

PANEL FOR FLOATING COVERS

FIELD OF THE INVENTION

This invention relates broadly to a buoyant panel for a floating cover for a liquid storage tank, a method of fabricating a buoyant panel for a floating cover for a liquid storage tank, and a floating cover for a liquid storage tank.

BACKGROUND OF THE INVENTION

Storage tanks are in common use at storage terminals or processing plants where huge stockpiles of liquid raw materials are necessary for their continuous operations. These storage tanks usually employ floating covers that move as the liquid levels change, and these covers provide protection against contamination to/from the external environment or weather and against evaporation losses.

The covers are typically made of steel or aluminium, mainly due to their ease of welding and their availability as construction materials. However, steel covers corrode relatively easily and are costly to maintain. For aluminium covers, the initial capital outlay is high but the maintenance cost is lower than that of steel. The materials of these covers or their coatings must also be compatible with the content in the tanks.

These tanks are usually very large and may range from a few metres to about a hundred metres in diameter. Before construction begins, a platform supported on scaffolding is erected and the cover is then formed on the platform. Due to the size of the cover, this type of construction is invariably carried on site. Owing to the nature of work, it involves welding from both sides, and this requires welders to carry out overhead welding from below the platform. However, welding creates hazardous fumes, and the working space, especially that below the platform must be properly ventilated.

It has also been known to make such covers from sheets of glass fibre, which overlap at their edges and which are supported on their undersides by buoyant urethane foam frames, for instance as is disclosed in published patent document GB 983,797.

WO 2004/067408 describes a floating cover for a liquid storage tank made from a plurality of prefabricated panels. Each panel has an upper glass fibre composite layer portion, a honeycomb layer the same size as the upper composite layer portion, and a lower fibreglass composite layer portion that extends around the edges of the honeycomb layer by about 0.1m. The panels are laid adjacent and abutting each other on a supporting form work and the gaps above the extended lower layered portion are filled in with sections similar to the structural layers of the panels. The upper parts of the in-filled sections overlap the upper layered portions of the prefabricated panels by about 0.1m. In such a construction, there may be a concern that relates to propagation of fire within the floating cover. More particular should the typically flammable honeycomb layer catch fire due to for example damage to the upper, typically fire-retardant glass fibre composite layered portion in one of the panels, there may be a risk that the fire may propagate to the flammable honeycomb layers of adjacent panels.

A need therefore exists to provide panels for floating covers, floating covers, and methods for making the same that seek to address at least one of the above problems.

SUMMARY OF THE INVENTION

In accordance with a first aspect of the present invention, there is provided a buoyant panel for a floating cover for a liquid storage tank, the panel comprising a flammable material portion; and an fire-retardant material portion encapsulating said flammable material portion such that, when the panel is assembled for formation of the cover, said fire-retardant material portion extends laterally between adjacent panels in a plane of the cover for providing a firewall between the adjacent panels.

Said fire-retardant material portion may comprise a first portion having an extent in the plane of the panel and a first side facing the flammable material portion, and the flammable material portion has an extent in the plane of the panel, which extent is less than the extent of the first portion and the first portion has an exposed portion on said first side.

The exposed portion may extend around an edge of the flammable material portion.

The first portion may be a laminate structure.

The first portion may be a glass reinforced structure.

The flammable material portion may be buoyant.

The fire-retardant material portion may further comprise a second portion in contact with the flammable material portion on the other side of the flammable material portion from the first portion.

The second portion may comprise wall segments disposed around an edge of said flammable material portion.

The second portion may have a laminate structure.

Layers of the second portion may each have an extent in the plane of the panel and the extent of a layer of the second portion furthestmost away from the flammable material portion is less than the extent of the layer of the second portion nearest the flammable material portion.

The fire-retardant material portion may further comprise wall segments disposed around an edge of said flammable material portion, and a capping structure disposed over the wall segments and adjacent sections of the first and second portions for securing the wall segments.

The second portion may be a glass reinforced structure.

The second portion has the same construction as the first portion.

In accordance with a second aspect of the present invention, there is provided a method of fabricating a buoyant panel for a floating cover for a liquid storage tank, the method comprising providing a flammable material portion; and encapsulating said buoyant material portion with an fire-retardant material portion such that, when the panel is assembled for formation of the cover, said fire-retardant material portion

extends laterally between adjacent panels in a plane of the cover for providing a firewall between the adjacent panels.

In accordance with a third aspect of the present invention, there is provided a cover comprising a plurality of panels as defined in the first aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention will now be described by way of non-limitative examples, with reference to the accompanying drawings, in which:-

Fig. 1 is a cross-section illustrating a typical liquid storage tank using a floating cover of the type described in this invention;

Fig. 2 illustrates cross sectional details of a sandwich panel making up the floating cover according to an embodiment of this invention;

Fig. 3 illustrates cross sectional details where two prefabricated sandwich panels of Fig. 2 join together; and

Fig. 4 is an exploded view of the component parts of Fig. 3.

Fig. 5 illustrates a portion of the floating cover of Fig. 3 with a test port for testing if the sandwich panel joints are airtight.

Fig. 6 illustrates a portion of the floating cover of Fig. 3 with another test port and a drain port.

Fig. 7 illustrates cross sectional details of a sandwich panel making up the floating cover according to another embodiment of this invention;

Fig. 8 illustrates cross sectional details where two prefabricated sandwich panels of Fig. 7 join together; and

Fig. 9 is an exploded view of the component parts of Fig. 8.

Fig. 10 illustrates a portion of the floating cover of Fig. 8 with a test port for testing if the sandwich panel joints are airtight.

Fig. 11 illustrates a portion of the floating cover of Fig. 8 with another test port and a drain port.

Fig. 12 shows a flowchart illustrating a method of fabricating a buoyant panel for a floating cover for a liquid storage tank according to an example embodiment.

DETAILED DESCRIPTION

Fig. 1 illustrates a large storage tank 10 having a cover 12 floating on liquid 14 contained in the tank. This floating cover 12 is made up of a number of prefabricated sandwich panels joined together.

The cover 12 includes other components for operation of the storage tank. For example, a ring flange, with a cross-sectional shape of an inverted "L" is provided around the peripheral edge of the cover. A flexible metal seal 16 is mounted on this flange to co-operate with the internal wall of the tank to keep the content of the tank beneath the cover 12 and to prevent external contaminants from entering. A plurality of vents is equally spaced along the ring flange is to allow for expansion or contraction of vapour that may be present in the tank as its temperature varies during the day. Other types of vents may also be provided, for example a vacuum breaker vent to allow the liquid in the tanks to be emptied, when the cover is resting on the tank floor and is no longer floating. This is to prevent damage to the cover caused by negative pressure when the balance of the content is pumped out.

Draining or sampling points are arranged in order to allow samples of the contents of a tank to be taken. Further, a gauge pole well is also provided for determining the quantity of the content in the tank.

Fittings, such as a wire rope 18 fixed between the roof and floor of the tank and passing through the cover prevent the cover 12 from rotating.

Vertically extending legs 20 are spaced apart below the cover 12 at regular intervals. These legs are provided to support the cover 12 when the scaffolding has been removed after the cover is completed and before the tank 10 is filled with sufficient liquid for the cover 12 to float. The legs 20 also provide headroom below the cover 12 for maintenance purposes. A hatch-cover complete with seals over a man-hole is also provided for maintenance purposes.

These provisions for the operation of the tank, such as the vents, sampling and drain points, anti-rotation fittings, legs or man-hole hatch cover, etc mean that some of the panels have apertures or flanges to allow them to be fitted, or are formed with various components already installed.

A roof 22 covers the whole tank 10.

A prefabricated sandwich panel 30, used to make up the floating cover 12, is shown in cross-section in Fig. 2. Because each panel is very much thinner than it is long or wide, the relative depth and width is distorted in Fig. 2 and other figures. Likewise, there is a distortion in the relative thicknesses of the different layers.

Each panel 30 has a lower fire-retardant glass-fibre reinforced composite layered portion 32, an upper fire-retardant glass-fibre reinforced composite layered portion 34 and a flammable honeycomb section (portion) 36, to provide buoyancy, sandwiched between the lower and upper layered portions 32,34. In an embodiment, the lower fire-retardant glass-fibre reinforced composite layered portion 32 is a first portion. In an embodiment, the upper fire-retardant glass-fibre reinforced composite layered portion 34 is a second portion. Each portion is preferably continuous, in that there are no holes or gaps all the way through them.

Both the lower layered portion 32 and the upper layered portion 34 are themselves composite, laminar structures of several layers, each of which contains a liquid polymerise resin such as an epoxy resin, for instance epoxy vinyl ester resin, and glass fibres. The glass fibres are orientated in different patterns or directions, at least relative to immediately adjacent layers to provide each panel with required strength and other desired mechanical properties.

The upper fire-retardant layered portion 34 includes extensions or wall segments 34a and 34b extending substantially vertical along and encapsulating the flammable honeycomb section 36. While two wall segments 34a, 34b are shown in Figure 2, it will be appreciated that the wall segments extend around the entire flammable honeycomb section 36 of the panel. For example, if the panel is of a generally rectangular shape, there is a total of four wall segments accordingly. In this described example embodiment, the flammable honeycomb section 36 is thus encapsulated by the fire-retardant material of the upper layered portion 34, including the wall segments 34a, 34b on the one hand, and the lower layered portion 32 on the other hand, thus advantageously providing a firewall between adjacent panels in an assembled floating cover 12 (Figure 1). It will be appreciated that, if for example the upper fire-retardant layered portion 34 is pierced due to some incident, and the flammable honeycomb section 36 underneath the damaged upper layered portion 34 has caught fire, then the fire advantageously will not "jump across" to the flammable honeycomb section of an adjacent panel, even if sufficient oxygen is available for migration of the fire from the damaged area to the periphery of the honeycomb section 36.

In general composition, in this exemplary embodiment, the lower and upper layered portions 32, 34 are mirror images of each other, although extending different amounts in the plane of each panel 30.

In the lower layered portion 32, the lowermost (outer) layer 42, is a V-layer. Above the V-layer 42 is a first mat or M-layer 44. An R-layer 46 is disposed above the first M-layer 44. A second M-layer 48, of a similar composition to the first M-layer 44 is provided on top of R-layer 46. This is the topmost layer of the lower layered portion 32 and is adjacent the underside of the honeycomb section 36.

The upper layered portion 34 is the inverse of the lower layered portion 32, with a V-layer 52 uppermost, above a first M-layer 54, above a R-layer 56 above a second M-layer 58, which is adjacent the topside of the honeycomb section 36. The V-layer 52, first M-layer 54, R-layer 56 and second M-layer 58 of the upper layered portion 34 have the same general composition as their corresponding layers in the lower layered portion 32.

The V-layers (surface veil layers) 42, 52 have a surfacing veil glass fibre mat of C glass reinforcements and have carbon (and colour pigments if desired) and enhance the surface finish as well as providing weather protection and corrosion resistant properties. Typically they are about 90 – 95% by weight of resin and about 0.5 – 0.6 mm thick. Different V-layers within the same panel can be of differing construction.

The M-layers (mat layers) 44, 48, 54, 58 have a chopped strand mat of glass fibres that are of certain lengths but are randomly orientated. Typically they are about 60 – 70% by weight of resin and about 1.1 – 1.2 mm thick. The M-layers absorb relatively more resin and give relatively higher resistance to corrosion to the composite layered portions 32, 34. Different M-layers within the same panel can be of differing construction.

The R-layers (woven roving layers) 46, 56 have a woven roving mat of glass reinforcements that are woven in two perpendicular directions. Typically they are about 40 – 50% by weight of resin and about 1.1 – 1.2 mm thick. Due to the orientations of the reinforcement, the R-layers provide mechanical strength in two directions. The lower resin absorption of these layers increases the glass to resin ratio with consequent increased mechanical strength. Different R-layers within the same panel can be of differing construction.

The honeycomb layer 36 is made of a polypropylene core, with two membranes on each side. An inner membrane permanently attaches to the core and acts as a seal to prevent resin penetration into the cells of the core. An outer membrane of a non-woven thermoplastic mat is porous and allows the resin of the composite layered portions (when wet) to penetrate and bond to the membrane's surface. The resulting bond contributes to the overall structural integrity of each panel 30.

This honeycomb layer 36 and its core may be substituted with other types of lightweight core materials as desired or appropriate.

The panels 30 are prefabricated at a factory. Each panel is typically 2.2 m square, this size being selected on a weight of about 70-80 kg per panel and general cumbersomeness. Each panel is not too heavy or large for a group of four to manhandle. As most storage tanks are cylindrical, a cover for such a tank would also

be circular. This means that not all panels will be square, but some will have a rounded edge according to the overall radius of the tank.

Generally the composite is made in a large continuous and uniform sheet which is cut into appropriately sized panels 30. Portions of each panel are then removed around its edges to give it a stepped form, as is shown in Fig. 2. In particular, the honeycomb section 36 are removed to form an undercut with regard to the upper layered portion 34, and the overhang of the undercut upper layered portion 34 is then folded in to form the wall segments 34a and 34b. The wall segments 34a, 34 b are secured using e.g a catalysed resin in this example embodiment. Additionally, the removal of the honeycomb section 36 and folding of the wall segments 34a and 34b is performed such that the lower layered portion 32 extends for example 0.1m beyond the upper layered portion 34 and honeycomb section 36 in an exposed portion 50 in each direction in the plane of the panel 30. Further, the top V-layer 52 is stripped back a bit further at its edges, leaving an exposed strip 40 of the top first M-layer 54. Again this strip is 0.1m wide in this example.

Before installation of the cover 12 (Figure 1), form work scaffolding is erected and a platform is provided so that the panels 30 making up the entire cover 12 (Figure 1) can be laid out with contiguous contact between the edges of the lower layered portions 32. In the spaces above the extended edges of the lower layered portions 32, the upper, horizontal surfaces are roughened with sandpaper, emery cloth or similar abrasive (for example having a grade size of about 30), if this has not been already been done. The resulting dust is removed by vacuum cleaning, otherwise the residue may cause weak bonding and joint failure.

A joint between adjacent panels 30 is shown in Fig. 3. An exploded view of this is shown in Fig. 4.

The resin used in the V-layer is applied to the extended facing edges 38 of the lower layered portions 32. However, rather than just filling in the gap between adjacent honeycomb structures 36 with more honeycomb, a reinforcing structure is mounted over the joints between adjacent panels 30. In particular, the gap is filled with what amounts to a narrower inverted panel with the top V-layer 52 completely removed. That is there is a reinforcing infill composite 60, having a first M-layer 62 in contact with

the abutting second M-layers 48 of two abutting lower layer portions 32. Above this is a first R-layer 64, then a second M-layer 66. Atop this is a honeycomb structure 68, on top of which is a third M-layer 70, then a second R-layer 72, then a fourth M-layer 74 and finally a topmost V-layer 76.

Whilst it is possible to prefabricate the infill composite 60 for improved strength it is preferred that they be made in situ. In particular, a catalysed resin is applied to the exposed and roughened surfaces of the second M-layers 48 and the infill composite is applied one layer at a time, either with each layer prefabricated or more preferably each layer made in situ, with some of the resin seeping down between the abutting edges 50 of the panels to help join them together. After each layer is laid down, it is compacted and air bubbles that may be present are rolled out, for example using metal rollers.

Before the resin bonding the infill second M-layer 66 to the infill first R-layer 64 in this lower fire-retardant infill portion 78 has hardened or cured, a catalysed resin is applied to the underside of the infill honeycomb structure 68 and this is applied to the top of the infill second M-layer 66. It is held down by weights until it has completely cured. A top fire-retardant infill portion 80, with the remaining layers, is then applied to the top of the infill honeycomb structure 68. Again this is done on a layer by layer basis, compressing the layers and rolling out the air bubbles each time. In the example embodiment, the final V-layer 76 is formed such that it extends and merges with the top V-layer 52 of the joining panels, as shown in Figure 3. This completes the joint. Once all the cover joints have been completed, the top surface can be finished off with any required top coat.

The creation of the infill composite 60 reflects the creation of the initial composite from which the panels are formed. Thus if there are additional or fewer processes in creating that, they could be reflected in the creation of the infill. This means that the infill has similar properties to the panels. Additionally it means that the heights of various layers of the infill correspond to heights of other layers in the panels. In particular, the top of the infill honeycomb structure 68 is level with the top of the exposed top first M-layer 54 and the infill third M-layer 70 is level with the top V-layer 52.

Further, in this embodiment, the top infill portion 80, that is the third M-layer 70, second R-layer 72, fourth M-layer 74 and topmost V-layer 76, extend further outwards relative to the rest of the infill structure 60. It is about 0.4m wide, whilst the infill honeycomb structure 68 and lower structural infill portion are for example about 0.2m, or a little less wide (to allow resin between the panels 30 and the infill composite 60. This means that the fire-retardant top infill structural portion 80 extends as far as the exposed top first M-layer 54, the infill third M-layer 70 bonding to the top exposed surface 40 of the top first M-layer 54. The top V-layer 76 extends down the exposed sides of the top fire-retardant infill portion 80, to join up with the top V-layers 52 of the panels being joined, to complete the outer protective layer.

After completion of the cover, the form work is removed from the underside and exposed edges on the underside are sealed and laminated with a further V-layer. This is to improve corrosion resistance, rather than being necessary for strength.

The construction of the cover 12 (Figure 1) from separate panels 30 by this method can be carried out from just one side, the top side, although the preferred finishing step after completion is carried out below. This is partly due to the fact that the panels are connected edge to edge, with vertical edges next to each other and without overlap. This means that people do not have to work in cramped and badly ventilated conditions underneath, thereby improving safety. Breathing equipment is therefore not necessary, or does not need to be used so much and there are improvements in work conditions and costs.

With this method of construction, the prefabricated panels are joined together to form an entire cover having similar structural layers. This method provides a cover that is mainly prefabricated at the factory and minimal work is carried out on site. As the working conditions and quality at the factory is easily controlled, this means that the structural integrity of the cover thus formed is relatively superior to that if formed on site. With this method, the entire job for completing a cover is also shorter, which means cost savings.

The lower and upper fire-retardant layered portions 32, 34 are formed layer by layer in the factory to suit each application. The resins binding the fibres in each layer may also differ from the adjacent layers, and together with the glass-fibres, each layer

provides the composite plate unique mechanical properties. The composition and number of layers of panels can vary from job to job, within the scope of the invention.

In this example, each lower and upper layered portion 32, 34 is 4 mm thick and the honeycomb layer is 60 mm thick. Depending on the size of the cover, the core thickness, the spacing between the supporting legs, the self-weight of the cover, the strength of the resin and glass fibres, the rigidity of the cover, the composite plate thickness or the number of laminates may vary, all relative to each other. Similarly, the honeycomb thickness or number of honeycomb layer may be increased for greater strength or rigidity. Yet it is also possible to maintain a common composite thickness and strength by providing more supporting legs at the lower side of the cover.

The exposed portions in the described embodiment are 0.1m wide. The invention covers other possibilities as required. For example, they could range from 0.05 to 0.2m or to other widths. The extension of the lower layered portion 32 relative to the upper layered portion 34 and core 36, and the overlap of the top infill structural portion 80 need not be 0.1m but could be different from each other and can be varied as desired, for instance depending on the type of resin used and the shear forces induced at these joints, etc. Moreover, the steps do not need to have vertical faces, but can be sloped.

The materials chosen for the cover are preferably compatible with the liquid in the tank.

The completed floating cover 12 (Figure 1) may need to be inspected and tested to verify that the floating cover 12 (Figure 1) formed according to the specification of work meets the industry or regulatory standards during and after commissioning. To allow testing that the bonding of the layers of the fibreglass and resin and joints are integral, testing ports 90 may be provided at the infill composite section 60 near the cut edges of the honeycomb 68 as shown in Fig. 5.

The infill honeycomb sections 68 are generally slightly smaller than the space between two adjacent wall segments 34a, 34b. This is to allow for dimensional tolerances in the fabrication of the panels 30 and honeycomb sections 68. As a result there is a gap 92 in between the cut edges of the honeycomb section 68, and this gap 92 runs along

the fabricated joints between the panels 30. In an integrally constructed floating cover, the gap 92 is sealed by the lower upper fire-retardant infill portions 78, 80 honeycomb section 68 and wall segments 34a, 34b.

To provide a testing port 90, a hole 94 is drilled through the upper infill portion 80 to the cut edge of the honeycomb 68. Epoxy resin such as that mixed with the catalyst used in fabricating the panels 30 is applied onto the walls of the hole 94. A sleeve 96, preselected to suit the hole 94, is inserted into the hole 94, and the gap, if any, between the hole 94 and the sleeve 96 is further filled with epoxy and catalyst so that there is no void between the hole 94 and the sleeve 96. The bonding between the upper infill portion 80 and the sleeve 96 can thereby be as strong as the upper infill portion 80 itself.

The sleeve 96 has a through hole with an internal thread. In the process of inserting the sleeve 96 in the hole 94, precautions are preferably taken not to allow the epoxy to block the internal hole of the sleeve 96. The upper end of the sleeve 96 may be temporary closed with a plug (not shown) (which may extend all the way to the bottom of the sleeve 96).

A number of test ports 90, for example, are provided at spaced apart positions. One such port 90 should normally be sufficient, as the gaps 92 are all joined together. However, more than one is provided to give the tester a choice of testing positions or in case some groups of the gaps are isolated. After the sleeves 96 are bonded to the composite layer 80, all the test ports except one are plugged. A nipple 100 is attached to the test port 90 which is not plugged. The nipple 100 is screwed into the internal thread of the sleeve 96 so as to form an airtight joint. A first end of a T-joint 102 is connected to the other end of the nipple 100. The other two distal ends of the T-joint 102 are connected to a pressure gauge 104 and a shutoff valve 106. The shutoff valve 106 has a thread that is suitable for connection to a line from a pump 200.

During commissioning of the cover, the pump 200 is operated to deliver a gas, for example air or nitrogen, to the enclosed space created by the gap 92 between the panels 30 in the floating cover. The gas is delivered with a positive pressure, for example 0.005 bar gauge (or 50 mm water head), and the shutoff valve 106 is closed once a predetermined pressure is attained. The pressure in the enclosed space in the

floating cover is monitored over a period of time, for example 24 hours. If this pressure is maintained over this time period, the joints formed in the panel are airtight. If the pressure is not maintained, one or more joints is not airtight. The actual leaking joints may be detected by applying a liquid such as a soap solution to a portion of the floating cover and observing air bubbles from a defective portion of the cover. The defective portion of the cover can then be identified, repaired and tested again to ensure that the joints formed in the floating cover are not defective.

To test for leaks in the joints, a vacuum pressure may be used instead of a positive pressure. Accordingly, the pressure gauge must be suitable for vacuum sensing. However, to identify the defective portion of the cover with ease, a positive pressure and a liquid such as a soap solution are used.

When the floating cover is put into use, these testing ports 90 are plugged up to prevent entry of vapour or liquid into the cover.

Although the hole 94 is smooth in the above embodiment, alternatively, the hole 94 may be threaded to fit an externally threaded sleeve.

Another alternative is to locate the sleeve 96 in the upper infill portion 80 as the infill composite section 60 is made.

A further alternative for the test ports is to provide the sleeve 96 with a flange 300 having an internal hole through which the sleeve 96 is positioned and to which the sleeve 96 is welded, to form a test port 91 as shown in Fig. 6. The flange 300 is anchored between the upper M-layer 74 of the upper infill portion 80, and a built-up section 80b, including an M-layer 70b on top of the M-layer 74 of the upper infill portion 80.

The flange 300 and sleeve 96 may both be made of metal, for example, steel or aluminium. The flange 300 is toroidal, for example with an outside diameter of about 70 mm and a thickness from about 3 mm to about 5 mm. Other shapes of the flange 300 are also suitable, although preferably they can fit an inscribed circle within them, for example of at least 70 mm diameter. The sleeve 96 has an internal thread and an internal bore of 12-mm, for example, nominal diameter. In the preferred embodiment,

the internal pressure is to be 0.005 bar gauge. Thus the external diameter of the sleeve may, for instance, be 25 mm. The diameter of the flange through hole matches the external diameter of the sleeve 96. Thus if a different pressure rating were required, the external diameter of the sleeve 96 might change, and so would the size of the flange through hole. The sizes of the sleeve 96 and flange 300 are not limited by these examples, and the sizes of the sleeve 96 and flange 300 are merely design choices.

The sleeve 96 and flange 300, which are prejoined together, are inserted during the formation of the upper infill portion 80. After the structural layers 70, 72, 74 of the upper infill portion 80 are formed, the hole 94 is drilled. Catalysed epoxy is applied to the walls of the hole 94 and the sleeve 96 is inserted such that there is no void between the hole 94 and sleeve 96, as done in the previous embodiment. Catalysed epoxy is also applied to the upper, lower and edge surfaces of the flange 300. With the test port 91 fully inserted, i.e. with the sleeve 96 portion pushed all the way down into the hole 94 until the flange 300 is in contact with the top M-layer 74, another set of structural fibreglass layers 70b, 72b, 74b is formed over and around the flange 300 to secure the test port 91 to the floating cover 12, and also to strengthen the structural layers of the cover around the test port 91. Once all the structural work is completed, the V-layer 76 is formed over the exposed layers of the upper infill portion 80 and built-up section 80b to complete the finishing and protective layer 76.

In this embodiment as shown in Fig. 6, a plurality of drain ports 191 are provided on the lower side of the panel 30. These drain ports 191 are provided so that any liquid that has entered the cover 12, such as the liquid from the storage tank (which entered during maintenance or repair of the floating cover or otherwise) or rain water collected on the uncompleted floating cover during its fabrication, can be drained out. Each drain port 191 is fabricated in the same manner as a test port 91, i.e. having a flange 302 welded to a sleeve 97. Again, the flange 302 is anchored using an extension segment 32b to the lower layered portion 32.

After the floating cover is formed and the supporting formwork is removed, a plurality of positions directly below the gap 92 are marked on the lower surface of the cover. These positions are spaced apart as desired. At each position, a hole 95 is drilled through the structural layers 42, 44, 46, 48 of the lower layered portion 32. The V-layer

42 in the area around each hole 95 is removed, if not previously done, over an area extending beyond the size and shape of the flange 302. The flange 302 is positioned on the sleeve 97 and they are prejoined together, such that when of the sleeve 99 is inserted into the hole 95 until the flange 302 is in contact with the exposed area of the outer M-layer 44 and the upper end of the sleeve 97 is about flush with the inner M-layer 48. Catalysed epoxy is applied onto the exposed area of the outer M-layer 44, onto the surfaces of the hole 95 and also on the upper, lower and edge surfaces of the flange 302. The sleeve 97 is then inserted into the hole 95 until the flange 302 is in contact with the exposed layer 44. Each drain port is mounted and secured onto the cover by forming a set of structural layers of fibreglass 70c, 72c, 74c over and around the flange 302 of the drain port 191 similar to layers 70b, 72b, 74b over and around the test port 91. Once the structural work is completed, a V-layer similar to layer 42 is formed over the exposed surfaces of the newly laid structural layers 70c, 72c, 74c and the exposed area of layer 44 to complete the finishing and protective coat on the lower surface of the floating cover.

Of course, although this embodiment shows test ports 91 and drain ports 191 together, other embodiments may have one or more test ports 91 without any drain ports 191 and yet further embodiments may have one or more drain ports 191 without any test ports 91.

A prefabricated sandwich panel 730 according to another embodiment, used to make up the floating cover 12, is shown in cross-section in Fig. 7.

Each panel 730 has a lower fire-retardant glass-fibre reinforced composite layered portion 732, an upper fire-retardant glass-fibre reinforced composite layered portion 734 and a flammable honeycomb section (portion) 736, to provide buoyancy, sandwiched between the lower and upper layered portions 732, 734. In an embodiment, the lower fire-retardant glass-fibre reinforced composite layered portion 732 is a first portion. In an embodiment, the upper fire-retardant glass-fibre reinforced composite layered portion 734 is a second portion. Each portion is preferably continuous, in that there are no holes or gaps all the way through them.

Both the lower layered portion 732 and the upper layered portion 734 are themselves composite, laminar structures of several layers, each of which contains a liquid

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polymerise resin such as an epoxy resin, for instance epoxy vinyl ester resin, and glass fibres. The glass fibres are orientated in different patterns or directions, at least relative to immediately adjacent layers to provide each panel with required strength and other desired mechanical properties.

In general composition, in this exemplary embodiment, the lower and upper layered portions 732, 734 are mirror images of each other, although extending different amounts in the plane of each panel 730.

In the lower layered portion 732, the lowermost (outer) layer 742, is a V-layer. Above the V-layer 742 is a first mat or M-layer 744. An R-layer 746 is disposed above the first M-layer 744. A second M-layer 748, of a similar composition to the first M-layer 744 is provided on top of R-layer 746. This is the topmost layer of the lower layered portion 732 and is adjacent the underside of the honeycomb section 736.

The upper layered portion 734 is the inverse of the lower layered portion 732, with a V-layer 752 uppermost, above a first M-layer 754, above a R-layer 756 above a second M-layer 758, which is adjacent the topside of the honeycomb section 736. The V-layer 752, first M-layer 754, R-layer 756 and second M-layer 758 of the upper layered portion 734 have the same general composition as their corresponding layers in the lower layered portion 732.

The V-layers (surface veil layers) 742, 752 have a surfacing veil glass fibre mat of C glass reinforcements and have carbon (and colour pigments if desired) and enhance the surface finish as well as providing weather protection and corrosion resistant properties. Typically they are about 90 – 95% by weight of resin and about 0.5 – 0.6 mm thick. Different V-layers within the same panel can be of differing construction.

The M-layers (mat layers) 744, 748, 754, 758 have a chopped strand mat of glass fibres that are of certain lengths but are randomly orientated. Typically they are about 60 – 70% by weight of resin and about 1.1 – 1.2 mm thick. The M-layers absorb relatively more resin and give relatively higher resistance to corrosion to the composite layered portions 732, 734. Different M-layers within the same panel can be of differing construction.

The R-layers (woven roving layers) 746, 756 have a woven roving mat of glass reinforcements that are woven in two perpendicular directions. Typically they are about 40 – 50% by weight of resin and about 1.1 – 1.2 mm thick. Due to the orientations of the reinforcement, the R-layers provide mechanical strength in two directions. The

lower resin absorption of these layers increases the glass to resin ratio with consequent increased mechanical strength. Different R-layers within the same panel can be of differing construction.

The honeycomb layer 736 is made of a polypropylene core, with two membranes on each side. An inner membrane permanently attaches to the core and acts as a seal to prevent resin penetration into the cells of the core. An outer membrane of a non-woven thermoplastic mat is porous and allows the resin of the composite layered portions (when wet) to penetrate and bond to the membrane's surface. The resulting bond contributes to the overall structural integrity of each panel 730.

This honeycomb layer 736 and its core may be substituted with other types of lightweight core materials as desired or appropriate.

The panels 730 are prefabricated at a factory. Each panel is typically 2.2 m square, this size being selected on a weight of about 70-80 kg per panel and general cumbersomeness. Each panel is not too heavy or large for a group of four to manhandle. As most storage tanks are cylindrical, a cover for such a tank would also be circular. This means that not all panels will be square, but some will have a rounded edge according to the overall radius of the tank.

Generally the composite is made in a large continuous and uniform sheet which is cut into appropriately sized panels 730. Portions of each panel are then removed around its edges and additional layers added to give and embedded a stepped form, as is shown in Fig. 7. In particular, the upper layered portion 734 and honeycomb section 736 are removed from a strip around every edge, in this example the strip is 0.1m wide. Thus the lower layered portion 732 extends 0.1m beyond the upper layered portion 734 and honeycomb section 736 in each direction in the plane of the panel 730. Further, the top V-layer 752 is stripped back a bit further at its edges, leaving an exposed strip of the top first M-layer 754. Again this strip is 0.1m wide in this example.

Next, prefabricated fire-retardant wall segments 734a and 734b are provided substantially vertical along and encapsulating the flammable honeycomb sections 736. While two wall segments 734a, 734b are shown in Figure 7, it will be appreciated that the wall segments are provided around the entire flammable honeycomb section 736

of the panel. For example, if the panel is of a generally rectangular shape, there is a total of four wall segments accordingly. The wall segments 734a, 734b are composed of two M-layers in the example embodiment.

Next, additional capping layers 735a, 735b are secured around the edge of the panels, securing the wall segments 734a, 734b in place. Catalysed resin is used in this example embodiment to mount the capping layers 735a, 735b. The layers 735a, 735b are prefabricated in a stepped shape, and as one unitary piece in the example embodiment.

In this example embodiment, the flammable honeycomb section 736 is thus again encapsulated by an fire-retardant material, more particular by the fire-retardant material of the upper layer portions 734, the wall segments 734a, 734b, layers 735a, 735b, and the lower layered portion 732, thus advantageously providing a firewall between adjacent panels in an assembled floating cover 12 (Figure 1).

Before installation of the cover 12 (Figure 1), form work scaffolding is erected and a platform is provided so that the panels 730 making up the entire cover 12 (Figure 1) can be laid out with contiguous contact between the edges of the lower layered portions 732. In the spaces above the extended edges of the lower layered portions 732, the upper, horizontal surfaces are roughened with sandpaper, emery cloth or similar abrasive (for example having a grade size of about 30), if this has not been already been done. The resulting dust is removed by vacuum cleaning, otherwise the residue may cause weak bonding and joint failure.

A joint between adjacent panels 730 is shown in Fig. 8. An exploded view of this is shown in Fig. 9.

The resin used in the V-layer is applied to the extended facing edges 738 of the lower layered portions 732. However, rather than just filling in the gap between adjacent honeycomb structures 736 with more honeycomb, a reinforcing structure is mounted over the joints between adjacent panels 730. In particular, the gap is filled with what amounts to a narrower inverted panel with the outer V-layers completely removed. That is there is a reinforcing infill composite 760, having a first M-layer 762 in contact with the abutting layers 735a, 735b of two abutting lower layer portions 732. Above

this is a first R-layer 764, then a second M-layer 766. Atop this is a honeycomb structure 768, on top of which is a third M-layer 770, then a second R-layer 772, and then a fourth M-layer 774.

Whilst it is possible to prefabricate the infill composite 760, for improved strength it is preferred that they be made in situ. In particular, a catalysed resin is applied to the exposed and roughened surfaces of the layers 735a, 735b and the infill composite is applied one layer at a time, either with each layer prefabricated or more preferably each layer made in situ, with some of the resin seeping down between the abutting edges of the panels to help join them together. After each layer is laid down, it is compacted and air bubbles that may be present are rolled out, for example using metal rollers.

Before the resin bonding the infill second M-layer 766 to the infill first R-layer 764 in this lower fire-retardant infill portion 778 has hardened or cured, a catalysed resin is applied to the underside of the infill honeycomb structure 768 and this is applied to the top of the infill second M-layer 766. It is held down by weights until it has completely cured. A top fire-retardant infill portion 780, with the remaining layers, is then applied to the top of the infill honeycomb structure 768. Again this is done on a layer by layer basis, compressing the layers and rolling out the air bubbles each time. Finally, a V-layer 776 is formed such that it extends and merges with the top V-layer 752 of the joining panels, as shown in Figure 8. This completes the joint. Once all the cover joints have been completed, the top surface can be finished off with any required top coat.

The creation of the infill composite 760 reflects the creation of the initial composite from which the panels are formed. Thus if there are additional or fewer processes in creating that, they could be reflected in the creation of the infill. This means that the infill has similar properties to the panels. Additionally it means that the heights of various layers of the infill correspond to heights of other layers in the panels. In particular, the top of the infill honeycomb structure 768 is level with the exposed layers 735a, 735b.

Further, in this embodiment the top infill portion 780, that is the third M-layer 770, second R-layer 772, and fourth M-layer 774, extend further outwards relative to the

rest of the infill structure 760. It is about 0.4m wide, whilst the infill honeycomb structure 768 and lower infill portion are about 0.2m, or a little less wide (to allow resin between the panels 730 and the infill composite 760. This means that the top infill portion 780 extends as far as the exposed layers 735a, 735b, the infill third M-layer 770 bonding to the layers 735a, 735b.

After completion of the cover, the form work is removed from the underside and exposed edges on the underside are sealed and laminated with a further V-layer. This is to improve corrosion resistance, rather than being necessary for strength.

The construction of the cover 12 (Figure 1) from separate panels 730 by this method can be carried out from just one side, the top side, although the preferred finishing step after completion is carried out below. This is partly due to the fact that the panels are connected edge to edge, with vertical edges next to each other and without overlap. This means that people do not have to work in cramped and badly ventilated conditions underneath, thereby improving safety. Breathing equipment is therefore not necessary, or does not need to be used so much and there are improvements in work conditions and costs.

With this method of construction, the prefabricated panels are joined together to form an entire cover having similar structural layers. This method provides a cover that is mainly prefabricated at the factory and minimal work is carried out on site. As the working conditions and quality at the factory is easily controlled, this means that the structural integrity of the cover thus formed is relatively superior to that if formed on site. With this method, the entire job for completing a cover is also shorter, which means cost savings.

The lower and upper fire-retardant layered portions 732, 734 are formed layer by layer in the factory to suit each application. The resins binding the fibres in each layer may also differ from the adjacent layers, and together with the glass-fibres, each layer provides the composite plate unique mechanical properties. The composition and number of layers of panels can vary from job to job, within the scope of the invention.

In this example, each lower and upper layered portion 732, 734 is 4 mm thick and the honeycomb layer is 60 mm thick. Depending on the size of the cover, the core

thickness, the spacing between the supporting legs, the self-weight of the cover, the strength of the resin and glass fibres, the rigidity of the cover, the composite plate thickness or the number of laminates may vary, all relative to each other. Similarly, the honeycomb thickness or number of honeycomb layer may be increased for greater strength or rigidity. Yet it is also possible to maintain a common composite thickness and strength by providing more supporting legs at the lower side of the cover.

The exposed portions in the described embodiment are 0.1m wide. The invention covers other possibilities as required. For example, they could range from 0.05 to 0.2m or to other widths. The extension of the lower layered portion 732 relative to the upper layered portion 34 and core 36, and the overlap of the top infill structural portion 80 need not be 0.1m but could be different from each other and can be varied as desired, for instance depending on the type of resin used and the shear forces induced at these joints, etc. Moreover, the steps do not need to have vertical faces, but can be sloped.

The materials chosen for the cover are preferably compatible with the liquid in the tank.

The completed floating cover 12 (Figure 1) may need to be inspected and tested to verify that the floating cover 12 (Figure 1) formed according to the specification of work meets the industry or regulatory standards during and after commissioning. To allow testing that the bonding of the layers of the fibreglass and resin and joints are integral, testing ports 790 may be provided at the infill composite section 760 near the cut edges of the honeycomb 768 as shown in Fig. 10.

The infill honeycomb sections 768 are generally slightly smaller than the space between two adjacent layers 735a, 735b. This is to allow for dimensional tolerances in the fabrication of the panels 730 and honeycomb sections 768. As a result there is a gap 792 in between the cut edges of the honeycomb section 768, and this gap 792 runs along the fabricated joints between the panels 730. In an integrally constructed floating cover, the gap 792 is sealed by the lower and upper fire-retardant infill portions 778, 780, honeycomb section 768, and layers 735a, 735b.

To provide a testing port 790, a hole 794 is drilled through the upper infill portion 780 to the cut edge of the honeycomb 768. Epoxy resin such as that mixed with the catalyst used in fabricating the panels 730 is applied onto the walls of the hole 794. A sleeve 796, preselected to suit the hole 794, is inserted into the hole 794, and the gap, if any, between the hole 794 and the sleeve 796 is further filled with epoxy and catalyst so that there is no void between the hole 794 and the sleeve 796. The bonding between the upper infill portion 780 and the sleeve 796 can thereby be as strong as the upper infill portion 780 itself.

The sleeve 796 has a through hole with an internal thread. In the process of inserting the sleeve 796 in the hole 794, precautions are preferably taken not to allow the epoxy to block the internal hole of the sleeve 796. The upper end of the sleeve 796 may be temporary closed with a plug 798 (not shown) (which may extend all the way to the bottom of the sleeve 796).

A number of test ports 790, for example, are provided at spaced apart positions. One such port 790 should normally be sufficient, as the gaps 792 are all joined together. However, more than one is provided to give the tester a choice of testing positions or in case some groups of the gaps are isolated. After the sleeves 796 are bonded to the composite layer 780, all the test ports except one are plugged. A nipple 800 is attached to the test port 790 which is not plugged. The nipple 800 is screwed into the internal thread of the sleeve 796 so as to form an airtight joint. A first end of a T-joint 802 is connected to the other end of the nipple 800. The other two distal ends of the T-joint 802 are connected to a pressure gauge 804 and a shutoff valve 806. The shutoff valve 806 has a thread that is suitable for connection to a line from a pump 808.

During commissioning of the cover, the pump 808 is operated to deliver a gas, for example air or nitrogen, to the enclosed space created by the gap 792 between the panels 730 in the floating cover. The gas is delivered with a positive pressure, for example 0.005 bar gauge (or 50 mm water head), and the shutoff valve 806 is closed once a predetermined pressure is attained. The pressure in the enclosed space in the floating cover is monitored over a period of time, for example 24 hours. If this pressure is maintained over this time period, the joints formed in the panel are airtight. If the pressure is not maintained, one or more joints is not airtight. The actual leaking joints may be detected by applying a liquid such as a soap solution to a portion of the

floating cover and observing air bubbles from a defective portion of the cover. The defective portion of the cover can then be identified, repaired and tested again to ensure that the joints formed in the floating cover are not defective.

To test for leaks in the joints, a vacuum pressure may be used instead of a positive pressure. Accordingly, the pressure gauge must be suitable for vacuum sensing. However, to identify the defective portion of the cover with ease, a positive pressure and a liquid such as a soap solution are used.

When the floating cover is put into use, these testing ports 790 are plugged up to prevent entry of vapour or liquid into the cover.

Although the hole 794 is smooth in the above embodiment, alternatively, the hole 794 may be threaded to fit an externally threaded sleeve.

Another alternative is to locate the sleeve 796 in the upper infill portion 780 as the infill composite section 760 is made.

A further alternative for the test ports is to provide the sleeve 796 with a flange 810 having an internal hole through which the sleeve 796 is positioned and to which the sleeve 796 is welded, to form a test port 791 as shown in Fig. 11. The flange 810 is anchored between the upper M-layer 774 of the upper infill portion 780, and a built-up section 780b, including an M-layer 770b on top of the M-layer 774 of the upper infill portion 780.

The flange 810 and sleeve 796 may both be made of metal, for example, steel or aluminium. The flange 810 is toroidal, for example with an outside diameter of about 70 mm and a thickness from about 3 mm to about 5 mm. Other shapes of the flange 300 are also suitable, although preferably they can fit an inscribed circle within them, for example of at least 70 mm diameter. The sleeve 796 has an internal thread and an internal bore of 12-mm, for example, nominal diameter. In the preferred embodiment, the internal pressure is to be 0.005 bar gauge. Thus the external diameter of the sleeve may, for instance, be 25 mm. The diameter of the flange through hole matches the external diameter of the sleeve 796. Thus if a different pressure rating were required, the external diameter of the sleeve 796 might change, and so would the size

of the flange through hole. The sizes of the sleeve 796 and flange 810 are not limited by these examples, and the sizes of the sleeve 796 and flange 810 are merely design choices.

The sleeve 796 and flange 810, which are prejoined together, are inserted during the formation of the upper infill portion 780. After the structural layers 770, 772, 774 of the upper infill portion 80 are formed, the hole 794 is drilled. Catalysed epoxy is applied to the walls of the hole 794 and the sleeve 796 is inserted such that there is no void between the hole 794 and sleeve 796, as done in the previous embodiment. Catalysed epoxy is also applied to the upper, lower and edge surfaces of the flange 810. With the test port 791 fully inserted, i.e. with the sleeve 796 portion pushed all the way down into the hole 794 until the flange 810 is in contact with the top M-layer 774, another set of structural fibreglass layers 770b, 772b, 774b is formed over and around the flange 810 to secure the test port 791 to the cover, and also to strengthen the structural layers of the cover around the test port 791. Once all the structural work is completed, the V-layer 776 is formed over the exposed layers of the upper infill portion 780 and built-up section 780b to complete the finishing and protective layer 776.

In this embodiment as shown in Fig. 11, a plurality of drain ports 812 are provided on the lower side of the floating cover. These drain ports 812 are provided so that any liquid that has entered the cover, such as the liquid from the storage tank (which entered during maintenance or repair of the floating cover or otherwise) or rain water collected on the uncompleted floating cover during its fabrication, can be drained out. Each drain port 812 is fabricated in the same manner as a test port 791, i.e. having a flange 814 welded to a sleeve 797.

After the floating cover is formed and the supporting formwork is removed, a plurality of positions directly below the gap 792 are marked on the lower surface of the cover. These positions are spaced apart as desired. At each position, a hole 795 is drilled through the structural layers 742, 744, 746, 748 of the lower layered portion 32. The V-layer 742 in the area around each hole 795 is removed, if not previously done, over an area extending beyond the size and shape of the flange 814. The flange 814 is positioned on the sleeve 797 and they are prejoined together, such that when of the sleeve 799 is inserted into the hole 795 until the flange 814 is in contact with the exposed area of the outer M-layer 744 and the upper end of the sleeve 797 is about

flush with the inner M-layer 748. Catalysed epoxy is applied onto the exposed area of the outer M-layer 744, onto the surfaces of the hole 795 and also on the upper, lower and edge surfaces of the flange 814. The sleeve 797 is then inserted into the hole 795 until the flange 814 is in contact with the exposed layer 744. Each drain port is mounted and secured onto the cover by forming a set of structural layers of fibreglass 770c, 772c, 774c over and around the flange 814 of the drain port 812 similar to layers 770b, 772b, 774b over and around the test port 791. Once the structural work is completed, a V-layer similar to layer 742 is formed over the exposed surfaces of the newly laid structural layers 770c, 772c, 774c and the exposed area of layer 744 to complete the finishing and protective coat on the lower surface of the floating cover.

Of course, although this embodiment shows test ports 791 and drain ports 814 together, other embodiments may have one or more test ports 791 without any drain ports 814 and yet further embodiments may have one or more drain ports 814 without any test ports 791.

Further variations include providing a cover having a slight camber and/or rainwater drainage, which is particularly suitable for a tank without a roof. The cover need not be round and it may be square, rectangular, or of any shape for fitting into any storage tank or reservoir to function as a cover. Instead of forming the in-fill sandwich sections on site, these could be prefabricated at the factory.

Fig. 12 shows a flowchart 1200 illustrating a method of fabricating a buoyant panel for a floating cover for a liquid storage tank according to an example embodiment. At step 1202, a flammable material portion is provided. At step 1204, said buoyant material portion is encapsulated with an fire-retardant material portion such that, when the panel is assembled for formation of the cover, said fire-retardant material portion extends laterally between adjacent panels in a plane of the cover for providing a firewall between the adjacent panels.

While only example embodiments of a panel, a cover and method of its construction have been described and illustrated in detail, it is to be understood that many changes, modifications and variations could be made to the present invention without departing from the scope of the invention.

CLAIMS:

1. A buoyant panel for a floating cover for a liquid storage tank, the panel comprising:

a flammable material portion; and

a fire-retardant material portion encapsulating said flammable material portion such that, when the panel is assembled for formation of the cover, said fire-retardant material portion extends laterally between adjacent panels in a plane of the cover for providing a firewall between the adjacent panels,

wherein said fire-retardant material portion comprises a first portion having an extent in the plane of the panel and a first side facing the flammable material portion, and the flammable material portion has an extent in the plane of the panel, which extent is less than the extent of the first portion and the first portion has an exposed portion on said first side,

wherein said fire-retardant material portion further comprises a second portion in contact with the flammable material portion on the other side of the flammable material portion from the first portion, and

wherein the fire-retardant material portion further comprises wall segments disposed around an edge of said flammable material portion, and a capping structure disposed over the wall segments and adjacent sections of the first and second portions for securing the wall segments.

2. A panel according to claim 1, wherein the first portion is a laminate structure.

3. A panel according to claim 1, wherein the first portion is a glass reinforced structure.

4. A panel according to any one of the preceding claims, wherein the flammable material portion is buoyant.

5. A panel according to claim 1, wherein the second portion comprises wall segments disposed around an edge of said flammable material portion.

6. A panel according to any preceding claim, wherein the second portion has a laminate structure.

7. A panel according to claim 6, wherein layers of the second portion each have an extent in the plane of the panel and the extent of a layer of the second portion furthestmost away from the flammable material portion is less than the extent of the layer of the second portion nearest the flammable material portion.

8. A panel according to any preceding claim, wherein the second portion is a glass reinforced structure.

9. A panel according to any preceding claim, wherein the second portion has the same construction as the first portion.

10. A method of fabricating a buoyant panel for a floating cover for a liquid storage tank, the method comprising:

providing a flammable material portion; and

encapsulating said flammable material portion with a fire-retardant material portion such that, when the panel is assembled for formation of the cover, said fire-retardant material portion extends laterally between adjacent panels in a plane of the cover for providing a firewall between the adjacent panels,

wherein said fire-retardant material portion comprises a first portion having an extent in the plane of the panel and a first side facing the flammable material portion, and the flammable material portion has an extent in the plane of the panel, which extent is less than the extent of the first portion and the first portion has an exposed portion on said first side,

wherein said fire-retardant material portion further comprises a second portion in contact with the flammable material portion on the other side of the flammable material portion from the first portion, and

wherein the fire-retardant material portion further comprises wall segments disposed around an edge of said flammable material portion, and a capping structure disposed over the wall segments and adjacent sections of the first and second portions for securing the wall segments.

11. A floating cover for a liquid storage tank, the cover comprising a plurality of panels according to any one of claims 1 to 9.