

INSULATED PANELS AND SHIPPING CONTAINER INCORPORATING SAID PANELS

FIELD OF THE INVENTION

5 The invention relates to insulated panels for use in shipping containers. The invention also relates to a shipping container intended for use in shipping and storing temperature-sensitive products, such as frozen tissues and other perishable products at critical temperature or range of temperatures.

10 BACKGROUND OF THE INVENTION

A wide range of containers has been used or proposed for use in storing and transporting temperature sensitive products. Containers can include a cardboard shipping carton lined with insulating material such as expanded polystyrene (EPS), polyurethane or other foam material. The insulating material may be provided in modular panels placed
15 together to provide a central insulated cavity. A plug or lid incorporating insulated material is generally used to seal the cavity before the carton is closed and prepared for shipping.

Alternatively, the insulated material can be provided by injection moulding techniques so as to provide an integral body having a central cavity. The body when fitted
20 with a lid may itself be used as a storage container or may be used within a cardboard shipping carton or other protective material. The insulation material can also be injected into an insulation space between an outer container wall and a rigid inner liner.

When transporting particularly sensitive products, such as certain medical or pharmaceutical products, rigid polyurethane containers are often used. Polyurethane has
25 thermal insulation properties that are generally superior to EPS.

There are benefits and disadvantages with the two general types of containers, particularly when they are used for the shipping of large quantities of goods. Injection moulded containers can be costly to manufacture due to the tooling costs and the need to use blowing agents with EPS. The use of polyurethane instead of EPS can reduce the
30 tooling costs. However, polyurethane tends to adhere to the wall surfaces creating disposing problems as both the outer container, polyurethane and inner liner must be

disposed together. There are also significant storage and transportation costs in respect of empty containers formed from EPS or polyurethane.

The use of modular panels can avoid some of these problems. Manufacturing costs are reduced due to the use of less complicated and smaller moulds. Transportation and storage costs of the panels tend to be reduced as the panels can be stored in a more compact stacked arrangement with separate flat packed cardboard shipping cartons for assembly into a container as required. Modular panels can more readily be reused as a damaged section will only require the replacement of the panel incorporating the damage and not the whole container. However, the effectiveness of the insulation in a shipping container assembled from the separate modular panels can be less than that of an equivalent integral container due to the additional seams through which air may enter and thereby warm the contents of the container. Whilst the insulation properties can be improved by increasing the width of the panels, this will reduce the internal storage capacity in the shipping carton for the same size shipping carton and increase transportation costs.

Another type of panel is the vacuum insulating panel (VIP). These panels have a vacuum core formed of an open cell polymer foam wholly encompassed by a suitable envelope such as mylar film or aluminium foil. The panels are reported to have high R-values (thermal resistances) in the order of R-30 per inch of thickness. However, whilst VIP provides great thermal insulation, the panels can be easily damaged. The R-value is significantly reduced as soon when the envelope is punctured. This limits the use and reuse of VIPs.

In addition to poor direct damage resistance, the R-values of the panels also decrease due to the "Edge Effect" and "Ageing Panel Effect" as described in *An Introduction to VIP Technology*, T. K. Stovall, Vacuum Insulation Panel Symposium, Baltimore, May 3-4, 1999, Page 6, line 26-31. As a consequence VIPs are not considered suitable for long life use.

Various types of insulated containers have been proposed and described in the patent literature.

US Patent No. 5,441,170 describes a modular shipping container with multiple inner compartments. Sandwiched insulation panels are fitted within a conventional corrugated shipping container. The panels are made from a polyisocyanurate core

sandwiched between reflective layers comprised of an aluminised coating bonded to the core. The panels are encapsulated within a thermoplastic envelope to allow the panels to be cleaned for reuse.

US Patent No. 6,325,281 describes an insulated shipping container having multiple
5 layers of insulation. The container comprises an outer cardboard carton, a rigid EPS housing, a removable inner housing formed from VIPs and an inner closeable carton within the inner housing. The patent attempts to overcome the durability problem with using VIPs. The panels have a vacuum core formed of an open cell polymer foam wholly encompassed by a suitable envelope such as mylar film or aluminium foil.

10 US Patent No. 5,924,302 describes an insulated shipping container having an integral body defining the cavity therein. The lid includes protrusions to provide an enhanced seal with the body.

US Patent No. 6,381,981 describes a shipping container intended for use with frozen tissue samples. The container has an outer housing formed of an insulated foam
15 material such as EPS and an inner container formed from VIP. The inner cavity incorporates a spring assembly, which adjusts the size of the cavity to fit smaller loads of transported product.

WO98/01359 describes a packaging container incorporating a laminate consisting of a fibre core layer, an outer plastic film of polypropylene, high density polyethylene or
20 polyester and an inner layer of aluminium foil coated with a polyethylene film.

US Patent No. 4,928,847; 5,102,004 and 5,111,957 all relate to storage containers formed from a core of polyurethane and four layers on the upper and lower surfaces, the four layers being reinforced by polypropylene webbing and laminated with a polyethylene film.

25 None of the above containers are entirely satisfactory so that there is a need to provide a shipping container for shipping and storing varying products at low temperatures for extended periods of time, while minimising manufacturing, use, storage and transportation costs of the container and its components. This is a clear benefit in reducing the cost of using insulated shipping containers by providing containers having a longer
30 effective lifespan (re-useable) and improved thermal efficiency so that less insulation material is required improving payload capacity for a standard size of shipping carton.

SUMMARY OF INVENTION

In an embodiment of the invention there is provided an insulation panel for use in thermally insulated shipping containers, the panel comprising a rigid core of an insulation
5 material, the core being wholly encompassed within a polyethylene foam envelope.

Preferably the core comprises a polyurethane, polystyrene or polyethylene terephthalate foam block.

Preferably the polyethylene foam is a closed cell foam.

Preferably the polyethylene foam is a non-cross-linked foam.

10 Preferably the panel has an inner surface, an outer surface and edge surfaces, the inner and outer surfaces comprising a layer of polyethylene foam, the density of the polyethylene foam forming the inner surface being greater than the density of the polyethylene foam forming the outer surface. Preferably the thickness of the polyethylene foam forming the inner surface is less than the thickness of the polyethylene foam forming
15 the outer surface.

Preferably the panel is adapted so that permit the panel to engage with at least one other panel. Preferably the panels are adapted to engage by tongue and groove, mitred or dove tail join.

In another embodiment of the invention there is provided a thermally insulated
20 container that incorporates one or more of the above insulation panel(s).

Preferably the thermally insulated container includes a plurality of the above insulation panels assembled into a square or rectangular box with interconnecting sides and a closed bottom.

In another embodiment of the invention there is provided a shipping container
25 having a plurality of interconnecting sides and a closed bottom and a sealable top, the shipping container including at least one thermally insulated container as described above.

In another embodiment of the invention there is provided a process for the manufacture of an insulation panel for use in thermally insulated shipping containers comprising the steps of:-

30 (i) providing a first, second, third and fourth rectangular polyethylene foam sections, each section having two opposed ends;

- (ii) joining the sections together at or near the ends of the sections so to provide a substantially rectangular frame;
 - (iii) providing a fifth polyethylene foam section and joining the frame and the fifth section together so to provide a container having a closed bottom and a cavity therein;
 - (iv) providing insulation material and locating the material within the cavity so to fill or substantially fill the cavity;
 - (v) providing a sixth polyethylene foam section and joining the container and the sixth section together to close the container and provide the insulation panel.
- 10 Preferably the joins between all sections are airtight or substantially airtight. Preferably the sections are joined by heat welding.

BRIEF DESCRIPTION OF THE DRAWING

15 The above invention will now be described with reference to the following detailed description of a preferred embodiment of the invention as illustrated in the accompanying drawings, in which:

FIG. 1 is a perspective view of a sandwich insulation panel of the invention.

FIG. 2 is an enlarged, fragmentary cross-section view of the sandwich panel shown in figure 1.

20 FIG. 3 is a side cross-sectional view of the sandwich insulation panel of figure 1 taken through A-A.

FIG. 4 is a top cross-sectional view of the sandwich insulation panel of figure 1 taken through B-B.

25 FIG. 5 is a perspective view of an insulated container formed from sandwich panels of the invention.

FIG. 6 is an exploded perspective view of an insulated shipping container of the invention. The container includes the insulated container of figure 5 together with a shipping carton, inserts, refrigerants, payload box and a sandwich pa

FIG. 8 is a fragmentary side view of an insulated shipping container of the invention. The broken parts show the insulated container formed from sandwich panels within the shipping carton.

FIG. 9 is a perspective view of an alternative shipping container of the invention. The shipping carton contains four insulated containers formed from sandwich panels.

FIG. 10 is plan view of the use of apparatus in a step in the manufacture of a sandwich panel of the invention.

FIG. 11 is a front view of the apparatus of figure 10 taken through C-C.

FIG. 12 is a side view of the apparatus of figure 10 in direction of D.

FIG. 13 is a plan view of apparatus of figure 10 when used in another step in the manufacture of a sandwich panel of the invention.

FIG. 14 is a side view of another apparatus when used in a step in the manufacture of a sandwich panel of the invention.

FIG. 15 is a perspective view of the intermediate product of using the apparatus of figures 10 to 14.

FIG. 16 is a side view of the apparatus of figure 14 when used in a further step in the manufacture of a sandwich panel of the invention.

FIG. 17 is a perspective view of alternative panels of the invention.

FIG. 18 is a perspective view depicting stages in the assemble of the panels of figure 17 into an insulated container.

FIG. 19 a perspective view of alternative panels of the invention.

FIG. 20 is a perspective view depicting stages in the assemble of the panels of figure 19 into an insulated container.

FIG. 21 is a temperature vs. time graph for insulation box formed from 1 inch (25 mm) polyurethane panels (without lamination – panels not of the invention).

FIG. 22 is a temperature vs. time graph for insulation box formed from 38mm (1 inch +13 mm) polyurethane panels (without lamination – panels not of invention).

FIG. 23 is a temperature vs. time graph for insulation box formed from polyurethane (1 inch) and polyethylene panels (13mm) (without lamination – panel not invention).

FIG. 24 is a temperature vs. time graph for an insulation container of the invention formed from sandwich insulation panels of the invention (10 mm polyethylene, 1 inch (25 mm) polyurethane, 3 mm polyethylene)

FIG. 25 is a temperature vs. time graph for insulation box formed from 2 inch (50 mm) polyurethane panels (without lamination – panels not of the invention).

FIG. 26 is a temperature vs. time graph for an insulation box formed from 73mm (2 inch +13 mm) polyurethane panels (without lamination – panels not of invention).

FIG. 27 is a temperature vs. time graph for an insulation box formed from polyurethane (2 inch) and polyethylene panels (13mm) (without lamination – panel not of invention).

FIG. 28 is a temperature vs. time graph for an insulation container of the invention formed from sandwich insulation panels of the invention (10 mm polyethylene, 2 inch (50 mm) polyurethane, 3 mm polyethylene)

DETAILED DESCRIPTION OF THE INVENTION

The invention is predicated on the finding that the insulation panels of the invention can, when fitted together to form a thermally insulated container, provide a container having enhanced thermal insulation properties over that expected from a similarly sized mass of foam insulation, such as rigid polyurethane or EPS insulation material. The improvement appears to be as a result of wholly encompassing the core insulation material within a polyethylene foam envelope. It is speculated that the envelope improves the insulation characteristics of core insulation material by providing an improved seal at the seams between interconnected panels. The envelope may also improve the insulation properties of the insulation material by providing an airtight covering over the core insulation material.

An insulation panel is depicted in figures 1 to 4. Each panel comprises a core of insulation material and polyethylene foam. The depicted insulation panel (1) is rectangular although it could be provided in a broad range of shapes depending on the shape of the shipping container in which the panel is intended to be used. The panel (1) comprises an outer polyethylene foam member (3), an inner polyethylene foam member (5), four perimeter polyethylene foam strip or side members (7, 9, 11, 13) located around a foam core (15). The outer member (3) of the panel forms part of the outer surface of an

insulated container and the inner member (5) defines part of the inner cavity defining wall of the insulated container when the panel is incorporated into an insulation container.

The foam core can be selected from a broad range of polymer insulation foams examples of which include polyolefins (such as polyethylene and polypropylene),
5 polystyrenes, polyurethanes (including polyisocyanurate), PET (Polyethylene terephthalate) and polyvinyl chloride, with EPS and rigid polyurethane being particularly preferred. The core should also provide some rigidity to the panel and this can be achieved by using rigid polyurethane. A plate such a lightweight aluminum sheet may also be included in the core to enhance the rigidity of the core and the panel containing the core. The properties of
10 polyurethane and EPS make both types of polymers particularly suitable for use in the panel as foam core (15). The foam core may be a single block or may comprise a number of blocks which together provide the foam core. The blocks can be provided in a suitable shape by any means, such as by using moulds or by cutting or shaping extruded materials. The foam core can also be provided by injecting suitable polymer material such as
15 polyurethane into the cavity within the polyethylene envelope. The use of polyurethane has the advantage of filling the cavity and bonding the foam core to the polyethylene envelope.

A closed cell polyethylene foam should be used for the polyethylene foam envelope. Whilst cross linked polyethylene foam can be used, it is preferred to use non-
20 cross linked polyethylene foam as it is both cheaper and easier to work with when forming the envelope. A large range of polyethylene foams are commercially available, and are thought to be useable. The preferred polyethylene foams are those provided by Fagerdala World Foams.

It is preferred for the outer polyethylene foam member (3) to be at least 5 mm
25 thick, more preferably of from 5 mm to 20 mm and most preferably approximately 10 mm. The width of the outer foam member enhances the insulation properties of the core, by both providing additional insulation and by providing the core insulation material with additional protection from damage, such as that which can occur during the transporting of shipping cartons. A 10 mm layer of polyethylene foam helps to cushion the core from
30 damage and thereby the insulation reducing affect that the damage may have had on the core. The density of the polymer is preferably equal to or greater than 15 kg/m^3 ,

preferably of from 20 to 40 kg/m³ and most preferably approximately 30 kg/m³. When necessary, further protection against damage can be provided by including a thin layer of a light weight resilient material such as an aluminium sheet between the outer foam member and the core.

- 5 The inner member (5) may be of from 0.5 mm in thickness, and more preferably of from 1 mm to 5 mm and most preferably approximately 2 or 3 mm. The thickness of the inner member (5) is preferably significantly less than that of the outer member (3) as it should not be necessary to cushion and protect the panel core from blows coming from within the insulation container once assembled. However, it is preferred to use a polymer layer that facilitates the re-use of the panels. For hygiene and ease of cleaning the inner member is preferably made from a polymer foam with a higher density than that of the polyethylene polymer used in the outer layer. The foam should have fine cell structures so that it is suitable for use with medical products with their more stringent hygienic requirements. It is preferred that the inner member has a density of from 60 kg/m³,
10 preferably of from 80 to 250 kg/m³, and most preferably approximately 100 kg/m³.

For additional insulation the inner foam member may also include an aluminum foil layer. The inclusion of a thin reflective layer such as aluminum may further increase the insulation properties of the panel. The foil may be protected with a thin film layer of polyethylene.

- 20 The perimeter polyethylene foam strip members (7, 9, 11 and 13) are preferably located in the gap between the outer and inner polyethylene foam members so as to provide a flush edge surface. An alternative arrangement of locating the strip members against the edge of the outer and inner members will also provide a flush edge surface but is less preferred. The edge portion of a panel is likely to be subject to stresses and damage during its placement and it is thought that the alternative arrangement would not provide a panel as resilient as the panel depicted. Another alternative is the use of corresponding mitre edges on both the strip members and the outer and inner members, although this arrangement is not preferred as it is thought to unnecessarily complicate the manufacture of the panels.

- 30 The strip members (7, 9, 11 and 13) are preferably made of polymer foam having the same thickness and density as the outer foam member as earlier described.

Fagerdala Fawolam polyethylene foams are suitable for use for the outer, inner and strip members. Fawolam 30 provides a closed cell, non-cross linked polyethylene foam having an average density of approximately 30 kg/m³. Fawolam 100 provides a closed cell, non-cross linked polyethylene foam with an average density of approximately 100 kg/m³.

The inner, outer and strip members are preferably bonded in a manner so as to create strong and preferably airtight joins between the adjoining members in each panel. This can be achieved by a range of known methods. Two preferred arrangements include heat welding and the use of adhesive. Additional bonding can be provided by the use of an adhesive with the core member, or by forming the core foam by injecting a polyurethane foam mixture into the cavity. However, it is generally sufficient to simply locate and encapsulate the core material within a polyethylene envelope.

The foam core (15) provides most of the insulation properties of the panel. Rigid polyurethane is preferred and provides good insulation properties with R-values in the order of R-8 to 9 per inch of thickness. EPS has lesser insulation properties with R-values in the order of R-4 to R-5. The difference is a result of the cell structure in polyurethane foams which is denser than in most other materials and the cells are filled with an inert gas that has a higher R-value. Over time the inert gas leaks from the cells in polyurethane and is replaced with air, resulting in a reduction in the R-value of the foam, to something in the order of R-7 per inch after 2 years. The R value of polyurethane will then stabilize around R-7, but can further decrease if the foam is damaged or cracked. The required thickness of the core thus depends on the insulation material used in the core and the time period and required temperature. The insulation panels when assembled into an insulation container should be capable of maintaining the temperature within the container within a desired temperature range for a required time period whilst the goods are stored and transported. Typical thicknesses of polyurethane cores are in the order of from 15 mm to 100 mm, more preferably 20 mm to 80 mm, most preferably approximately 24 or 51 mm (1 or 2 inches). The thickness of the core must be increased when EPS is used to provide the same insulation properties.

The ability of an insulation panel to slow down the transfer of heat into the container is dependent on the R-value of the panel. With the same thickness of panel, the

materials with a better R-value will provide better insulation. The combined core and envelope foam concept has resulted in an increase in the R-value of the panel and therefore better thermal performance.

Figure 5 depicts an arrangement of five insulation panels (35, 36, 38, 40 and 42) assembled together so to form an insulation container. A horizontal rectangular panel (35) provides the container bottom with four walls being provided by four vertical panels (36, 38, 40 and 42). As depicted the vertical panels are located on top of the base panel with the outer surface of the vertical panels being aligned with the perimeter of the base panel. Other arrangements providing the same general shape of insulation container are possible. For example the vertical panels can be arranged to form a tube and the base panel fitted therein so that downward horizontal face of the vertical panels in combination with the base panel forms the bottom of the container.

The vertical panels are arranged so that panels (36) and (40) and panels (38) and (42) are directly opposite and parallel to each other, with panels (38) and (42) being located between panels (36) and (40), with the vertical sides of the panels (38) and (42) abutting against the inner polyethylene layer of panels (36) and (40). Alternatively, the pairs of panels can be parallel but offset from one so that an outer vertical edge of each panel defines a corner of the container. The other outer vertical edge (and the adjacent vertical side face) of each panel abuts against the inner vertical surface of the adjacent panel.

The panels may be fixed together and fitted with a lid so as to provide a stand alone container or may be arranged within a shipping carton or other container. When forming a stand alone container the panels may be joined together by commonly used fastening means. Adhesive, sealant and / or fasteners may used to hold and seal touching panels together. Adhesives that do not damage the contacting polyethylene foam layers are preferred. A board range of fasteners can be used such as screws, nails and nuts and bolts. The shaft of bolts can be fitted into aperture in one panel and threaded into a nut located within a bore in an adjacent panel. The panels themselves may be shaped so that they engage adjacent panels and tightly fit together. The side edges of the panels may be configured so to provide tongue-in-groove or dove tailed joins. Such an arrangement is depicted in Figures 17 and 18 and is discussed further below.

The lid may be another insulation panel of the invention or may be formed from other insulation materials. It can be useful to use a breathable lid so to allow for the release of gas pressure within the container when it is used with dry ice as a coolant. As dry ice evaporates to its gas form it creates a large volume of carbon dioxide gas which
5 needs to be vented to avoid dangerous pressure build ups within the container. The United Parcel Service of America requires insulation boxes used with dry ice to be appropriately vented so to avoid the pressure build up.

The insulation container shown in figure 5 is preferably assembled within a cardboard shipping carton. Shipping cartons are provided in standardized shapes for ease
10 of storage and transport. The carton provides additional protection for the panels and the goods being stored and transported. The internal walls of the carton can be used to position and restrain the movement of panels of an appropriate size and shape thereby avoiding the need to affix the panels together. Such an arrangement is shown in figures 6 to 8.

15 The insulated shipping carton includes a conventional reinforced shipping carton comprising a horizontal bottom wall (19), four vertical side walls (20, 22, 24 and 26) and an opening sealable by the four top flaps (28, 30, 32 and 34) hingedly joined to the side walls. The opening can be sealed by folding inward the four top flaps so to provide a substantially horizontal surface and sealed using conventional fastening means such as tape
20 or staples.

An insulation panel (35) is laid horizontally at the bottom of the carton to form the bottom of the insulation container. The outer polyethylene member of the panel faces downward and contacts the inner surface of the bottom wall (19) of the carton. The length and breadth of the panel (35) are such that each of the four horizontal side faces abut
25 against or are closely adjacent to the inner surface of carton walls (20, 22, 24 and 26). Four insulation panels (36, 38, 40 and 42) are placed vertically on top of the bottom panel to provide the insulation container as depicted in figure 5. The outer polyethylene members of the panels (36, 38, 40 and 42) respectively abut against the inner surface of carton walls (20, 22, 24 and 26). The outer polyethylene member of panel (36) is in facial
30 contact with the inner surface of carton wall (20). One vertical side face of the panel abuts against a portion of the inner surface of carton wall (22) at and near the junction of walls

(20) and (22). The opposite vertical side face of panel (36) abuts the inner carton wall (26) at and near the junction of walls (20) and (26). Likewise the panel (40) is in facial contact with the inner carton wall (24) and the side faces contact inner carton walls (22) and (26). The panels (38) and (42) fit between and abut against panels (36) and (40) with the outer
5 polyethylene member in facial contact with the inner carton walls (22) and (26).

The insulated shipping container includes bottom and top inserts (44) and (46) of open cell polyurethane. The horizontal inserts are positioned within the insulation container and the side faces thereof abut against or are closely adjacent to the inner surface of the vertical panels and thereby act to hold panels (38) and (42) into position by
10 preventing the inward movement of these panels. The inserts can be formed from a range of materials although it is preferred to use polyurethane foam. The bottom insert is preferably formed from an absorbent open cell material such as the polyurethane foam so that the absorbent material absorb liquid spills and protects against damage caused by leakage. The top insert also braces the panels (38) and (42) and thereby prevents the
15 inward movement of the panels. The bracing action of inserts (44) and (46) can be seen in figure 7.

The top insert can also be used to hold the payload (50) and the refrigerants (52) in a fixed position and thereby reduce the likelihood of damage to the payload due to vertical movement within the overall insulated shipping container. The top insert (46) is preferably
20 made from open cell polyurethane as it will allow gas to escape through the open cell structure and thereby permit the use of the dry ice in the USA as a coolant. The use of polyurethane foam inserts (44) and (46) also has the advantage of placing additional insulation about the payload.

The insulated container is then closed by placing a top insulated panel (48) on top
25 of the vertical panels (36, 38, 40 and 42). The outer polyethylene member of panel (48) should be positioned upwards. The inner member faces downwards and a portion of the inner member at and near the perimeter of the panel abuts against the top side faces of panels (36, 38, 40 and 42). This is the preferred arrangement as the six panels (35, 36, 38, 40, 42 and 48) together provide a rigid protective barrier around the payload. If a second
30 carton was stacked on top of the first, the weight of the second carton would need to break

the top bridging panel (48) before the weight of the second container would compress and possibly damage the payload.

In an alternative arrangement the vertical panels extend the height of the carton and a top panel is used as a horizontal plug within the vertical panels. However, this
5 alternative arrangement is not preferred as the payload may be at a greater risk of damage. If a smaller carton were to be stacked on top of an insulated shipping carton of the alternate arrangement then the smaller carton could be stacked directly above the plug panel. Whilst a significant portion of the forces involved may be borne by the sealed top flaps (28, 30, 32 and 34) the weight of the smaller carton would press down on the plug panel which could
10 move downward and damage the payload.

Whilst not shown in the figures, a plastic liner, such as a polyethylene film can also be used to protect against spills and damage. Individual panels can be provided within a plastic liner so as to facilitate the cleaning and re-use of the panels. The payload within the insulation container and the insulation container per se can each be located within a
15 protective plastic liner.

Whilst a single insulation box has been shown, it is well within the scope of this invention to vary the number of the sandwich panels, the corresponding sizes thereof or even the number of compartments so as to provide a wide range of insulated shipping cartons. Figure 9 depicts a four compartment insulation shipping carton of the invention.
20 Insulation panels (58) have been assembled within a shipping carton (56) to provide the four insulated compartments each with a plug lid (60). One compartment is shown open with the plug lid (60) placed on top of the adjacent compartments. The plug lid can comprise an insulation panel of the invention or may comprise a polyurethane insert such as that used as the top insert in figure 6.

25 The insulated shipping container can be used for the transport of various temperature sensitive payloads. The payload (50) may be packaged within a separate box or bag and located with the insulated container. The temperature sensitive nature of the payload will affect the selection of an appropriate refrigerant (52) for use within the container. For example a temperature range of from 2 to 8°C may be required for
30 shipment and transportation of vaccines, pro-biotics, muscle relaxant drugs, dental bonding adhesives and human organ preservations. A temperature range of 0 to -19°C can be

required for shipment of biologics, diagnostic kits (such as HIV, HBV and HVC kits), reagent test kits and "surgical glues" for wound closures. A temperature range of -20 to -68°C can be required for the storage of blood plasma concentrate, tissue grafts and activated myoblasts. A range of commonly available refrigerants, such as cubes of ice and
5 dry ice, can be used to meet the required temperature ranges.

The method and apparatus for use in forming the insulation panels of the invention is shown in figures 10 to 16. Three 10 mm thick polyethylene strip members of Fawolam-FS-30 (7, 9, 11) are positioned on the apparatus and secured in position by the back stopper (70), side stopper (72) and the pneumatically operated back (74) and side clamps
10 (76). Hot air is piped through pipe (78) into a hot air discharge blade (80) which discharges the hot air through a vertical line of apertures (82) located on both sides of the blade. The hot air heats the end faces of strips (9) and (11) and end portions of the rear face of strip (7) at an appropriate temperature for specific time period. Once heated for the required time, the hot air discharge blades withdraw to the sides of the apparatus. The strip
15 members (9) and (11) are then moved into contact with strip (7) so that the heated parts of the strips bond together.

Once the strips (7, 9 and 11) have been heat sealed together the partially completed frame is then flipped 180° manually to the opposite side as shown in figure 13. Once the partial frame is secured in the flipped position, another strip member (13) is clamped into
20 position placed against the back (70) and side stopper (72).

The free end faces of strips (9) and (11) and end portions of the inner face of strip (13) are heated by a repositioned hot air discharge blade (80) and strip (13) is then heat sealed to the partially completed frame to provide the completed frame.

The frame is then sealed to a 10 mm thick outer foam member (3) of Fawolam-FS-
25 30 foam as shown in figure 14. A hot air discharge pipe (84) is used to heat an edge surface of the frame (83) and the outer foam member is gently rolled between the hot air discharge pipe (84) and the fine-tune roller (86) to seal the foam member to the frame which is moved by the frame roller (88).

A foam core (15) of rigid polyurethane is then inserted into the central cavity
30 formed by the sealed combination of the outer and strip members (3, 7, 9, 11 and 13) as shown in figure 15.

As shown in figure 16, the panel is then completed by bonding an inner foam member (5) of a thinner, higher density polyethylene foam (Fawolam-FS-100; 3 mm thick) over the open face of the foam core (15) and the surrounding frame of strip members (7, 9, 11 and 13). The apparatus used is that of figure 14 and it is operated in the same manner.

5 The apparatus shown in figures 10 to 14 can be modified for use in heat sealing insulation panels together so to provide rigid insulation container which can be used alone or within shipping cartons. The strips members (7, 9, 11 and 13) and outer member (3) are respectively replaced with the vertical panels (36, 38, 40 and 42) and horizontal panel (35) and enlarged hot air discharge blades are used. An insulation container formed by heat
10 sealing the panels together should have improved insulation properties due to the effective removal of seams.

Figures 17 to 20 relate to shaped panels of the invention. Each sandwich panel has been adapted to engage the adjacent (non-lid) panels so that they inter- fit and / or inter- lock together. The panels are formed from shaped form cores of polyurethane
15 encompassed within a polyethylene foam envelope. The method of forming the panels is substantially the same as that described above with reference to figures 10 to 16.

In figure 17 the side wall four panels (90, 92, 94, 96) are adapted for a male / female engagement with adjacent side panels. Each side panel has a tongue (98) extending from a vertical side edge and a vertically extending groove (100) on the internal side face
20 proximal to the opposed vertical side edge of the panel. The tongue and groove of adjacent side panels are shaped so as to allow the tongue of one panel to fit within the groove of the adjacent panel. Preferably the tongues and grooves closely correspond so that a tight fit is provided between fitted together side panels. The dimensions of the tongue and groove do not need to be precise and there is some tolerance due to the compressibility of the
25 polyethylene foam layer around the tongue and groove.

As shown in figure 17 the tongue and groove engagement between side panels are incline so prevent the panels for being pulled apart in use. The angle of the tongues and grooves prevents the sideways separation of side panels but allows the panels to be separated by moving one panel relative to the other along of the length of groove. This is a
30 preferred arrangement and it is expected that the incline can be omitted with some applications of the insulated container. This can be done by restraining the movement of

the walls of the container by another means such as straps or other fasteners, or the internal walls of a shipping carton.

The panels are side panels (90, 92, 94 and 96) are adapted to engage the bottom panel (101) by having tongues that extend from their bottom edges capable of fitting
5 within grooves (102, 104, 106, 108) located in the inner face of the bottom panel near the perimeter of the inner face. The two of the grooves (102, 104) are inclined so to restrain the vertical movement of two of the side panels (90, 92) which have tongues with corresponding angles. As above, the incline can be omitted with some uses of the insulated container. The tongue of the other two panels (94, 96) and the equivalent
10 grooves (106 and 108) have vertical or near vertical sides so to permit the downward extending tongues to be inserted into the bottom panels as the panels (94, 96) are fitted into panels (90, 92).

An alternative fitting arrangement is shown in figure 19. Two of the side panels (110, 114) have two substantially vertically extending grooves (120, 122) in the inner face,
15 a groove located near oppose side edges of the panel. Two of the side panels (112, 116) each have two side tongues (124, 126) extending from the side edges of the panels. The tongues of the panels (112, 116) are adapted to fit within and engage with the grooves of panels (110, 114). In essence, two of the side panels (112, 116) are male / male and are adapted to fit and engage the grooves of the female / female side panels (110, 114). The
20 side panels have downward extending tongues (128) which fit into grooves (130) located in the bottom panel (117).

The steps involved in the assemble of the panels of figures 17 and 19 into an insulation container are respectively shown in figures 18 and 20. The assemble method is similar for both sets of panels.

25 As shown at (A), the tongue of a side panel is being fitted in the corresponding groove of the bottom panel and pushed so that the bottom edge tongue slides along the groove, but is vertically held within the groove. When this step has been completed the assembly will look like (B). The tongue of an oppose side panel is slide along the opposite groove (C) the groove, until it was satisfactorily positioned. (D). A further side panel is
30 positioned (E) for location into the assembled position so that the tongues and grooves of adjacent side panels interfit, and eventually the bottom edge tongue of the fits within a

corresponding groove in the bottom panel (F). Another side panel is then positioned so that the tongues and grooves of the adjacent side panels can interfit (G) and slide down into position (H).

Figures 21 to 28 depict the results of testing the insulation properties of assorted insulated containers formed from comparative panels (Figs. 21 to 23, 25 to 27) and from panels of the invention (Figs. 24 and 28).

The tests were conducted using a datalogger XR 440M Pocket Logger (Pace Scientific Inc).

The polyurethane foam had a density of 85 kg/m^3 .

The polyethylene foams were Fawolam 30 kg/m^3 on the outer side of the panels and Fawolam 100 kg/m^3 on the inner side of the panels.

The test panels were assembled into insulation boxes and fitted with temperature sensors. Each box was loaded with 5 kg of gel ices (Techni Ice) and the internal temperature within the box was monitored over time.

The results of the tests show that providing a polyethylene foam envelope around the polyurethane core material significantly improves thermal insulation by as much as 21 hours, compared to 100% polyurethane without any polyethylene material. This can be seen from a comparison of figures 21 and 24, and 25 and 28.

The results appear to go beyond a mere additive effect. A significant improvement in the insulation properties of the containers by using a polyethylene envelope was noted from the temperature time profiles shown in figure 24 over 23 and figure 28 over 27.

The addition of a polyethylene foam layer alone without enveloping the core was found to provide an increase in thermal insulation over the core alone. This is apparent from a comparison of Figs, 21 and 23, and 25 and 27. Surprisingly, the addition of a layer of Fagerdala Fawolam polyethylene to polyurethane foam core seem to provide a significant improvement over a comparable total thickness of polyurethane foam, (compare the temperature time profiles of the graphs of Figs 22 with 23, and also Figs 26 with 27) and despite the lower R value for the polyethylene foam.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. An insulation panel for use in thermally insulated containers assembled from a plurality of separate panels, the panel comprising a rigid core of a thermal insulation material, the core being wholly encompassed within a polyethylene foam envelope.
2. The insulation panel of claim 1 wherein the core comprises a polyurethane, polystyrene or polyethylene terephthalate foam block.
3. The insulation panel of claim 2 wherein the core comprises a polyurethane foam block.
4. The insulation panel of any one of claims 1 to 3 wherein polyethylene foam is a closed cell foam.
5. The insulation panel of any one of claims 1 to 4 wherein the polyethylene foam is a non-cross-linked foam.
6. The insulation panel of any one of claims 1 to 5 wherein the panel has an inner surface, an outer surface and edge surfaces, the inner and outer surfaces comprising a layer of polyethylene foam, the density of the polyethylene foam forming the inner surface being greater than the density of the polyethylene foam forming the outer surface.
7. The insulation panel of claim 6 wherein the thickness of the polyethylene foam forming the inner surface is less than the thickness of the polyethylene foam forming the outer surface.
8. The insulation panel of claim 6 or 7 wherein the outer polyethylene foam surface is a thickness of from 5 mm to 20 mm and a density of from 20 to 40 kg/m³.

9. The insulation panel of any one of claims 6 to 8 wherein the inner polyethylene foam layer has a thickness of from 1 mm to 5 mm and a density of from 80 to 250 kg/m³.
10. The insulation panel of any one of claims 6 to 9 wherein the edge surfaces
5 comprise a layer of polyethylene foam having the same thickness and density as the outer polyethylene foam layer.
11. The insulation panel of any one of claims 1 to 10 wherein the rigid core of thermal insulation material is polyurethane and has a thickness from 15 mm to 100 mm.
10
12. A thermally insulated container which includes at least one insulation panel of any one of claims 1 to 11.
13. The insulated container of claim 12 which includes a plurality of insulation panels
15 of any one of claims 1 to 11 assembled into a square or rectangular box with interconnecting sides and a closed bottom.
14. An insulated shipping container which includes at least one thermally insulated container of claim 12 or 13.
20
15. The insulated shipping container of claim 14 which also includes a reinforced cardboard carton in which the thermally insulated container is located.
16. A process for the manufacture of an insulation panel for use in thermally insulated
25 containers comprising the steps of:-
- (i) providing a first, second, third and fourth rectangular polyethylene foam sections, each section having two opposed ends;
 - (ii) joining the sections together at or near the ends of the sections so to provide a substantially square or rectangular frame;

- (iii) providing a fifth polyethylene foam section and joining the frame and the fifth section together so to provide a container having a closed bottom and a cavity therein;
 - (iv) providing thermal insulation material and locating the material within the cavity so to fill or substantially fill the cavity;
 - (v) providing a sixth polyethylene foam section and joining the container and the sixth section together to close the container and provide the insulation panel.
- 10 17. The process of claim 16 wherein the sections are joined together with airtight joins.
18. The process of claim 16 or 17 wherein the sections are joined together by heat welding.
- 15 19. A process for the manufacture of a thermally insulated container wherein insulation panels of any one of claims 1 to 11 are joined together to provide an insulated shipping container.
20. The process of claim 19 wherein the panels are joined together with airtight joins.
- 20 21. The process of claim 19 or 20 wherein the panels are joined together by heat welding.
22. The insulation panel according to claim 1, the panel comprising a rigid core of polyurethane foam having a density of 85 kg/m^3 , the thickness of approximately 25 mm or 50 mm, the panel having an inner surface, an outer surface and edge surfaces, the inner surface comprising a layer of non-cross-linked closed cell polyethylene foam of a density of approximately 100 kg/m^3 and a thickness of approximately 2 or 3 mm and the outer and edge surfaces comprising a layer of non-cross-linked closed cell polyethylene foam of a density of approximately 30 kg/m^3 and a thickness of approximately 10 mm.
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23. The insulation panel according to claim 1 substantially as herein before described with reference to the figures.

24. The insulated container according to claim 12 substantially as herein before
5 described with reference to the figures.

25. The insulated shipping container according to claim 14 substantially as herein before described with reference to the figures.