PermaTherm
Insulation Innovation

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THE IDEAL PACKAGING ALTERNATIVE

Environmentally Friendly Expanded Polystyrene

Reduce Reuse Recycle
The final decision whether to use expanded polystyrene (EPS) or other alternatives such as corrugated paperboard (CPB) as packaging material boils down to four interrelated critical factors:

1) Cost efficiencies
2) Protective capabilities
3) Ease of assembly
4) Environmental “green” attributes

The purpose of this document is to highlight the Environmental Attributes, yet it may be helpful to summarize the first three “non-environmental”, criteria by listing the *performance* attributes of EPS. EPS protective packaging is light, strong, and effective in protecting a wide range of products. EPS packaging reduces breakage and the total weight of waste disposed as compared to other alternatives:

- Ability to be molded and/or cut into complex shapes.
- High compressive strength at low density
- High dynamic stiffness
- Good thermal properties
- Low thermal conductivity
- Low thermal expansion
- Structurally stable between -311F and 187F
- Excellent durability
- Low water vapor diffusion and water absorption
- Resistance to a wide range of chemicals and other media
- Resistance to biological attack
- Flame and smoke retardancy
- Very low weight after molding
- Approved by FDA for food containment
- Low freight costs due to low, uniform package weight

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- Excellent product protection due to high energy absorbance when dropped or under heavy weight
- Vibration free packaging of even awkwardly shaped goods due to accurately shaped moldings
- No contamination of sensitive products by dust
- Time saving because of easy handling
- Protection against heat and cold due to good thermal insulation properties;
- Rain-proof and dust-proof due to closed surface and suitable closures;
- Safe stackability, not only in the warehouse but also during transit.

Now, with respect to *Environmental Sustainability*

Interest in, and indeed mandates for, packaging products continues to grow. While many packaging suppliers may promote their products as "green", many fail to be able to back up their claims. To help clients, shippers, contractors, architects, and engineers evaluate the environmental impact of packaging products, we offer the following summary of the environmental attributes of PermaTherm EPS packaging.

1.0 Summary

A Life-Cycle-Assessment (LCA), sometimes referred to as "cradle to grave" analysis, determines the environmental impacts of products, processes or services, through production, usage, and final disposal. LCA analyses comparing EPS and paper-based products have concluded that the EPS containers require 30 percent less energy than the paper-based containers, contribute 46 percent lower atmospheric emissions, and contribute 42 percent less waterborne wastes. [1] [2]

EPS packaging is resistant to substances such as water, acids (with the exception of strongly oxidizing acids such as nitric acid), solutions of alkalis, and common alcohols.

Additionally, EPS containers used to ship produce and other food products provide insulation; and they have demonstrated the ability to better protect food and other temperature-sensitive products. Such protection can control acidity, maintain solid content, reduce pigment loss, reduce vitamin loss, and extend freshness.[3]

2.0 Chemistry of EPS

Expanded polystyrene is made from a styrene monomer and hydrocarbon blowing agents.

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[1] The Council for Solid Waste Solutions (now American Plastics Council), *Resource and Environmental Profile Analysis of Foam Polystyrene and Bleached Paperboard Containers*, Prairie Village, Kans., June 1990, prepared by Franklin Associates, Ltd.

[2] Martin B.Hocking, "Reusable and Disposable Cups: An Energy-Based Evaluation," *Environmental Management*, Vol. 18, No. 6, pp. 889–99; and "Is Paper Better than Plastic?" *Consumers' Research*, October 1991, pp. 28–50.

[3] Hyung Woo Park, *Effects of EPS Packaging Boxes on the Freshness Extension of Agricultural Produce*, Korea Food Research Institute, Sungnam City, Korea, April 17, 1997.

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Molecules of styrene monomer are linked together to form the polymer called polystyrene. Styrene has been produced synthetically since the 1930s from ethyl-benzene, which is derived from byproducts of natural gas and/or petroleum processing[4].

Styrene also is a naturally occurring substance that has been known since the time of the ancient Greeks. It is found in many foods and beverages, such as milk, beer, coffee, strawberries, peas, tomatoes, olives, and various nuts. Styrene is approved by the Federal Food and Drug Administration (FDA) for use as a flavoring agent.

Man-made styrene is used not only to make polystyrene, but also in the manufacture of products such as automobile parts, electronic components, boats and other recreational vehicles, and synthetic rubber.

Expanded polystyrene is approved by the Federal Food and Drug Administration for use in food contact packaging. It has been shown in several studies to be more sanitary than cardboard or corrugated paperboard, and even more than reusable plastic-ware. Many health organizations, in fact, encourage use of polystyrene because it does not support the growth of bacteria, as reusable plastic-ware can. Expanded polystyrene's light weight, excellent thermal insulation and sturdiness make it easy to use and safe.

3.0 Waste Management

In our role as an environmental steward, PermaTherm takes an integrated, balanced approach involving source reduction, recycling, and prudent waste management such as waste-to-energy conversion when feasible.

In the design of packaging products, PermaTherm works with its clients to consider:

1) Designing products and packaging in such a manner that less material is used in production and/or transportation.

2) Increasing the useful life of products (including making products reusable).

3) Replacement of single-use products that cannot be recycled effectively with recyclable or compostable alternatives.

When compared to cardboard, where shipping/protection may require bubble-wrap, LDPE, shrink-wraps, etc., the EPS approach also minimizes the need for “extras”.

3.1. Source reduction

In a first-of-a-kind Life-Cycle-Assessment (LCA) study (‘cradle-to-gate’), the weights of the original EPS and corrugated paperboard (CPB) packaging inserts required to perform the same protective function were determined to be 1.716 pounds versus 5.310 pounds, respectively[5].

[4] Based on a study of annual per capita usage of EPS in Europe the total consumed energy is equivalent to only 0.6 liters of crude oil. This amount of crude oil represents one car journey of just five miles.

[5] Life cycle assessment of EPS and CPB inserts: design considerations and end of life scenarios; Reginald B.H. Tan and Hsien H. Khoo;Chemical and Environmental Engineering Department, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260; Available online 19 November 2004;

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It is important to note that PermaTherm has chosen to manufacture EPS products that enable easy collection and recycling, and has avoided “fast food packaging” which is difficult to collect and properly dispose (more than 60 times more “protective packaging” is recycled than “food service packaging”).

PermaTherm, in fact, agrees that the use of cardboard for fast-food-packaging may be best for communities that do not have a progressive recycling/waste management approach since cardboard will generally bio-degrade when not properly disposed - - and assuming the cardboard is produced under “sustainable practices”. An additional downside, however, of cardboard is that 1000 pounds of paper will decompose into 394 pounds methane and 545 pounds carbon dioxide (greenhouse gases).

And if the cardboard is not produced with sustainable practices, there can be other problems. For example, if the original product was loaded with inks, adhesives and other substances, these chemicals can leach into soil or groundwater or can be expelled in combustion gases if burned. A chemical of particular concern is di-isobutyl phthalate (DIBP).

3.2. Recycling

Recycling is an important aspect of the larger solution toward responsible waste management. As background, polystyrene is a thermoplastic, which allows it to be repeatedly melted and reformed, making EPS a highly recyclable product. PermaTherm channels 100% of PermaTherm’s off-fall or waste from our manufacturing processes to some form of recycling. It is either processed into other EPS products or densified and sent to a recycling plant where it is returned to polystyrene resin. As mentioned earlier, PermaTherm does not manufacture fast-food-containers, which present unique challenges to collection, or loose-fill packaging “peanuts” which similarly present problems.

Further along the life-cycle of EPS, the collection of post-intermediary or post-consumer EPS for recycling requires client and/or consumer participation, and PermaTherm is committed to working with intermediaries and end-users to promote recycling. For instance, PermaTherm is certified by the American Foamed Plastics Recyclers Association as a responsible EPS collection facility. Collected EPS waste can then be either ground up, melted, and mixed with new polystyrene, or can be densified and ultimately turned into polystyrene resin.

Post-construction EPS waste can be reground and mixed with concrete to produce new building products such as Rastra and prefabricated concrete blocks. Adding EPS regrind increases the thermal performance of these applications in addition to providing an alternative to the landfill. An example of post-consumer EPS use also can be found in products such as decking and lumber.

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An oft-touted alternative for packaging, cardboard, presents problems when it is recycled. For example, if the original cardboard product was loaded with inks, adhesives and other substances, these chemicals will be passed into the new recycled material. If that material is used to package food then the food could be exposed to the chemicals from recycling. One chemical of particular concern is di-isobutyl phthalate (DIBP).

3.3. Waste-to-Energy

If not recycled, collected post-consumer EPS waste, when converted in state-of-the-art incineration systems will yield 17,000 to 18,000 BTUs of energy per pound, which is slightly more than coal. In a modern incinerator, EPS releases most of its energy as heat, aiding in the burning of municipal solid waste and emitting only carbon-dioxide, water-vapor and a trace of non-toxic ash. The fumes are non-toxic and are not harmful to the environment as no dioxins or furans are emitted. The energy gained can be used for local heating and the generation of electricity.

3.4. Landfill / Biodegradability

If not recycled or combusted, expanded polystyrene products are inert and safe in landfills, although the durability attribute that makes EPS so valuable in packaging also means that EPS will not decompose. Yet even in California, only an estimated 0.8 percent of the weight of all material disposed of is polystyrene, with a proportionately smaller segment that is “expanded” polystyrene. And the even broader reality is that nothing readily degrades in landfills — not EPS, nor paper, not food, nor yard waste. Landfills are designed to entomb material and prevent bio-degradation by depriving the oxygen so essential for decomposition. When conditions do allow for decomposition, 1000 pounds of paper will degrade to 394 pounds of methane (a greenhouse gas) and 545 pounds carbon dioxide[6], while EPS does not leach toxic chemicals, heavy metals, or create decomposition gases.

Furthermore, EPS does not provide a nutrient medium for mold, fungus, bacteria, or insects.

4.0 Natural Resource Consumption

4.1. Eco-balance Proves the Point

EPS contains between 90-98% air. The remaining percentage consists of the neutral basic substance polystyrene, a pure hydrocarbon.

EPS uses fewer raw materials to manufacture a functional packaging component. If all EPS packaging were replaced, for instance, with corrugated cardboard, paper, wood, molded fiber etc., raw material requirements would raise to 560%, power consumption to 215% and the landfill volume to 150%.[7]

Especially in comparison with corrugated cardboard, for example, as a shock-absorbing

[6] Martin B. Hocking, Associate Professor of Chemistry at the University of Victoria, British Columbia, reports in "Science," 2/1/93

[7] GVM, Wiesbaden

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material and for similar applications, EPS rates three to twenty-five times better in terms of burden on air and water, power consumption and contribution to the greenhouse effect. The ecological benefits of EPS relative to molded fiber packaging are equally impressive.[8]

4.2. Energy

The energy balance of EPS has dominant advantages over alternative packaging materials.

1. Thermal Insulating Efficiency

Expanded polystyrene has outstanding thermal insulating performance compared to alternative packaging products, meaning the packaged product temperature is maintained longer - - reducing energy loss and retaining viability/freshness.

2. Energy Consumption during Manufacture

The manufacture of EPS requires very little energy compared to alternative products. The energy used to make one unit of EPS, for example, would only allow the manufacture of $^1/_3$ to ½ the volume of cardboard material. Based on a study of annual per capita usage of EPS in Europe the total consumed energy is equivalent to only 0.6 liters of crude oil. This amount of crude oil represents one car journey of just five miles.

3. Energy Consumption During Transportation

The low density EPS equates to light weight of the total packaging structure, thus reducing energy costs related to transportation.

4.3. Water

Water used as a coolant during the manufacturing process is recovered and reused in the production process. The manufacture of EPS results in considerable less water pollution than cardboard, for example: 17 water volumes used per cubic foot of cardboard material versus 0.6 for EPS.[9] [10]

5.0 Clean Air

Neither EPS, nor the raw materials used to manufacture EPS, contain any CFC's, HCFC's, plasticizers (phtalates), formaldehydes, or toxic chemicals. EPS has never utilized any greenhouse gases in the manufacturing process, nor does the manufacturing process result in emissions of greenhouse gases. Combustion equipment is well maintained and efficiently operated in order to minimize C02 emissions.

5.1. Volatile organic compounds (VOC's)

The EPA has not found it necessary or appropriate to regulate the VOC content in EPS resin, and PermaTherm's emission of VOC's is below any threshold limit that would require its

[8] InFo Kunststoff, Berlin
[9] EPS Molders Association, EPS Building and Construction Recycling Fact Sheet
[10] Polystyrene life cycle study conducted by the BASF in 2006/7

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regulation.

5.2. Pentane

Yet in this framework of fact and full disclosure, PermaTherm uses EPS beads as a raw material, and EPS beads typically contain 5%-7% pentane by weight[11], which is defined as a VOC by the EPA. EPA estimates that 85% of the pentane contained in the EPS bead is emitted within 48 hours starting with the expansion process (which would within the manufacturing facility). Considering PermaTherm's extended curing process and typical shipping times, there should be negligible pentane content in EPS by the time it reaches the end-user.

1. More about Pentane

Pentane is a VOC as defined by EPA, yet the amount of VOC generated is very small and does not reportable under EPA regulations and does not require any particular treatment or special processing before discharge.

All three pentane isomers have zero Ozone Depleting Potential (ODP) and either a zero or very low Global Warming Potential (GWP) potential (less than .00044). On the other hand, HCFC 22 is still used in the manufacture of extruded polystyrene (e.g. Styrofoam®[12]), and has a high ODP rating of 0.055, and a GWP of 1700.

To add perspective, VOC emissions from mobile sources (i.e. mainly motor vehicles) are significantly larger than from EPS manufacture. For example, if VOCs from mobile sources were lowered by a mere 1%, air quality would be improved substantially more than with a 100% elimination of all pentane emissions from all EPS processing plants.

Additionally, pentane is a VOC only to the extent it helps create ozone, which only occurs when significant Nitrous Oxides (NOx) are present, such as in urban areas with significant automobile emissions. PermaTherm's manufacturing facilities are located far from urban areas, where nitrogen oxides are insignificant; which leads to the conclusion that Permatherm EPS does not contribute to problematic ozone even at ground levels.

5.3. Styrene

Styrene is also considered a VOC by the EPA. While Certificates of Analysis (CoA's) from PermaTherm's bead suppliers typically do not state a styrene monomer content of EPS bead, several EPS bead suppliers (not necessarily PermaTherm suppliers) have reported that EPS beads typically contain styrene monomer, 900 to 1000 ppm by weight.

1. More about Styrene Monomer

Styrene is a naturally occurring substance that has been known since the time of the ancient

[11] http://cat.inist.fr/?aModele=afficheN&cpsidt=13725654: A method for determination of residual styrene monomer and other volatile organic compounds in expanded polystyrene (EPS) was developed using HS SPME and gas chromatography with FID. The extraction products were identified by GC/MS. Good reproducibility of the measurements with RSD values between 3.2-3.6%. The contents of residual styrene monomer in two samples of EPS were 153.2 and 65.7 mg/kg, respectively. Other compounds identified in EPS were pentane, benzene, toluene, ethylbenzene, isomers of xylene, n-propylbenzene, 1,2,4-trimethylbenzene, o-methylstyrene, benzaldehyde, benzyl alcohol, and acetophenone.

[12] Styrofoam is a registered trademark of the Dow Chemical Company

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Greeks. It is found in many foods and beverages, such as milk, beer, coffee, strawberries, peas, tomatoes, olives, and various nuts. Styrene is, in fact, approved by the Federal Food and Drug Administration (FDA) for use as a flavoring agent. The low levels of residual styrene found in expanded polystyrene products are environmentally safe for use in packaging. Independent research shows no adverse health effects in animals exposed for their lifetimes to styrene at concentrations of up to 250,000 parts per billion, 10,000 times higher than potential exposure from food service products.

6.0 Cancer Causing Chemicals (Carcinogens)

Neither the Agency for Toxic Substances and Disease Registry (ATSDR), the Environmental Protection Agency (EPA), nor the National Toxicology Program (NTP) define pentane, styrene, or any other chemical within EPS as a carcinogen.

Expanded polystyrene is approved by the Federal Food and Drug Administration for use in food contact packaging. It has been shown in several studies to be more sanitary than reusable ware. Many health organizations, in fact, encourage use of polystyrene because it does not support the growth of bacteria, as reusable ware does.

6.1. U.S. EPA's Toxics Release Inventory

PermaTherm’s manufacturing process avoids the release of any substances included in the Toxics Release Inventory. This product and its components are listed on, or are exempt from, the Toxic Substances Control Act’s Chemical Substance Inventory.

6.2. OSHA requirements

PermaTherm meets all OSHA regulations and compliance has been audited by OSHA.

7.0 Corporate Environmental Policy

7.1. Written environmental policy

For a copy PermaTherm's environmental policy, visit our website at www.permatherm.net of contact your local PermaTherm sales representative.