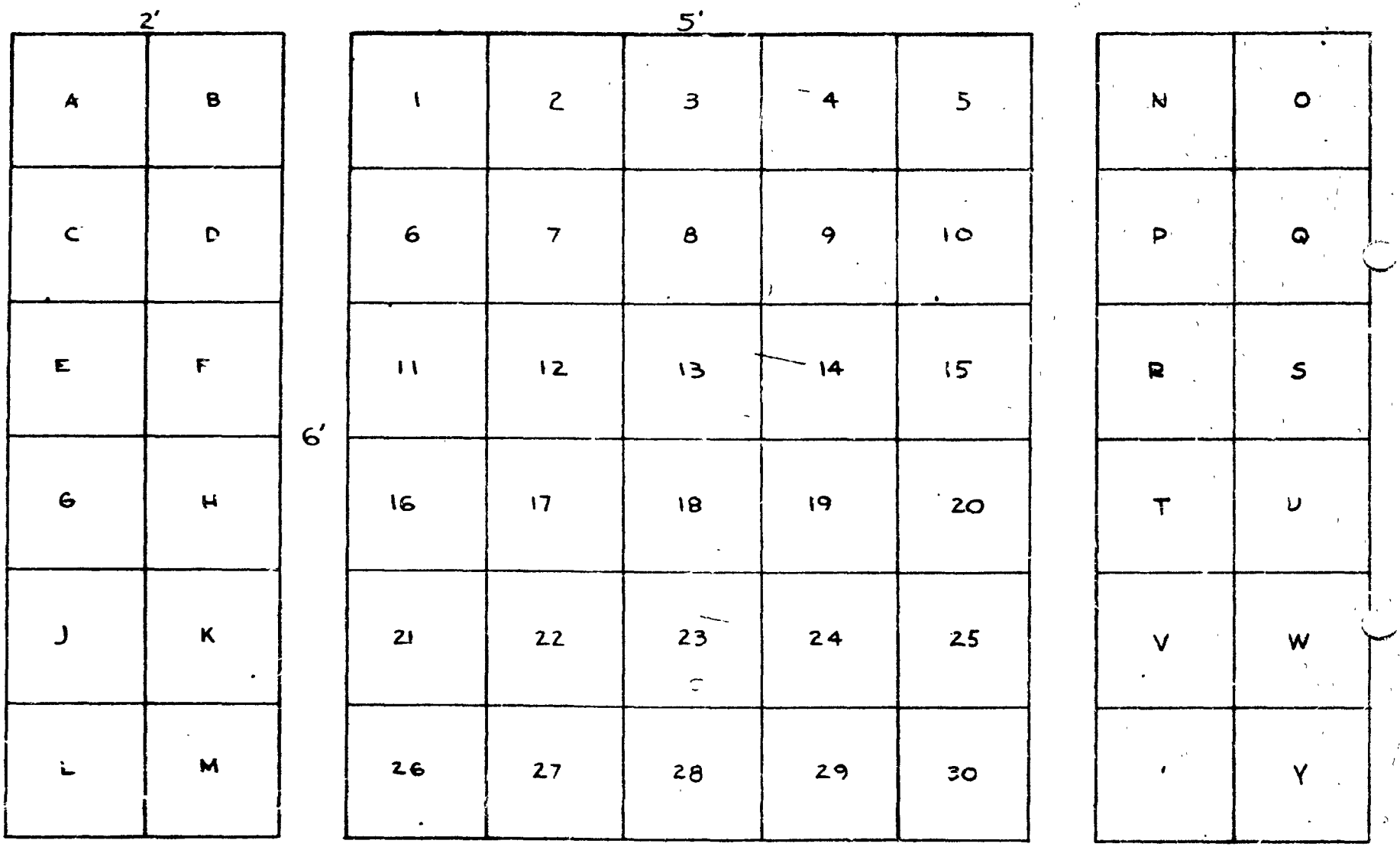
The 5' section is radiographed using an Ind-X X-Ray Unit having a .8x1 mm focal spot at approximately 110 KV for 16 milliampere minutes at 6' on type M film for an H&D density of 2.3. In this instance, a beryllium window tube unit is not used since there would be no advantage due to the fact that the longer wave lengths of the beryllium window tube would be attenuated to a point of zero or nearly zero by the thickness of material penetrated.

Very truly yours,

Harold Hovland

Harold Hovland
Manager

HH:jsr



PHASE III X-RAY LAYOUT

NASA BLOCK SERIAL No. _____

GENERAL PLASTICS MFG. COMPANY
3481 South 35th Street
Tacoma, Washington

FINAL REPORT

PHASE IV

SUBJECT: DEVELOPMENT OF A FORMULA AND TECHNIQUE FOR PATCHING AND REPAIRING DAMAGED RIGID POLYURETHANE FOAM.

COMPLETION DATE: 22 OCTOBER 1964

CONTRACT NUMBER: NAS8-11688

ATTENTION: PR-RC

SUMMARY OF PHASE IV

The objective of Phase IV was to develop a systematic and reliable method for repairing damaged rigid polyurethane foam. A method has been developed and has been detailed to insure reproducible satisfactory results in meeting the strength requirements and dimensional tolerances. The fulfillment of this objective requires consideration in the following four areas:

1. Application: There is a limit to the usefulness of this technique. Only certain types, and only to a certain extent of damage, can rigid polyurethane foam be repaired by this technique.

2. Formulation: In order for any formulation to be suitable, the two properties which are absolutely necessary are good adhesion and high compressive strength. Also a cast density similar to that of the damaged foam is desirable.

3. Testing: To insure no loss in physical properties due to the patching foam or the patch itself, tests on typical defects which had been repaired were performed.

4. Technique: A step by step procedure has been developed and includes the following four steps:

    1. Preparation of the damaged area.
    2. Mixing and pouring the foam.
    3. Curing the foam.
    4. Trimming and finishing.

22 October 1964
Contract NAS8-11688
General Plastics Mfg. Compa

DESCRIPTION - PHASE IV

The repair formulation designated R-4504 required good adhesion and high compressive strength. To obtain this foam, a series of bench formulations was established and samples of each were cast into one-half gallon paper containers.

Particular attention was given to the cure requirements of these samples. From this series of foams it was evident that a high catalyst level and the use of water in addition to the fluorocarbon 11 blowing agent would be necessary to achieve a successful patching formulation and still maintain the required four pound density.

The most likely candidates for a successful patching formulation were chosen from these samples and after preliminary testing a re-formulation designated R-4504 was obtained and used in the sample patching described below.

Sample Patching:

A series of typical defects was established and samples of the Phase I (R-4803.5) casting foam were prepared containing each of these defects. These included the following:

1. Cracks: A typical narrow clean crevice which sometimes occurs in a casting.
2. Voids: Trapped air pockets or holes included in a casting.
3. Dents: Damage caused by the impact of some object against the foam.
4. Chips: Sections of foam that have been broken away from the parent casting.

Repairs were made on each of the above defects and the repair technique is described in this report.

22 October 1964
Contract NAS8-11588
General Plastics Mfg.Company

DESCRIPTION OF PHASE IV

(Continued)

Patch Testings:

In order to insure no less in strength resulting from repair patches, a testing program designed to relate the relative strengths of different patching situations was set up. The relative strengths were measured as percentage of creep and the standard creep procedure was used. The tests were made on actual patch samples which were made following the instructions in this report.

Creep tests were made on both the precut foam and the straight patching foam to determine the relative strength of each. Then two sample patches were tested, No. 1 with union of the two foams perpendicular to the direction of compression (to simulate a large shallow patch) and patch No. 2 was a patched hole with the long direction parallel to the direction of compression. (See the diagrams on the respective creep curves in Appendix II).

Results: The results of the tests performed on the patching foam and the patched samples are shown below. This summary of the creep tests shows no reduction in compressive properties of the patched area.

1.	Parent Foam (R-4803.5)	3.7% creep
2.	Patching Foam (R-4504)	2.3% creep
3.	Patch No. 1	3.0% creep
4.	Patch No. 2	3.1% creep

The creep data and resulting curves are included with this report.

The properties of R-4504 are somewhat better than those of the parent foam R-4803.5 as shown in the comparison below. (This is due to higher density and higher catalyst level).

		R-4504	R-4803.5
1.	Density:	4.00 p.c.f.	3.60 p.c.f.
2.	Compressive strength: parallel to blow	95 psi	82 psi
3.	Maximum Creep:	2.3%	3.7%
4.	Closed Cells:	Greater than 90%	Greater than 90%
5.	Water Absorption:	Less than 0.02 lbs/ft^2	Less than 0.02 lbs/ft^2

DESCRIPTION - PHASE IV
(Continued)

Application:

Listed below are the types of patches or repairs to which this technique applies. As well as classifying the defect, an attempt to place a practical size limit on the reparable void has been made.

1. Punctures, dents, holes and voids:

This type patch may be applied easily up to approximately thirty cubic inches. Attempts to patch larger defects may or may not encounter difficulties resulting from too much internal pressure. For example, a hole to be filled three inches wide, four inches long, and four inches deep, if located near the edge of a block may result in cracking the whole section loose from the block because of internal pressure.

2. Cracks, shears and narrow punctures:

The maximum size here depends so much upon the conditions that a single value is inadequate. For cracks, shears, etc., less than one-half inch across, cracks up to twenty cubic inches may be filled. Difficulty often exists in filling the crack completely because of trapped air and very narrow places where the patching foam will not flow. For cracks, shears, etc., over one-half inch, the maximum volume should not exceed approximately fifteen cubic inches. This technique is not recommended for cracks or shears wider than three-fourths of an inch, or if the crack is more than three inches deep. (Internal pressure caused by the patching foam will make the crack enlarge itself.)

3. Edge, corner and tip defects:

Open and exposed defects, where a section of foam has been repaired up to volumes of approximately thirty cubic inches. Larger defects would possibly require a reduced catalyst level in the patching formulation and would require a confined molding setup specific to the individual part.

DESCRIPTION PHASE IV
(Continued)

Technique:

For repair patches, where a molded skin is unnecessary, there are three steps to the repair operation: (1) preparation; (2) foaming; and, (3) finishing. Where a molded skin is desired, only the preparation and the foaming are required to finsh the job, however, the technique requires some practice. In fact, a familiarization with the handling characteristics of the foam and some practice patches on scrap material are suggested before attempting to repair a damaged part. Although the technique is not difficult, some practice will help to insure a successful repair on the first try.

The steps listed below under each step should be followed as closely as possible since a failure to comply or mission of a step may weaken or ruin a patch.

Step One - Preparation:

1. Damaged, crushed or loose foam around the area to be repaired must be cut away so the patching foam will adhere to only strong foam.

2. The void to be filled must be vacuumed or blown free of dust or any other foreign material.

3. The block being repaired or the immediate are under repair should be warmed approximately to 100°F. at the time the patching foam is poured.

4. In some cases, a small barrier must be built to keep the expanding foam properly positioned. This may be made from masking tape and cardboard, or other suitable barrier material.

5. It is also desirable to protect the finished foam surrounding the patch area by masking the foam surfaces with masking tape. This will reduce the chance of spills damaging the finished foam and also aid in finishing the patched surface.

DESCRIPTION PHASE IV
(Continued)

Technique (Cont'd)

Step Two - Foaming:

1. Both liquid components (Part A, Part B) are weighed, in the proper ratio, into a mixing vessel. (Paper cups work very nicely for mixing). The vessel is taken to the mixer and the liquids are mixed for ten to fifteen seconds. A drill press has been found to be satisfactory as a mixing machine with the rpm set at 1100 to 1400. A variety of mixers, or beaters, may be used with equal success. Perhaps the easiest is a single beater from a household electric mixer.

2. The mixed, but still liquid, foam is poured immediately into the area to be filled, with caution not to pour a large excess of mixed ingredients. (The foam expands to approximately ten times its liquid volume).

3. If a molded skin is desired on the repaired surface, the void is quickly covered with heavy gauge (1/16 to 1/8") polyethylene sheet which must be firmly clamped or weighted down with 8 to 10 psi. Special care must be taken not to add too much excess foam to the void.

Step Three - Curing and finishing:

1. Each repair patch requires a cure cycle of twelve hours at 120°F. or forty-eight hours at 70 to 75°F. before the repair can be finished. It is suggested that all small patches, or patches with any dimension less than one-half inch, be cured at 120°F.

   If the size of the repaired block is such that over curing is impossible, a heat lamp or air circulating heater applied directly above the patch will reduce the foam friability and shorten the room temperature cure cycle.

2. Where molded skins are unnecessary, the excess foam may be rough trimmed using a hand saw, hack saw or similar trimming tool. Care should be taken to prevent damage to the surrounding foam. The patched area may then be finished using a sanding block.

DESCRIPTION PHASE IV
(Continued)

Step Three - Curing and Finishing: (Cont'd)

3. Patches with molded surfaces must always be cured at 120°F. for twelve hours then the polyethylene may be carefully pealed away to give a smooth molded surface and the patch is finished.

2[illegible] OCTOBER 1964
Contract NAS8-11688
General Plastics Mfg. Company

PHASE IV

Patching Formulation:

R-4504

R-4504 Part A (Parts by weight)

Polyether Resin	(510 OH#)	80
Toluene Diisocyanate	(80-20 Isomer)	29
Benzoyl Chloride		0.2
Silicone Glycol Copolymer	(DC 201)	3.9

R-4504 Part B (Parts by weight)

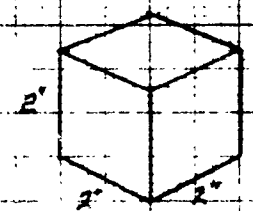
Polyether Resin (450 OH#)	60
Tetrakis (2 Hyroxypropyl) Ethylenediamine	10
Fluorocarbon 11 (stablized)	8.0
Silicone Glycol Copolymer (DC 201)	1.0
Triethylenediamine	0.33
Dipropylene Glycol	0.66
Water	0.5

To Obtain the Patching Foam:

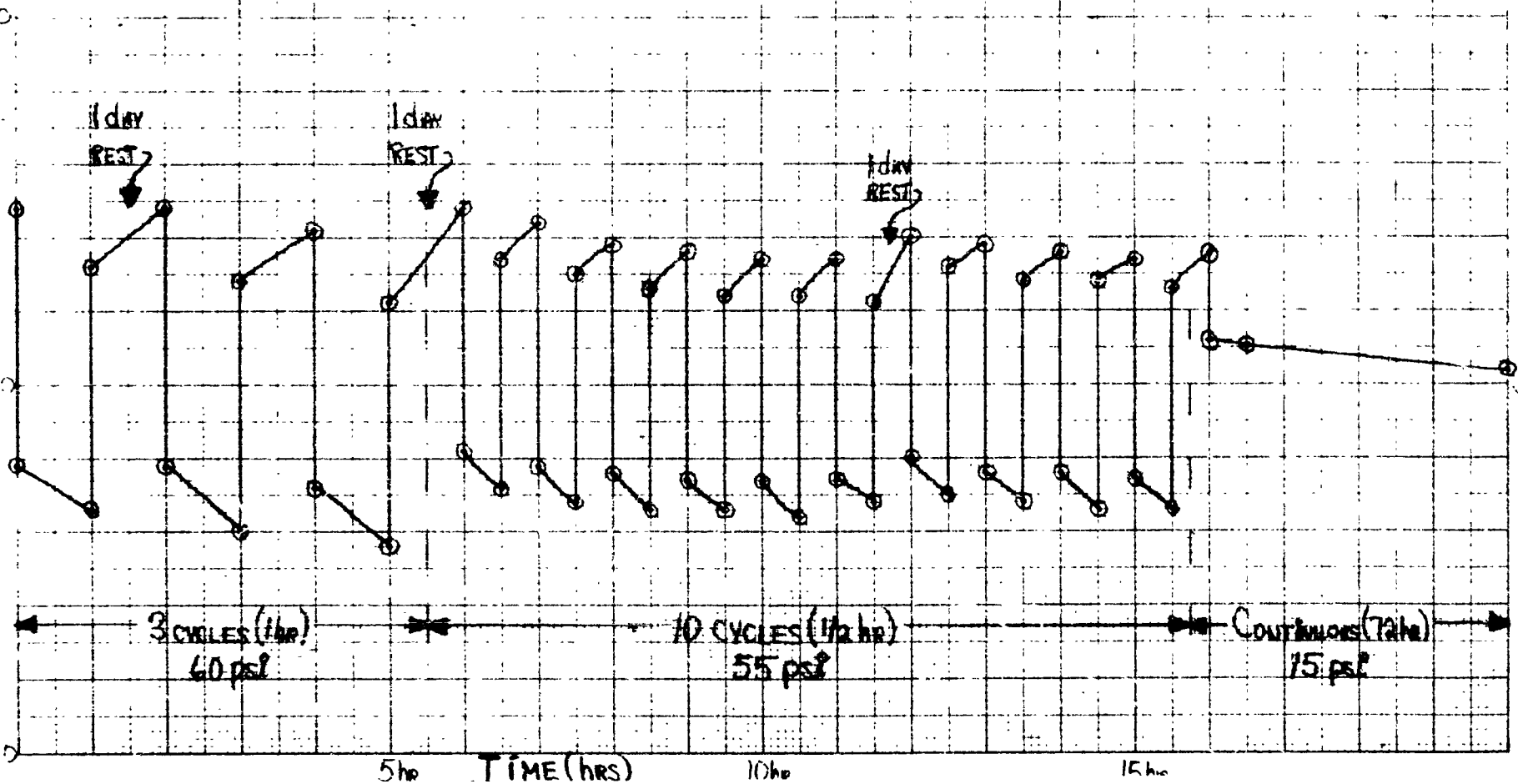
The above ingredients are mixed in a ratio of 100 parts by weight Part A to 80 parts by weight Part B.

K+E 10 X 10 TO THE ½ INCH KEUFFEL & ESSER CO 358-12

R-4504
Maximum Creep 2.3 %



R-4504 SAMPLE



CREEP TEST #1 and #3

Foam No. R-4504 Batch No. A 100-527 BATCH No. B [redacted] N 111-64

Date Poured _____ Date Tested JUNE 3, '64

SEPARATE PATCHING FOAM

TEST #1

	Time	Height	Deflection
Initial	3:50	3.004	
Loaded t = 0m	3:50	2.989	
t = 60m	4:50	2.983	
Unloaded t = 60m	4:50	3.016	
t = 120m	8:15	3.004	
Loaded t = 120m	8:15	2.989	
t = 180m	9:15	2.980	
Unloaded t = 180m	9:15	3.014	
t = 240m	10:15	3.021	
Loaded t = 240m	10:15	[redacted]	
t = 300m	11:15	2.978	
Unloaded t = 360m	11:15	3.011	

TEST #3

	Time	Height	Deflection
Initial 6TH	[illegible]	3.018	
Loaded t = 0 hr	[illegible]	3.006	
t = 1 hr	[illegible]	3.005	
t = 24 hr	11:30	3.004	
JUNE 8TH t = 48 hr	12:00	3.003	
t = 60 hr	5:00	3.003	
Loaded t = 72 hr	11:30	3.002	
Unloaded 9TH t = 72 hr			

CREEP TEST #2

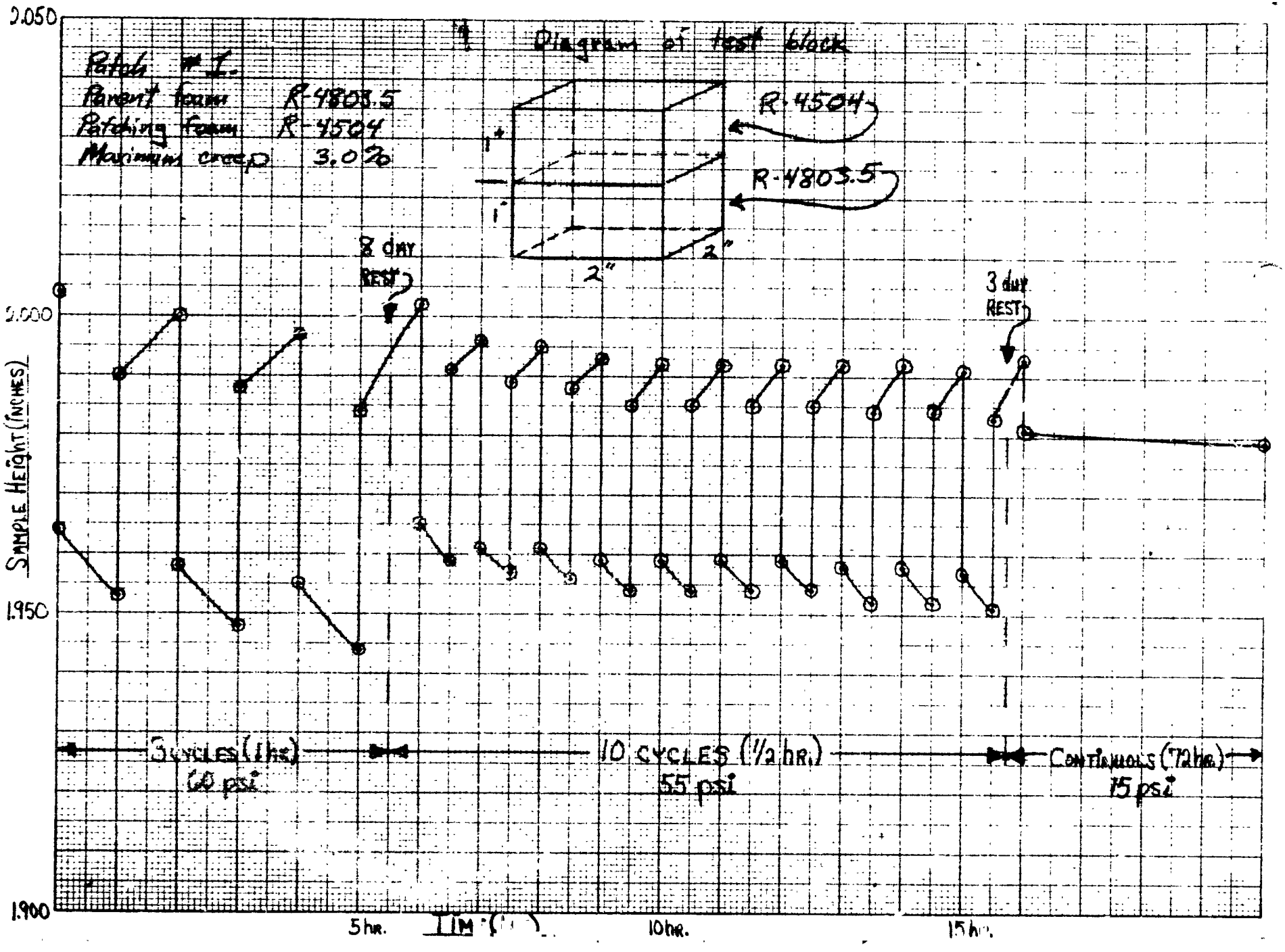
Foam No. R-4504 Batch No. A 100-527 Batch No. B N111-64

Date Poured _____ Date Tested JUNE 5TH

TEST #2 Serial No. PATCHING FOAM

		Time	Height		Time	Height
Initial 5TH		10:15	3.024			
Loaded	t = 0m	10:15	2.991	t = 300	3:20	2.987
	t = 30m	10:45	2.986	t = 330	3:50	2.984
Unloaded	t = 30m	10:45	3.017	t = 330	3:50	3.011
	t = 60m	11:15	3.022	t = 360 June 6	7:30	3.020
Loaded	t = 60m	11:15	2.989	t = 360	7:30	2.990
	t = 90m	11:50	2.984	t = 390	8:00	2.985
Unloaded	t = 90m	11:50	3.015	t = 390	8:00	3.016
	t = 120m	12:20	3.019	t = 420	8:30	3.019
Loaded	t = 120m	12:20	2.988	t = 420	8:30	2.988
	t = 150m	12:50	2.983	t = 450	9:00	2.984
Unloaded	t = 150m	12:50	3.013	t = 450	9:00	3.014
	t = 180m	1:20	3.018	t = 480	9:30	3.018
Loaded	t = 180m	1:20	2.987	t = 480	9:30	2.988
	t = 210m	1:50	2.983	t = 510	10:00	2.983
Unloaded	t = 210m	1:50	3.012	t = 510	10:00	3.014
	t = 240m	2:20	3.017	t = 540	10:30	3.017
Loaded	t = 240m	2:20	2.987	t = 540	10:30	2.987
	t = 270m	2:50	2.982	t = 570	11:00	2.983
Unloaded	t = 270m	2:50	3.012	t = 570	11:00	3.013
	t = 300m	3:20	3.017	t = 600		

K+E 10 X 10 TO THE ½ INCH 358-12
KEUFFEL & ESSER CO MADE IN U.S.A.



CREEP TEST #1 and #3

Foam No. R-4803-4504 Batch No. A 100-527 Date Tested N111-64

Date Poured _____ Date Tested JUNE 9TH

50-50 PATCHING FOAM

TEST #1

	Time	Height	Deflection	
Initial 9TH	8:15	3.004		
Loaded t = 0m	8:15	2.964		
t = 60m	9:15	2.953		
Unloaded t = 60m	9:15	2.990		
t = 120m	10:15	3.000		
Loaded t = 120m	10:15	2.958		
t = 180m	11:15	2.948		
Unloaded t = 180m	11:15	2.988		
t = 240m	12:45	2.997		
Loaded t = 240m	12:45	2.955		
t = 300m	1:45	2.944		
Unloaded t = 360m	1:45	2.984		

TEST #3

	Time	Height	Deflection	
Initial 20TH	3:45	2.993		
Loaded t = 0 hr	3:45	2.981		
SUNDAY t = 1 hr	—	—		
SUNDAY t = 24 hr	—	—		
2ND 41 hr t = [illegible]	8:45	2.980		
3RD [illegible] hr t = [illegible]	8:00	2.979		
Loaded t = 72 hr	3:45	2.979		
Unloaded t = 72 hr	3:45	2.986		

CREEP TEST #2

Foam No. R-4803-4504 Batch No. A 100-527 Batch No. B N111-64

Date Poured _____ Date Tested JUNE 17TH

TEST #2 SERIAL No. 50-50 PATCHING FOAM

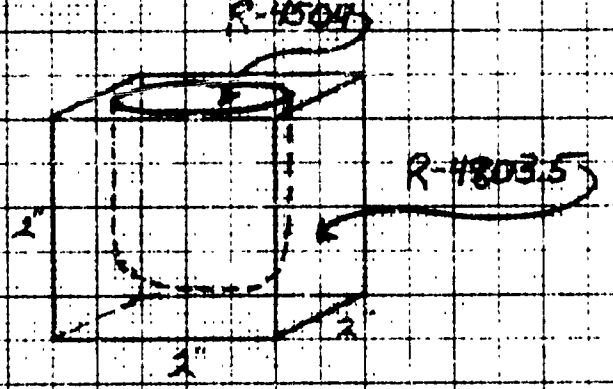
		Time	Height		Time	Height
Initial	17TH	8:00	3.002			
Loaded	t = 0m	8:00	2.965	t = 300	1:00	2.959
	t = 30m	8:30	2.959	t = 330	1:30	2.954
Unloaded	t = 30m	8:30	2.991	t = 330	1:30	2.985
	t = 60m	9:00	2.996	t = 360	2:00	2.992
Loaded	t = 60m	9:00	2.961	t = 360	2:00	2.959
	t = 90m	9:30	2.957	t = 390	2:30	2.954
Unloaded	t = 90m	9:30	2.989	t = 390	2:30	2.985
	t = 120m	10:00	2.995	t = 420	3:00	2.992
Loaded	t = 120m	10:00	2.961	t = 420	3:00	2.958
	t = 150m	10:30	2.956	t = 450	3:30	2.952
Unloaded	t = 150m	10:30	2.988	t = 450	3:30	2.984
	t = 180m	11:00	2.993	t = 480	4:00	2.992
Loaded	t = 180m	11:00	2.959	t = 480	4:00	2.958
	t = 210m	11:30	2.954	t = 510	4:30	2.952
Unloaded	t = 210m	11:30	2.985	t = 510	4:30	2.984
	t = 240m	12:00	2.992	t = 540	5:00	2.991
Loaded	t = 240m	12:00	2.959	t = 540	5:00	2.957
	t = 270m	12:30	2.954	t = 570	5:30	2.951
Unloaded	t = 270m	12:30	2.985	t = 570	5:30	2.983
	t = 300m	1:00	2.992	t = 600		

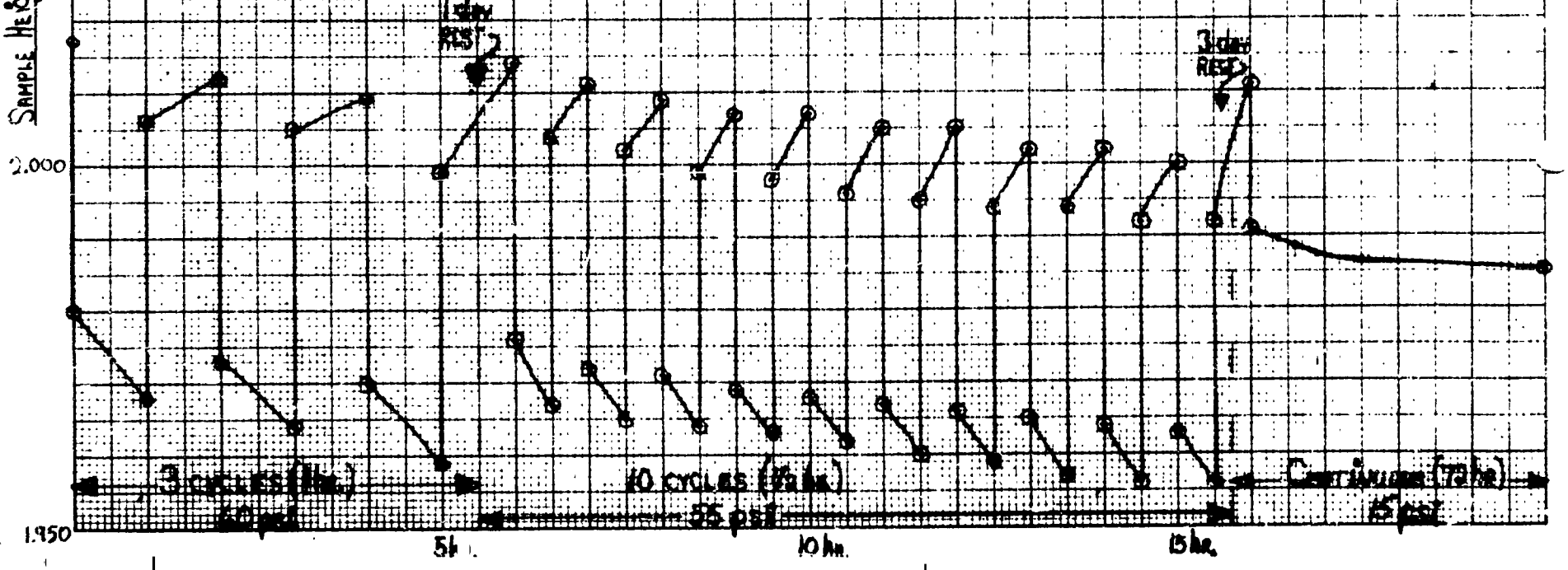
2.62

K·E 10 X 10 TO THE ⅛ INCH 358-12
KEUFFEL & ESSER CO

Patch #2.
Pad-out foam R-4803.5
Patching foam R-4504
Maximum creep 3.1%

Diagram of test block





CREEP TEST #1 and #3

Foam No. R-4803-4504 Batch No. A 100-527 Batch No. B N111-64

Date Poured _____ Date Tested JUNE 16TH

Serial No. SPOT PATCH

TEST #1

	Time	Height	Deflection	
Initial 17TH	8:10	3.017		
Loaded t = 0m	8:10	2.980		
t = 60m	9:10	2.968		
Unloaded t = 60m	9:10	3.006		
t = 120m	10:10	3.012		
Loaded t = 120m	10:10	2.973		
t = 180m	11:10	2.964		
Unloaded t = 180m	11:10	3.005		
t = 240m	12:10	3.009		
Loaded t = 240m	12:10	2.970		
t = 300m	1:10	2.959		
Unloaded t = 360m	1:10	2.999		

TEST #3

	Time	Height	Deflection	
Initial 20TH	3:45	3.011		
Loaded t = 0 hr	3:45	2.991		
SUNDAY t = 1 hr	—	—		
SUNDAY t = 24 hr	—	—		
22ND 41 hr t = ~~48 hr~~	8:45	2.987		
23RD 64 hr t = ~~72 hr~~	8:00	2.986		
Loaded t = 72 hr	3:45	2.985		
Unloaded t = 72 hr	3:45	3.004		

CREEP TEST #2

Foam No. R-4803-4504 Batch No. A 100-527 Batch No. B N 111-64

Date Poured _____ Date Tested JUNE 17TH

TEST #2 SERIAL NO. SPOT PATCH

		Time	Height		Time	Height	
Initial		7:30	3.014				
Loaded	t = 0m	7:30	2.976	t = 300	12:30	2.967	
	t = 30m	8:00	2.961	t = 330	1:00	2.960	
Unloaded	t = 30m	8:00	3.004	t = 330	1:00	2.995	
	t = 60m	8:30	3.011	t = 360	1:30	3.005	
Loaded	t = 60m	8:30	2.972	t = 360	1:30	2.966	
	t = 90m	9:00	2.965	t = 390	2:00	2.959	
Unloaded	t = 90m	9:00	3.002	t = 390	2:00	2.994	
	t = 120m	9:30	3.009	t = 420	2:30	3.002	
Loaded	t = 120m	9:30	2.971	t = 420	2:30	2.965	
	t = 150m	10:00	2.964	t = 450	3:00	2.957	
Unloaded	t = 150m	10:00	2.999	t = 450	3:00	2.994	
	t = 180m	10:30	3.007	t = 480	3:30	3.002	
Loaded	t = 180m	10:30	2.969	t = 480	3:30	2.964	
	t = 210m	11:00	2.963	t = 510	4:00	2.956	
Unloaded	t = 210m	11:00	2.998	t = 510	4:00	2.992	
	t = 240m	11:30	3.007	t = 540	4:30	3.000	
Loaded	t = 240m	11:30	2.968	t = 540	4:30	2.963	
	t = 270m	12:00	2.962	t = 570	5:00	2.956	
Unloaded	t = 270m	12:00	2.996	t = 570	5:00	2.992	
	t = 300m	12:30	3.005	t = 600			