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Properties of 30 lb/ft³ Rigid Polyurethane Foams

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Properties of 30 lb/ft³ Rigid Polyurethane Foams

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Abstract

This report summarizes tests on five different foams. Two are manufactured at Allied Signal, two at North Carolina Foam Industries, and one at General Plastics. The tests conducted are: thermal conductivity at various temperatures, specific heat at 60°C, compressive strength at ambient and 60°C, thermogravimetric analysis to 800°C, intumescence, and char formation properties. A CHN analysis was also performed. Funding for the testing of rigid polyurethane foams originated from the AT-400A container program at Sandia National Laboratories. This testing supported the development of the AT-400A container. The AT-400A is a storage and transportation container that will be used initially at the Pantex Plant for storage of plutonium from dismantled nuclear weapons.

Executive Summary

This final report summarizes the testing that was conducted on the five foam systems for the AT-400A container project. The five candidate foam systems for the AT400A project (in the order as tested) were:

1. AlliedSignal, KCP 44307-21,
2. AlliedSignal, KCP 44307-21 w/ PE 200 additive,
3. North Carolina Foam Industries, NCFI 24-125 w/ PE200 additive,
4. General Plastic, GP 3725, and
5. North Carolina Foam Industries, NCFI-VS w/PE 200 additive.

Six different property tests were conducted on each of the polyurethane foams with cast sample densities of 30 lb/ft³. The six property tests were:

1. Thermal Conductivity at 75 °F, 140 °F, 250 °F, & 350 °F,
2. Specific Heat at 60 °C,
3. Compressive Properties at ambient temperature and 60 °C,
4. Thermogravimetric Analysis to 800 °C,
5. Intumescent Properties Analysis, and
6. Char Formation Property Test.

This final report is divided into separate sections documenting the average values obtained for each test. These results consist of the test values that were reported in each interim report. Attached in Addendum A through E are the actual interim reports on the five candidate foams. In addition, Addendum F contains the additional char formation testing that was not documented in the individual interim reports.

Results for this final report are presented in tabular form and all experimental plots are presented in the interim reports for any further review. Testing for this study was conducted to the Statement of Work dated 3/29/94 using referenced test methods and/or documented procedures. Any questions in regards to this testing can be directed to Ed Wenski, (816) 997-2667.

This analysis report on this certification has been performed in accordance with AlliedSignal Aerospace, Kansas City Division, standard laboratory practices and other named specifications. The information contained represents only the material tested.

5/22/95 Edward G. Wenski P.E., Outside Testing Representative

Test I: Thermal Conductivity

Thermal conductivity testing was performed on the foam in accordance with ASTM-C-177. The auxiliary heaters, cooler liquid and guard heater were adjusted to obtain test results near 75, 140, 250, and 350 °F. Three different sample pairs were tested for each foam system at each temperature range. The average test results are tabulated below:

<i>Temperature Range</i>	<i>KCP 44307-21</i>	<i>KCP 44307-21 w/PE200 additive</i>	<i>NCFI 24-125 w/PE200 additive</i>	<i>GP 3725</i>	<i>NCFI-VS w/PE200 additive</i>
74-80 °F	0.527	0.523	0.521	0.518	0.496
132-141 °F	0.553	0.558	0.552	0.551	0.535
248-255 °F	0.613	0.619	0.610	0.627	0.603
348-350 °F	0.680	0.687	0.647	0.649	0.642

(all values in BTU-in/hr-ft²-°F)

Test II: Specific Heat

Specific heat values for the foam were determined on five different samples for each foam system. The specific heat was determined at 60°C, by comparison of the specific heat of the foam samples to a certified sapphire standard with precisely known specific heat value. The average specific heat values obtained are tabulated below:

	<i>KCP 44307-21</i>	<i>KCP 44307-21 w/PE200 additive</i>	<i>NCFI 24-125 w/PE200 additive</i>	<i>GP 3725</i>	<i>NCFI-VS w/PE200 additive</i>
Specific Heat (Calories/gram-°C)	0.32	0.41	0.43	0.39	0.34

Test III: Compressive Properties Analysis

Compressive property tests were conducted on ten samples of foam system at ambient temperature and 60 °C. These tests were conducted per ASTM D1621 with a foam sample of approximately 4-square inches. The average test results for each foam system are tabulated below for stress at 10% & 60% strain, maximum strain and the maximum stress.

Mechanical Properties at Room Temperature

	<i>KCP 44307-21</i>	<i>KCP 44307-21 w/PE200 additive</i>	<i>NCFI 24-125 w/PE200 additive</i>	<i>GP 3725</i>	<i>NCFI-VS w/PE200 additive</i>
Stress @ 10%	2600 psi	2620 psi	2190 psi	2430 psi	2320 psi
Stress @ 50%	3415 psi	3550 psi	3610 psi	4520 psi	4270 psi
Stress @ 60%	N/A *	N/A*	N/A*	N/A*	N/A*
Strain @ Max. Stress	59.1 %	58.8 %	58.0 %	52.9 %	55.9 %
Max. Stress	4620 psi	5230 psi	5240 psi	5240 psi	5240 psi

* numerous samples failed to reach the 60% strain level before compressive failure.

Mechanical Properties at 60 °C

	<i>KCP 44307-21</i>	<i>KCP 44307-21 w/PE200 additive</i>	<i>NCFI 24-125 w/PE200 additive</i>	<i>GP 3725</i>	<i>NCFI-VS w/PE200 additive</i>
Stress @ 10%	2125 psi	2140 psi	1320 psi	1800 psi	1350 psi
Stress @ 50%	3320 psi	3350 psi	2410 psi	3405 psi	2850 psi
Stress @ 60%	N/A*	N/A*	4150 psi	N/A*	3990 psi *
Strain @ Max. Stress	59.6 %	59.8 %	62.1 %	58.4 %	61.7 %
Max. Stress	5140 psi	5230 psi	4860 psi	5260 psi	4770 psi

* numerous samples failed to reach the 60% strain level before compressive failure.

Test IV: Thermogravimetric Analysis

TGA analysis was run on the foam with an air atmosphere and a heating rate 10°F/minute. The decomposition temperature for the foam samples were generally around 300 °C as expected. Three test samples were used for each foam system and the average values are tabulated below.

	<i>KCP 44307-21</i>	<i>KCP 44307-21 w/PE200 additive</i>	<i>NCFI 24-125 w/PE200 additive</i>	<i>GP 3725</i>	<i>NCFI-VS w/PE200 additive</i>
Decomposition Temperature (°C)	310	320	270	280	277

Test V: Intumescent Properties

Intumescent properties of the foam were determined on five samples of each foam system by placing the foams in a muffle furnace at 801°C for 90 seconds. The Intumescence is defined as the amount the foam has expanded along one side of a two inch cube of the foam sample. The height of the furnace is five inches and the foam samples were placed on a one inch thick tile allowing for a free expansion of two inches with a two inch sample. Many of the tested samples expanded to the top of the muffle furnace which stopped the free expansion of the foam. Below are the tabulated average results from the intumescence testing.

	<i>KCP 44307-21</i>	<i>KCP 44307-21 w/PE200 additive</i>	<i>NCFI 24-125 w/PE200 additive</i>	<i>GP 3725</i>	<i>NCFI-VS w/PE200 additive</i>
% growth	3.8	84.1 **	23.0	100+	8.9

** all samples would have exceeded 100% if not restricted by roof of furnace.

Test VI: Char Formation Property Test

Char formation property tests were conducted on the five foam systems. Char testing was conducted Addendum 2 of the Statement of Work dated 6/3/94. Five samples were tested for each foam and the average weight retention percentage is tabulated below.

	<i>KCP 44307-21</i>	<i>KCP 44307-21 w/PE200 additive</i>	<i>NCFI 24-125 w/PE200 additive</i>	<i>GP 3725</i>	<i>NCFI-VS w/PE200 additive</i>
% weight retention	not tested	76.8	67.7	70.7	67.5

APPENDIX A
Allied-Signal
KCP 44307-21 Foam

Description of Work

This report describes the initial phase of testing that was conducted on the first of four different foam systems to be analyzed for the AT-400A container project. This interim report tabulates five different tests that was conducted on the polyurethane foam produced by AlliedSignal in Kansas City. This foam is identified as KCP-44307-21 and was formulated to have a cast density of 30 lbs/ft³.

The five tests that were conducted on the foam were:

1. Thermal Conductivity at 83 °F, 140 °F, 250 °F, & 350 °F,
2. Specific Heat at 60 °C,
3. Compressive Properties at ambient temperature and 60 °C,
4. Thermogravimetric Analysis to 800 °C, and
5. Intumescent Properties analysis.

This report is divided into 5 different sections for each different test. Results are presented in tabular form (where possible) or the actual experimental plot is given for review. All testing was conducted to the Statement of Work dated 3/29/94. Any questions in regards to this testing can be directed to Ed Wenski, (816) 997-2667.

This analysis report on this certification has been performed in accordance with AlliedSignal Aerospace, Kansas City Division, standard laboratory practices and other named specifications. The information contained represents only the material tested.

Edward G. Wenski P.E., Testing Coordinator

Test I: Thermal Conductivity

Thermal conductivity testing was performed on the foam in accordance with ASTM-C-177. The auxiliary heaters, cooler liquid and guard heater were adjusted to obtain test results near 70, 140, 250, and 350 °F. Three different sample pairs were tested at each temperature. The results are tabulated below:

<i>Sample Number</i>	<i>Temperature (°C)</i>	<i>Temperature (°F)</i>	<i>Conductivity (W/m-°C)</i>	<i>Conductivity (BTU-in/hr-ft²-°F)</i>
1	26.8	80.3	.0756	.524
1	56.0	132.7	.0800	.554
1	123.7	254.6	.0879	.610
1	176.6	349.9	.0933	.647
2	27.4	81.3	.0756	.524
2	56.5	133.8	.0791	.548
2	123.8	254.9	.0872	.605
2	176.9	350.5	.0980	.680
3	27.0	80.6	.0769	.533
3	56.2	133.1	.0802	.556
3	123.3	254.0	.0901	.624
3	176.0	348.8	.1029	.713

Test II: Specific Heat

Specific heat values for the foam were determined on five different samples. The specific heat was determined at 60°C, by comparison of the specific heat of the foam samples to a certified sapphire standard with precisely known specific heat value. The specific heat values obtained are shown below:

<i>Sample Number</i>	<i>Specific Heat Value (Calories/gram-°C)</i>
1	0.31
2	0.34
3	0.33
4	0.32
5	0.31
Average	0.32

Test III: Compressive Properties Analysis

Compressive property tests were conducted on ten samples of foam at ambient temperature and 60 °C. These tests were conducted per ASTM D1621 with a foam sample of approximately 4-square inches. Two different groups of test samples (representing two foam pours) were analyzed for the testing. Results are tabulated for Young's Modulus, stress at 10% & 60% and the maximum stress. Actual stress-strain curves for each sample are also attached for your review.

Compressive Properties at ambient temperature (Group 1)

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

ASTM D 1621

Test type: Compressive

Instron Corporation

Series IX Automated Materials Testing System 6.04

Operator name: KEITH WALBURN

Test Date: 11 May 1994

Sample Identification: 312341A1

Sample Type: 2.20

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1000
Extensometer switch value: 80.0000% offset

Humidity (%): 50
Temperature (deg. C): 23

LTR Number 312341
Lot Number
Part Number KC FOAM AT-400
Description COMPRESSION TEST TO 60% STRAIN
Test Temperature AMBIENT

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5

Diameter (in) SEPARATE
Ext. gauge len (in) SEPARATE
Spec gauge len (in) 1.1000 1.1000 1.1000 1.1000 1.1000

Out of 5 specimens, 0 excluded.

Result(s) marked with a U were above pre-set limits.

Result(s) marked with a L were below pre-set limits.

Sample comments: Specimen #1 hit software travel limit prior to reaching 60% strain.

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	1-007	2.200	U 1.096	60.5	2630.	-----	12200.	3200.	56.3
2	2-008	2.159	U 1.100	64.6	2540.	3690.	14400.	3940.	61.3
3	3-008	2.261	U 1.098	64.5	2660.	4150.	16900.	4200.	62.8
4	4-009	2.261	U 1.107	65.1	2720.	4450.	18000.	4490.	60.2
5	5-009	2.200	U 1.102	67.8	2800.	5430.	20800.	5460.	60.1
Mean:		2.216	1.101	64.5	2670.	-----	16400.	4260.	60.2
Standard Deviation:		.044	.004	2.6	97.	-----	3310.	826.	2.4

312341A1

SPEC # 001

312341A1

SPEC # 002

312341A1

SPEC # 003

Percent Strain (%)

312341A1

SPEC # 004

312341A1

SPEC # 005

Compressive Properties at ambient temperature (Group 2)

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

ASTM D 1621

Test type: Compressive

Instron Corporation

Operator name: KEITH WALBURN

Series IX Automated Materials Testing System 6.04

Test Date: 23 May 1994

Sample Identification: 312341A2

Sample Type: 2.26

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000

Humidity (%): 46

Crosshead Speed (in/min): .1000

Temperature (deg. C): 23

Extensometer switch value: 80.0000% offset

LTR Number 312155

Lot Number

Part Number KC FOAM AT-400

Description COMPRESSION TEST TO 60% STRAIN

Test Temperature AMBIENT

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5

Diameter (in) SEPARATE

Ext. gauge len (in) SEPARATE

Spec gauge len (in) 1.0080 1.0080 1.0080 1.0080 1.0080

Out of 5 specimens, 0 excluded.

Result(s) marked with a U were above pre-set limits.

Result(s) marked with a L were below pre-set limits.

Sample comments: SOME SPECIMENS EXCEEDED LOAD CAPACITY PRIOR TO REACHING 60% STRAIN

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Specimen Mass (g)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	6-012	2.260	U 1.015	29.593	55.8	2510.	-----	21000.	5230.	59.2
2	7-012	2.259	U 1.009	29.700	56.1	2500.	5020.	21000.	5240.	60.8
3	8-012	2.257	U 1.004	30.964	65.7	2770.	-----	21000.	5250.	56.4
4	9-012	2.261	U 1.007	30.961	62.8	2720.	-----	21000.	5230.	55.9
5	10-011	2.600	U 1.010	31.403	49.0	2150.	-----	21000.	3960.	56.9
Mean:		2.327	1.009	30.524	57.9	2530.	-----	21000.	4980.	57.9
Standard Deviation:		.152	.004	.822	6.6	245.	-----	9.	573.	2.1

312341A2

SPEC # 001

312341A2

SPEC # 002

Percent Strain (%)

312341A2

SPEC # 003

312341A2

SPEC # 004

312341A2

SPEC # 005

Compressive Properties at 60 °C (Group 1)

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

ASTM D 1621

Test type: Compressive

Instron Corporation

Operator name: KEITH WALBURN

Series IX Automated Materials Testing System 6.04

Test Date: 11 May 1994

Sample Identification: 312341H1

Sample Type: 2.20

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1000
Extensometer switch value: 80.0000% offset

Humidity (%): 48

Temperature (deg. C): 23

LTR Number 312341

Lot Number

Part Number KC FOAM AT-400

Description COMPRESSION TESTED TO 60% STRN

Test Temperature 60 DEG. C (140 DEG. F)

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5

Diameter (in)

SEPARATE

Ext. gauge len (in)

SEPARATE

Spec gauge len (in)

1.1000 1.1000 1.1000 1.1000 1.1000

Out of 5 specimens, 0 excluded.

Result(s) marked with a U were above pre-set limits.

Result(s) marked with a L were below pre-set limits.

Sample comments: Tests 2 & 4 terminated prior to 60% strain due to ext. slip and cell capacity.

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	6-008	2.258	U 1.103	57.7	2030.	5120.	21000.	5240.	60.4
2	7-009	2.268	U 1.104	59.3	2160.	-----	18300.	4540.	57.3
3	8-009	2.186	U 1.080	61.1	2200.	5130.	20400.	5430.	60.9
4	9-009	2.264	U 1.101	65.0	2200.	-----	21000.	5210.	56.4
5	10-009	2.259	U 1.103	59.3	2210.	4400.	19100.	4760.	61.2
Mean:		2.247	1.098	60.5	2160.	-----	20000.	5040.	59.2
Standard Deviation:		.034	.010	2.8	74.	-----	1200.	373.	2.2

312341H1

SPEC # 001

312341H1

SPEC # 002

312341H1

SPEC # 003

312341H1

SPEC # 004

312341H1

SPEC # 005

Percent Strain (%)

Compressive Properties at 60 °C (Group 2)

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

ASTM D 1621

Test type: Compressive

Instron Corporation

Series IX Automated Materials Testing System 6.04

Operator name: KEITH WALBURN

Test Date: 23 May 1994

Sample Identification: 312341H2

Sample Type: 2.26

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000

Humidity (%): 46

Crosshead Speed (in/min): .1000

Temperature (deg. C): 23

Extensometer switch value: 80.0000% offset

LTR Number 312155

Lot Number

Part Number KC FOAM AT-400

Description COMPRESSION TEST TO 60% STRAIN

Test Temperature 60 DEG C (140 DEG F)

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5

Diameter (in) SEPARATE

Ext. gauge len (in) SEPARATE

Spec gauge len (in) 1.0080 1.0080 1.0080 1.0080 1.0080

Out of 5 specimens, 0 excluded.

Result(s) marked with a U were above pre-set limits.

Result(s) marked with a L were below pre-set limits.

Sample comments: SOME SPECIMENS EXCEEDED LOAD CAPACITY PRIOR TO REACHING 60% STRAIN

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Specimen Mass (g)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	6-012	2.259	U 1.003	29.669	50.9	2020.	4880.	21000.	5240.	61.2
2	7-012	2.259	U 1.009	30.056	49.3	2060.	-----	21000.	5240.	59.9
3	8-012	2.259	U 1.010	31.694	57.6	2250.	-----	21000.	5240.	56.8
4	9-012	2.260	U 1.006	29.826	49.5	2030.	5060.	21000.	5230.	60.6
5	10-012	2.257	U 1.009	30.068	51.3	2080.	4810.	21000.	5250.	61.4
Mean:		2.259	1.007	30.263	51.7	2090.	-----	21000.	5240.	60.0
Standard Deviation:		.001	.003	.817	3.4	94.	-----	15.	8.	1.9

312341H2

SPEC # 001

312341H2

SPEC # 002

Percent Strain (%)

312341H2

SPEC # 003

312341H2

SPEC # 004

Percent Strain (%)

312341H2

SPEC # 005

Test IV: Thermogravimetric Analysis

TGA analysis was run on the foam with an air atmosphere and a heating rate 10°F/minute. The decomposition temperature for the foam samples was about 300°C, as expected. Three different TGA profiles on the foam are attached in the report for your review.

Sample: AT-400 FOAM 009 #1
Size: 5.84 mg
Rate: 10 C/MIN AIR 7 350C/MIN
Program: TGA Analysis V2.0

TGA

Date: 12-May 94 Time: 8:05:41
File: LTR#312341.01 TGA #19
Operator: C.L. LONG
Platelo: 12-May 94 10:45:29

Sample: AT-400 FOAM J09 #2
Size: 7.88 mg
Rate: 10 C/MIN AIR 2 3500/MIN
Program: TGA Analysis 12.0

TGA

Date: 12-May-94 Time: 10:48:31
File: LTR/312341.02 TGA #15
Operator: C.L. DNG
Plotted: 12-May-94 12:43:58

Sample: AT-400 30AM 009 #3
Size: 6.13 mg
Rate: 10 C/MIN AIR 35CC/MIN
Program: TGA Analyze V2.0

Date: 12-Nov-94 Time: 12:49:56
File: LTR#212341.03 TGA #19
Operator: C.L.L.UNG
Plotted: 12-Nov-94 15:35:51

Test V: Intumescent Properties

Intumescent properties of the foam were determined on five samples by placing the foams in a muffle furnace at 801°C for 90 seconds. The Intumescent is defined as the amount the foam has expanded along one side of a two inch cube of the foam sample. The intumescence is shown in the table below.

<i>Sample No.</i>	<i>Intumescence</i>
1	5.2%
2	3.8%
3	4.2%
4	1.9%
5	4.0%

AVE 3.8

APPENDIX B
Allied-Signal
KCP 44307-21 Foam with
PE200 Additive

Description of Work

This report describes the initial phase of testing that was conducted on the second of four different foam systems to be analyzed for the AT-400A container project. This interim report tabulates five different tests that was conducted on the polyurethane foam produced by AlliedSignal in Kansas City. This foam is identified as KCP44307-21 with the PE200 additive and was formulated to have a cast density of 30 lbs/ft³.

The five tests that were conducted on the foam were:

1. Thermal Conductivity at 77 °F, 140 °F, 250 °F, & 350 °F,
2. Specific Heat at 60 °C,
3. Compressive Properties at ambient temperature and 60 °C,
4. Thermogravimetric Analysis to 800 °C, and
5. Intumescent Properties analysis.

This report is divided into 5 different sections for each different test. Results are presented in tabular form (where possible) or the actual experimental plot is given for review. All testing was conducted to the Statement of Work dated 3/29/94. Any questions in regards to this testing can be directed to Ed Wenski, (816) 997-2667.

This analysis report on this certification has been performed in accordance with AlliedSignal Aerospace, Kansas City Division, standard laboratory practices and other named specifications. The information contained represents only the material tested.

7/12/94 Edward G. Wenski P.E., Testing Coordinator

Test I: Thermal Conductivity

Thermal conductivity testing was performed on the foam in accordance with ASTM-C-177. The auxiliary heaters, cooler liquid and guard heater were adjusted to obtain test results near 70, 140, 250, and 350 °F. Three different sample pairs were tested at each temperature. The results are tabulated below:

<i>Sample Number</i>	<i>Temperature (°C)</i>	<i>Temperature (°F)</i>	<i>Conductivity (W/m-°C)</i>	<i>Conductivity (BTU-in/hr-ft²-°F)</i>
1	25.1	77.2	0.0698	0.484
1	61.1	141.9	0.0740	0.513
1	121.3	250.4	0.0819	0.568
1	176.0	348.7	0.0943	0.653
2	24.6	76.3	0.0769	0.533
2	60.6	141.0	0.0822	0.570
2	120.2	248.4	0.0910	0.631
2	175.8	348.5	0.1007	0.698
3	24.5	76.0	0.0797	0.553
3	60.4	140.7	0.0853	0.591
3	120.5	248.8	0.0949	0.658
3	175.7	348.3	0.1025	0.710

Test II: Specific Heat

Specific heat values for the foam were determined on five different samples. The specific heat was determined at 60°C, by comparison of the specific heat of the foam samples to a certified sapphire standard with precisely known specific heat value. The specific heat values obtained are shown below:

<i>Sample Number</i>	<i>Specific Heat Value (Calories/gram-°C)</i>
1	0.45
2	0.39
3	0.38
4	0.44
5	0.38
Average	0.41

The variation noted in these test results may be due to voids in the foam samples. The KC foam with the PE200 additive seemed to have larger air bubbles in the foam structure than the previously tested KC foam without the additive.

Test III: Compressive Properties Analysis

Compressive property tests were conducted on ten samples of foam at ambient temperature and 60 °C. These tests were conducted per ASTM D1621 with a foam sample of approximately 4-square inches. Results are tabulated for Young's Modulus, stress at 10% & 60% and the maximum stress. Actual stress-strain curves for each sample are also attached for your review.

Compressive Properties at ambient temperature

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

ASTM D 1621

Test type: Compressive

Operator name: KEITH WALBURN

Sample Identification: 312342A

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1000
Extensometer switch value: 80.0000% offset

Instron Corporation

Series IX Automated Materials Testing System 6.04

Test Date: 20 May 1994

Sample Type: 2.26

Humidity (%): 52

Temperature (deg. C): 23

LTR Number 312342
Lot Number
Part Number AT-400-2
Description KANSAS CITY FOAM W/PT200
Test Temperature AMBIENT

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in) SEPARATE
Ext. gauge len (in) SEPARATE
Spec gauge len (in) 1.0060 1.0060 1.0060 1.0060 1.0060 1.0060 1.0060 1.0060

Out of 10 specimens, 0 excluded.

Result(s) marked with a U were above pre-set limits.

Result(s) marked with a L were below pre-set limits.

Sample comments: SOME SPECIMENS EXCEEDED MACHINE CAPACITY PRIOR TO 60% STRAIN

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	1-X0103	2.260	U 1.007	57.4	2530.	4590.	20900.	5220.	62.7
2	2-X0103	2.255	U 1.005	64.4	2890.	-----	21000.	5250.	57.4
3	3-X0103	2.256	U 1.004	63.3	2730.	-----	21000.	5250.	58.5
4	4-X0103	2.252	U 1.007	57.1	2550.	4500.	21000.	5260.	62.4
5	5-X0103	2.257	U 1.005	60.2	2570.	-----	21000.	5240.	57.4
6	6-X0104	2.260	U 1.008	52.4	2520.	-----	21000.	5230.	59.1
7	7-X0108	2.259	U 1.005	58.2	2730.	-----	21000.	5230.	57.6
8	8-X0108	2.259	U 1.007	56.9	2540.	-----	21000.	5230.	57.8
9	9-X0108	2.260	U 1.006	56.7	2600.	-----	21000.	5220.	58.7
10	10-X0108	2.260	U 1.008	56.1	2590.	-----	21000.	5230.	56.6
Mean:		2.258	1.006	58.3	2620.	-----	21000.	5230.	58.8
Standard Deviation:		.003	.001	3.5	119.	-----	7.	13.	2.1

312342A

SPEC # 001

Percent Strain (%)

312342A

SPEC # 002

312342A

SPEC # 003

312342A

SPEC # 004

312342A

SPEC # 005

312342A

SPEC # 006

312342A

SPEC # 007

312342A

SPEC # 008

312342A

SPEC # 009

312342A

SPEC # 010

Compressive Properties at 60 °C

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

ASTM D 1621

Test type: Compressive

Instron Corporation

Series IX Automated Materials Testing System 6.04

Operator name: KEITH WALBURN

Test Date: 20 May 1994

Sample Identification: 312342H

Sample Type: 2.26

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1000
Extensometer switch value: 80.0000% offset

Humidity (%): 52

Temperature (deg. C): 23

LTR Number 312342
Lot Number
Part Number AT-400-2
Description KANSAS CITY FOAM W/PT200
Test Temperature 60 DEG C (140 DEG F)

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in) SEPARATE
Ext. gauge len (in) SEPARATE
Spec gauge len (in) 1.0060 1.0060 1.0060 1.0060 1.0060 1.0060 1.0060 1.0060

Out of 10 specimens, 0 excluded.

Result(s) marked with a U were above pre-set limits.

Result(s) marked with a L were below pre-set limits.

Sample comments: SOME SPECIMENS EXCEEDED MACHINE CAPACITY PRIOR TO 60% STRAIN

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	11-X0103	2.253	U 1.005	53.9	2150.	5250.	21000.	5260.	60.0
2	12-X0103	2.259	U 1.005	53.7	2020.	4880.	21000.	5230.	61.1
3	13-X0103	2.253	U 1.005	56.4	2340.	-----	21000.	5260.	57.0
4	14-X0103	2.260	U 1.007	51.3	2050.	5000.	21000.	5230.	60.7
5	15-X0103	2.263	U 1.008	53.0	2150.	-----	21000.	5220.	59.7
6	16-X0104	2.260	U 1.009	57.0	2300.	-----	21000.	5230.	58.4
7	17-X0108	2.259	U 1.005	50.9	2000.	5170.	21000.	5230.	60.2
8	18-X0108	2.260	U 1.008	53.7	2200.	-----	21000.	5230.	59.4
9	19-X0108	2.260	U 1.006	46.3	1990.	5080.	21000.	5230.	60.4
10	20-X0108	2.260	U 1.006	52.7	2150.	4950.	21000.	5220.	60.9
Mean:		2.259	1.006	52.9	2140.	-----	21000.	5230.	59.8
Standard Deviation:		.003	.002	3.0	121.	-----	8.	14.	1.3

312342H

SPEC # 001

312342H

SPEC # 002

312342H

SPEC # 003

312342H

SPEC # 004

312342H

SPEC # 005

312342H

SPEC # 006

312342H

SPEC # 007

Percent Strain (%)

312342H

SPEC # 008

312342H

SPEC # 009

312342H

SPEC # 010

Test IV: Thermogravimetric Analysis

TGA analysis was run on the foam with an air atmosphere and a heating rate 10°F/minute. The decomposition temperature for the foam samples was about 300°C, as expected. Three different TGA profiles on the foam are attached in the report for your review.

Sample: KC FOAM AT-400-2 RUN#1
Size: 5.86 mg
Rate: 10 C/MIN AIR Z 35CC/MIN
Program: TGA Analysis V2.0

TGA

Date: 19-May-94 Time: 11:41:42
File: LTR#312342.01 TGA #20 5/19
Operator: C.L.LONG
Plotted: 19-May-94 13:27:03

Sample: KC FOAM AT-400-2 RUN#2
Size: 7.75 mg
Rate: 10 C/MIN AIR Z 35CC/MIN
Program: TGA Analysis V2.0

TGA

Date: 19-May-94 Time: 13:30:00
File: LTR#312342.02 TGA #20 5/19
Operator: C.L. LONG
Plotted: 19-May-94 15:15:26

Sample: KC FOAM AT-400-2 RUN#2
Size: 5.81 mg
Rate: 10 C/MIN AIR Z 35CC/MIN
Program: TGA Analysis V2.0

TGA

Date: 19-May-94 Time: 15:21:29
File: LTR#312342.03 TGA #20 5/19
Operator: C.L. LONG
Plotted: 19-May-94 16:38:05

Test V: Intumescent Properties

Intumescent properties of the foam were determined on five samples by placing the foams in a muffle furnace at 801°C for 90 seconds. The Intumescence is defined as the amount the foam has expanded along one side of a two inch cube of the foam sample. During testing, these foam samples expanded a large amount. Samples 1 & 2 expanded to the top of the furnace, which may have stopped the expansion. At this point, a tile was removed from the base of the furnace to allow for more free expansion. Samples 3, 4 & 5 were all run with the tile removed allowing for a free rise expansion of 2 inches. These samples also expanded to the top of the furnace resulting in an expansion of greater than 100% or in excess of 2 inches. Based on these observations, it is felt that all of the test samples would have expanded over 100% if not restricted by the roof of the furnace. With these observations in mind, the following intumescence values are given below.

<i>Sample No.</i>	<i>Intumescence</i>
1	67.5%
2	67.6%
3	97.7%
4	84.8%
5	102.8%
Ave.	84.1%

APPENDIX C

North Carolina Foam Industries
Foam NCFI 24-125 with PE200
Additive

Description of Work

This report describes the initial phase of testing that was conducted on the third of four different foam systems to be analyzed for the AT-400A container project. This interim report tabulates five different tests that was conducted on the polyurethane foam produced by North Carolina Foam Industries, Inc. This foam is identified as NCFI 24-125 with the PE200 additive and was formulated to have a cast density of 30 lbs/ft³.

The five tests that were conducted on the foam were:

1. Thermal Conductivity at 77 °F, 140 °F, 250 °F, & 350 °F,
2. Specific Heat at 60 °C,
3. Compressive Properties at ambient temperature and 60 °C,
4. Thermogravimetric Analysis to 800 °C, and
5. Intumescent Properties analysis.

This report is divided into 5 different sections for each different test. Results are presented in tabular form (where possible) or the actual experimental plot is given for review. All testing was conducted to the Statement of Work dated 3/29/94. Any questions in regards to this testing can be directed to Ed Wenski, (816) 997-2667.

This analysis report on this certification has been performed in accordance with AlliedSignal Aerospace, Kansas City Division, standard laboratory practices and other named specifications. The information contained represents only the material tested. This report shall not be reproduced except in full, without the written approval of the Analytical Sciences Laboratory.

8/4/94

Edward G. Wenski P.E., Testing Coordinator

Test I: Thermal Conductivity

Thermal conductivity testing was performed on the foam in accordance with ASTM-C-177. The auxiliary heaters, cooler liquid and guard heater were adjusted to obtain test results near 77, 140, 250, and 350 °F. Three different sample pairs were tested at each temperature. The results are tabulated below:

<i>Sample Number</i>	<i>Temperature (°C)</i>	<i>Temperature (°F)</i>	<i>Conductivity (W/m-°C)</i>	<i>Conductivity (BTU-in/hr-ft²-°F)</i>
1	25.1	77.1	0.0719	0.499
1	60.7	141.2	0.0761	0.528
1	120.6	249.0	0.0864	0.599
1	176.9	350.4	0.0902	0.626
2	24.9	76.8	0.0759	0.526
2	60.7	141.3	0.0804	0.557
2	120.8	249.4	0.0884	0.613
2	176.3	349.3	0.0923	0.640
3	24.6	76.3	0.0777	0.539
3	60.5	140.9	0.0825	0.572
3	120.6	249.1	0.0893	0.619
3	176.0	348.7	0.0972	0.674

Test II: Specific Heat

Specific heat values for the foam were determined on five different samples. The specific heat was determined at 60°C, by comparison of the specific heat of the foam samples to a certified sapphire standard with precisely known specific heat value. The specific heat values obtained are shown below:

<i>Sample Number</i>	<i>Specific Heat Value (Calories/gram-°C)</i>
1	0.40
2	0.42
3	0.42
4	0.45
5	0.44
Average	0.43

Test III: Compressive Properties Analysis

Compressive property tests were conducted on ten samples of foam at ambient temperature and 60 °C. These tests were conducted per ASTM D1621 with a foam sample of approximately 4-square inches. Results are tabulated for Young's Modulus, stress at 10% & 60% and the maximum stress. Actual stress-strain curves for each sample are also attached for your review.

Compressive Properties at ambient temperature

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

*ASTM D 1621

Test type: Compressive

Instron Corporation

Series IX Automated Materials Testing System 6.04

Operator name: KEITH WALBURN

Test Date: 13 Jul 1994

Sample Identification: 312343A1

Sample Type: 2.26

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1000
Extensometer switch value: 80.0000% offset

Humidity (%): 52
Temperature (deg. C): 23

LTR Number 312343

Lot Number

Part Number

Description NORTH CAROLINA FOAM

Test Temperature AMBIENT

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in) SEPARATE

Ext. gauge len (in) SEPARATE

Spec gauge len (in) 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000

Out of 10 specimens, 0 excluded.

Sample comments: ALL SPECIMENS EXCEEDED LOAD CELL CAPACITY PRIOR TO REACHING 60% STRAIN

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Specimen Mass (g)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	C3-X1005	2.258	1.0060	29.394	61.8	2150.	-----	21000.	5240.	59.0
2	C3-X1005	2.258	.9950	29.544	64.5	2190.	-----	21000.	5240.	58.6
3	C3-X1005	2.258	1.0000	29.237	68.8	2170.	-----	21000.	5240.	58.2
4	C3-X1005	2.257	.9670	29.128	39.2	2220.	-----	21000.	5250.	57.9
5	C3-X1006	2.257	1.0050	29.129	64.2	2140.	-----	21000.	5250.	58.5
6	C3-X1006	2.257	.9950	29.194	64.8	2170.	-----	21000.	5240.	58.1
7	E3-X1009	2.258	1.0030	29.080	58.2	2120.	-----	21000.	5240.	58.7
8	E3-X1009	2.259	1.0000	29.823	74.6	2210.	-----	21000.	5240.	56.9
9	C3-X1011	2.258	1.0080	30.291	73.9	2280.	-----	21000.	5250.	57.2
10	C3-X1011	2.258	1.0030	29.874	70.9	2210.	-----	21000.	5240.	57.1
Mean:		2.258	.9982	29.469	64.1	2190.	-----	21000.	5240.	58.0
Standard Deviation:		.001	.0118	.407	10.2	46.	-----	9.	2.	.7

312343A1

SPEC # 001

Percent Strain (%)

312343A1

SPEC # 002

312343A1

SPEC # 003

312343A1

SPEC # 004

312343A1

SPEC # 005

312343A1

SPEC # 006

312343A1

SPEC # 007

Percent Strain (%)

312343A1

SPEC # 008

312343A1

SPEC # 009

312343A1

SPEC # 010

Compressive Properties at 60 °C

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/838

*ASTM D 1621

Test type: Compressive

Instron Corporation

Operator name: KEITH WALBURN

Series IX Automated Materials Testing System 6.04

Test Date: 14 Jul 1994

Sample Identification: 312343H1

Sample Type: 2.26

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000

Humidity (%): 52

Crosshead Speed (in/min): .1000

Temperature (deg. C): 23

Extensometer switch value: 80.0000% offset

LTR Number 312343

Lot Number

Part Number

Description NORTH CAROLINA FOAM

Test Temperature 60 DEG C (140 DEG F)

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in) SEPARATE

Ext. gauge len (in) SEPARATE

Spec gauge len (in) 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000

Out of 10 specimens, 0 excluded.

Sample comments: TEST TERMINATED MANUALLY AFTER 60% STRAIN ACHIEVED. EACHING 60% STRAIN

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Specimen Mass (g)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	C3-X1005	2.257	.9980	29.481	37.4	1300.	4050.	20100.	5030.	62.8
2	C3-X1005	2.257	.9980	29.162	46.4	1280.	4010.	19500.	4860.	62.5
3	C3-X1005	2.258	1.0020	29.354	47.7	1300.	4100.	19000.	4750.	62.0
4	C3-X1005	2.257	1.0010	29.269	41.0	1300.	4050.	18900.	4720.	62.1
5	C3-X1006	2.258	.9990	29.310	43.6	1330.	4080.	19300.	4830.	62.2
6	C3-X1006	2.258	1.0050	29.737	40.1	1360.	4130.	18700.	4670.	61.7
7	E3-X1009	2.258	1.0020	29.362	44.2	1300.	4120.	18800.	4700.	61.8
8	C3-X1011	2.257	1.0010	30.756	45.3	1390.	4630.	21000.	5250.	61.6
9	C3-X1016	2.257	1.0010	29.566	49.1	1310.	4220.	19900.	4970.	62.1
10	C3-X1016	2.256	1.0030	29.515	47.8	1300.	4120.	19100.	4790.	62.0
Mean:		2.257	1.0010	29.551	44.3	1320.	4150.	19400.	4860.	62.1
Standard Deviation:		.001	.0022	.454	3.8	33.	179.	718.	180.	.4

312343H1

SPEC # 001

312343H1

SPEC # 002

312343H1

SPEC # 003

312343H1

SPEC # 004

312343H1

SPEC # 005

312343H1

SPEC # 006

312343H1

SPEC # 007

312343H1

SPEC # 008

312343H1

SPEC # 009

312343H1

SPEC # 010

Test IV: Thermogravimetric Analysis

TGA analysis was run on the foam with an air atmosphere and a heating rate 10°F/minute. The decomposition temperature for the foam samples was about 300°C, as expected. Three different TGA profiles on the foam are attached in the report for your review.

Sample: N CAROLINA FOAM #1 RUN2
Size: 7.49 mg
Rate: 10 C/MIN AIR
Program: TGA Analysis V2.0

TGA

Date: 5-Jul-94 Time: 11:26:42
File: LTR#312343.02 TGA #20 5/19
Operator: C.L.LONG
Plotted: 5-Jul-94 15:17:30

Sample: N CAROLINA FOAM #2
Size: 7.25 mg
Rate: 10 C/MIN AIR
Program: TGA Analysis V2.0

TGA

Date: 5-Jul-94 Time: 12:51:25
File: LTR#312343.03 TGA #20 5/19
Operator: C.L.LONG
Plotted: 5-Jul-94 15:03:08

Sample: N CAROLINA FOAM #3

Size: 8.21 mg

Rate: 10 C/MIN AIR

Program: TGA Analysis V2.0

TGA

Date: 5-Jul-94 Time: 15:15:29

File: LTR#312343.04 TGA #20 5/19

Operator: C.L.LONG

Plotted: 6-Jul-94 8:54:22

Test V: Intumescent Properties

Intumescent properties of the foam were determined on five samples by placing the foams in a muffle furnace at 801°C for 90 seconds. The Intumescence is defined as the amount the foam has expanded along one side of a two inch cube of the foam sample. The intumescence for the five samples are shown in the Table below:

<i>Sample No.</i>	<i>Intumescence</i>
1	25.5%
2	23.0%
3	25.3%
4	20.0%
5	21.2%
Ave.	23.0%

APPENDIX D
General Plastics
GP3725 Foam

Description of Work

This report describes the initial phase of testing that was conducted on the final foam system for the AT-400A container project. This interim report tabulates five different tests that was conducted on the polyurethane foam produced by General Plastics. This foam is identified as GP3725 and was formulated to have a cast density of 30 lbs/ft³.

The five tests that were conducted on the foam were:

1. Thermal Conductivity at 83 °F, 140 °F, 250 °F, & 350 °F,
2. Specific Heat at 60 °C,
3. Compressive Properties at ambient temperature and 60 °C,
4. Thermogravimetric Analysis to 800 °C, and
5. Intumescent Properties analysis.

This report is divided into 5 different sections for each different test. In addition, densities for each test sample has been provided to quantify the test data. Results are presented in tabular form (where possible) or the actual experimental plot is given for review. All testing was conducted to the Statement of Work dated 3/29/94. Any questions in regards to this testing can be directed to Ed Wenski, (816) 997-2667.

This analysis report on this certification has been performed in accordance with AlliedSignal Aerospace, Kansas City Division, standard laboratory practices and other named specifications. The information contained represents only the material tested. This report shall not be reproduced except in full, without the written approval of the Analytical Sciences Laboratory.

11/2/94 Edward G. Wenski P.E., Outside Testing Representative

Test I: Thermal Conductivity

Thermal conductivity testing was performed on the foam in accordance with ASTM-C-177. The auxiliary heaters, cooler liquid and guard heater were adjusted to obtain test results near 70, 140, 250, and 350 °F. Three different sample pairs were tested at each temperature. The results are tabulated below:

<i>Sample Number</i>	<i>Density (lbs/ft³)</i>	<i>Temperature (°C)</i>	<i>Temperature (°F)</i>	<i>Conductivity (W/m-°C)</i>	<i>Conductivity (BTU-in/hr-ft²-°F)</i>
1	29.64	24.7	76.5	0.0756	0.524
		60.4	140.7	0.0813	0.563
		120.2	248.4	0.0940	0.652
		175.9	348.6	0.1001	0.694
2	29.22	24.6	76.3	0.0756	0.524
		60.3	140.4	0.0800	0.555
		121.7	251.1	0.0905	0.628
		176.2	349.2	0.0904	0.627
3	29.35	24.9	76.8	0.0729	0.505
		60.8	141.4	0.0775	0.535
		121.5	250.7	0.0869	0.602
		176.4	349.5	0.0903	0.626

Test II: Specific Heat

Specific heat values for the foam were determined on five different samples. The specific heat was determined at 60°C, by comparison of the specific heat of the foam samples to a certified sapphire standard with precisely known specific heat value. The specific heat values obtained are shown below:

<i>Sample Number</i>	<i>Specific Heat Value (Calories/gram-°C)</i>
1	0.38
2	0.37
3	0.41
4	0.39
5	0.38
Average	0.39

Test III: Compressive Properties Analysis

Compressive property tests were conducted on ten samples of foam at ambient temperature and 60 °C. These tests were conducted per ASTM D1621 with a foam sample of approximately 4-square inches. Results are tabulated for Young's Modulus, stress at 10% & 60% stain and the maximum stress. Actual stress-strain curves for each sample are also attached for your review.

Compressive Properties at ambient temperature

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/834

*ASTM D 1621

Test type: Compressive

Instron Corporation

Operator name: KEITH WALBURN

Series IX Automated Materials Testing System 6.04

Test Date: 25 Sep 1994

Sample Identification: 312293a1

Sample Type: 2.26

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
Crosshead Speed (in/min): .1000
Extensometer switch value: 80.0000% offset

Humidity (%): 40
Temperature (deg. C): 23

LTR Number 312293
Lot Number
Part Number General Plastics Foam
Description Compression Test to 60% Strain
Test Temperature AMBIENT

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in) SEPARATE
Ext. gauge len (in) SEPARATE
Spec gauge len (in) 1.0030 1.0030 1.0030 1.0030 1.0030 1.0030 1.0030 1.0030

Out of 10 specimens, 0 excluded.

Sample comments: All specimens exceeded load capacity prior to reaching 60% strain.

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Specimen Mass (g)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	1A-CS-1	2.258	1.0040	31.366	77.8	2590.	-----	21000.	5240.	52.0
2	2A-CS-1	2.257	1.0040	31.017	67.9	2340.	-----	21000.	5240.	53.6
3	3A-CS-1	2.259	1.0040	31.134	67.9	2350.	-----	21000.	5230.	53.2
4	4A-CS-2	2.257	1.0050	31.179	63.5	2390.	-----	21000.	5240.	53.1
5	5A-CS-2	2.263	1.0040	31.295	68.5	2410.	-----	21000.	5220.	52.7
6	6A-CS-2	2.259	1.0020	31.041	75.9	2420.	-----	21000.	5240.	52.2
7	7A-CS-2	2.247	1.0040	30.922	64.9	2410.	-----	21000.	5290.	53.7
8	8A-CS-3	2.258	1.0020	31.389	75.3	2450.	-----	21000.	5240.	52.9
9	9A-CS-3	2.258	.9980	31.334	79.7	2470.	-----	21000.	5240.	53.0
10	10A-CS-3	2.258	1.0010	31.466	7 .1	2420.	-----	21000.	5240.	52.4
Mean:		2.257	1.0030	31.214	71.8	2430.	-----	21000.	5240.	52.9
Standard Deviation:		.004	.0021	.183	5.6	71.	-----	10.	19.	.6

312293A1

SPEC # 001

Percent Strain (%)

312293A1

SPEC # 002

312293A1

SPEC # 003

312293A1

SPEC # 004

Percent Strain (%)

312293A1

SPEC # 006

312293A1

SPEC # 007

Percent Strain (%)

312293A1

SPEC # 008

312293A1

SPEC # 009

Percent Strain (%)

D.15

312293A1

SPEC # 010

Compressive Properties at 60 °C

AlliedSignal Aerospace Co.
Kansas City Division
Analytical Sciences, D/834

*ASTM D 1621

Test type: Compressive

Instron Corporation

Operator name: KEITH WALBURN

Series IX Automated Materials Testing System 6.04

Test Date: 28 Sep 1994

Sample Identification: 312293h1

Sample Type: 2.26

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000

Humidity (%): 40

Crosshead Speed (in/min): .1000

Temperature (deg. C): 23

Extensometer switch value: 80.0000% offset

LTR Number 312293

Lot Number

Part Number General Plastics Foam

Description Compression Test To 60% Strain

Test Temperature 60 Deg C (140 Deg F)

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in)

SEPARATE

Ext. gauge len (in)

SEPARATE

Spec gauge len (in)

1.0030 1.0030 1.0030 1.0030 1.0030 1.0030 1.0030 1.0030

Out of 10 specimens, 0 excluded.

Sample comments: All specimens exceeded load cell capacity prior to reaching 60% strain.

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Specimen Mass (g)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Load (lbs)	Maximum Stress (psi)	Strain @ Max Load (%)
1	1H-CS-1	2.258	1.004	31.426	68.6	1900.	-----	21000.	5240.	58.5
2	2H-CS-1	2.255	1.005	31.352	64.6	1890.	-----	21000.	5250.	59.2
3	3H-CS-1	2.259	1.003	31.056	66.3	1780.	-----	21000.	5230.	58.3
4	4H-CS-1	2.259	1.004	31.014	58.7	1730.	-----	21000.	5230.	58.2
5	5H-CS-2	2.262	1.005	31.303	55.8	1790.	-----	21000.	5220.	58.2
6	6H-CS-2	2.255	1.005	31.059	58.2	1790.	-----	21000.	5250.	58.1
7	7H-CS-2	2.205	1.004	29.677	57.8	1780.	-----	21000.	5490.	59.1
8	8H-CS-3	2.258	1.003	31.322	59.9	1740.	-----	21000.	5240.	58.0
9	9H-CS-3	2.259	1.002	31.358	73.8	1790.	-----	21000.	5230.	58.2
10	10H-CS-3	2.259	1.002	31.358	57.9	1820.	-----	21000.	5240.	58.3
Mean:		2.253	1.004	31.092	62.2	1800.	-----	21000.	5260.	58.4
Standard Deviation:		.017	.001	.519	5.9	55.	-----	8.	82.	.4

312293H1

SPEC # 001

Percent Strain (%)

312293H1

SPEC # 002

312293H1

SPEC # 003

312293H1

SPEC # 004

312293H1

SPEC # 005

Percent Strain (%)

D. 23

312293H1

SPEC # 006

312293H1

SPEC # 007

Percent Strain (%)

D. 25

312293H1

SPEC # 008

312293H1

SPEC # 009

Percent Strain (%)

312293H1

SPEC # 010

Test IV: Thermogravimetric Analysis

TGA analysis was run on the foam with an air atmosphere and a heating rate 10°F/minute. The decomposition temperature for the foam samples was about 300°C, as expected. Three different TGA profiles on the foam are attached in the report for your review.

Sample: GEN PLASTIC FOAM #1B

Size: 5.62 mg

Rate: 10 C/MIN AIR

Program: TGA Analysis V2.0

TGA

Date: 11-Oct-94 Time: 11:28:00

File: LTR#312293.01 TGA #20 5/19

Operator: C.L. LONG

Plotted: 11-Oct-94 13:07:31

D.30

Sample: GEN PLASTIC FDAM #2
Size: 6.55 mg
Rate: 10 C/MIN AIR
Program: TGA Analysis V2.0

TGA

Date: 11-Oct-94 Time: 13:12:34
File: LTR#312293.02 TGA #20 5/15
Operator: C.L.LONG
Plotted: 11-Oct-94 14:31:50

Sample: GEN PLASTIC FOAM #3
Size: 5.35 mg
Rate: 10 C/MIN AIR
Program: TGA Analysis V2.0

TGA

Date: 11-Oct-94 Time: 14:37:03
File: LTR#312293.03 TGA #20 5/19
Operator: C.L.LONG
Plotted: 11-Oct-94 15:57:57

Test V: Intumescent Properties

Intumescent properties of the foam were determined on five samples by placing the foams in a muffle furnace at 801°C for 90 seconds. The Intumescence is defined as the amount the foam has expanded along one side of a two inch cube of the foam sample. The height of the furnace is five inches and the foam samples were placed on a one inch thick tile allowing for a free expansion of two inches with a two inch sample. The General Plastics foam samples expanded a large amount. These samples expanded to the top of the muffle furnace which may have stopped the expansion. Each of the five samples expanded to the top of the furnace in about 30 seconds. From these observations, it is felt that the samples would have expanded more if not restricted by the roof of the furnace. Therefore, the intumescence value listed in the table is 100+ %.

<i>Sample No.</i>	<i>Density (lbs/ft³)</i>	<i>Intumescence</i>
1	29.9	100+ %
2	29.9	100+ %
3	29.5	100+ %
4	29.0	100+ %
5	29.3	100+ %
Ave.	29.5	100 %

APPENDIX E
North Carolina Foam Industries
NCFI-VS foam with PE200
Additive

Description of Work

This report describes the initial phase of testing that was conducted on the final foam system for the AT-400A container project. This interim report tabulates six different tests that was conducted on the polyurethane foam produced by North Carolina. This foam is identified as NCFI Very Slow w/ PE200 was formulated to have a cast density of 30 lbs/ft³.

The six tests that were conducted on the foam were:

1. Thermal Conductivity at 75°F, 140 °F , 250 °F , & 350 °F,
2. Specific Heat at 60 °C,
3. Compressive Properties at ambient temperature and 60 °C,
4. Thermogravimetric Analysis to 800 °C,
5. Intumescent Properties analysis, and
6. Char Formation Property Test.

This report is divided into 6 different sections for each different test. In addition, densities for each test sample has been provided to quantify the test data. Results are presented in tabular form (where possible) or the actual experimental plot is given for review. All testing was conducted to the Statement of Work dated 3/29/94. Any questions in regards to this testing can be directed to Ed Wenski, (816) 997-2667.

This analysis report on this certification has been performed in accordance with AlliedSignal Aerospace, Kansas City Division, standard laboratory practices and other named specifications. The information contained represents only the material tested. This report shall not be reproduced except in full, without the written approval of the Analytical Sciences Laboratory.

Edward G. Wenski P.E., Outside Testing Representative

Test I: Thermal Conductivity

Thermal conductivity testing was performed on the foam in accordance with ASTM-C-177. The auxiliary heaters, cooler liquid and guard heater were adjusted to obtain test results near 70, 140, 250, and 350 °F. Three different sample pairs were tested at each temperature. The results for the foam are tabulated below:

<i>Sample Number</i>	<i>Density (lbs/ft³)</i>	<i>Temperature (°C)</i>	<i>Temperature (°F)</i>	<i>Conductivity (W/m-°C)</i>	<i>Conductivity (BTU-in/hr-ft²-°F)</i>
1	30.76	23.8	74.8	0.0750	0.520
		60.2	140.4	0.0801	0.555
		121.0	249.8	0.0901	0.625
		176.3	349.4	0.0903	0.626
2	27.57	24.3	75.8	0.0669	0.464
		61.4	142.5	0.0729	0.505
		121.0	249.8	0.0824	0.571
		176.5	349.7	0.0918	0.636
3	27.62	23.9	75.1	0.0727	0.504
		61.2	142.1	0.0785	0.545
		120.7	249.3	0.0885	0.613
		176.7	350.0	0.0925	0.642

Test II: Specific Heat

Specific heat values for the foam were determined on five different samples. The specific heat was determined at 60°C, by comparison of the specific heat of the foam samples to a certified sapphire standard with precisely known specific heat value. The specific heat values obtained are shown below:

<i>Sample Number</i>	<i>Specific Heat Value (Calories/gram-°C)</i>
1	0.30
2	0.36
3	0.33
4	0.33
5	0.36
Average	0.34

Test III: Compressive Properties Analysis

Compressive property tests were conducted on ten samples of foam at ambient temperature and at 60 °C. These tests were conducted per ASTM D1621 with a foam sample of approximately 4-square inches. Results are tabulated for stress at 10% & 60% strain, maximum strain and the maximum stress. Actual stress-strain curves for each sample are also attached for your review.

Compressive Properties at ambient temperature

AlliedSignal Aerospace Co.
 Kansas City Division
 Analytical Sciences, D/834

ASTM D 1621 And Density

Test type: Compressive

Operator name: Ron Freeman

Sample Identification: 309039A1

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
 Crosshead Speed (in/min): .1000
 Extensometer switch value: 80.0000% offset

Instron Corporation

Series IX Automated Materials Testing System 6.05

Test Date: 23 Mar 1995

Sample Type: 2.26

Humidity (%): 50

Temperature (deg. C): 22

LTR Number 309039
 Lot Number C10
 Part Number W/PE200
 Description NCFI Foam (Very Slow)
 Test Temperature AMBIENT

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in) SEPARATE

Ext. gauge len (in) SEPARATE

Spec gauge len (in) 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000

Out of 10 specimens, 0 excluded.

Sample comments: Nine specimens exceeded load cell capacity prior to reaching 60% strain.

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Stress (psi)	Strain @ Max Stress (%)	Mass (g)	Density (lb/cu-ft)
1	C10 A1	2.258	.9960	71.6	2310.	-----	5240.	54.7	31.575	30.15
2	C10 A2	2.258	.9975	66.9	2080.	-----	5240.	57.4	29.816	28.43
3	C10 A3	2.256	1.0000	79.3	2550.	-----	5240.	52.3	32.616	31.07
4	C10 A4	2.256	.9995	61.4	2030.	4760.	5240.	61.9	27.973	26.66
5	C10 A5	2.256	1.0000	73.2	2330.	-----	5240.	54.9	31.711	30.22
6	C10 A6	2.256	1.0000	68.8	2070.	-----	5240.	59.7	29.120	27.75
7	C10 A7	2.257	.9980	68.0	2090.	-----	5240.	59.5	29.112	27.76
8	C10 A8	2.257	.9975	103.0	2910.	-----	5240.	46.5	35.066	33.45
9	C10 A9	2.258	1.0020	63.9	2240.	-----	5230.	59.2	29.755	28.25
10	C10 A10	2.258	1.0000	78.4	2570.	-----	5240.	53.0	32.762	31.15
Mean:		2.257	.9991	73.5	2320.	-----	5240.	55.9	30.9506	29.492
Standard Deviation:		.001	.0018	12.0	284.	-----	4.	4.6	2.1673	2.072

309039A1

SPEC # 001

309039A1

SPEC # 002

309039A1

SPEC # 003

309039A1

SPEC # 004

309039A1

SPEC # 005

309039A1

SPEC # 006

309039A1

SPEC # 007

309039A1

SPEC # 008

309039A1

SPEC # 009

309039A1

SPEC # 010

Compressive Properties at 60 °C

AlliedSignal Aerospace Co.
 Kansas City Division
 Analytical Sciences, D/834

ASTM D 1621 And Density

Test type: Compressive

Operator name: Ron Freeman

Sample Identification: 309039H1

Interface Type: 4500 Series

Machine Parameters of test:

Sample Rate (pts/sec): 10.000
 Crosshead Speed (in/min): .1000
 Extensometer switch value: 80.0000% offset

Instron Corporation

Series IX Automated Materials Testing System 6.05

Test Date: 24 Mar 1995

Sample Type: 2.26

Humidity (%): 50

Temperature (deg. C): 22

LTR Number 309039
 Lot Number C10
 Part Number W/PE200
 Description NCFI Foam (Very Slow)
 Test Temperature 60 Deg. C

Dimensions:

Spec. 1 Spec. 2 Spec. 3 Spec. 4 Spec. 5 Spec. 6 Spec. 7 Spec. 8

Diameter (in) SEPARATE
 Ext. gauge len (in) SEPARATE
 Spec gauge len (in) 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000 1.0000

Out of 10 specimens, 0 excluded.

Sample comments: Specimens Tested at 60 Deg. C

Specimen Number	Spec. ID	Specimen Diameter (in)	Specimen Gage Length (in)	Young's Modulus (ksi)	Stress @ 10% Strain (psi)	Stress @ 60% Strain (psi)	Maximum Stress (psi)	Strain @ Max Stress (%)	Mass (g)	Density (lb/cu-f)
1	C10 1H	2.257	.9985	42.3	1260.	3480.	4110.	62.4	28.037	26.7
2	C10 2H	2.257	1.0030	44.9	1280.	3730.	4150.	61.5	28.512	27.0
3	C10 3H	2.257	1.0000	48.7	1320.	-----	4320.	60.0	29.672	28.2
4	C10 4H	2.256	1.0040	46.6	1300.	4200.	4920.	62.5	29.325	27.8
5	C10 5H	2.255	1.0040	65.0	1790.	-----	5250.	56.2	34.345	32.6
6	C10 6H	2.257	1.0010	45.1	1280.	3780.	4400.	62.2	28.623	27.2
7	C10 7H	2.257	1.0010	47.8	1350.	4410.	5240.	62.4	29.716	28.2
8	C10 8H	2.257	1.0000	44.3	1290.	3690.	4880.	63.9	28.500	27.1
9	C10 9H	2.257	.9990	46.6	1340.	4390.	5180.	62.4	29.432	28.0
10	C10 10H	2.257	.9965	47.6	1340.	4210.	5230.	63.0	29.175	27.8
Mean:		2.257	1.0010	47.9	1350.	3990	4770.	61.7	29.5337	28.0
Standard Deviation:		.001	.0025	6.3	157.	-----	474.	2.2	1.7816	1.6

309039H1

SPEC # 001

309039H1

SPEC # 002

309039H1

SPEC # 003

309039H1

SPEC # 004

309039H1

SPEC # 005

309039H1

SPEC # 006

309039H1

SPEC # 007

309039H1

SPEC # 008

309039H1

SPEC # 009

309039H1

SPEC # 010

Test IV: Thermogravimetric Analysis

TGA analysis was run on the foam with an air atmosphere and a heating rate 10°C/minute. The decomposition temperature for the foam samples was about 300°C, as expected. Three different TGA profiles on the foam are attached in the report for your review.

Sample: LTR# 309039 TGA ON D10

Size: 8.6982 mg

Method: 10°C RAMP >1000C-TGA

Comment: SAMPLE #1 D10 IN AIR; 10C RAMP TO 1000C

TGA

File: C:LT309039.001

Operator: LANE

Run Date: 22-Mar-95 10:05

Sample: LTR# 309039 TGA ON D10

Size: 6.2689 mg

Method: 10°C RAMP >1000C-TGA

Comment: SAMPLE #2 D10 IN AIR; 10C RAMP TO 1000C

TGA

File: C:LT309039.002

Operator: LANE

Run Date: 22-Mar-95 13:12

TGA V5.1A DuPont 2200

Sample: LTR# 309039 TGA ON D10

Size: 6.2955 mg

Method: 10°C RAMP >700C-TGA

Comment: SAMPLE #3 D10 IN AIR; 10C RAMP TO 700C

TGA

File: C:LT309039.004

Operator: LONG

Run Date: 23-Mar-95 08:49

Test V: Intumescent Properties

Intumescent properties of the foam were determined on five samples by placing the foams in a muffle furnace at 801°C for 90 seconds. The Intumescence is defined as the amount the foam has expanded along one side of a two inch cube of the foam sample. The intumescence values for the foam are shown below:

<i>Sample No.</i>	<i>Density (lbs/ft³)</i>	<i>Intumescence</i>
1	28.6	5.8 %
2	29.1	12.5 %
3	30.2	3.8 %
4	27.6	10.5 %
5	31.1	11.9 %
Average	29.3	8.9 %

Test VI: Char Formation Property Test

Char formation property tests were conducted at 800 °C for 90 seconds. The char formation is determined by placing a two inch cube on a screen so it is exposed to oven heat on all sides. The percent char is the amount of the foam (by weight) that is remaining after 90 seconds compared to the original weight of the test sample. The char (or percent weight retention) for the foam is given below:

<i>Sample No.</i>	<i>Density (lbs/ft³)</i>	<i>Percent Weight Retention</i>
1	26.5	65.3 %
2	30.2	70.1 %
3	26.9	69.0 %
4	26.7	67.6 %
5	27.5	65.6 %
Average	27.6	67.5 %

APPENDIX F

Char Formation Report

Date: May 18, 1995

To: D. R. Watson, D/833 and E. G. Wenski, D/834

From: C. L. Long, D/838, SA-1

Subject: **PROPERTIES OF AT-400 FOAMS, REF LTR309035**

Three types of urethane foam blocks were tested to determine the density and the char forming properties per the statement of work for the AT-400 container materials. The foams were designated as NCFI, GPI and KCI foams. Five samples of each foam were weighed and measured to determine density and the same samples were subjected to 800°C for 90 seconds to determine the char forming properties by weight before and after the exposure to 800°C temperature.

PROPERTIES OF FOAM SAMPLES

SAMPLE	DENSITY (lb/ft ³)	CHAR FORMATION
NCFI #1	28.5	64.8%
#2	27.7	65.9
#3	28.1	68.3
#4	28.0	68.7
#5	27.7	70.9
GPI#1	29.8	72.0
#2	29.8	74.5
#3	29.7	67.7
#4	29.8	69.5
#5	29.8	69.9
KCI#1	27.5	75.3
#2	27.4	75.6
#3	28.9	78.0
#4	28.1	76.9
#5	28.5	78.1

Some portions of each sample had portions of char spall off the sample and may not have been collected to be weighed with the sample, resulting in some variation the % char. The % char values appear to increase in % char as the test progresses. This may be due to a decrease in overall oven temperature as the samples are run. The oven

Page 2

temperature was noted and a subsequent test block was not run until oven temperature had recovered to $800\pm 5^{\circ}$ on the temperature indicator. The test was started in one oven and completed in a second oven when a thermocouple broke in the first oven. The oven change was made after the GPI#2 sample was completed. The % char for the GPI samples appear to change with the change in ovens.

Charles Long

cc H. Thompson, D/834

APPENDIX G
Chemical Analyses
CHN Test Report

Sandia National Laboratories

Albuquerque, New Mexico 87185
Livermore, California 94551-0969

date: March 13, 1995

to: Distribution

R. E. Stinebaugh

from: R. E. Stinebaugh, 5165

subject: Polyurethane Foam Chemical Analysis Results

Attached is the Allied Signal Report summarizing the results of the chemical analysis performed on the candidate polyurethane foams for the AT-400A container. If you have any questions regarding this information, please call Don Watson of Allied Signal at (816) 997-4092.

copy to:

G. Dittman, LLNL (MS L-125) w/o attachment

Tom Healy, LLNL (MS L-125)

David Heinrichs, LLNL (MS L-390)

0483 R. L. Alvis w/o attachment

0483 R. E. Glass

0483 A. R. York

0483 R. E. Stinebaugh w/o attachment

0483 AT-400A file .334

AlliedSignal Inc.
Kansas City Division
P.O. Box 419159
Kansas City, MO 64141-6159

(816) 997-2000
(816) 997-3331 Fax

March 8, 1995

Mr. Robert Stinebaugh
Sandia National Laboratory
Org. 5165, Bldg. 836
Albuquerque, New Mexico 87185-5800

STINEBAUGH
BOB. 844-8745
9-PAGES
FROM
KCP. D.R. WATSON

Dear Mr. Stinebaugh:

Please find enclosed a data table listing the CHN analysis results, a table containing the nitrogen content determination results and a memorandum summarizing the PE-200 elemental analysis.

The principal elemental make-up of the foam components and PE-200 additive is carbon, hydrogen, nitrogen and oxygen. Any other elements present would be at trace levels and would require additional, more sophisticated testing. I have summarized the material elemental analysis below:

Foam Sample Results

Sample Material / ID	wt% C	wt% H	wt% N	wt% O
NCFI24-125 fast / 001	67.10	6.94	5.61	20.35
NCFI24-125 fast / 002	68.38	6.96	5.70	18.96
NCFI24-125 fast / 003	67.56	6.93	5.70	19.81
NCFI24-125 fast / 004	67.94	6.93	5.71	19.42
NCFI24-125 fast / 005	68.10	6.92	5.69	19.29
NCFI24-125 fast / 006	69.60	6.98	5.69	17.73
KCP44307-20 / 001	68.91	6.54	6.11	18.44
KCP44307-20 / 002	69.76	6.54	6.09	17.61
KCP44307-20 / 003	69.32	6.59	6.06	18.03
KCP44307-20 / 004	68.77	6.51	6.09	18.63
KCP44307-20 / 005	68.14	6.53	6.10	19.23
KCP44307-20 / 006	70.28	6.80	6.14	16.78
GP3725 / 001	70.27	6.62	6.21	16.90
GP3725 / 002	72.72	6.68	6.19	14.41
GP3725 / 003	69.51	6.64	6.23	17.62
GP3725 / 004	67.87	6.60	6.21	19.32
GP3725 / 005	67.27	6.58	6.24	19.91
GP3725 / 006	69.19	6.61	6.25	17.95

TO:
Page 2

03/10/95

Considerable activity was conducted to determine the actual make-up of the pentaerythritol. Material data sheets received from Aqualon indicated that KCP had received PE-200 that contained 85% di-pentaerythritol mixed with mono-pentaerythritol at 15%. The elemental analysis results indicated that the material supplied was actually the technical grade of pentaerythritol. The technical grade typically contains mono-pentaerythritol at a 80 to 90% level and the di-pentaerythritol at a 10 to 20% level. The di-pentaerythritol contains a higher percentage of carbon than the mono-pentaerythritol and may slightly increase the amount of cross linkage occurrences due to the additional pentaerythritol site on the dimer. However, KCP Materials Engineering has indicated that any foam property differences would be very slight.

Pentaerythritol Sample Results

SampleMaterial / ID	wt% C	wt% H	wt% N	wt% O
PE-200, Used	44.6	8.80	0.00	46.6
Mono-Pentaerythritol	44.1	8.80	0.00	47.1
di-Pentaerythritol	47.2	8.70	0.00	44.1

If you need additional information or have questions concerning the information provided please contact Don Watson at (816) 997-4092.

Sincerely,

Don Watson
Plastics Engineering

DRW:dw

Enclosure

cc: Ed Wenski, KCP 834

Memorandum

Kansas City Division

Date: March 09, 1995
To: D. R. Watson, D/833
From: C. L. Long, D/838, SA-1
Subject: **ANALYSIS OF DC-200 ADDITIVE FOR URETHANE FOAM**
REF: LTR 112558

The PE-200 foam additive was analyzed to determine the composition of the additive. The PE-200 was supposed to be dipentaerythritol (dipentek) per specification. The analyses run on the PE-200 indicate the material is 80-90% mono pentaerythritol (monopentek) and 10-20% dipentek.

FTIR ANALYSIS

The analysis of the PE-200 by FTIR was made using a diamond anvil cell to compress the powder into a transparent film. The resulting spectrum indicated the material is monopentek and not dipentek.

MASS SPECTROSCOPIC ANALYSIS

The analysis by mass spectroscopy indicated the presence of both the mono and dipentek, with the intensity to mono being about ten times greater than the dipentek. This would indicate 90% monopentek in the PE-200.

ELEMENTAL ANALYSIS

The elemental analysis was performed to determine the percent carbon and hydrogen in the PE-200. The elemental composition for theoretically pure mono and dipentek and the actual analysis of the PE-200 sample are shown below.

ELEMENTAL COMPOSITION

ELEMENT	MONOPEN TEK	DIPEN TEK	PE-200
Carbon	44.1%	47.2%	44.6%
Hydrogen	8.8	8.7	8.8%

The remaining portion of the compounds above are due to Oxygen which is not determined directly by the elemental analysis. To have a carbon percent of 44.6 as

Page 2

indicated by the elemental analysis the make up of the PE-200 would be 84% monopentek and 16% dipentek.

THERMAL ANALYSIS

The differential scanning calorimeter (DSC) analysis indicated the melt point of the PE-200 to be near 190°C. This is much below the literature melt point for either mono or dipentek. This would indicate the PE-200 is a mixture of two or more compounds and the melt point is lowered due to the eutectic lowering of the mixture.

Charles Long, D/834

cc T. E. Neet, D/834
H. Thompson, D/834

DISTRIBUTION: White: Return to Originator After Complete
 Pink: Permanent Laboratory Copy
 Yellow: Originator's Copy
 Green: Accompanies Material

Bondix Kansas City
 Division
 KCD 267
 (9/79)

UNCLASSIFIED LABORATORY TEST REQUEST

REQUESTOR COMPLETES
 ALL UNSHADED BLOCKS

TO DEPT 838/SL3

LTR NO
 107393

DATE REQUIRED 01/02/95		ORIGINATOR NAME D.R. WATSON		INDEX NO 5354	PHONE 4092	DEPT 833	DATE SUBMITTED 12/18/94
CROSS REF		PART DESCRIPTION (NAME/NUMBER) FOAM SAMPLES			QTY 18	FCD	MAT'L CLASSIFICATION Y ☐ N ☒ DESIG ☐
		CHARGE NO 04751400			CHRG CD	RETURN MAT'L TO D/34-FN33	
TEST 1	SECT	PRIORITY	SPEC/TEST DESCRIPTION CHN			EST HRS	EST COMPLETE DATE
DATA LOCATION 153-59-W		EQUIP CD 13085	ANALYST NAME		INDEX NO 08877	ACTL HRS 18	ACTL COMPLETE DATE 1-11-95
TEST 2	SECT	PRIORITY	SPEC/TEST DESCRIPTION			EST HRS	EST COMPLETE DATE
DATA LOCATION		EQUIP CD	ANALYST NAME		INDEX NO	ACTL HRS	ACTL COMPLETE DATE
TEST 3	SECT	PRIORITY	SPEC/TEST DESCRIPTION			EST HRS	EST COMPLETE DATE
DATA LOCATION		EQUIP CD	ANALYST NAME		INDEX NO	ACTL HRS	ACTL COMPLETE DATE
TEST 4	SECT	PRIORITY	SPEC/TEST DESCRIPTION			EST HRS	EST COMPLETE DATE
DATA LOCATION		EQUIP CD	ANALYST NAME		INDEX NO	ACTL HRS	ACTL COMPLETE DATE
TEST 5	SECT	PRIORITY	SPEC/TEST DESCRIPTION			EST HRS	EST COMPLETE DATE
DATA LOCATION		EQUIP CD	ANALYST NAME		INDEX NO	ACTL HRS	ACTL COMPLETE DATE

SERVICES REQUESTED:

PLEASE PERFORM C, H, & N ANALYSIS ON THE FOLLOWING
 FOAM SAMPLES:

NC001, NC002, NC003, NC004, NC005, NC006,
 KC001, KC002, KC003, KC004, KC005, KC006,
 GP001, GP002, GP003, GP004, GP005, GP006

SUMMARY OF TEST RESULTS:

See attachment

[Signature]
 12/18/94

LTR No. 107393Date Completed 01-11-95Specification 9952036

Test Procedures

NITROGEN CONTENT DETERMINATION

TEST RESULTS

SAMPLE ID (S/N)	TEST RUN # 1	TEST RUN # 2	TEST RUN # 3		AVG. OF THREE ANALYSES	STANDARD DEVIATION
NC 001	5.58	5.59	5.66		5.61	0.04
NC 002	5.69	5.69	5.71		5.70	0.01
NC 003	5.72	5.70	5.69		5.70	0.02
NC 004	5.68	5.73	5.73		5.71	0.03
NC 005	5.68	5.70	5.69		5.69	0.01
NC 006	5.70	5.71	5.66		5.69	0.03
KC 001	6.12	6.12	6.10		6.11	0.01
KC 002	6.08	6.11	6.09		6.09	0.02
KC 003	6.05	6.06	6.07		6.06	0.01
KC 004	6.08	6.10	6.08		6.09	0.01
KC 005	6.11	6.09	6.10		6.10	0.01
KC 006	6.10	6.19	6.14		6.14	0.05
GP 001	6.21	6.21	6.20		6.21	0.01
GP 002	6.20	6.18	6.18		6.19	0.01
GP 003	6.21	6.22	6.25		6.23	0.02
GP 004	6.21	6.21	6.21		6.21	0.00
GP 005	6.24	6.26	6.23		6.24	0.02
GP 006	6.24	6.24	6.28		6.25	0.02

Submitted by: Pat NewsomeCE #: 73085Extension: 4321

ANALYTICAL SCIENCES TEST REPORT

LTR No. 107393Date Completed 01-11-95

Specification

Test Procedures

C H and N CONTENTS

TEST RESULTS

SAMPLE ID (S/N)	RUN #	WT % C	WT % H	WT % N	AVG WT % C	AVG WT % H	AVG WT % N	STANDARD DEVIATION + or -
NC 001	1	69.29	7.03	5.58	>67.10	6.94	5.61	C= 1.91
	2	65.78	6.89	5.59				H= 0.08
V	3	66.23	6.89	5.66				N= 0.04
NC 002	1	65.65	6.93	5.69	>68.28	6.96	5.70	C= 3.80
	2	72.64	7.05	5.69				H= 0.08
V	3	66.54	6.90	5.71				N= 0.01
NC 003	1	67.66	6.97	5.72	>67.56	6.93	5.70	C= 0.48
	2	67.99	6.95	5.70				H= 0.05
V	3	67.04	6.87	5.69				N= 0.02
NC 004	1	70.68	7.03	5.68	>67.94	6.93	5.71	C= 2.78
	2	68.02	6.92	5.73				H= 0.09
V	3	65.12	6.85	5.73				N= 0.03
NC 005	1	65.23	6.91	5.68	>68.10	6.92	5.69	C= 3.68
	2	66.82	6.87	5.70				H= 0.05
V	3	72.24	6.97	5.69				N= 0.01
NC 006	1	63.22	6.86	5.70	>69.60	6.98	5.69	C= 5.73
	2	74.30	7.09	5.71				H= 0.12
V	3	71.29	6.99	5.66				N= 0.03
KC 001	1	70.84	6.63	6.12	>68.91	6.54	6.11	C= 2.51
	2	66.08	6.49	6.12				H= 0.08
V	3	69.82	6.51	6.10				N= 0.01
KC 002	1	64.39	6.49	6.08				C= 4.88

	2	70.97	6.54	6.11	>69.76	6.54	6.09	H= 0.05
V	3	73.92	6.59	6.09				N= 0.02
KC 003	1	69.10	6.61	6.05				C= 0.33
	2	69.17	6.61	6.06	>69.32	6.59	6.06	H= 0.04
V	3	69.70	6.54	6.07				N= 0.01
KC 004	1	64.64	6.46	6.08				C= 3.71
	2	71.83	6.57	6.10	>68.77	6.51	6.09	H= 0.06
V	3	69.83	6.51	6.08				N= 0.01
KC 005	1	72.19	6.64	6.11				C= 3.56
	2	66.73	6.51	6.09	>68.14	6.53	6.10	H= 0.10
V	3	65.51	6.45	6.10				N= 0.01
KC 006	1	67.74	6.56	6.10				C= 2.20
	2	71.51	6.84	6.19	>70.28	6.80	6.14	H= 0.23
V	3	71.58	7.01	6.14				N= 0.05
GP 001	1	74.40	6.75	6.21				C= 5.41
	2	72.26	6.65	6.21	>70.27	6.62	6.21	H= 0.15
V	3	64.14	6.45	6.20				N= 0.01
GP 002	1	73.37	6.73	6.20				C= 0.84
	2	73.02	6.66	6.18	>72.72	6.68	6.19	H= 0.04
V	3	71.78	6.66	6.18				N= 0.01
GP 003	1	69.23	6.67	6.21				C= 0.92
	2	70.53	6.65	6.22	>69.51	6.64	6.23	H= 0.04
V	3	68.76	6.60	6.25				N= 0.02
GP 004	1	70.04	6.66	6.21				C= 2.01
	2	66.07	6.53	6.21	>67.87	6.60	6.21	H= 0.07
V	3	67.49	6.60	6.21				N= 0.00
GP 005	1	67.61	6.61	6.24				C= 1.84
	2	65.28	6.52	6.26	>67.27	6.58	6.24	H= 0.05
V	3	68.92	6.60	6.23				N= 0.02
GP 006	1	70.24	6.67	6.24				C= 1.15

	2	67.96	6.55	6.24	>69.19	6.61	6.25	H= 0.06
V	3	69.38	6.60	6.28				N= 0.02

Distribution

1	MS0429	R. Andreas	2100
1	MS0483	T.D. Hernandez	2165
1	MS0483	R.E. Glass	2165
5	MS0483	A.R. York	2165
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1	DOE/AL/NESD	W.J. Baca	

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