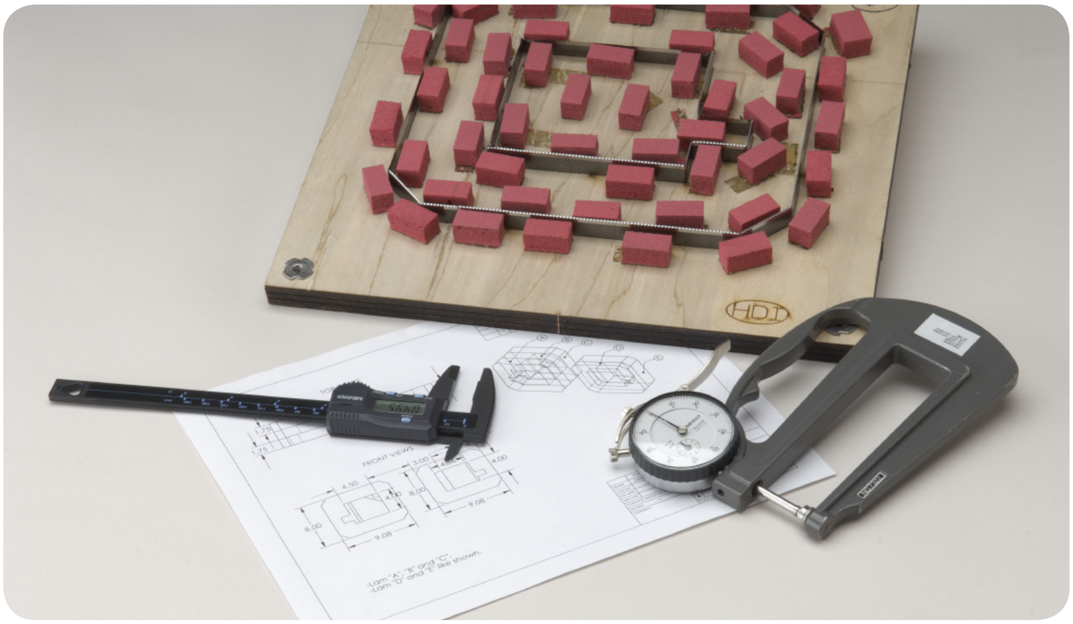
DESIGNING FOR OPTIMAL CUSHIONING PERFORMANCE WITH ARPRO® EPP AND ARPAK® EPE



Packaging design is critical for package protection and cost control. Inadequate design results in shipping damage. Over design results in excessive packaging costs.

This document will help you consider the basic packaging elements when using EPE and EPP foam materials. The easy interactive Design Worksheet on page 16 helps you manage and track your new design and re-design projects.

Also, see our Fabrication Tip Sheet, Fabrication Video, Sample Request Form, and technical documents like Cushion Curves on our web site at www.arplanksales.com. If you have any questions, or if we can be of further assistance, please contact us at **1-800-799-0642**.

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DETERMINE PRODUCT FRAGILITY

Product fragility is also commonly expressed as the "G" value or average deceleration amount.

The more fragile the product the lower its "G" value. The higher the "G" value the more rugged the product is.

If the fragility or "G" is estimated too high the product may be under-designed and significant shipping damage may occur. If the "G" value is estimated too low the package may be over-designed causing it to rebound too much after being dropped resulting in unnecessary damage. Low "G" estimates may also cost more than the part requires for protection.

APPROXIMATE FRAGILITY OF TYPICAL PACKAGED ARTICLES

Extremely Fragile	Aircraft altimeters, gyroscopes, items with delicate mechanical alignments.	**15-25 g's**
Very Delicate	Medical diagnostic apparatus, X-ray equipment.	**25-40 g's**
Delicate	Display terminals, printers, test instruments, hard disk drives.	**40-60 g's**
Moderately Delicate	Stereos and television receivers, CD/DVD drives.	**60-85 g's**
Moderately Rugged	Major appliances, furniture.	**85-115 g's**
Rugged	Table saws, sewing machines, machine tools.	**115 g's and up**

DETERMINE CONDITIONS

Next, consider the handling, transportation, and storage environments that the product may encounter.

Determine the amount of shock, or "drop height" the product may encounter. Usually you can then relate the drop height to the package weight. Reference the drop height and handling guides shown below.

UPS DROP HEIGHT GUIDE

Package Weight	Drop Height (in inches)
0 - 20.99 lbs.	30
21 - 40.99 lbs.	24
41 - 60.99 lbs.	18
61 - 99.99 lbs.	12
100 - 150 lbs	8

Determine what type and how many drops the product might suffer. Determine if the drops or impacts will be horizontal, vertical, flat drops, corner drops or both.

ADDITIONAL CONDITIONS:

TEMPERATURE
Consider that all thermoplastic foams will become softer and "grow" at higher temperatures and become stiffer and "shrink" at lower temperatures. Determine the temperature, humidity, and length of storage. EPE service temperature -76 F - 160 F. EPP service temperature -22 F - 212 F.

CHEMICAL RESISTANCE
Determine if the foam will be in contact with chemicals. EPE and EPP are both highly chemical resistant.

OFF-GASSING
Determine if the foam's blowing agents or off-gassing might harm or alter the packaged product. Refer to the acceptable LEL (lower explosive limit) for all military applications for closed containers. EPE and EPP are both inert and use air as the blowing agent and have no off-gassing.

LOW ABRASION
EPE is considered low abrasion foam and meets the automotive Class A surface requirements for dunnage packaging.

MATERIAL SELECTION

The decision to specify EPE or EPP depends on the application.

EPE is best for multiple drop situations, lower G height drops, high energy dissipation, faster recovery times and low abrasion surface characteristics.

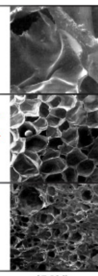
EPP is best for high G drops, high compressive strength, excellent dimensional stability, vibration isolation and higher service temperatures.

DENSITY SELECTION

Polyolefin bead foams tend to perform better than extruded and crosslink foams on a pound for pound basis.

ARPLANK DENSITY COMPARISON

Extruded PE	1.7	2.2	4.0	6.0	9.0
ARPLANK EPE/EPP	1.3	1.5	2.3 / 1.9	2.8	4.2 / 3.7
Crosslink PE	1.5	2.0	3.0	4.0	6.0



(50X)

Along with density, two of the most critical characteristics of any foam's performance characteristics are compressive strength and compressive creep.

COMPRESSIVE STRENGTH

ASTM D3575-08-Suffix D, PSI loading, vertical @25% and 50% compression.

EPE has similar compressive strength as extruded foam at about one half the material density. EPP on average has 30% more compressive strength than extruded foam at 50% less density. Beaded polyolefin foam allows the designer to do more with less.

COMPRESSIVE CREEP

ASTM D3575-08-Suffix BB, PSI loading for <10% creep for 1000 hours.

Consult the compressive load range and stacking strength of the foam selected. This is often overlooked and may cause foam "creep," or permanent foam set, that may lead to loosing of the part, additional vibration issues, more extreme drop damage and significant loss of cushion performance.

The creep rate for all common package cushion materials is greatest at initial loading and declines with time. After the load has been removed, a cushion will regain most of its original thickness, but some permanent set will remain.

Creep of 10% is recognized as a practical upper limit. If creep is more than 10% designers should recalculate the functional foam requirement and increase the foam height to off-set the compressive creep. It is customary to add extra foam thickness to either the top or bottom cushion but not both cushions.

MATERIAL PHYSICAL PROPERTY COMPARISON FOR ARPLANK® PRODUCTS ARPAK® EXPANDED POLYETHYLENE (EPE) – LOW DENSITY (1.3 PCF TO 2.3 PCF) VS. EXTRUDED PE FOAMS – LOW & MID DENSITY (1.7 PCF TO 4.0 PCF)

Physical Properties†	Test Method	Units	ARPAK® EPE				Extruded PE			
Density (Grade)	ASTM-D3575	pcf	1.3	1.5	1.9	2.3	1.7	1.9	2.3	4.0
Density	ASTM-D3575	g/l	20	24	30	37	27	30	37	64
Compressive Strength @ 10%	ASTM-D3575	psi	7	9	10	14	2	5	7	17
Compressive Strength @ 25%		psi	10	11	12	17	4	7	9	19
Compressive Strength @ 50%		psi	18	19	22	28	10	15	17	32
Compressive Strength @ 75%		psi	44	49	56	65	NA	NA	NA	NA
Tensile Strength	ASTM-D3575	psi	40	45	52	62	26	31	32	50
Tensile Elongation	ASTM-D3575	%	38	35	32	31	40	50	50	50
Tear Strength	ASTM-D3575	lbs/in	14	16	17	19	7	10	14	19
Compressive Set @ 25%	ASTM-D3575	%	3	4	4	4	<10	<10	<10	<10
Compressive Set @ 50%	ASTM D3575	%	14	13	12	12	<20	<20	<20	<20
Buoyancy	ASTM-D3575	lbs/ft³	60.6	59.5	59.5	59.3	55	58	58	58.0
Thermal Conductivity	ASTM-C177	(K) BTU-in/ft²-hr-°F	0.24	0.25	0.25	0.24	0.5	0.4	0.4	0.4
Thermal Resistance	ASTM-C177	(R) @70°F	4.1	4.0	4.0	4.2	2.0	2.5	2.5	2.5
Coeff. of Lin. Thermal Expan.	ASTM-D696	in/in/°F x 10^{-5}	8.2	7.2	6.2	5.5	NA	NA	NA	NA
Service Temperature	ASTM-D3575	°F	160	160	160	160	NA	NA	NA	NA
Water Absorption	ASTM-D3575/C272	%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Compressive Creep	ASTM-D3575	1000hr, % (psi)	2.8 (1)	3.0 (1)	3.3 (1)	<10 (5)	<10 (1.5)	<10 (1.5)	<10 (2.5)	<10 (5)
Flammability	FMVSS-302	<4.0 in/min	Pass	Pass	Pass	Pass	NA	NA	NA	NA
Chemical Resistance	Various	1 hr exposure (solvents, acids, and alkalines)	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Fuel Immersion	Coast Guard; Fuel B per 33 CFR §183.114	<5% (chg in vol)	Pass	Pass	Pass	Pass	NA	NA	NA	NA

†Note: The data presented for the JSP ARPAK Expanded Polyethylene (EPE) are for standard JSP ARPLANK Products. While values shown are typical of the product, they should not be construed as specification limits. (NA = Not Available) For Additional Information or Technical Support contact www.arplanksales.com or 1-877-ARPLANK.

MATERIAL PHYSICAL PROPERTY COMPARISON FOR ARPLANK® PRODUCTS ARPRO® EXPANDED POLYPROPYLENE (EPP) – LOW DENSITY (1.3 PCF TO 1.9 PCF) VS. EXTRUDED PE FOAMS – LOW & MID DENSITY (1.7 PCF TO 4.0 PCF)

Physical Properties†	Test Method	Units	ARPRO® EPP		Extruded PE			
Density (Grade)	ASTM-D3575	pcf	1.3	1.9	1.7	1.9	2.3	4.0
Density	ASTM-D3575	g/l	20	30	27	30	37	64
Compressive Strength @ 10%	ASTM-D3575	psi	12	18	2	5	7	17
Compressive Strength @ 25%		psi	15	24	4	7	9	19
Compressive Strength @ 50%		psi	24	34	10	15	17	32
Compressive Strength @ 75%		psi	45	64	NA	NA	NA	NA
Tensile Strength	ASTM-D3575	psi	38	56	26	31	32	50
Tensile Elongation	ASTM-D3575	%	16	15	40	50	50	50
Tear Strength	ASTM-D3575	lbs/in	10	13	7	10	14	19
Compressive Set @ 25%	ASTM-D3575	%	8	7	<10	<10	<10	<10
Compressive Set @ 50%	ASTM D3575	%	14	12	<20	<20	<20	<20
Buoyancy	ASTM-D3575	lbs/ft³	60.5	59.5	55	58	58	58.0
Thermal Conductivity	ASTM-C177	(K) BTU-in/ft²-hr-°F	0.25	0.25	0.5	0.4	0.4	0.4
Thermal Resistance	ASTM-C177	(R) @70°F	4.0	4.0	2.0	2.5	2.5	2.5
Coeff. of Lin. Thermal Expan.	ASTM-D696	in/in/°F x 10^{-5}	6.0	5.7	NA	NA	NA	NA
Service Temperature	ASTM-D3575	°F (MAX)	212	212	NA	NA	NA	NA
Water Absorption	ASTM-D3575/C272	%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
Compressive Creep	ASTM-D3575	1000hr, % (psi)	1.8 (1.5)	1.2 (2.0)	<10 (1.5)	<10 (1.5)	<10 (2.5)	<10 (5)
Flammability	FMVSS-302	<4.0 in/min	Pass	Pass	NA	NA	NA	NA
Chemical Resistance	Various	1 hr exposure (solvents, acids, and alkalines)	Pass	Pass	Pass	Pass	Pass	Pass
Fuel Immersion	Coast Guard; Fuel B per 33 CFR §183.114	<5% (chg in vol)	Pass	Pass	NA	NA	NA	NA

†Note: The data presented for the JSP ARPRO Expanded Polypropylene (EPP) are for standard JSP ARPLANK Products. While values shown are typical of the product, they should not be construed as specification limits. (NA = Not Available) For Additional Information or Technical Support contact www.arplanksales.com or 1-877-ARPLANK.

CALCULATING CUSHION REQUIREMENTS

Once the product fragility and drop height have been determined the cushion curves can be used to select the best material type, density, and thickness for each application. **Please refer to the Design Worksheet located at the end of this document.**

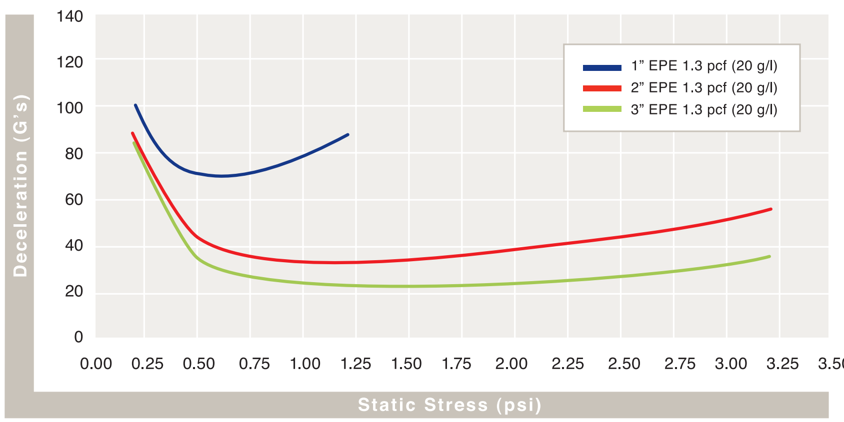
Cushion curves are generated by dropping a series of known weights onto EPE or EPP cushion samples at specified heights while measuring the amount of shock absorbed by the foam. The results are then plotted on a graph that represents the foams cushioning curves.

The vertical axis of the cushion curve represents the shock experienced as the EPE or EPP cushion is impacted. The horizontal axis represents the range of static loadings that the packaged item applies to the cushioning material. Cushion curves are often presented for both the first impact and subsequent ones. The second thru fifth drop averages are shown below.

CUSHIONING PERFORMANCE CURVES

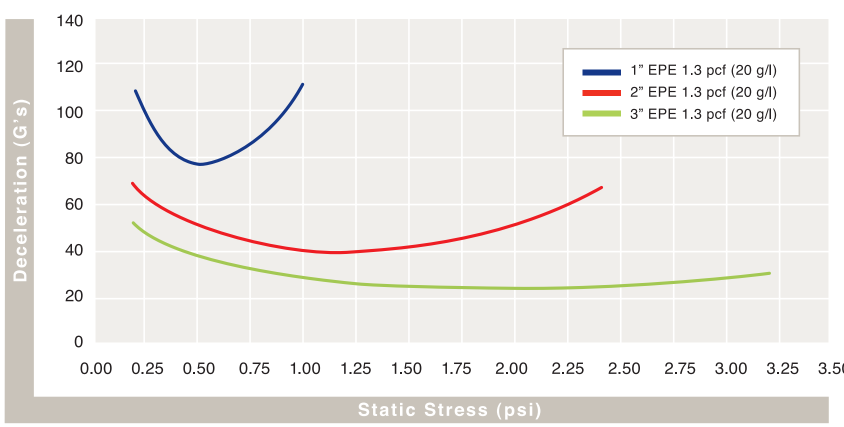
1", 2" & 3" THICKNESS FOR 1.3 PCF (20 G/L) ARPAK® EPE FOAM, 24" DROP,

FIRST IMPACT/DROP



Note: 20 g/l = 1.25 pcf = 45X (g/l = grams per liter; pcf = pounds per cubic foot; X = foam expansion ratio)

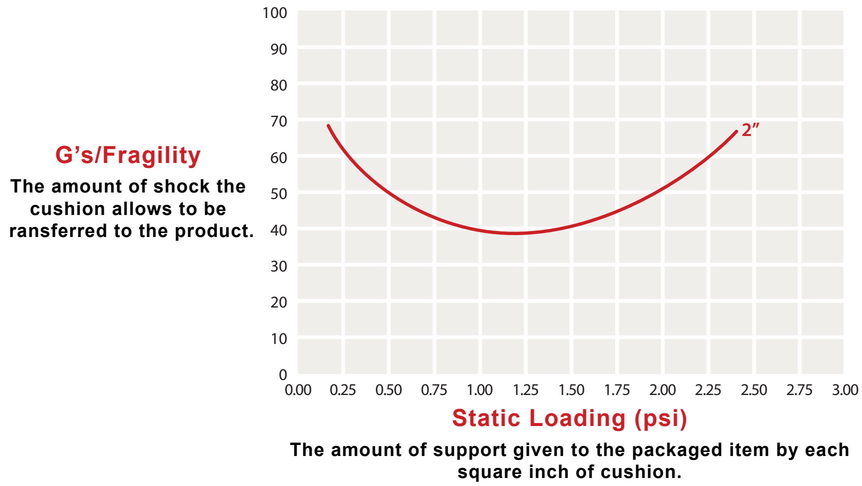
SECOND THRU FIFTH IMPACT/DROP

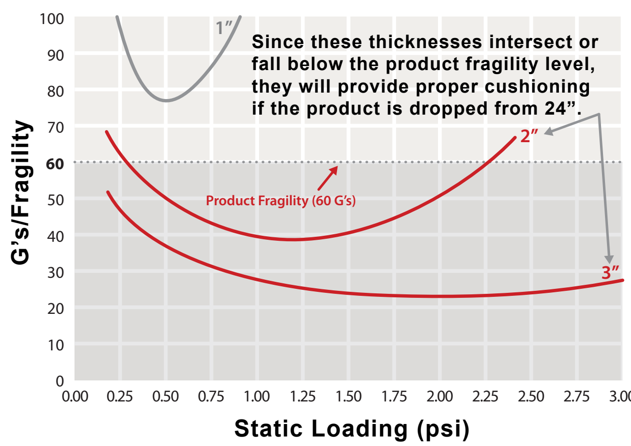


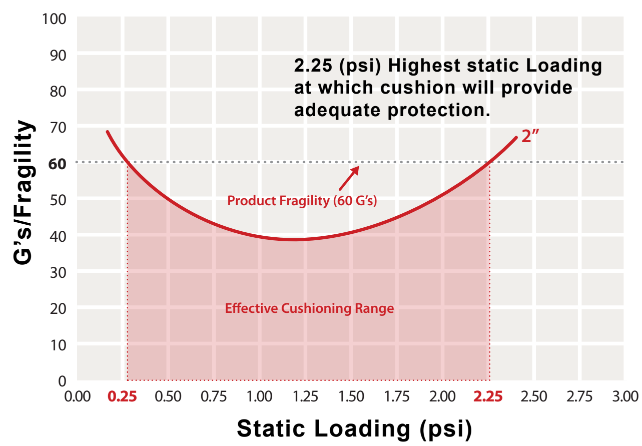
Note: 20 g/l = 1.25 pcf = 45X (g/l = grams per liter; pcf = pounds per cubic foot; X = foam expansion ratio)

CALCULATING CUSHION CURVES

Determine how much foam is required to support the weight or load of the part while still absorbing the shock impact from the selected drop height. The following cushion curve example is for EPE13 with a 24” drop height, multiple drops, at 60 G’s.







CUSHION CURVE CALCULATION STEPS

1. Select several material cushion curves that meet the drop height conditions for single or multiple drops.
2. Locate the product fragility level on the vertical axis of the cushion curve and draw a horizontal line across the curve to separate the chart into two sections. The area below the 60 G’s fragility line represents the safe zone while the area above the 60 G’s fragility line represents the unsafe zone.
3. Choose a thickness of 2” as the thinnest cushion thickness to protect the part while staying below the 60 G’s line and in the safe zone.
4. Note that the static load range is between .25 – 2.25 psi , meaning a static load can be applied anywhere in this range. Typically, choosing a higher static loading value means less cushioning material is needed while still providing adequate protection.
5. The cushion bearing area is calculated by dividing the product’s weight by the chosen static loading. **In most cases EPE and or EPP will allow the designer to use less foam to support and protect the same part.**
6. After the material has been selected decide how to distribute the load in the package to protect all parts of the shipped component. Consider the unit’s profile, loading points and peripheral equipment. Modify the design as required and document any design changes.
7. Repeat the above procedure to generate comparisons which allow you to balance between material cost and package size.

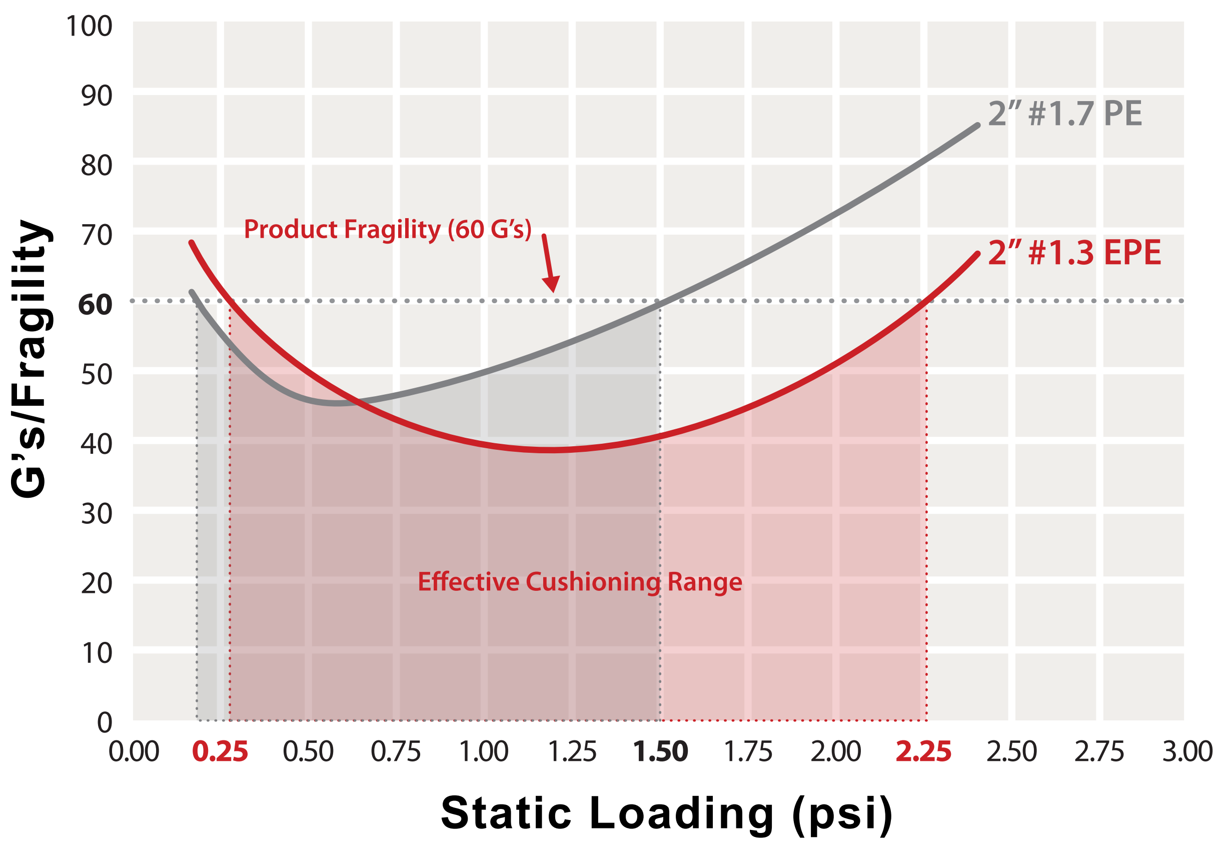
ARFLEX 2000 VS. #1.7 PE DESIGN EXAMPLE

A 10" cube weighing #40 with a fragility of 60 G's will face repeated impacts during shipment.

The typical drop height for this product's weight is 24". Select different EPE and EPP using the 2nd - 5th, 24" cushion curves. Determine the nominal material thickness required, based on the part's available surface bearing area along with yield considerations.

Next, locate the product's fragility level on the vertical axis and draw an imaginary horizontal line across the curve chart at this level. The section below the fragility line is where the packaged item will be able to survive the anticipated shock level. The section above the fragility line is where the shock level is high enough to damage the product.

Choose the 2" thick material for the thinnest cushion thickness while being below the 60 G's safe zone. In this case, the material cushioning range for EPE13 will support a load between .50 psi - 2.15 psi based on the cushion curve data.



Note, that the EPE 13 material has a wider loading range than traditional #1.7 PE foam.

DESIGN EXAMPLE, CONTINUED

The cushions surface bearing area is calculated by dividing the packaged part's weight by the static loading amount chosen.

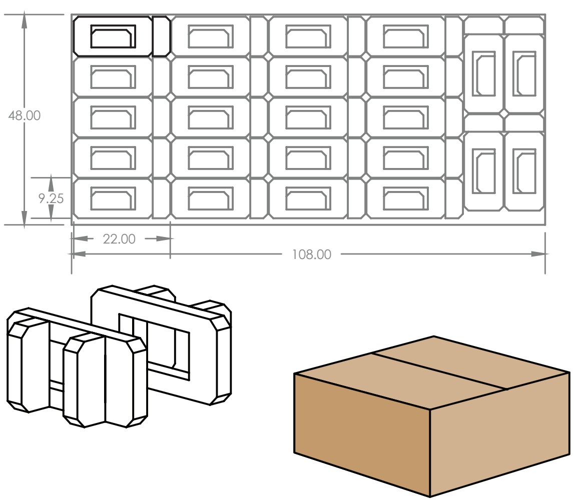
	Minimum	Ideal	Maximum
Static Loading (psi)	EPE13 .25 psi #1.7PE .25 psi	**EPE13 1.25 psi #1.7PE .50 psi**	EPE13 2.25 psi #1.7PE 1.50psi
Bearing Area (per side)	160 sq. in. 160 sq. in	**EPE13 32 sq. in #1.7PE 80 sq. in**	EPE13 17.7 sq. in #1.7 26.6 sq. in

Designing to the minimum thickness is the general practice. In most cases, the use of EPE or EPP will allow for using less bearing area compared to extruded PE materials resulting in cost savings and smaller cube sizes.

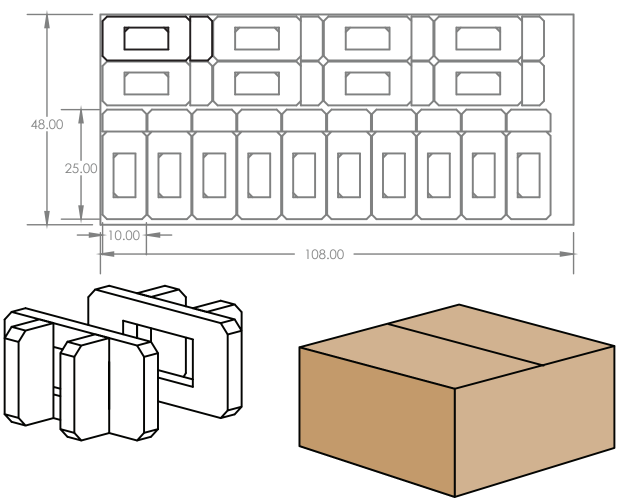
After the material has been selected decide how to distribute the load in the package to protect all parts of the shipped component. Consider the unit's profile, loading points and peripheral equipment.

Be careful to not overload the cushion which risks the possibility of the part bottoming out through the foam. Also consider the part's specific configuration and its center of gravity. Distribute the foam's surface bearing area according to the part's weight distribution.

Material: Arflex Sheet Yield: 24 PCS



Material: #1.7PE Sheet Yield: 18 PCS



THE POTENTIAL COST SAVINGS FOR CUBE OPTIMIZATION ARE SUBSTANTIAL.

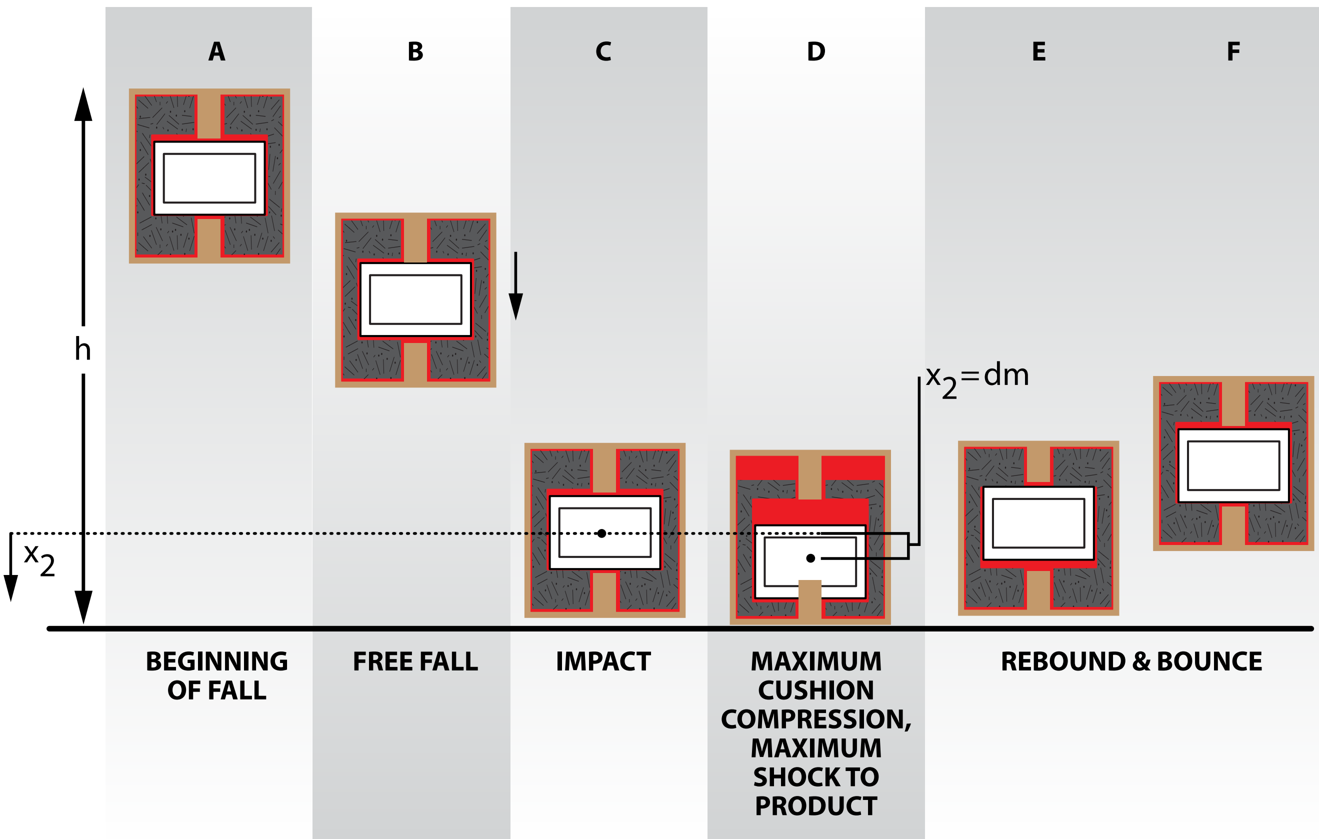
- Less raw material cost: foam, corrugated and any other packaging products included to secure the shipped parts.
- Reduced fuel and shipping costs with smaller package designs.
- Less oversized shipping cost. EPE and EPP designs can reduce the shipping class.
- More parts per pallet resulting in lower warehousing costs.
- Less material entering the waste stream.

SHOCK IMPACT CONSIDERATIONS FOR PACKAGE DESIGN

As shown in the Figure below, a package will rebound a little or a lot depending on the drop height, part weight, density, thickness and the surface that it hits.

A mechanical shock occurs when an object's position, velocity or acceleration suddenly changes. A typical package shock may be 20 milliseconds long in duration and may drop from a height or magnitude of 115 G's.

THE IMPACT OF A PRODUCT-PACKAGE SYSTEM



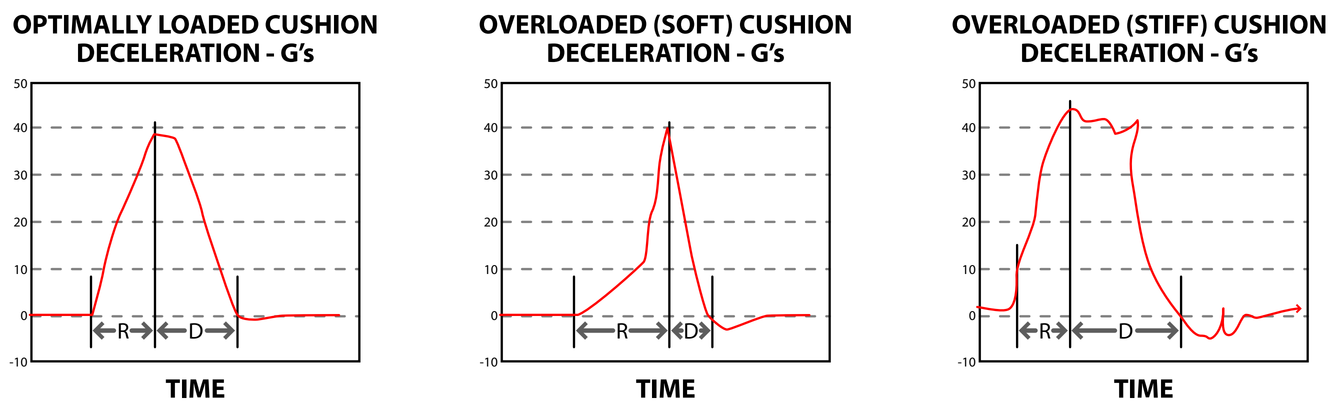
DROP TESTING/SHOCK IMPACT

The diagram below outlines the relationship between the cushions shock response, the foam's stiffness and the foam's compressive strength. Typically referred to as drop testing, the package is subjected to a series of flat impacts. At impact the package part decelerates through the foam cushion and is measured with an accelerometer mounted to the product.

Expect the rise time of a shock response pulse to be 30-50% of the total pulse duration. **A shorter rise time indicates that the cushion is too stiff or too lightly loaded. A longer rise time indicates that the cushion is too flexible or is overloaded.**

A sharp spike at the end of the waveform indicates that the loading is too light. A sharp spike near the end of the wave form indicates that the loading is too great.

SHOCK RESPONSE TESTING DIAGRAM



R= Pulse Rise Time D=Pulse Decay Time

During testing the position of the accelerometer must be as rigid as possible and as close to the interface of the product and cushion as possible. Care must be taken that all impacts are flat. The difference between a flat drop and an "almost flat" drop can substantially change the response acceleration.

Another potential issue when drop testing is that the product may be rotating within the cushion on impact. Product rotation is usually an indication that the cushion material is not properly distributed in relation to the product's weight.

Typical drop and shock test procedure are ASTM D775 or similar. ASTM D4169 is a shock integrity test involving a series of drops on corners and edges. Other test specifications such as ISTA combine flat and edge/corner drops in one sequence.

INFLUENCE OF RIBS

The surface bearing area of the shipped parts is always smaller than that of the package being used to protect the part so the use of additional protective ribs are necessary to help protect the part from damage.

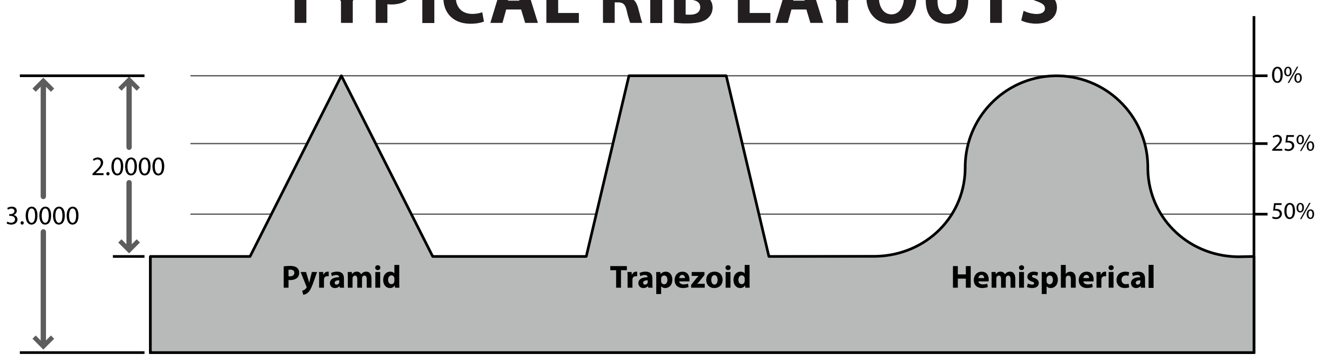
To be effective, ribs must be opposite the interior bearing area of the product. Typically, for square parts use one rib at each corner and for rectangular parts use two ribs per corner if possible.

As a rule of thumb the rib's depth should not exceed 50-65% of the total cushion thickness. The use of ribs results in both higher loading and greater deflection of the remaining material, so they must be placed carefully in the design.

Keep in mind that a high depth to width ratio may cause any foam to buckle. **As a rule of thumb, the height to width ratio should be 1:1.4 for EPE and 1:1.2 for EPP.**

For example, if the EPE material chosen is 2" thick the ribs should be 2.8" wide and 2.12" for EPP material.

TYPICAL RIB LAYOUTS



- *Ribs at 0 % deflection should be loaded at 200% the suggested static cushion curve recommendation.*
- *Ribs at 25% deflection should be loaded at suggested static cushion recommendations.*
- *Ribs at 50% deflection should be loaded at one half suggested static cushion recommendations.*

DESIGN-VIBRATION

The probability of vibration input during transit is 100%. Each mode of transportation such as truck, rail, aircraft and ships subjects the package component to different levels of vibration at different frequencies.

Each packaging material being used to protect shipped parts has a range of vibration frequencies some of which may amplify and transfer a more severe vibration to the packaged component.

TYPICAL RESONANCE FREQUENCIES OF CARRIERS

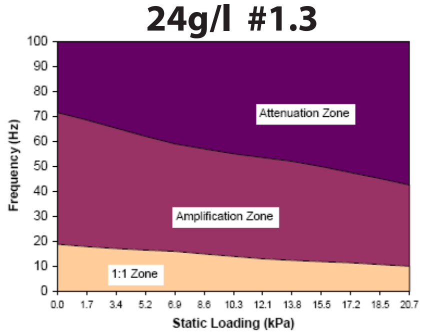
TRAIN/RAILROAD	2 - 10 Hz (suspension) 50 - 70 Hz (structural)	Moving rail car over rail tracks
TRUCK	2 - 10 Hz (suspension) 15 - 25 Hz (tires) 50 - 70 Hz (structural)	Normal highway travel
AIRCRAFT	2 - 10 Hz (propeller) 50 - 70 Hz (jet engine)	Aircraft structure during normal flight
SHIPBOARD	10 Hz (on deck) 100 Hz (structure/bulkheads)	Vibrations caused by normal shipboard travel due to the flow of water around the ship and from any imbalance and misalignment of the propeller drive shaft system.

EPE and EPP vibration response curves will help you estimate whether the package will perform in one of three vibration frequency ranges: direct coupling, amplification or attenuation mode.

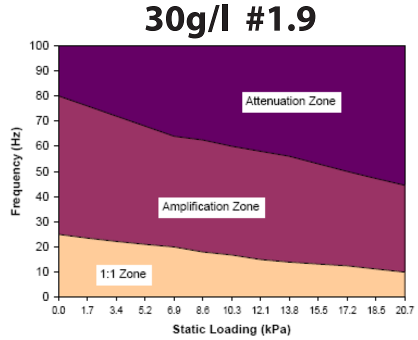
When using the vibration response curves select the appropriate vibration response plot for the foam material selected to protect the shipped part. Then select the minimum static loading by determining the intersection of the attenuation boundary with the lowest vibration frequency.

VIBRATION RESPONSE FOR #1.3 - #2.8 EPP

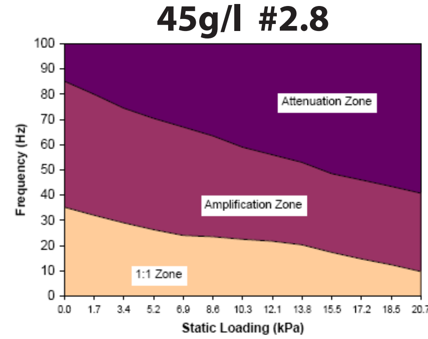
24g/l #1.3



30g/l #1.9



45g/l #2.8



THREE VIBRATION RESPONSE FREQUENCY ZONES ASSOCIATED WITH SHIPPED PARTS:

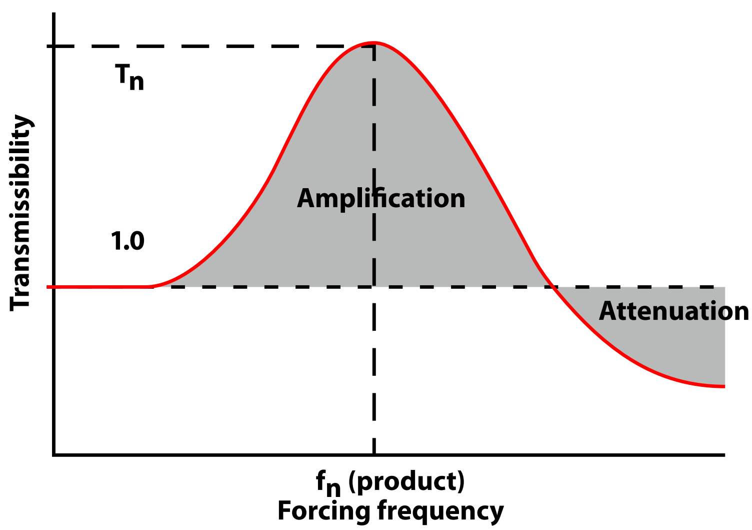
COUPLING ZONE: The vibration frequencies are lower than the amplification range of the packaging materials being shipped. In these cases the packaging material is within the 1:1 range to the external container. The coupling zone is considered a neutral or safe vibration level.

AMPLIFICATION ZONE: The vibration forces transmitted by the packaging materials are greater than the natural vibration forces from the specific mode of transportation. The amplification zone is considered a unsafe or possible damage zone.

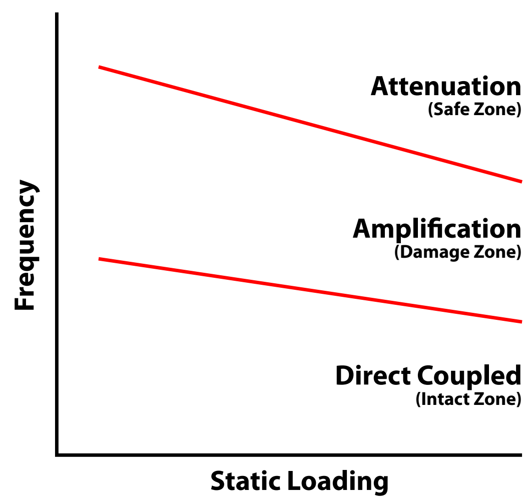
The packaging designer can modify or tune the foam's vibration response by changing the surface contact area to a level where attenuation is reached. For both EPE and EPP higher loading is generally better to help attenuate the packaging material with the packaged part.

ATTENUATION ZONE: Frequencies are higher than the amplification range where the packaging material will attenuate or absorb the transmitted vibration within the packaging materials and reduce the severity of the vibration to the packaged component.

TYPICAL VIBRATION RESPONSE CHARACTERISTIC OF A PRODUCT



TYPICAL VIBRATION RESPONSE OF A CUSHIONING MATERIAL



EPE & EPP: DESIGN BENEFITS

Both EPE and EPP are very predictable design materials. EPE and EPP will protect shipped components from damage with the same degree of shock absorption from any direction. The material's compressive strength values are the same in all drop directions and will respond to repeated dynamic impact with very little deformation.

EPE and EPP materials offer excellent protection for longer shipping cycles, multiple drop protection and improved package reliability.

Item	EPP (Expanded Polypropylene)	EPE (Expanded Polyethylene)	PE (Extruded Polyethylene)	XPE (Crosslink)
Product Examples	ARPRO	ARPAK	Extruded PE	Chemical Crosslink
Compression Strength	**Excellent**	Average	Average	Average
Durability	Good	Good	Good	Excellent
Elasticity	Good	**Excellent**	Excellent	Excellent
Flexibility	Good	**Excellent**	Excellent	Excellent
Tensile Strength	**Excellent**	**Excellent**	Excellent	Good
Chemical Resistance	**Excellent**	**Excellent**	Excellent	Excellent
Heat Resistance	**Excellent**	Average	Average	Poor
Thermal Insulation	Good	Good	Average	Average
Dimensional Stability	**Excellent**	Average	Average	Poor
Dynamic Cushion 1st Drop	Good	Good	Good	Good
Repetitive Dynamic Cushion	**Excellent**	**Excellent**	Good	Good
Contains HCFC's or VOC's	No	No	Yes	Yes
Amount of VOC's	N/A	N/A	Varies	Varies

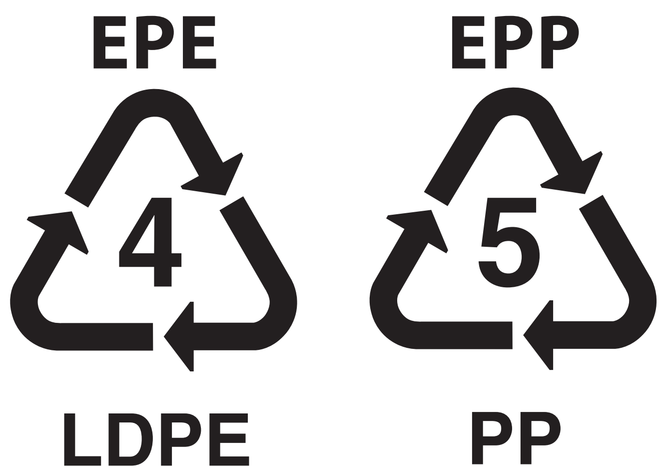
PROTOTYPING & TESTING

It is highly recommended that you build and test a prototype of your protective foam cushion design to determine its actual performance. The layout, fabrication techniques, part orientation, container size, and testing methods are different for virtually every design.

Physical testing in a lab environment or live field testing is always required to verify the design results for the given application conditions.

RECYCLING

Both EPE and EPP are 100% recyclable. Please contact us for additional recycling questions.



DESIGN WORKSHEET

www.arplanksales.com

Customer: ____________________
Contact: ____________________
Design Request: ____________________
Part Number: ____________________
Re-Design: ____________________
End User: ____________________

Date: ____________________
REF. No.: ____________________
Sales Rep.: ____________________
Distributor: ____________________

Weight (lbs.): ____________________
Fragility (G's): ____________________
Dimensions: ____________________
Weight: ____________________
Drop Height: ____________________
Drop Test Specification: ____________________

	Minimum	Ideal	Maximum
Static Loading (PSI):			
Bearing Area (Per Side):			
Material:			
Thickness:			

Container Style: ____________________
Container Size: ____________________
Palletised/Unit Load: ____________________
Vibration Test Specification: ____________________
Other Criteria/Comments: ____________________