# Expanded Polypropylene

# Design Guide

April 2012

## Utilization of Expanded Polypropylene (EPP) in Component or Product Designs:

EPP has successfully been utilized in a variety of industries and applications where it is well suited to solve a number of common and difficult design, application and manufacturing problems.

### Industry Examples (Not limited to these):

- Transportation (Automotive, etc.)
- Consumer Electronics
- Medical Devices
- Industrial Systems
- Household Appliances
- Returnable Systems

### Differentiated Solution Areas:

- Sound Absorption
- Sound Transmission Reduction
- Component Cooling Efficiency Improvements
- Thermal Insulation
- Vibration Dampening and Isolation
- Electrical Insulation
- Tuning of Sound and Vibration Dampening/Absorption Possible Within Design Parameters
- Product Weight Reduction
- Component Housing Part Reduction
- Fastening and Mounting Hardware Part Reduction
- Increased Product and Component Protection from Shock & Vibration
- Assembly Time Reduction
- Serviceability Time Improvement
- Reduction in Transport Packaging
- Anti-Static Properties
- Can Meet Many Flammability Requirements (UL, FMVSS, ASTM, etc.)
- 100% Recyclable
- Excellent Chemical Resistance
- RoHS Compliant
- No Phthalates
- CFC Free

### Material Properties:

- Data Provided at Different Density Values
- Thermal properties Generally Acceptable within 110°C to -40°C, but are stress dependent.

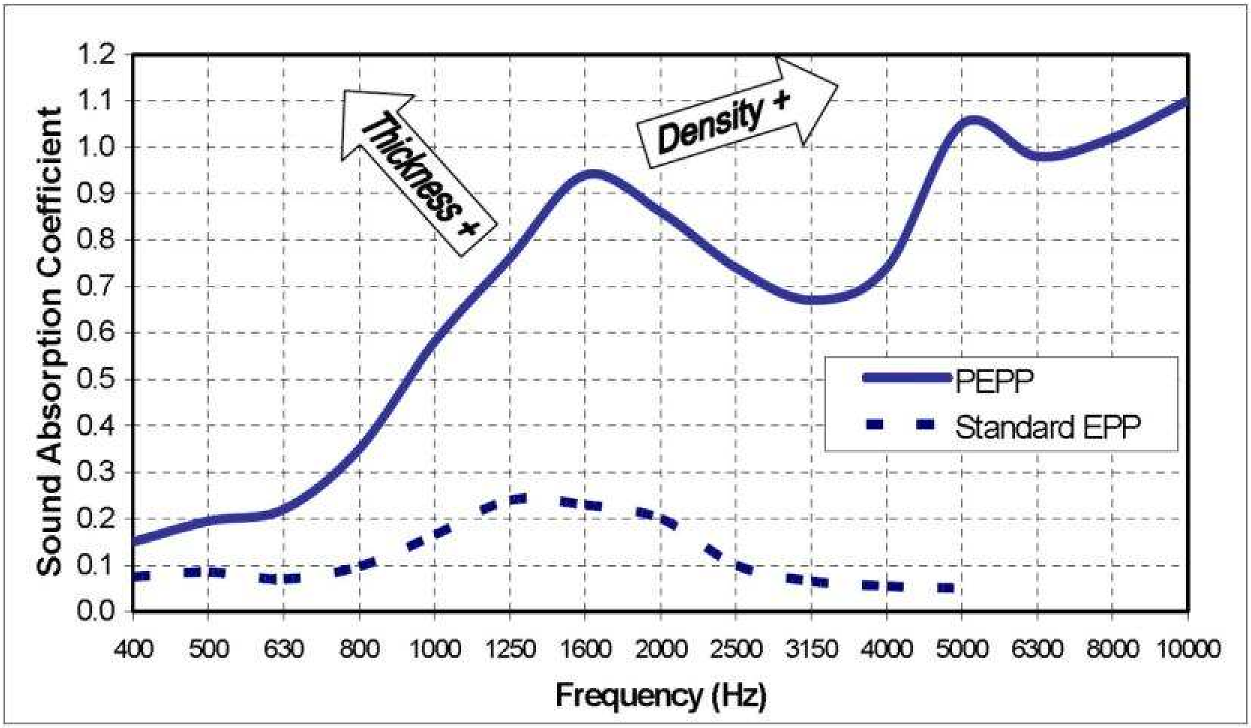
| PHYSICAL PROPERTY | TEST METHOD | UNITS | TEST RESULTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Density | ASTM-D3575 | grams/liter | 20 | 30 | 45 | 60 | 67 | 82 | 90 |
| Compressive Strength<br>@25% Strain<br>@50% Strain<br>@75% Strain | ASTM-D3575 | MPa | 0.10<br>0.16<br>0.31 | 0.16<br>0.23<br>0.44 | 0.28<br>0.37<br>0.77 | 0.39<br>0.53<br>1.07 | 0.44<br>0.58<br>1.26 | 0.60<br>0.80<br>1.80 | 0.69<br>0.93<br>2.08 |
| Compression Set | ASTM-D3575 | % | 14 | 12 | 12 | 11 | 11 | 10 | 10 |
| Tensile Strength | ASTM-D3575 | MPa | 0.26 | 0.38 | 0.46 | 0.62 | 0.71 | 0.87 | 0.97 |
| Tensile Elongation | ASTM-D3575 | % | 15 | 15 | 14 | 14 | 13 | 13 | 12 |
| Tear Strength | ASTM-D3575 | KN/m | 1.74 | 2.13 | 2.73 | 3.25 | 3.51 | 4.07 | 4.35 |
| Flexural Strength | ASTM-D790 | MPa | .21 | .38 | .54 | .72 | .86 | 1.08 | 1.16 |
| Flexural Modulus | ASTM-D790 | MPa | 9.8 | 11.6 | 14.5 | 19.0 | 22.2 | 28.9 | 31.1 |
| Coefficient of Linear Thermal Expansion<br>20°C to -40°C<br>20°C to 80°C | ASTM-D696 | mm/mm/°C x $10^{-5}$ | 6.8<br>10.8 | 5.9<br>10.2 | 5.5<br>9.8 | 4.3<br>8.7 | 4.1<br>7.9 | 3.9<br>7.5 | 3.7<br>6.8 |
| Water Absorption | ASTM-C272 | gms/cc x $10^{-3}$ | 10.4 | 8.1 | 6.2 | 5.1 | 4.5 | 4.2 | 3.5 |
| Flammability | FMVSS 302 | < 100 mm/min. | Pass | Pass | Pass | Pass | Pass | Pass | Pass |
| Chemical Resistance (Auto fuels, fluids, solvents) | Various | 1 hr exposure | Pass | Pass | Pass | Pass | Pass | Pass | Pass |

Note: Data for JSP ARPRO® White/Colored Material (3000/7000 Series) and Black Material (5000 Series). Typical Values Shown.

| PHYSICAL PROPERTY | TEST METHOD | UNITS | TEST RESULTS | | | | | |
|---|---|---|---|---|---|---|---|---|
| Density | ASTM-D3575 | grams/liter | 106 | 120 | 150 | 180 | 200 | 225 |
| Compressive Strength<br>@25% Strain<br>@50% Strain<br>@75% Strain | ASTM-D3575 | MPa | 0.87<br>1.20<br>2.90 | 1.02<br>1.45<br>3.70 | 1.50<br>2.18<br>5.80 | 1.95<br>3.00<br>8.25 | 2.05<br>3.30<br>9.90 | 2.80<br>4.10<br>13.50 |
| Compression Set | ASTM-D3575 | % | 10 | 10 | 11 | 11 | 12 | 12 |
| Tensile Strength | ASTM-D3575 | MPa | 1.05 | 1.21 | 1.37 | 1.42 | 1.46 | 1.51 |
| Tensile Elongation | ASTM-D3575 | % | 12 | 11 | 11 | 10 | 10 | 9 |
| Tear Strength | ASTM-D3575 | KN/m | 4.86 | 5.15 | 5.77 | 6.36 | 6.80 | 7.33 |
| Flexural Strength | ASTM-D790 | MPa | 1.4 | 1.58 | 1.9 | 2.4 | 2.65 | 2.95 |
| Flexural Modulus | ASTM-D790 | MPa | 41.0 | 58.0 | 73.0 | 87.0 | 96.0 | 109.0 |
| Coefficient of Linear Thermal Expansion<br>20°C to -40°C<br>20°C to 80°C | ASTM-D696 | mm/mm/°C x $10^{-5}$ | 3.6<br>6.8 | 3.4<br>5.6 | 3.2<br>4.7 | 2.9<br>3.7 | 2.6<br>3.2 | 2.2<br>2.9 |
| Water Absorption | ASTM-C272 | gms/cc x $10^{-3}$ | 3.1 | 2.7 | 2.3 | 1.9 | 1.7 | 1.3 |
| Flammability | FMVSS-302 | < 100 mm/min. | Pass | Pass | Pass | Pass | Pass | Pass |
| Chemical Resistance (Auto fuels, fluids, solvents) | Various | 1 hr exposure | Pass | Pass | Pass | Pass | Pass | Pass |

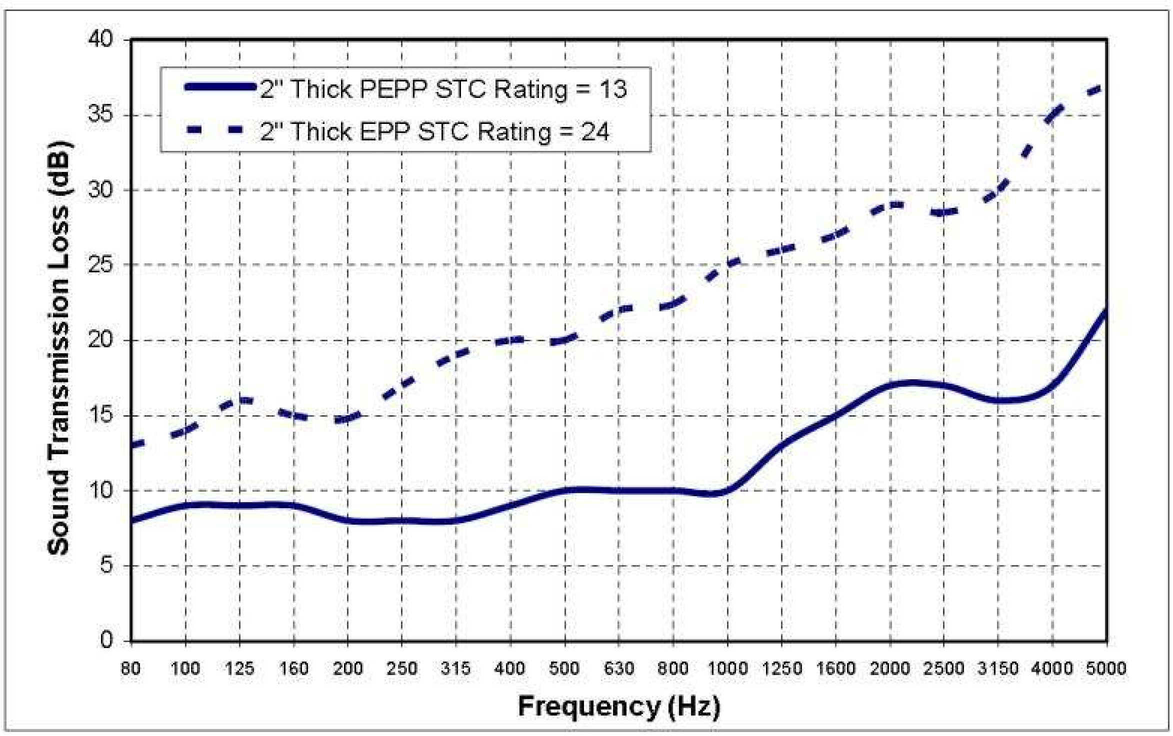
## **Acoustic Properties:** Sound Absorption

Note: PEPP is a special porous grade of EPP designed for acoustic performance (See appendix)




Density: 2.8 pcf (45 g/l), Thickness: 1.2 " (30 mm)

Sound Transmission Loss




Note: Tested per ASTM E90

Density: 2.8 pcf (45 g/l)

## Vibration Dampening

- Good vibration dampening and even isolation can be readily achieved with EPP. This is highly application specific engineered on an ad hoc basis.

## Flame Retardant Properties:

- Un-modified bead can meet:
  - FMVSS-302
  - UL-94 HBF (13mm wall thickness @ a minimum density of 60gm/l in standard black color)
  - UL-94 HBF (13mm wall thickness @ a minimum density of 45gm/l in white color)
- Modified bead can meet
  - UL-94 HF1(7mm wall thickness @ a minimum density of 45 gm/l)
  - UL-94 V0 (13mm wall thickness @ a minimum density of 45 gm/l)
  - ASTM-E84 Flame Spread and Smoke Development
  - See Appendix for more details on FR material properties

## Electrical Properties:

- Standard EPP
  - Surface Resistivity: >10 x $10^{14}$ ohms/square
- Specialty Anti-Stat Grades of EPP Available
  - Surface Resistivity: >10 x $10^{12}$ ohms/square
  - Surface Resistivity: >10 x $10^{7}$ ohms/square

## Chemical Resistant Properties:

- EPP has very good chemical resistance overall, with resiliency against acids and alkaline's, solvents, grease, oil, etc. A comprehensive guide to chemical resistance is published and available.

## Ultraviolet Radiation Resistance:

- EPP has good UV resistance for most applications. Long-term exposure primarily affects surface color while some embrittlement, chalking and crazing can occur depending on exposure levels and durations. Data is published and available

## Humidity and Water Resistance:

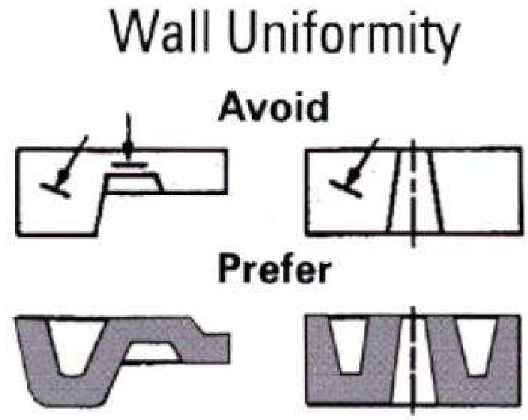
- EPP has very good resistance to humidity and water exposure. Typical water absorption is 0.1% to 0.3% by volume after 24 hours submersion and 0.6% after 1 week. See property data for more detail.

## Design Guidelines:

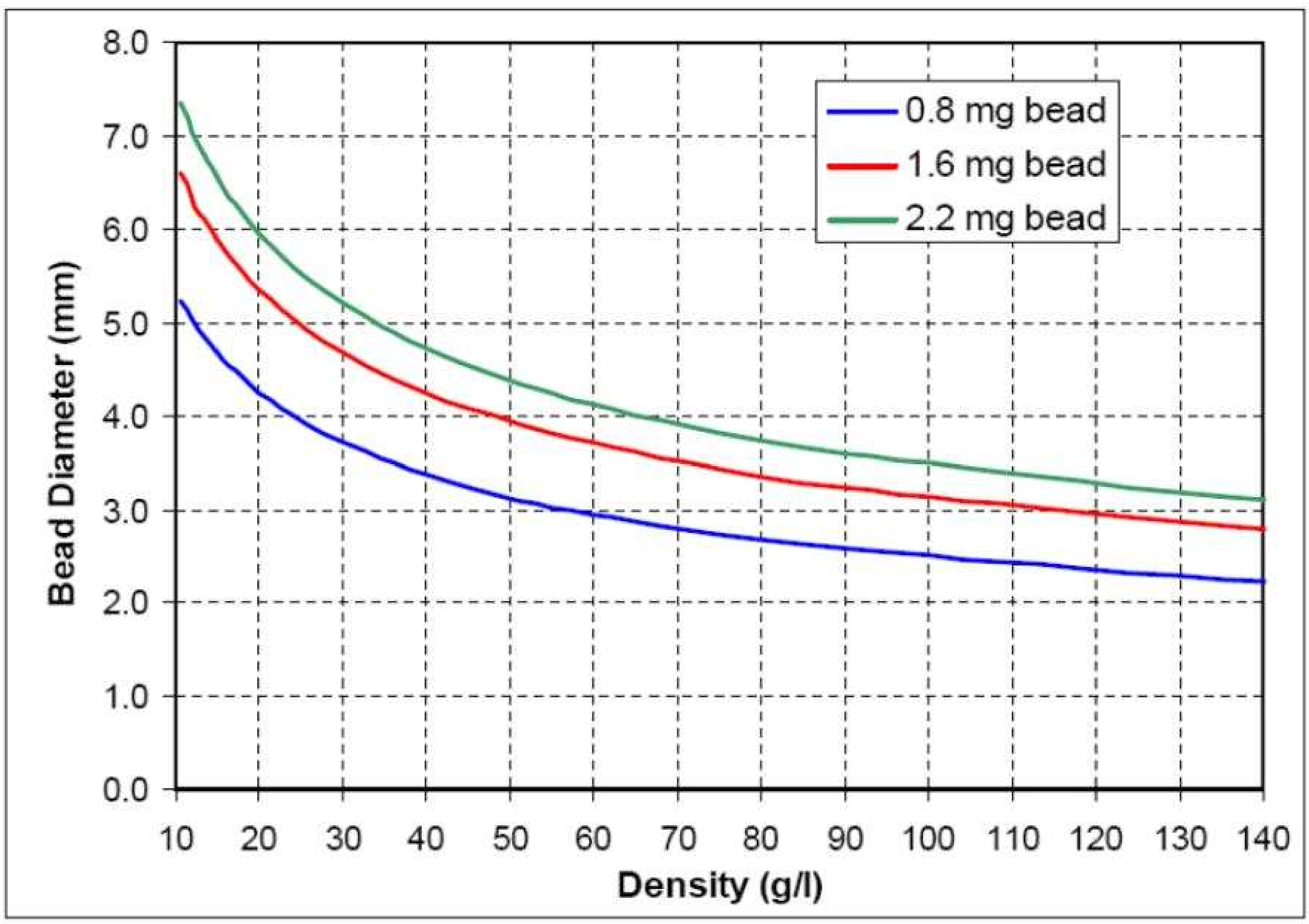
As with most product designs, designing with EPP begins with the mechanical architecture. In this context, system architecture refers to the logical arrangement of all components in a given 3-D volume. In most cases, the outer dimensions and interfaces are driven by the industrial design. The best results from EPP are typically obtained when the application is designed from the beginning with EPP in mind (rather than designed for sheet metal and/or plastic concepts and then converted to EPP). Knowing the design rules, hints, tricks and limitations prior to this step will help you achieve optimum results in working with EPP.

**Sizes, Ratios, Etc.**
The following guidelines give readers the recommended ranges for most of the important design parameters. If you find these guidelines too limiting, please consult the Protexic engineering staff to discuss tooling, process and/or mechanical tradeoffs. Techniques exist which can help minimize some of these general design limitations.

**Wall Thickness**
To support good filling of the part, minimum wall thickness should be 8 mm (Note smaller wall thicknesses around 3-4 mm are achievable and depend on bead size, wall height to width ratio and manufacturing parameters). See additional detail below. Please note that most of the current UL 94 material listings require a minimum wall thickness of 8 mm. With typical bead diameters of 4 mm, you want to have at least two layers of pellets. Certain techniques are available to produce parts with thinner wall sections.

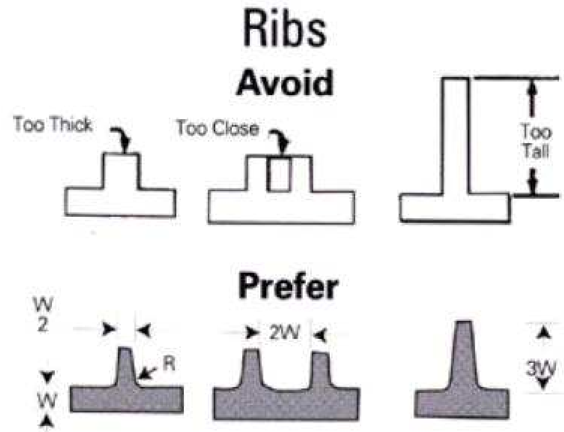



Bead Size vs. Density (Note: Standard Grade is 1.6 mg)

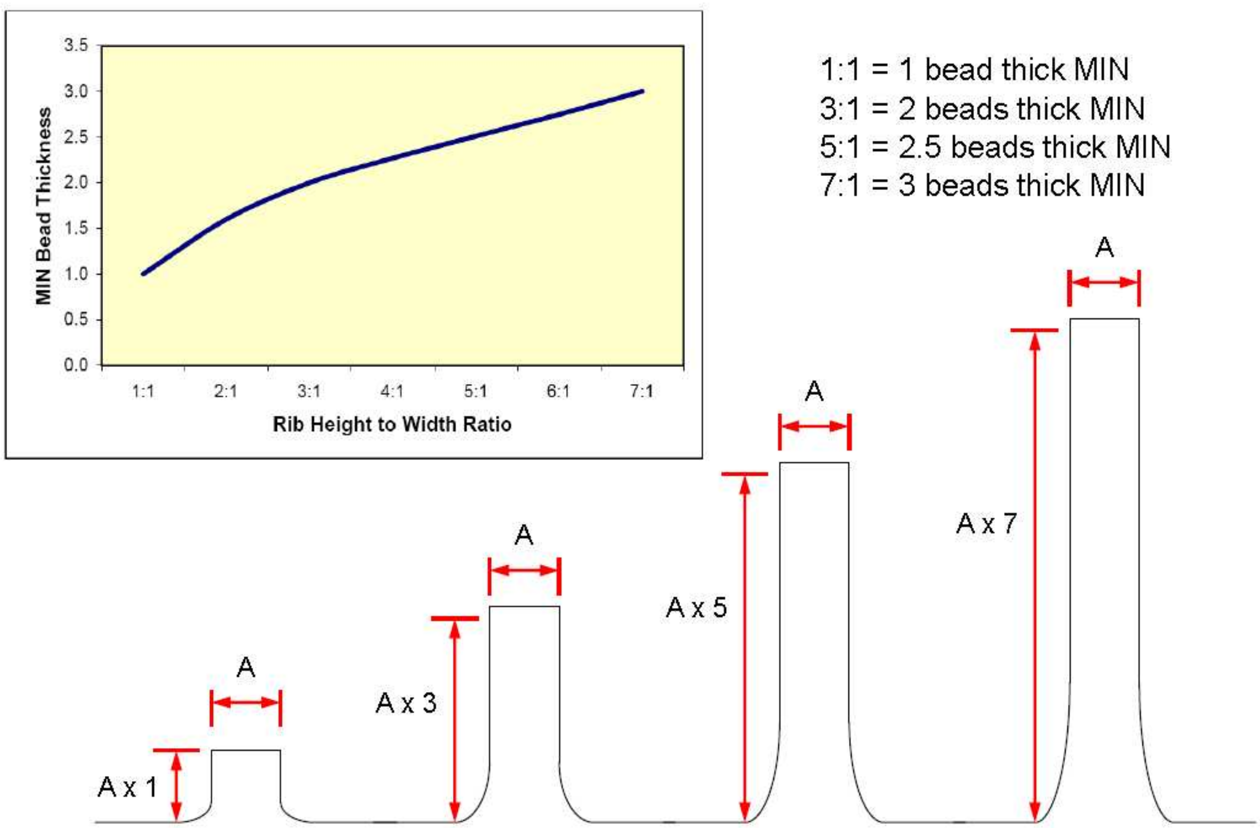


**Ribs**

A wall is defined when the dimensions in X-Y are larger than the thickness D. Unlike a wall, a rib is defined as a feature with an aspect ratio (h/t) of less than 1.2. Part markings, such as raised lettering, are a form of ribs which can be easily included in your part design. Letter size should be >6 mm. You may wish to consider negative letters, rather than raised letters, since negative letters tend to minimize fill problems.

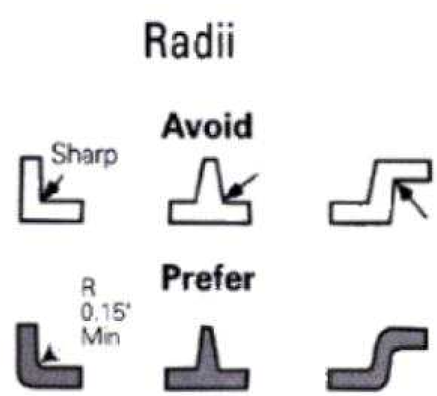



Dimensional Design Guide: Height to Width Ratio of Ribs




**Radii**

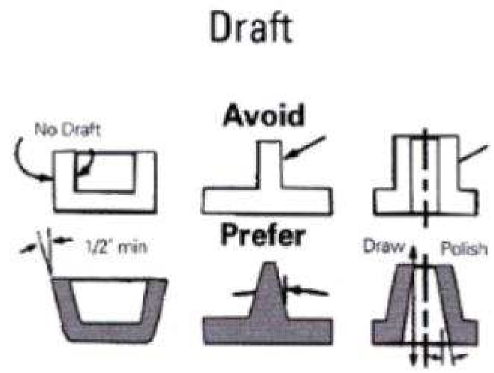
To support sufficient mold filling, allow radii of 0.3 mm on edges (cavity side). Avoid radii on the parting line and on the core edges. Definition of the parting line should be done together with the toolmaker. Allow flash of 0.2 to 1.0 mm on the parting line.



**Filling**
Aspects of the material and the molding process both require specific consideration during the part design process. As described previously, the foam plastic beads (or pellets) are blown into the steam chest with pressurized air. This contrasts with the injection molding process, where a homogeneous liquid is injected into the cavity to fill the mold. Consequently, complicated and/or very thin filling sections should be avoided for EPP parts.

**Fill Gun, Ejectors**
Typically, fill gun and ejector placement are on the cavity side. Provide a plane surface of at least 20 mm diameter. If required, the fill gun diameter can be reduced in diameter to 16 mm. For complex part geometry, more than one fill gun may be necessary to support even filling. Ejectors are typically four per cavity.

**Draft Angles**
To ease part ejection, allow a typical 1° draft angle. As you would with an injection molded part, designate the location for the draft since the applied draft will reduce the volume of the part. Especially for parts with a low aspect ratio (width to height) and complex geometry (many surfaces), allow draft of more than 1° for better ejection.




**Tolerance**
The elasticity of the material helps compensate for the component tolerances as well as for the manufacturing tolerances of the part itself. Generally speaking, EPP parts should be over designed (interference fit). To avoid too high forces and deflections, provide compression ribs.

The following are the recommended tolerances for EPP designs:

| Part Dimensions (mm) | Typical Tolerance (+/- in mm) | Functional Tolerance (+/- in mm) |
|---|---|---|
| **0 to 30** | **0.3** | **0.2** |
| **30 to 120** | **0.5** | **0.3** |
| **120 to 140** | **0.8** | **0.4** |
| **140 to 400** | **1.0 or 5%** | **0.5** |

**Additional Considerations when Designing with EPP**
- A range of fasteners, inserts and accessories are available and designed specifically for EPP.
- A large variety of colors and textures are available (See appendix for examples)

## Appendix:

## PEPP Material Properties

| PHYSICAL PROPERTY | TEST METHOD | UNITS | TEST RESULTS | | |
|---|---|---|---|---|---|
| Density | ASTM-D3575 | pcf (g/l) | 1.6 (25) | 2.8 (45) | 3.7 (60) |
| Porosity[1] | JSPI Internal | % | 30 | 30 | 30 |
| Compressive Strength<br>@25% Strain<br>@50% Strain<br>@75% Strain | ASTM-D3575 | <br>psi<br>psi<br>psi | <br>10.0<br>17.0<br>48.0 | <br>23.0<br>35.0<br>79.0 | <br>33.0<br>50.0<br>115.0 |
| Compression Set | ASTM-D3575 | % | 8.0 | 9.0 | 9.0 |
| Tensile Strength | ASTM-D3575 | psi | 22.0 | 27.0 | 28.0 |
| Tensile Elongation | ASTM-D3575 | % | 15.0 | 13.0 | 12.0 |
| Tear Strength | ASTM-D3575 | lbs/inch | 14.5 | 18.8 | 22.0 |
| Thermal Conductivity | ASTM-C177<br>@ 75°F | (K) BTU-in/($ft^2$-hr-°F) | 0.26 | 0.25 | 0.25 |
| Thermal Stability<br>Linear Dimensional Change | ASTM-D3575<br>24 hrs @ 225°F | % | < 1.0% | < 1.0% | < 1.0% |
| Thermal Resistance | ASTM-C177 | (R) | 3.8 | 4.0 | 4.0 |
| Coefficient of Linear<br>Thermal Expansion<br>70°F to -40°F<br>70°F to 180°F | <br>ASTM-D696 | <br><br>in/in/°F x $10^{-5}$<br>in/in/°F x $10^{-5}$ | <br><br>7.5<br>11.5 | <br><br>6.4<br>10.8 | <br><br>5.0<br>9.7 |
| Water Vapor Permeability | ASTM-E96 | lbs/$ft^2$/hr/mmHg | 7.5 x $10^{-5}$ | 6.6 x $10^{-5}$ | 5.9 x $10^{-5}$ |
| Water Absorption | ASTM-C272 | lbs/$in^3$ x $10^{-3}$ | 7.2 | 6.5 | 5.3 |
| Flammability | FMVSS-302 | < 4.0 in/min. | Pass | Pass | Pass |
| Chemical Resistance<br>(Auto fuels, fluids, solvents) | Various | 1 hr exposure | Pass | Pass | Pass |

## FR EPP and PEPP Material Properties

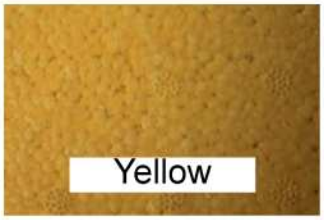
Material Properties for Fire Retardant EPP Beads

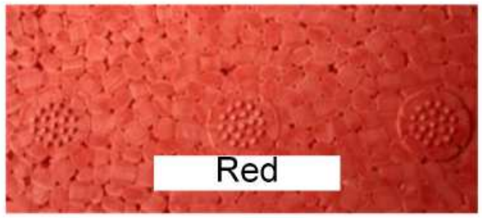
| PHYSICAL PROPERTY | TEST METHOD | UNITS | RESULTS |
|---|---|---|---|
| Density | ASTM-D3575 | pcf (g/l) | 2.8 (45) |
| Compressive Strength<br>@25% Strain<br>@50% Strain<br>@75% Strain | ASTM-D3575 | <br>psi<br>psi<br>psi | <br>41.0<br>54.0<br>110.0 |
| Compression Set | ASTM-D3575 | % | 11.0 |
| Tensile Strength | ASTM-D3575 | psi | 67.0 |
| Tensile Elongation | ASTM-D3575 | % | 12.0 |
| Tear Strength | ASTM-D3575 | lbs/inch | 16.0 |
| Thermal Conductivity | ASTM-C177<br>@ 75°F | (K) BTU-in/(ft$^2$-hr-°F) | 0.24 |
| Thermal Stability<br>inear Dimensional Change | ASTM-D3575<br>24 hrs @ 225°F | % | < 1.0% |
| Thermal Resistance | ASTM-C177 | (R) | 4.2 |
| Coefficient of Linear<br>Thermal Expansion<br>70°F to -40°F<br>70°F to 180°F | ASTM-D696 | <br><br>in/in/°F x 10$^{-5}$<br>in/in/°F x 10$^{-5}$ | <br><br>3.1<br>5.4 |
| Water Absorption | ASTM-C272 | % | <1.0 |
| Flammability | FMVSS-302<br>ASTM-E84<br>ASTM-E84<br>UL-94 | < 4.0 in/min.<br>Flame Spread Index[1]<br>Smoke Development Index[1]<br>Flame Class[2] | Pass<br><20 (1" thk)<br><25 (2" thk)<br><200 (1" thk)<br><300 (2" thk)<br>HF1/HF2 |
| Chemical Resistance<br>(Auto fuels, fluids, solvents) | Various | 1 hr exposure | Pass |

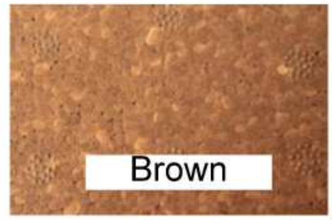
Material Properties for Fire Retardant PEPP Beads

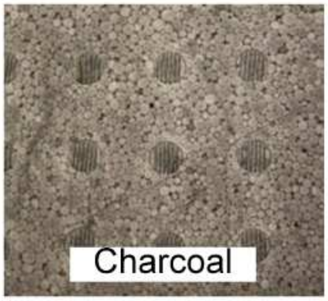
| PHYSICAL PROPERTY | TEST METHOD | UNITS | RESULTS |
|---|---|---|---|
| Density | ASTM-D3575 | pcf (g/l) | 2.8 (45) |
| Porosity[1] | JSP | % | 30 |
| Compressive Strength<br>@25% Strain<br>@50% Strain<br>@75% Strain | ASTM-D3575 | <br>psi<br>psi<br>psi | <br>23.0<br>35.0<br>79.0 |
| Compression Set | ASTM-D3575 | % | 9.0 |
| Tensile Strength | ASTM-D3575 | psi | 27.0 |
| Tensile Elongation | ASTM-D3575 | % | 13.0 |
| Tear Strength | ASTM-D3575 | lbs/inch | 18.8 |
| Thermal Conductivity | ASTM-C177<br>@ 75°F | (K) BTU-in/($ft^2$-hr-°F) | 0.28 |
| Thermal Stability<br>inear Dimensional Change | ASTM-D3575<br>24 hrs @ 225°F | % | < 1.0% |
| Thermal Resistance | ASTM-C177 | (R) | 3.5 |
| Coefficient of Linear<br>Thermal Expansion<br>70°F to -40°F<br>70°F to 180°F | ASTM-D696 | <br><br>in/in/°F x $10^{-5}$<br>in/in/°F x $10^{-5}$ | <br><br>6.4<br>10.8 |
| Water Vapor Permeability | ASTM-E96 | lbs/$ft^2$/hr/mmHg | 6.6 x $10^{-5}$ |
| Water Absorption | ASTM-C272 | lbs/$in^3$ x $10^{-3}$ | 6.5 |
| Flammability | FMVSS-302<br>ASTM-E84<br>ASTM-E84<br>UL-94 | < 4.0 in/min.<br>Flame Spread Index[2]<br>Smoke Development Index[2]<br>Flame Class[3] | Pass<br>3 (1" thick)<br>5 (2" thick)<br>84 (1" Thick)<br>113 (2" Thick)<br>HF1 / HF2 |
| Chemical Resistance<br>(Auto fuels, fluids, solvents) | Various | 1 hr exposure | Pass |

Color Options

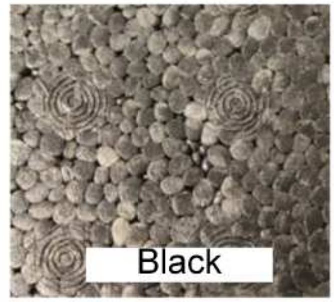


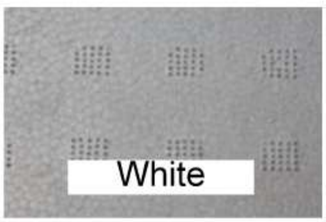



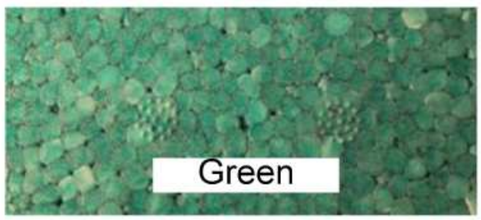



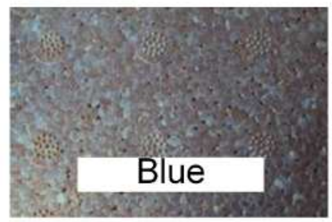




| Color | Type | Non FR | FR | Antistat |
|---|---|---|---|---|
| | | | | |
| Black | Standard | Yes | No | Yes |
| White | Standard | Yes | Yes | Yes |
| Charcoal | Standard | No | Yes | Yes |
| Blue | Custom | Yes | Yes | No |
| Green | Custom | Yes | Yes | No |
| Yellow | Custom | Yes | Yes | No |
| Red | Custom | Yes | Yes | No |
| Brown | Custom | Yes | Yes | No |

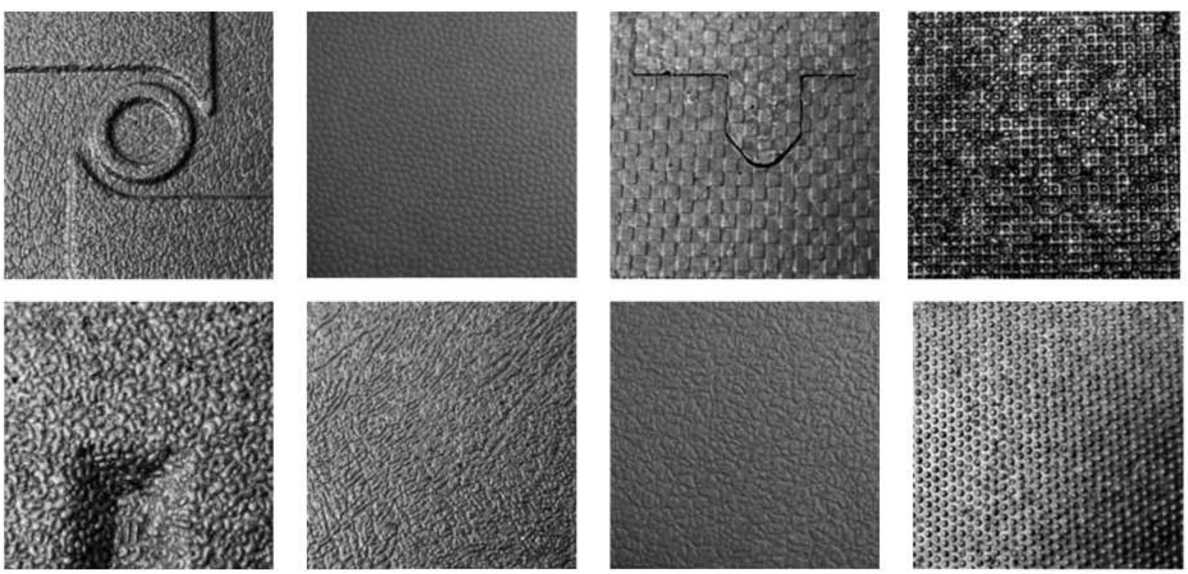



Texture Examples



Different texture options available based
on customer needs and specification