Packaging Insulation 101

Considerations for choosing the right material and construction for temperature controlled packaging

Jean Bedard, VP of Cold Chain Operations, Mesa Labs
Kevin Kohleriter, Marketing, Mesa Labs

MesaLabs

How temperature controlled packaging works, types available, and how to choose the right one

Packaging insulation is vital to combat energy losses during transportation and storage. Thermal Insulation material acts as a barrier preventing heat transfer between objects of differing temperatures. The same principle works for packaging containers as they do for building insulation. Insulation reduces unwanted heat flow between the product and the environment.

Thermal Insulated packaging is indispensable for the safe transit of biodegradable and highly perishable food items, such as medicines, biotech, electronics, horticulture and chemicals. The purpose of which is to avoid deterioration in quality and efficacy.

There are different types of thermal insulation materials available in the market today. Balancing between cost, weight, effectiveness, and environmental factors all weigh into the decision.

Characteristics of a good packaging insulation material.

The objective of a good insulation material is to effectively maintain product temperatures within permissible range and reduce the deterioration rate of a product during transit until it reaches the recipient.

Depending upon the application, a good thermal packaging insulation material has the following relevant characteristics:

- high resistance to heat transfer by conduction, convection or radiation
- low cost
- low weight
- low moisture susceptibility
- ease of fabrication and transportation
- durability
- mechanical strength

In packaging applications, any material that offers a high resistance to the transfer of heat by conduction, convection or radiation serves as a form of insulation. Resistance to heat transfer plays the most significant role in determining the effectiveness of an insulation material. The wall thickness of shipping containers (conduction), the number of surfaces (convection) and the number of reflective surfaces such as aluminum foil (radiation) determines the insulating ability of a container. The ease with which heat flows through a material is measured by its thermal conductivity. The higher the conductivity, the easier the heat flow.

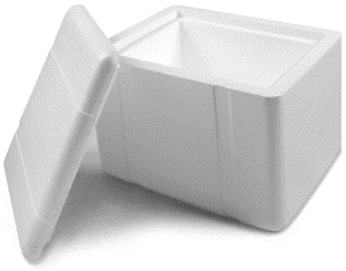
Types of Insulation:

There are two main construction designs for insulated containers: molded and panels (fabricated cut sheets). The main difference is in how the box is constructed rather than the type of materials used. In most cases, the same type of material (EPS, PUR, EPP, etc) is found in both types.

Mesa Labs, Inc.
12100 West 6th Ave.
Lakewood, CO 80228

303.987.8000
packaging@mesalabs.com
www.temptrust.mesalabs.com

Molded insulation packaging containers are typically made of two non-collapsible components, a body and a matching lid. It provides the highest protection from damaging shocks and vibrations during transport. The most popular insulation materials used in molded containers are Expanded Polystyrene (EPS) and polyurethane (PUR).



The following is a typical molded insulation container:

Panel insulated packaging containers are collapsible boxes typically made of six matching components: sides, ends, top and bottom. These boxes are susceptible to greater thermal losses at the edges and may leak cold or let in heat during drops and vibration during transit.

Types of Insulation Materials

The most common thermal insulation packaging materials are

- Plastic foam
- Polystyrene (EPS) foam
- Rigid Polyurethane (PUR) foam
- Extruded PolyStyrene (XPS)
- PE foam
- Vacuum Insulated Panels (VIP)
- Reflective Materials (radiant barrier films)
- Corrugated Fiberboard

and other composite packaging such as thermal insulating bags and phase change materials (PCMs) such as gel packs and dry ice.

The packaging industry today may use the above as fibers, foams, reflectors or loose-fills.

Expanded Polystyrene (EPS)

Expanded Polystyrene, the “white” foam, is probably the most widely employed single-use insulation material for protecting products. Consisting mainly of air bubbles, EPS has good insulating properties because it slows the progress of heat through the material. It also is one of the foams most resistant to moisture absorption. EPS absorbs energy and can be manufactured in nearly unlimited shapes and sizes. The advantages of EPS include low cost, light weight, wide availability and greater flexibility to allow molding and fabrication. However, EPS has low insulation properties, and is typically not reusable unless used with a

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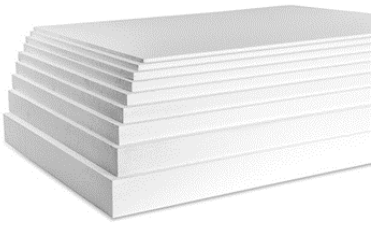
protective outer shell such as cardboard, EPP, or plastic tote containers.

The following pictures are examples of EPS insulated packaging:



Extruded PolyStyrene (XPS) and Polyethylene (PE) Foam

EPS and PE foam are less commonly used as packaging insulation materials. Although both types of insulation are comprised of polystyrene, they are used more as a cushioning material or sold in sheets and are therefore not as effective for cold chain applications.

The pictures above are examples of EPS and PE foams.

Expanded Polypropylene (EPP)

The addition of an external EPP shell to EPS packaging often not only protects the product from shock and vibration, but adds insulating properties to the shipper. Durability maximizes the investment in your packaging by making them reusable multiple times.

EPP is best known as the material used inside car bumpers to reduce the shock felt in an accident. It not only reduces the damage to the car, but makes the car safer for the passenger. The same goes for a product inside an EPP container. It gives you the durability, but also the protection, all without adding weight. Foams molded from EPP also retain their high degree of dimensional stability when exposed to temperature extremes. The elasticity of EPP is very appropriate for packaging valuable and vulnerable products such as glass vials, organs or syringes.

For more details, read the article EPS and EPP: Working together to create the best-qualified packaging has to offer.

Polyurethane (PUR):

Polyurethane, the “yellow” foam, is also a very commonly used insulation material. PUR is considered more durable than EPS. The advantages of PUR include wide availability, flexibility in molding (as it can be injected into a molded container), has better insulation properties and performance, and reusability. However, PUR cannot typically be recycled as easily due to its high density/weight.

Vacuum Insulated Panels (VIP):

Vacuum insulated panels have been recently introduced as insulation materials for cold chain packaging. A VIP consists of an almost gas-tight enclosure surrounding a rigid core from which the air has been evacuated. A packaging box can be constructed using up to six vacuum insulated

panels and then placing them inside another container. They are typically not used as an external shipper due to the concern of a perforate the foil lining and losing the vacuum. The advantages of using VIP include greater performance over other insulation options, and collapsibility. The disadvantage is cost (it is the highest of the insulators) and customized designing, low durability and low availability.

The following pictures are examples of vacuum insulated panels.

Refrigerants / Phase Change Materials (PCMs)

No discussion around packaging and insulation would be complete without mentioning refrigerants. They may go by many names, such as PCMs, gel packs, hard bottle gels, or the full name “Phase Change Material”. Regardless of what you call them, they have the same purpose, to provide temperature stability while they absorb and release thermal energy. PCMs do this during the process of melting and freezing.

Temperature consistency when a PCM oscillates between solid and liquid phases is where a truly good one comes in handy. It matches the temperature of the product while it is going through its phase change, making it ideal for temperature sensitive applications like packaging for life sciences, pharmaceutical, sea food, frozen foods, dairy products, etc.

When a PCM freezes, it releases a large amount of energy in the form of latent heat at a relatively constant temperature. PCMs are measured using latent heat storage (LHS) units. A number of different types of PCMs are available and can be ordered in any required temperature range.

They store 5 to 14 times more heat per unit volume than conventional storage materials such as water or ice (which is also a type of PCM). Organic PCMs include paraffin and fatty acids. Salt Hydrates are examples of Inorganic PCMs.

PCM Hard Bottle Gels, Soft Pouches & Gel Blankets

In the case of Mesa Labs’ TempTrust product line, soft pouches and hard bottle gels are made specifically for packaging applications. They are sealed in a heavy-duty constructed pouch or hard bottle that can be easily cleaned for reuse and are constructed of a durable material that can be molded prior to freezing. They use a non-toxic gel that cools more uniformly and colder than ice. Additionally, they can be environment-friendly, as developed by TempTrust: Disposable in standard waste stream and reusable.

Gel blankets consist of pouches containing a formula providing superior temperature control. Each can be cut and sized to the container, allowing you to use the optimum amount of refrigerant per shipment. Applications range from covering a full pallet-load to a small product cooler. The advantage of gel blankets over standard PCMs and gel packs is the ability to wrap around a payload to eliminate thermal "dead zones" created by traditional gel packs. They are also flexible when frozen.

Following are examples of soft gel pack, PCM hard bottle and gel blanket respectively:

How to choose the right insulation material for your application?

With such a wide range of insulation materials available for thermal packaging, companies have to balance cost, weight, insulating factors as well as environmental factors. To help you make that decision, you should look to partners who can supply solutions backed by data and use cases.

Mesa Labs has not only collected temperature profile data from thousands of data points to optimize packaging and insulation, but with the use of the Mesa Labs' laboratories, properties such as heat absorption, melting point and R-value are tested and validated to qualify materials for specific temperature and duration ranges.

Mesa Labs Qualified Packaging

Mesa Labs is a leading provider of cold chain packaging solutions and related cold chain packaging services for the life sciences market. Mesa Labs Qualified Packaging, called TempTrust, is ISTA 7E Standard 20 Qualified, and assures clients that their delicate products like pharmaceuticals, vaccines, blood, tissue, and other biologics remain in compliance with regulatory guidelines and are stored or transported under ideal conditions.

Mesa Labs has analyzed and documented thousands of data points, across all major origins and destinations. This expertise enables the company to offer its customers a solution that exceeds all industry standards, reduces failures and cuts total-cost-of-ownership for shipping products.

Click here to visit www.temptrust.mesalabs.com to see the complete TempTrust packaging portfolio of qualified passive and active packaging solutions, PCM refrigerants, VIPs, and shippers.

Contact us for more information.

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