Chapter 2, Ref 61 — GENERAL PLASTICS
Design Guide for LAST-A-FOAM FR-3700

GENERALPLASTICS

MANUFACTURING COMPANY

Design Guide

LAST-A-FOAM® FR-3700
Crash & Fire Protection of
Radioactive Material
Shipping Containers

4910 Burlington Way, Tacoma, WA 98409
Ph: (253) 473-5000, F: (253) 473-5104, email: sales@generalplastics.com, www.generalplastics.com

Preface

Thank you for your interest in General Plastics Manufacturing Company and its LAST-A-FOAM products! For over 60 years, General Plastics has been a leader in non-metallic and cellular-solid technologies. This design guide contains the collected knowledge of LAST-A-FOAM® FR-3700 and presents it for the designers of nuclear (or hazardous waste) material transportation packages, fire protection applications, or other applications which involve conditions which require absorption of significant mechanical or thermal energy.

The designer is invited to use these discussions when considering LAST-A-FOAM® FR-3700 in a crash and/or fire protection application. In addition to FR-3700, General Plastics has many other foam formulations, each with unique properties, to address a variety of applications.

General Plastics is happy to offer design assistance ranging from telephone advice to testing of scale models.

Disclaimer

This data is presented in good faith and is believed to be accurate and well suited for comparative analysis. However, General Plastics Manufacturing Company cannot assume responsibility for the results obtained by others over whose methods we have no control. Therefore, this information is made available for guidance purposes. Because many factors can affect subsequent material processing, application, and use, it is important that prospective users conduct any performance testing necessary to assure the suitability and safety of LAST-A-FOAM products in any proposed application.

No warranties of any kind, either express or implied, including warranties of merchantability or fitness for a particular purpose, are made, regarding the materials described, data, or information set forth, or that the materials, data or information may be used without infringing upon the intellectual property rights of others. In no case shall the descriptions, information, or data provided be considered a part of our terms and conditions of sale. General Plastics Manufacturing Company specifically disclaims any liability for consequential or incidental damages of any kind, including lost profits.

Further, users expressly understand and agree that these data and information are provided gratis and that General Plastics Mfg. Co. assumes no obligation or liability for this information or results obtained, all such being accepted at the user's risk. General Plastics further reserves the right to make changes to our products at any time and without prior or subsequent notification, except where such notification is a contractual or regulatory requirement.

Table of Contents

Preface 2

Introduction 4

Company Background 4

Quality 4

LAST-A-FOAM® FR-3700 Product Description 4

Product Data 4

Basic Properties 5

Fire Safety & Protection 6

Chemical Resistance 7

Bonding, Filling, and Sealing LAST-A-FOAM 7

Long-Term Performance 7

Effect of Radiation 8

Water Immersion 9

Static Crush Strength 9

Dynamic Crush Strength 11

References 12

Introduction

This design guide presents a synopsis of the collected knowledge of LAST-A-FOAM® FR-3700 and its application to radioactive material shipping container design. Presented within are both specific data and generalized discussions to assist the designer in understanding the behavior of LAST-A-FOAM® FR-3700 when exposed to the design conditions typical to radioactive materials shipping containers. The information provided is intended to help customers with design concepts only. Please contact Rick Brown (rick_brown@generalplastics.com, direct: 253-330-7778) at General Plastics for data before setting specifications.

Company Background

General Plastics Manufacturing Company has been a manufacturer of plastic parts and aircraft assemblies for over 50 years, and a producer of rigid and flexible polyurethane foams and parts for over 30 years.

As a world leader in the formulation and manufacture of cellular solid materials, we are in a unique position to provide material test and evaluation services to technical organizations. Our extensive customer base, which includes military, nuclear, and aerospace firms, requires General Plastics to maintain a very capable quality and testing facility to support our customers' needs. Diversity is our strength. Ongoing research and development programs have kept General Plastics ahead in our markets. The company has experienced a steady, growing demand for its products in the aerospace, defense, nuclear, construction, and marine industries.

Lasting partnerships have been forged with industry giants including Boeing, Sandia, BWXT Pantex, and Lockheed to name a few, ensuring a consistent demand for services and a competent operation capable of producing premium materials for a variety of customers.

Quality

General Plastics has Quality Assurance programs and test facilities necessary to provide all required test data and certifications for application in nuclear material shipping containers. General Plastics is qualified to NQA-1 as well as MIL-I-45208 and AS9100 (AS9100 is effectively ISO for aerospace). Additionally, General Plastics is DI-9000A qualified, and is a delegated-source-inspection raw material supplier to the Boeing Commercial Airplane Company. We have held this delegated-source appointment since 1988.

LAST-A-FOAM FR-3700 Product Description

LAST-A-FOAM® FR-3700 makes an ideal candidate material for many highly engineered applications. A prime example of a highly engineered application in which LAST-A-FOAM® FR-3700 has a history of successful use is radioactive materials (RAM) transportation packages. The regulations governing RAM packages often require accident conditions energy absorption of 30-foot free drops and exposure to a 1,475°F, 30-minute fire. LAST-A-FOAM® FR-3700 is one of very few materials that can serve the dual purpose of assisting the RAM package design in mitigating both mechanical and thermal energy.

Product Data

LAST-A-FOAM® FR-3700 is an HCFC-free, rigid, closed-cell, flame-retardant polyurethane foam available in densities ranging from four to 40 pounds per cubic foot. It exhibits a high strength-to-weight ratio due to its cellular structure and cross-linked resin. Also, because of its closed-cell structure, LAST-A-FOAM® FR-3700 has great resistance to water absorption, and will not swell, crack, or split on exposure to water. LAST-A-FOAM is stable, inert, and is resistant to most chemicals and solvents. It is easily worked with common tools, and performs well as a primary or replacement material in a variety of applications.

Table 1: Basic Physical Properties

Property	English/Metric	Test Method
Closed-Cell Content	96.7%	ASTM D-2856 Procedure B
Water Absorption	< 85% by weight	ASTM D-2842
Glass Transition	279°F / 137°C	MDSC
Hardness, Shore-D	1.7812(D) + 0.37	ASTM D-2240
Tumbling Friability - loss $^{w}/_{o}$	$41.314 \times 2.7183^{-0.1873(D)}$	ASTM C-421 (20 min. @ 60 rpm)

Table 2: Thermal Properties

Property	English	Metric	Test Method
Thermal Conductivity	BTU/hr-ft^2-°F/inch	W/m-K	
FR-3704	0.200	0.029	
FR-3706	0.205	0.030	
FR-3708	0.209	0.030	
FR-3710	0.213	0.031	ASTM C177 @75°F (24°C)
FR-3718	0.324	0.047	
FR-3720	0.349	0.050	
FR-3725	0.414	0.060	
Specific Heat @ 25°C	0.353 BTU/lb-°F	1.477 J/g°C	ASTM E-1269
Heat of Combustion	11,706 BTU/lb	27.17 MJ/Kg	ASTM D-240
Coefficient of Linear Thermal Expansion From -50°F to 200°F	3.5×10^{-5} in/in/°F to 5.0×10^{-5} in/in/°F	6.2×10^{-5} K^{-1} to 9.0×10^{-5} K^{-1}	ASTM C-518

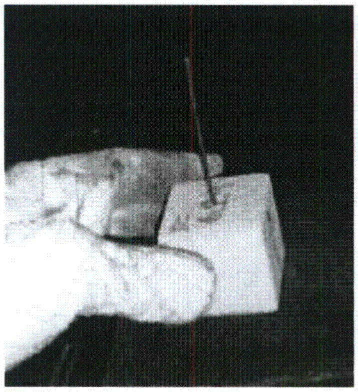
Fire Safety & Protection

LAST-A-FOAM® FR-3700 rigid polyurethane foam is flame-retardant. However, it is an organic material and will burn in the presence of sufficient heat and oxygen. It is important to understand that FR-3700 is a thermoset plastic and does not melt.

Applications using FR-3700 for fire protection take advantage of the fire-retardant mechanisms engineered into the product. The primary fire-retardant mechanism of FR-3700 is the production of an intumescent char when thermally attacked. Two tests demonstrate the capabilities of LAST-A-FOAM® FR-3700 in a fire. The basic fire-retardant nature of FR-3700 is determined using Federal Aviation Regulation (FAR) 25.853 flame test {14CFR25.853(a) App. F(a)(1)(I)}. The second test is intumescence. Both tests are described below.

The pyrolysis gases produced by decomposition reactions must be vented from the vessel to avoid an explosive pressure release and to allow the gases to remove the heat from the container. It is recommended that vents be provided in a ratio of one square inch to 10-25 square feet of exposed hot face surface. Vents should be placed so that the breakdown products and gases are channeled away from sensitive areas of the payload, such as seal sections.

When subjected to thermal attack, FR-3700 decomposes and forms an intumescent char. The intumescent char formed during pyrolysis allows the foam to 'heal' cracks from any proceeding event (such as a mechanical impact). The resulting intumescing char produced by FR-3700 can effectively seal openings and preclude the "chimney effect," or other heat transfer modes. In the following figures, you can see how the sample which began as a 2" cube, demonstrates intumescence in the direction of heat application. The char also provides a secondary thermal barrier that decomposes (very slowly) at temperatures above 2,000°F.



Before

After

The Federal Aviation Regulation (FAR) 25.853(a) App. F(a)(1)(I) flame test is commonly used to assess the relative burning characteristics of foam plastic materials under controlled laboratory conditions. The results of these tests performed on LAST-A-FOAM® are shown in Table 3.

Table 3: Typical FAR 25.853 flame test results

LAST-A-FOAM® Grade	FAR 25.835 12-second Ignition		FAR 25.835 60-second Ignition	
	Extinguish Time, seconds	Burn Distance, inches (mm)	Extinguish Time, seconds	Burn Distance, iinches (mm)
FR-3704	0.5	5.7 (144.8)	0.7	5.6 (142.2)
FR-3706	3.0	5.2 (132.0)	0.8	5.4 (137.2)
FR-3710	2.5	3.8 (96.5)	-0-	4.6 (116.8)
FR-3718	6.1	2.7 (68.6)	-0-	4.5 (114.3)
FR-3720	5.5	2.9 (73.7)	-0-	4.7 (119.4)

The results of these tests are not to be considered or used as fire hazard classifications, and are not intended or implied to reflect hazards presented by this or any other material in acutual fire conditions.

In the above tests, a foam sample 0.5 inch x 3.0 inch x 12 inch (12.7 mm x 76.2 mm x 305 mm) long is mounted in a vertical position. The lower end is exposed to a 1.5-inch (38.1 mm) Bunsen burner flame for the described time. The time to extinguishment after removal of the flame and the burned length of the sample are recorded.

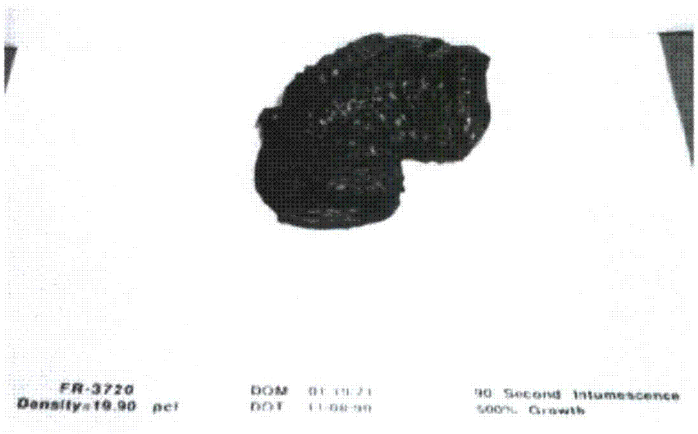
Chemical Resistance

LAST-A-FOAM products exhibit very good to excellent resistance to a wide range of chemicals and solvents. Common petroleum products such as oil or gasoline have a negligible effect on LAST-A-FOAM. Exposure to liquid acids and bases, either in dilute or highly concentrated forms, does not significantly deteriorate foam properties at normal room temperatures. Some chlorinated solvents will cause LAST-A-FOAM to temporarily swell or soften on exposure, which can be useful in some production situations. If you need specific advice regarding chemical resistance, please contact us.

Long-Term Performance

General Plastics Manufacturing Company's LAST-A-FOAM® FR-3700 is often chosen for long-term applications.Therefore it is imperative that the foam retain its physical properties over the normal life span of the application. A sample of twenty- year-old LAST-A-FOAM® FR-3720 was obtained and tested for compressive strength and char formation. Maintenance of compressive strength is a good indicator of the material's overall structural performance while the formation of closed-cell char foam is the key factor in fire retardancy.

Figure 2 - The photo at left demonstrates that the intumescent-char-forming ability of FR-3720 is not affected by age.



Bonding, Filling, and Sealing LAST-A-FOAM

LAST-A-FOAM can be bonded, filled, sealed, and painted with a wide variety of commercially available finishing products. Our customers report greatest success with automotive and wood finishing materials, but the range of usable products is not limited to those types.

General Plastics Manufacturing Company's "Guide to Bonding, Filling, and Sealing LAST-A-FOAM Products" is available on request with appropriate finishing material selections. You should follow manufacturers' safety instructions when using any bonding, filling, or finishing product with LAST-A-FOAM, and observe their recommended precautions.

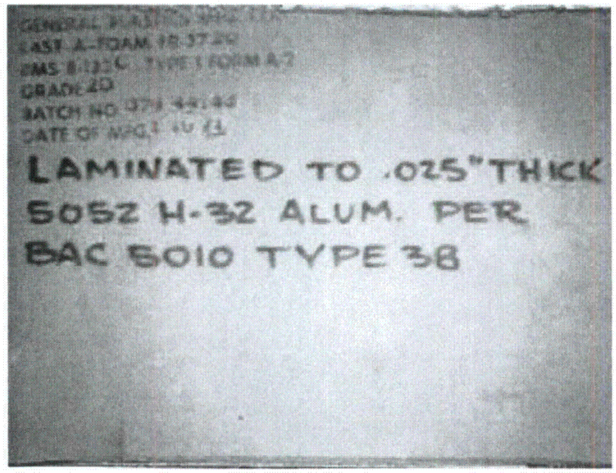


Figure 1 - The sample pictured at right was manufactured in January of 1971 and tested in November 1990. The sample consists of two sheets of 0.5-inch FR-3720 laminated to an aluminum sheet. The foam was cut off the aluminum sheet prior to testing.

The compressive strength was 1,393 psi with a modulus of 34,968 psi/in. This compares very favorably with General Plastics' published nominal compressive strength values for LAST-A-FOAM® FR-3720 of 1,105 psi and 27,957 psi/in. The higher values found in the 20-year-old sample may be partly due to the 0.5-inch-thick sample vs the standard 1.0-inch-thick, and partly due to long-term cure effects (see Figure 3).

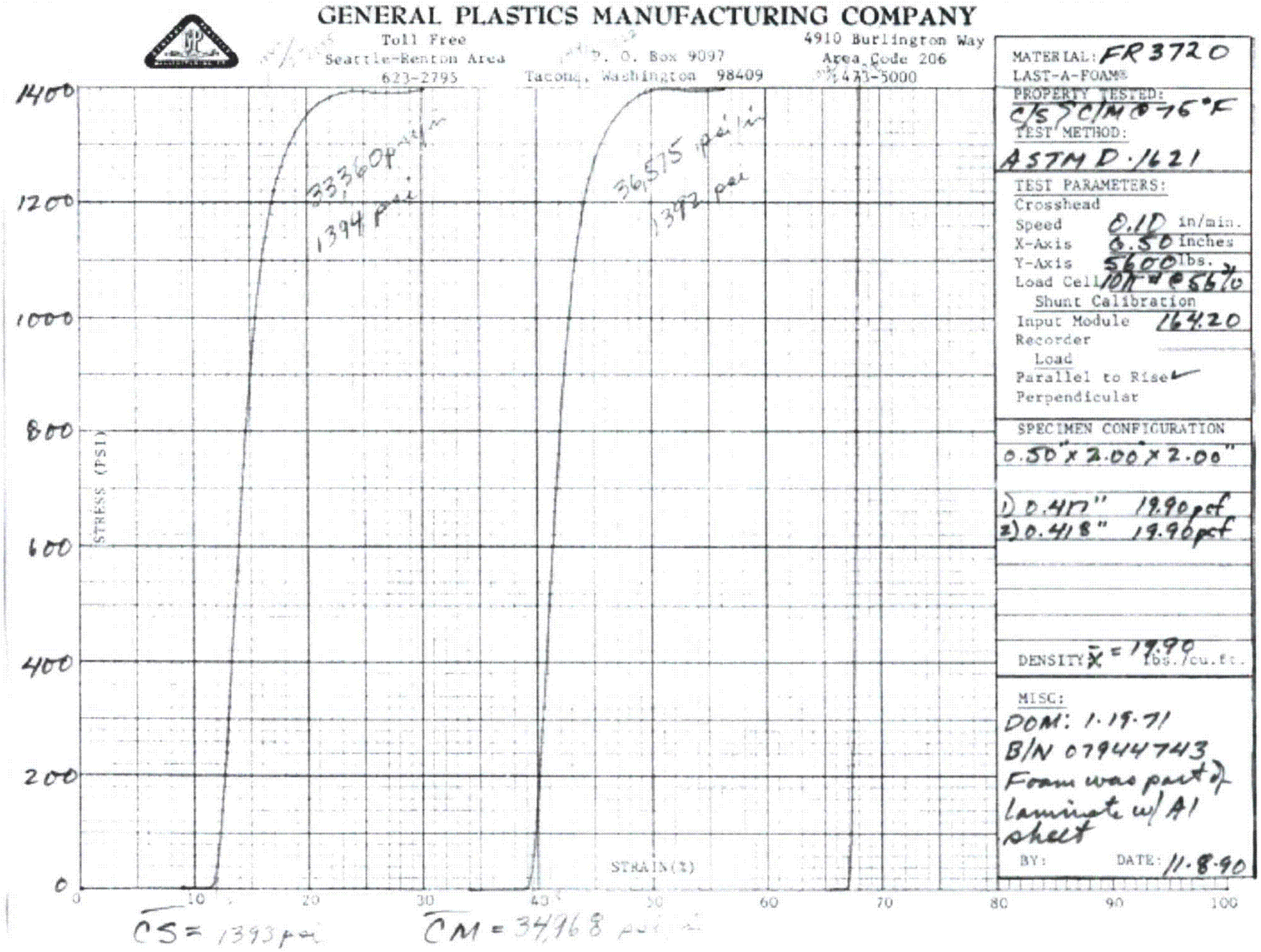


Figure 3: Long-Term Compressive Strength

Effect of Radiation

Cubic specimens (2.5 inch) of LAST-A-FOAM® FR-3710 were submitted to the University of Michigan Phoenix Memorial Laboratory. The specimens were irradiated in a Cobalt-60 Irradiator to a maximum cumulative dose of $2x10^8$ rads (gamma). This dosage is representative of approximately 40 years of life in a field of 500 rads per hour. Discoloration was observed to increase with dosage but was not correlated with any change of physical properties. The compressive strength of the specimens was unaffected by the radiation as evidenced by the data shown in Table 4 and Table 5 (Test date: 1994).

Table 4: Average of five specimens at each dosage
(results for individual tests available upon request)

Exposure	DENSITY lbs./ft.^{3}	Stress(psi) @ % Crush							
		10%	20%	30%	40%	50%	60%	65%	70%
Control	10.78	352	359	382	426	508	686	851	1,121
2 X 10^7 rads	10.68	341	348	373	417	499	678	848	1,137
4.2 X 10^7 rads	10.58	328	336	360	405	488	666	835	1,122
7 X 10^7 rads	10.64	333	341	366	408	491	666	831	1,106
2 X 10^8 rads	10.76	347	356	380	422	507	682	844	1,112

Water Immersion

Using the same cubic samples from the radiation testing, LAST-A-FOAM® FR-3710 was shown to remain resistant to significant water absorption. The samples were placed in water at temperature of 125°F (52°C) and a pressure of 17.7 psig (122 kPa). As shown by the results presented in Table 5, water absorption occurs slowly, even considering the effects of radiation exposure. Resistance to water absorption is consistent with the greater than 95% closed-cell content of LAST-A-FOAM® FR-3700.

Table 5: Water Absorption as a Function of Time and Radiation Exposure

Time and Radiation Exposure	Density, lbs/ft³	Before Submersion	After Submersion	Weight Gain, grams	% Gain By Volume
1-Day Immersion					
Non Irradiated	10.61	44.19	47.29	3.10	1.21
2.0 X 10^7 rads	10.72	44.72	48.47	3.75	1.46
4.2 X 10^7 rads	10.96	45.66	48.88	3.22	1.26
7.0 X 10^7 rads	10.64	44.66	48.67	4.01	1.57
10-Day Immersion				**Average-->**	**1.37**
Non Irradiated	10.80	44.73	50.12	5.39	2.11
2.0 X 10^7 rads	10.61	44.51	51.93	7.42	2.90
4.2 X 10^7 rads	10.62	44.62	52.85	8.23	3.21
7.0 X 10^7 rads	10.65	44.29	53.78	9.49	3.71
100-Day Immersion				**Average-->**	**2.98**
Non Irradiated	10.87	45.35	61.74	16.39	6.40
2.0 X 10^7 rads	10.59	44.3	66.30	22.00	8.59
4.2 X 10^7 rads	10.89	45.35	67.70	22.35	8.73
7.0 X 10^7 rads	10.62	44.44	69.26	24.82	9.69
156-Day Immersion				**Average-->**	**8.35**
Non Irradiated	10.67	44.22	65.12	20.90	8.16
2.0 X 10^7 rads	10.52	43.89	69.70	25.81	10.08
4.2 X 10^7 rads	10.73	44.66	72.06	27.40	10.70
7.0 X 10^7 rads	10.73	44.58	74.59	30.01	11.72
				Average-->	**10.17**

Static Crush Strength

The Static Crush Strength of the foam has been developed from experimental test results of various densities of LAST-A-FOAM® FR-3700 series rigid polyurethane foams at various compressive strains. This information is provided as an aid to designers of crushable, energy-absorbing packaging systems in selecting the appropriate density of General Plastics' FR-3700 series foams. While impact data may be helpful in the selection of a foam density for a particular application, it is often more practicable to use the static crush strength values in Quality Assurance Testing.

If a crush strength other than that found in the table is desired for a particular application, General Plastics would be pleased to engineer LAST-A-FOAM® FR-3700 to more nearly meet the desired properties. This is accomplished by developing intermediate nominal density foam. For example, a nominal 14.5 lbs_m/ft^3 density would produce a crush strength (predicted) of about 1,000 psi at 50% strain parallel to rise.

The design data provided in Table 6 and Table 7 has been updated to provide the most suitable correlation of crush strength to density to the designers of Radioactive Materials Packages. All of the crush strength values are nominal and the effect of tolerance should be carefully considered. The minimum tolerance on the nominal crush strength is ±10% for densities above 8 lb/ft³, and ±15% for densities equal to or below 8 lb/ft³; however, we recommend ±15% for densities above 8 lb/ft³, and ±20% for densities equal to or below 8 lb/ft³.

The data presented in this design guide is based on testing of samples taken from our production bun stock. The conditions surrounding in-situ installations are invariably different than the conditions used to manufacture the bun stock from which the samples were taken. Both the nominal values and recommended tolerances are likely to be somewhat affected by the design of the in-situ installation.

Table 6: Static Nominal Crush Strength, *Parallel* to Direction of Rise
(see Table 7 for Perpendicular to Rise)

For 4 to 10 lb_m/ft^3									
Temp	Correlation Factors	Crush Strength, psi, Parallel to Direction of Rise							
		10%	20%	30%	40%	50%	60%	65%	70%
-20°F	C_T	1.29	1.36	1.32	1.29	1.26	1.28	1.29	1.37
75°F	Y_{int}	**7.3058**	**6.7276**	**6.4961**	**6.9137**	**5.6711**	**5.3279**	**5.9871**	**6.2085**
	S	**1.6590**	**1.7021**	**1.7350**	**1.7255**	**1.8877**	**2.0431**	**2.0870**	**2.1868**
100°F	C_T	0.87	0.88	0.89	0.89	0.90	0.91	0.91	0.96
140°F	C_T	0.73	0.75	0.76	0.77	0.78	0.78	0.79	0.84
180°F	C_T	0.65	0.66	0.67	0.68	0.69	0.68	0.68	0.71
220°F	C_T	0.61	0.60	0.60	0.61	0.61	0.59	0.59	0.61
260°F	C_T	0.45	0.44	0.46	0.47	0.48	0.49	0.49	0.52
For 11 to 40 lb_m/ft^3									
Temp	Correlation Factor	Crush Strength, psi, Parallel to Direction of Rise							
		10%	20%	30%	40%	50%	60%	65%	70%
-20°F	C_T	1.35	1.33	1.32	1.31	1.31	1.30	1.28	1.26
75°F	Y_{int}	**4.3422**	**3.8755**	**3.5241**	**3.0307**	**3.0402**	**3.4889**	**5.8935**	**5.6055**
	S	**1.8809**	**1.9321**	**1.9872**	**2.0755**	**2.1451**	**2.2143**	**2.1041**	**2.2368**
100°F	C_T	0.86	0.87	0.88	0.88	0.89	0.90	0.90	0.97
140°F	C_T	0.72	0.74	0.75	0.75	0.75	0.76	0.76	0.81
180°F	C_T	0.62	0.63	0.65	0.65	0.65	0.65	0.64	0.68
220°F	C_T	0.56	0.56	0.57	0.57	0.56	0.54	0.54	0.57
260°F	C_T	0.40	0.40	0.41	0.42	0.41	0.43	0.43	0.47

The room-temperature (75°F) foam crush strength is calculated at each %-Crush and is a function of density; $\sigma=Y_{int}(\rho)^s$, where Y_{int} and S are defined above, ρ is the nominal foam density in lb/ft^3 and σ in the resulting crush stress in psi at the indicated strain. The foam crush strength at temperatures other than 75°F is calculated at each %-Crush and is a function of the strength at 75°F; $\sigma=\sigma_{75°F}C_T$. General Plastics Mfg. Co. is re-investigating the correlations factors at temperatures above and below 75°F. Please contact us for more specific and detailed data, as needed.

Table 7: Static Nominal Crush Strength, *Perpendicular* to Direction of Rise (see Table 6 for Parallel to Rise)

For 4 to 10 lb_m/ft^3									
Temp	Correlation Factors (see below)	Crush Strength, psi, Perpendicular to Direction of Rise							
		10%	20%	30%	40%	50%	60%	65%	70%
-20°F	C_T	1.32	1.35	1.34	1.32	1.32	1.33	1.34	1.36
75°F	Y_{int}	**6.3841**	**6.5943**	**6.1154**	**5.7722**	**5.3041**	**5.3181**	**5.7864**	**5.7701**
	S	**1.7182**	**1.6946**	**1.7403**	**1.8023**	**1.9054**	**2.0392**	**2.1002**	**2.2255**
100°F	C_T	0.85	0.87	0.88	0.89	0.90	0.91	0.91	0.92
140°F	C_T	0.75	0.77	0.78	0.79	0.79	0.79	0.79	0.80
180°F	C_T	0.63	0.66	0.68	0.69	0.69	0.70	0.69	0.70
220°F	C_T	0.59	0.59	0.60	0.61	0.60	0.60	0.59	0.60
260°F	C_T	0.45	0.45	0.47	0.48	0.48	0.48	0.48	0.48
For 11 to 40 lb_m/ft^3									
Temp	Correlation Factors (see below)	Crush Strength, psi, Perpendicular to Direction of Rise							
		10%	20%	30%	40%	50%	60%	65%	70%
-20°F	C_T	1.34	1.33	1.32	1.33	1.30	1.28	1.24	1.17
75°F	Y_{int}	**4.1342**	**3.5581**	**3.2664**	**2.8352**	**2.8988**	**3.3972**	**6.5439**	**5.6464**
	S	**1.8957**	**1.9593**	**2.0109**	**2.0955**	**2.1602**	**2.2242**	**2.0660**	**2.2321**
100°F	C_T	0.84	0.85	0.86	0.88	0.87	0.88	0.88	0.90
140°F	C_T	0.72	0.73	0.74	0.76	0.75	0.76	0.76	0.79
180°F	C_T	0.62	0.63	0.64	0.65	0.65	0.65	0.65	0.67
220°F	C_T	0.53	0.53	0.54	0.55	0.54	0.54	0.54	0.56
260°F	C_T	0.39	0.39	0.40	0.41	0.41	0.40	0.40	0.42

The room-temperature (75°F) foam crush strength is calculated each %-Crush and is a function of density; $\sigma=Y_{int}(\rho)^S$ where Y_{int} and S are defined above, ρ is the nominal foam density in lb/ft^3 and σ in the resulting crush stress, in psi at the indicated strain. The foam crush strength at temperatures other than 75°F is calculated at each %-Crush and is a function of the strength at 75°F; $\sigma=\sigma_{75°F}C_T$. General Plastics Mfg. Co. is reinvestigating the correlations factors at temperatures above and below 75°F. Please contact us for more specific and detailed data, as needed.

Dynamic Crush Strength

The crush strength of LAST-A-FOAM, like many materials, is modestly sensitive to strain rate. The static to dynamic adjustment shown in Table 8 is based on a significant testing program and included strain rates in the range of 30 sec^{-1} to 100 sec^{-1}. It is expected that the adjustment will provide good predictions of dynamic impact strength of FR-3700 for most packaging design conditions. This information is intended to be a guide for designers of impact-mitigating devices. The constitutive material models may be useful in targeting a foam density or range for a particular application. However, each design should be thoroughly analyzed or tested to understand the implications of the complete design.

Table 8: Static to Dynamic Crush Strength Adjustment

Strain	10%	20%	30%	40%	50%	60%	65%	70%
Y_{int}	1.2971	1.4397	1.5181	1.3887	1.4419	1.4275	1.3871	1.4660
S	1.0330	1.0069	0.9941	1.0028	0.9912	0.9831	0.9910	0.9586

The dynamic crush strength is calculated at each %-strain and a function of the static crush strength at the same %-strain;

$$\sigma_{Dynamic} = y_{int}(\sigma_{Static})^S$$

Caution: Use only units of PSI for input σ_{static} value.

References

Collected papers and discussions about the behavior of LAST-A-FOAM® FR-3700. Many of these papers were written for, and presented at design symposiums such as Waste Management and PATRAM.

1. Thermal Assault and Polyurethane Foam - Evaluating Protective Mechanisms - Presented at PATRAM 2004
2. Thermal Assault and Polyurethane Foam - Evaluating Protective Mechanisms for Transport Containers - Presented at PATRAM 2004
3. A Comparison of Requirements and Test Methodologies for a Variety of Impact-Absorbing Materials - Presented at Waste Management 2001
4. Machine Design Magazine cut sheet; Foam Protects Waste Containers from Fire and Shock, 1991
5. Rigid Polyurethane Foam for Impact and Thermal Protection – Presented at PATRAM 1995
6. LAST-A-FOAM® FR-3700 In Fire Protection Applications, General Plastics Mfg. Co. White Paper, 1991
7. LAST-A-FOAM® FR-3700 Intumescent Char and Fire Resistance, General Plastics Mfg. Co. White Paper, 1991
8. Fire Resistance Performance, General Plastics Mfg. Co. White Paper, 1990
9. Thermal Decomposition of LAST-A-FOAM® FR-3700, General Plastics Mfg. Co. White Paper, 1991
10. LAST-A-FOAM® FR-3700 Dynamic Impact Applications, General Plastics Mfg. Co. White Paper, 1998
11. LAST-A-FOAM® FR-3700 Impact Configuration Effects, General Plastics Mfg. Co. White Paper
12. LAST-A-FOAM® FR-3700 Material Safety Data Sheet

Examples (limited set) of licensed Radioactive Material Packages using LAST-A-FOAM® FR-3700.

Package Model No.: **TRUPACT II** US Certificate No.: **USA/9218/B(U)F-85** Licensee: **U.S. Department of Energy**	Package Model No.: **RH-TRU 72-B** US Certificate No.: **USA/9212/B(M)F-85** Licensee: **U.S. Department of Energy**
Package Model No.: **125-B** US Certificate No.: **USA/9200/B(M)F-85** Licensee: **U.S. Department of Energy**	Package Model No.: **NUHOMS® MP187 Multi-Purpose Cask** US Certificate No.: **USA/9255/B(U)F-85** Licensee: **Transnuclear, Inc.**
Package Model No.: **F-423** US Certificate No.: **USA/9299/B(U)-85** Licensee: **MDS Nordion**	Package Model No.: **Traveller STD and Traveller XLR** US Certificate No.: **USA/9279/AF-96** Licensee: **Westinghouse Electric Company**
Package Model No.: **UX-30** US Certificate No.: **USA/9196/B(U)-85** Licensee: **Duratek**	Package Model No.: **New Powder Container (NPC)** US Certificate No.: **USA/9294/AF-96** Licensee: **Global Nuclear Fuel**

GENERALPLASTICS
MANUFACTURING COMPANY

4910 Burlington Way Tacoma, WA 98409
TF: (800) 806-6051 • Ph:(253) 473-5000 • Fax: (253) 473-5104

sales@generalplastics.com
www.generalplastics.com