

Sealed and thermally insulating tank

Technical field of the invention

The invention relates to the field of sealed and thermally insulating membrane tanks.

5 The invention relates in particular to the field of sealed and thermally insulating tanks for storing and/or transporting liquid at low temperature, such as tanks for transporting liquid petroleum gas (also known as LPG) at a temperature for example between -50°C and 0°C inclusive or for transporting liquefied natural gas (LNG) at approximately -162°C at atmospheric pressure. These tanks may be installed on land or on a floating structure. In the
10 case of a floating structure the tank may be intended for transporting liquefied gas or to receive liquefied gas serving as fuel for the propulsion of the floating structure.

Technological background

A sealed and insulating tank including two thermally insulating barriers is described
15 in French patent application FR2781557. These insulating barriers consist of an assembly of prefabricated panels. The junction zone between the prefabricated panels is filled with strips of thermally insulating material such as glass wool.

In French patent application FR2599468 there is proposed a sealed and thermally insulating tank integrated into a support structure to which are fixed cellular foam panels
20 constituting a thermally insulating barrier. The gaps between the panels are filled in with interleaved seals to ensure the continuity of the thermally insulating barrier.

In French patent application FR2813111 there is described a sealed and thermally insulating tank integrated into a support structure. The support structure has a first support wall and a second support wall forming an angle and joining at the level of an edge. Each
25 support wall comprises panels forming a thermally insulating barrier. The thermal continuity between the two thermally insulating barriers at the level of the edge is assured by a glass wool seal. The thermal continuity within each thermally insulating barrier is assured by inserting a sheet of glass wool folded on itself.

The glass wool interleaved seals proposed in the publications cited hereinabove are
30 not entirely satisfactory. In fact, interstices propitious to the phenomena of convection between the exterior and the interior of the tank, in particular in the presence of liquefied natural gas, are liable to appear at the level of these interleaved seals.

Alternatively, in Japanese patent application JPH4194498 there are described gaskets comprising an insulating material, such as glass wool or polyurethane, enveloped in a sealed plastic film bag. The gaskets are inserted in a vacuum compressed state into the gaps between panels. Once inserted the bag is pierced to allow the seal to expand and to
5 occupy all of the gap between panels. However, the applicant has found that these gaskets contract more than the gap between panels in which they are accommodated at low temperature. From this contraction there results the appearance of interstices separating the gaskets and the faces of the panels delimiting the gap between panels. Such interstices favor the phenomena of convection and are prejudicial to the continuity of the thermally
10 insulating barrier.

Summary

An idea on which the invention is based is to provide a sealed and thermally insulating tank free of these drawbacks. Thus the object of the invention is to improve control
15 of the thermal continuity of the thermally insulating barriers when said tank is cooled, in particular in a longitudinal direction of the gap between at least two rows of blocks constituting the thermally insulating barriers.

To this end, the present invention has for object a sealed and thermally insulating tank for the storage of a fluid, integrated into a supporting structure, including in succession
20 in a thickness direction a supporting structure, a thermally insulating barrier retained on the supporting structure, and a sealing membrane supported by the thermally insulating barrier, the thermally insulating barrier including insulating panels arranged in the form of at least two parallel rows, the two rows of insulating panels being separated by a gap having a small width compared to the dimensions of the insulating panels, the thermally insulating barrier
25 further including gaskets, the gaskets being arranged in the gap in such a manner that they are compressed between the two rows of insulating panels, the thermally insulating barrier further including at least one insert arranged in a contiguity zone where a first gasket and a second gasket are contiguous in such a manner as to compress the insert between the gaskets in a longitudinal direction of the gap.

30 The gaskets are compressed between two rows after they have been inserted into the gap. During cooling of the tank, the insulating panels will contract and likewise the gaskets. However, the gaskets will not contract sufficiently for interstices to be created between the insulating panels and the gaskets. Thus thermal continuity is always assured in the direction of the width of the gap.

In accordance with one embodiment, the gaskets are compressed only in the direction of the width of the gap, in particular after they have been inserted into the gap.

In accordance with one embodiment, the compression of the gaskets is greater in the direction of the width of the gap than in the longitudinal direction of the gap. In this
 5 embodiment the contiguous gaskets have been pushed or pressed toward one another in the longitudinal direction so that, before the insertion of the insert, there exists an initial compression force in a longitudinal direction of the gap, that initial compression force being less than the force compressing the gaskets between two rows of insulating panels.

The gaskets are not or not much compressed in a longitudinal direction of the gap.
 10 An interstice can therefore be created or created easily in a contiguity zone in which two gaskets are contiguous during cooling of the tank. The addition of the insert will compress the gaskets and said insert in the longitudinal direction of the gap. Thus during cooling of the tank the gaskets will contract because of the effect of the cold but not sufficiently so for interstices propitious to the phenomena of convection to be created. Thermal continuity is
 15 therefore assured in the longitudinal direction of the gap thanks to the insert compressed between the two gaskets.

Moreover, the tank may have the following features, separately or in combination.

The gaskets advantageously include a compressible insulating material covered partly or entirely by a film material envelope. This kind of envelope can facilitate the sliding of
 20 the gasket against the lateral walls of the insulating panels during the insertion of said gasket. If it is closed, this kind of envelope can also serve to apply a reduced pressure to reduce the thickness of the gasket during its insertion.

The insert advantageously includes a support film folded in two to form a pleat and a layer of compressible insulating material arranged at least in part inside said pleat. This kind
 25 of support film facilitates the sliding of the insert against the gaskets during fitting of said insert.

In accordance with one embodiment, the insert extends in the thickness direction of said tank, the pleat being oriented toward the support structure. This kind of pleat can easily receive a thrust to position the insert between the gaskets.

30 The gap between the two rows may extend over one or more plane walls of the tank. In accordance with one embodiment, the support structure includes a first support wall and a second support wall forming an angle and joining at the level of an edge, the two rows being oriented transversely to the edge, the first gasket being arranged in a first portion of the gap separating at least two insulating panels situated on the first support wall, the second

gasket being arranged in a second portion of the gap separating at least two insulating panels situated on the second support wall.

In accordance with one embodiment, the contiguity zone is situated in line with the edge.

5 The gasket advantageously has a longitudinal end face inclined relative to the longitudinal direction of the gap.

In accordance with one embodiment, the inclined longitudinal end face of the gasket is substantially parallel to a bisector of the angle between the first and second support walls.

10 In accordance with one embodiment, the inclination between the end face and the longitudinal direction of the gap is between 45° , for example for an angle of 90° between the two walls, and 68° inclusive, for example for an angle of 135° between the two walls.

The compressible insulating material of the gasket advantageously includes laminated glass wool and/or rock wool.

15 In accordance with one embodiment, the laminated glass wool has a density between 20 and 80 kg/m^3 inclusive.

In accordance with one embodiment, the direction of lamination of the laminated glass wool is parallel to a width direction of the gap.

The film material envelope of the gasket advantageously includes paper.

20 In accordance with one embodiment, the paper has a weight per unit area between 60 and 150 g/m^2 inclusive, preferably between 70 and 100 g/m^2 inclusive.

The support film advantageously includes paper and/or PVC.

The support film advantageously includes an adhesive tape onto which the layer of insulating material is stuck.

25 The layer of compressible insulating material advantageously includes a fibrous material, for example glass wool, or a polymer foam, for example polyethylene or polyurethane foam.

The insulating panels of the thermally insulating barrier advantageously include blocks of polymer foam.

30 In accordance with one embodiment, the blocks of polymer foam comprise polyurethane.

In accordance with one embodiment, the polyurethane has a density between 70 kg/m^3 and 220 kg/m^3 inclusive.

In accordance with one embodiment, the thermally insulating barrier fixed to the support structure is a secondary thermally insulating barrier, the sealing membrane fixed to the secondary thermally insulating barrier being a secondary sealing membrane, the tank further including in the direction of thickness, from the outside to the inside, over the secondary thermally insulating barrier and the secondary sealing membrane, a primary thermally insulating barrier and a primary sealing membrane intended to be in contact with the liquid contained in the tank.

10 In accordance with one embodiment, the invention also provides a method of manufacturing a sealed and thermally insulating tank for storing a fluid, including a step of depositing insulating panels arranged in the form of at least two parallel rows on a support structure, the two rows of insulating panels being separated by a gap having a width that is small compared to the dimensions of the insulating panels, a step for inserting gaskets in the gap so as to compress the gaskets between the two rows of insulating panels, and a step for
15 interleaving an insert in a contiguity zone between two flat gaskets in such a manner as to compress the insert between the gaskets in a longitudinal direction of the gap.

Note here that the step of interleaving an insert in a contiguity zone between two gaskets may be carried out during the production of the gasket, the latter then being equipped with a fixed insert, at the level of the zone intended to form the contiguity zone of the gasket, for example by gluing it or stapling it. In this case, the interleaving step consists in pushing at least the gasket already equipped with the insert against the other, contiguous gaskets itself also possibly equipped with an insert or an insert portion. Of course, in this embodiment, the insert or the insert portion fixed beforehand to the gasket could have a shape suited to said function of compression of the insert, for example a triangular section
20 shape having a greater thickness in the upper part of the gasket (once the latter has been mounted in the tank).

Hereinafter the invention is described in accordance with its preferred, non-limiting embodiment in which the step of interleaving the insert in the contiguity zone between two gaskets is carried out, or effected, after the erection/assembly of a set of insulating panels on
30 one or more walls of the tank.

In accordance with one embodiment, the method further includes a step during which a reduced pressure is applied in the envelope in such a manner as to reduce the thickness of said gaskets during the insertion of the gaskets into the gap, the gaskets including a compressible insulating material covered partly or entirely by a film material
35 envelope.

In accordance with one embodiment, the insert is folded in two before being inserted into the contiguity zone by exerting a thrust in a bottom part of the pleat.

In accordance with one embodiment, the insert is inserted in the contiguity zone, in which the insert is forcibly inserted in the contiguity zone.

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This kind of tank can form part of a terrestrial storage installation, for example for storing LNG, or be installed in a coastal or deep water floating structure, in particular a methane tanker ship, a floating storage and regassification unit (FSRU), a floating production storage and offloading (FPSO) unit, etc. This kind of tank can also serve as a fuel tank in any
10 type of ship.

In accordance with one embodiment, a ship for transporting a cold liquid product includes a double hull and an aforementioned tank disposed in the double hull.

In accordance with one embodiment, the invention also provides a method of loading or offloading a ship of the above kind in which a cold liquid product is routed through
15 insulated pipes from or to a floating or terrestrial storage installation to or from the tank of the ship.

In accordance with one embodiment, the invention also provides a system for transferring a cold liquid product, the system including the aforementioned ship, insulated pipes arranged in such a manner as to connect the tank installed in the hull of the ship to a
20 floating or terrestrial storage installation and a pump for driving a flow of cold liquid product through the insulated pipes from or to the floating or terrestrial storage installation to or from the tank of the ship.

Brief description of the figures

25 The invention will be better understood and other aims, details, features and advantages thereof will become more clearly apparent in the course of the following description of a plurality of particular embodiments of the invention given by way of nonlimiting illustration only with reference to the appended drawings.

- **Figure 1** is an exploded view in section of a tank zone situated at the corner
30 between two plane walls, the section plane being parallel to a row of insulating panels.

- **Figure 2** is a schematic cutaway representation of a gasket being inserted into a gap between panels.

- **Figure 3** is a schematic perspective view of the corner zone III from figure 1 during the insertion of two gaskets by means of a vacuum pump.

- **Figure 4** is a schematic perspective view of two contiguous gaskets suitable for a 135° tank corner.

5 - **Figure 5** is a schematic perspective view of two contiguous gaskets suitable for a 90° tank corner.

- **Figure 6** is a schematic view from above of the thermally insulating barrier and the gaskets inserted in the gaps between panels.

- **Figure 7** is a schematic view in section of the insulating insert.

10 - **Figure 8** is a schematic view in section on the plane VIII-VIII in figure 3 of interleaving the insert between two contiguous gaskets in a tank corner.

- **Figure 9** is a schematic cutaway representation of a methane tanker ship tank and a terminal for loading/offloading that tank.

15 **Detailed description of embodiments**

By convention, the terms “external” and “internal” are used to define the relative position of one element with respect to another with reference to the interior and to the exterior of the tank. A sealed and thermally insulated tank for storing and transporting a cryogenic fluid, for example liquefied natural gas (LNG), includes a plurality of tank walls
20 each having a multilayer structure.

Referring in particular to figure 1, there is seen a tank 1 formed of sealed and thermally insulating walls, for example for storing and/or transporting a fluid at very low temperature. Here, and by way of example only, such as a very cold liquefied gas, such as in
25 particular methane.

The tank 1 includes a sealed internal envelope adapted to contain the fluid to be stored that is constituted by assembling prefabricated elements conjointly forming a sealing membrane 4 for each wall of the tank 1. In figure 1 the sealing membrane 4 is formed of thin metal, such as stainless steel or aluminum, elements. The reference 41 designates ribs
30 projecting toward the interior of the tank that enable the envelope constituted by this barrier to be substantially flexible, in order to be able to be deformed by the effect of the loads, in particular thermal loads, generated by the fluid stored therein.

A rigid external partition constitutes the support structure 2 of the tank 1 and serves as a support for the latter. In the example illustrated, this support structure 2 is a self-supporting metal plate of a hull or double hull of a merchant ship, such as a methane tanker. Other types of rigid partition with appropriate mechanical properties, such as in particular a concrete wall in a construction on *terra firma* could be employed as supports for the tank 1. Moreover, a secondary thermally insulating barrier 3, a secondary sealing membrane 16 and a primary insulating barrier 15 are provided between the sealing membrane 4 and the support structure 2.

The secondary thermally insulating barrier 3 is formed by juxtaposing insulating panels 5 the shape of which is generally that of a rectangular prism. The insulating panels 5 are generally disposed edge-to-edge and therefore arranged so as to define parallel rows 51, 52 covering all the support structure. In figure 1 the row of insulating panels 5 is parallel to the section plane. As can be seen in figures 2 and 3, two rows 51, 52 of insulating panels 5 are separated by a gap 6. That gap 6 is generally linear and generally extends over at least all the thickness of the insulating panels 5. Moreover, the gap 6 has a width E that is small compared to the dimensions of the insulating panels 5.

Moreover, the support structure 2 also includes edges 10. These edges 10 of the support structure 2 are formed by a first support wall 21 and a second support wall 22 defining a corner A. As can be seen in figure 3, two rows 51, 52 are oriented transversely to the edge 10. The insulating panels 5 could be beveled at an angle appropriate for that which is formed by the support structure 2 at the level of these edges 10.

The insulating panels 5 could be prefabricated, preferably with standard dimensions.

In figure 6, which illustrates a plane wall of the tank 1, the connector filling the gap 6 between two parallel rows 51, 52 of insulating panels 5 to assure the continuity of the thermally insulating barrier 3 is obtained by inserting a plurality of gaskets 7.

At the level of a corner A of the tank 1 two contiguous gaskets form an angle between them, as illustrated by the gaskets 7 in figure 3; 75, 76 in figure 4 and 77, 78 in figure 5.

As can be seen in figure 2, each gasket 7, 75, 76, 77, 78 includes a compressible insulating material 72 covered at least partly by a film material envelope 71. The film material envelope 71 preferably surrounds the compressible insulating material 72 completely and forms a closed pocket in which it is possible to generate a reduced pressure.

The compressible insulating material 72 may be made of glass wool. The glass wool employed may be a laminated glass wool, that is to say a glass wool mat consisting of multiple interleaved parallel layers visible to the naked eye that are superposed in a lamination direction. The fibers may therefore be by far the greater part oriented in planes perpendicular to the lamination direction. The laminated glass wool could have a density between 20 and 80 kg/m³ inclusive. Alternatively rock wool may be used as the compressible insulating material 72.

In figures 2 to 5 the film material envelope 71 includes envelope portions fixed, for example glued, to the compressible insulating material 72, that is to say to the glass wool. The envelope portions 71 cover the compressible insulating material 72 entirely. The envelope 71 is made of Kraft paper. This kind of Kraft paper offers a low coefficient of friction thus allowing the gasket 7, 75, 76, 77, 78 to slide into the gap 6 during its insertion into said gap 6. Moreover, this kind of Kraft paper has a coefficient of thermal contraction of the order of 5 to 20.10⁻⁶/K. Thus this kind of Kraft paper has a coefficient of thermal contraction close to that of the compressible insulating material 72. Thus the gasket 7, 75, 76, 77, 78 has a uniform behavior when cold. In fact, there is no risk of the compressible insulating material 72 being deformed by the effect of a compression linked to the thermal contraction of the film material envelope 71. In particular, there is no risk of the compressible insulating material being deformed to assume a corrugated shape because of the effect of that compression, this kind of corrugated shape generating in the gap 6 interstices favoring convection and therefore compromising the insulating properties of the thermally insulating barrier. The Kraft paper of the envelope 71 has a weight per unit area greater than 60 g/m² in order to avoid the risks of the envelope 71 tearing during insertion of the gasket 7 into the gap 6. Moreover, this Kraft paper has a weight per unit area less than 150 g/m² in order for the envelope 71 to retain sufficient flexibility to allow deformation of the gasket 71 by compression. The weight per unit area of the Kraft paper is preferably between 70 and 100 g/m² inclusive.

The gaskets 7, 75, 76, 77, 78 have an elongate shape with a rectangular parallelepipedal section corresponding to the rectangular section of the gap 6. Thus the gasket has two parallel lateral faces extending in a longitudinal direction of the gap. Longitudinal end faces 79 extend across the width E of the gap 6 and connect the lateral faces.

However, some gaskets may take an alternative form in particular in line with the edge of a corner structure as described above. Examples of such gaskets 75, 76, 77, 78 are illustrated in figures 3 and 4. The gaskets 75, 76, 77, 78 have an inclined longitudinal end face 79 in line with the edge 10 of the corner structure. This inclined longitudinal end face 79 is at an angle respectively equal to 45° and 67.5° relative to the longitudinal direction of the

gap 6 in such a manner as to correspond to the bisector of the corner A of the tank. In other words, these gaskets 75, 76, 77, 78 have a rectangular trapezoidal shape contour.

More generally, the shape of the gaskets is not limited to that described hereinabove and could be adapted according to the constraints encountered.

5 The method of inserting the gasket into the gap will now be described with reference to figure 3. This insertion method uses a suction system. This kind of suction system is in the remainder of the description and by way of example a vacuum pump 11 as illustrated in figure 3. In an embodiment that is not illustrated, one such suction system is a Venturi system vacuum generator. This kind of vacuum pump 11 is connected to a suction nozzle 13
10 via a pumping tube 12. The suction nozzle 13 has a frustoconical shape in such a manner as to offer an opposite end of the pumping tube 12 able to perforate the Kraft paper envelope 71. Thus the suction nozzle 13 and more particularly its perforator end is inserted into the gasket 7 and perforates the Kraft paper film material envelope 71. This perforation of the envelope 71 generates a suction orifice in the gasket.

15 As soon as the suction nozzle 13 is inserted in the gasket 7 and positioned correctly the vacuum pump 11 is actuated in order to generate a reduced pressure in the gasket 7. The suction generated by the vacuum pump 11 has a suction flow rate between 8 and 30 m³/h inclusive. The pumping flow rate is preferably 15 m³/h. Such a pumping flow rate of the vacuum pump 11 enables a reduced pressure to be generated in the gasket 7 without
20 risking degrading the Kraft paper envelope 71 by too high a suction flow rate. The vacuum pump 11 preferably includes a filter for filtering any fibers and dust from the glass wool that might be sucked in by the vacuum pump 11.

 In the description hereinafter Kraft paper is referred to for producing the envelope 71. Other materials may also be employed to produce all or part of the envelope 71. These
25 materials are for example polymer films, composite films including mineral fibers and a polymer matrix, composite films including mineral fibers stuck to a paper or polymer film, and combinations thereof. The polymer may be a resin selected in the group consisting of polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PTE) and polyvinyl chloride (PVC). In particular, the envelope may be manufactured in the form of an assembly
30 of a plurality of portions obtained by cutting one or more film materials from the above list.

 The gasket 7 is typically dimensioned to have, in the unstressed state, that is to say the uncompressed state, a thickness greater than or equal to the width of the gap 6 and when under vacuum thanks to the vacuum pump 11 a thickness less than said width of the gap 6. For example, in the context of a gap 6 between 33 mm and 27 mm, the gasket 7 is
35 sized to have in an initial state, that is to say in the unstressed state, a thickness of 35 mm

and, under vacuum, a thickness of 25 mm. The gasket 7 is then inserted into the gap 6. As illustrated in figure 3 by the arrows 14, the gasket 7 is inserted into the gap 6 with its lateral faces parallel to the lateral faces of the adjacent insulating panels 5 delimiting the gap 6. During this insertion the suction nozzle 13 is retained in the gasket 6 and the vacuum pump

5 11 continuously generates a reduced pressure in said gasket 7 in order to maintain the gasket 7 in its under vacuum state in order to facilitate its insertion into the gap 6 because the gasket 7 then has a thickness less than the width of the gap 6.

The gasket 7 is inserted into the gap 6 in such a manner that the lateral face through which the suction nozzle 13 passes faces toward the interior of the tank, thus facilitating

10 manipulation of the assembly formed by the gasket 7 and the suction nozzle 13.

As soon as the gasket 7 is correctly positioned in the gap 6 the suction nozzle 13 is removed from the gasket 7. At that moment the interior of the envelope 5 is in communication with the exterior environment via the orifice left by the perforation produced by the suction nozzle 13. Because the reduced pressure is no longer maintained in the

15 gasket 7, this communication allows the glass wool 11 to expand in the absence of any compression stress. The expansion of the glass wool 72 allows an increase in the thickness of the gasket 7 so that the gasket 7 completely fills the gap 6, thus assuring good continuity of the insulation of the thermally insulating barrier.

In an embodiment that is not illustrated a rigid guide system may be used as a guide

20 tool during the insertion of the gasket 7 into the gap 6.

Figure 6 is an illustration of the position occupied by the gaskets after they have been arranged in the gap 6 formed by a first row 51 of insulating panels 5 and a second row 52 of insulating panels 5. Note that the gaskets 7 are contiguous with one another at the level of their longitudinal end faces.

Finally, in figure 8, it is seen that the gaskets 77, 78 in the gap between two walls, that is to say at the level of a corner structure, may have their inclined longitudinal end faces contiguous. Once gaskets 7 and/or 75, 76 and/or 77, 78 have been placed along all the length of the gap 6 it is possible for the clamping of two contiguous gaskets in the lengthwise direction of the gap 6 to be locally insufficient, in particular at the level of the edge 10 of the

25 support structure 2. If this clamping is insufficient, an interstice is liable to appear at the

30 junction between the two gaskets when cooling the tank, in particular because of the thermal contraction of the gaskets. Where this clamping is insufficient, an insert is introduced between the two gaskets. The contiguity zone 9 observed between the two inclined longitudinal end faces is intentionally exaggerated to assist with understanding the insertion

of the insert 8. To complete the continuity of the thermally insulating barrier over all the length of the gap 6, inserts may be interleaved between two consecutive gaskets.

Referring to figure 7, an insert 8 includes a support film 81 having two faces and a layer 82 of compressible insulating material on one of the two faces. The insert when
 5 unfolded has a rectangular shape the width of which corresponds to the width E of the gap 6. Given that the insert is to be interleaved between two contiguous gaskets 7 or 75/76 or 77/78, the length of the insert represents twice the thickness of the secondary insulating barrier 3.

The layer of compressible insulating material 82 may be made of glass wool. The
 10 glass wool employed may be a laminated glass wool, that is to say a glass wool mat consisting of multiple layers of interleaved parallel fibers, visible to the naked eye, that are superposed in a lamination direction. The very great majority of the fibers can therefore be oriented in planes perpendicular to the lamination direction. The laminated glass wool could have a density between 20 and 80 kg/m³ inclusive. Alternatively, the glass wool may be used
 15 for the layer 82 of compressible insulating material.

The support film 81 may consist of Kraft paper to which is fixed, for example using glue, the layer 82 of compressible insulating material, that is to say the glass wool. Kraft paper offers a low coefficient of friction thereby enabling the insert to slide. The support film 81 has two faces. The glass wool covers partly or entirely one of the faces of the Kraft paper.

To interleave the insert 8 in the contiguity zone 9, the insert 8 is first folded in two in
 20 the lengthwise direction. The pleat can then assume the shape of a U as indicated in figure 7. This U-shape pleat can be limited to an end portion of the insert 8. The folding is therefore effected so that at least a portion of the glass wool is oriented in the interior of the pleat. The curved portion of the pleat is then positioned at the level of the contiguity zone. A
 25 knife with a flat rectangular blade is then forced into the interior of the pleat. Once at the bottom of the pleat, the knife enables the insert to be pushed into the contiguity zone until it is completely interleaved between two gaskets 7. Although the Kraft paper facilitates the sliding of the insert between two gaskets, the insert may be interleaved by force.

In the above description Kraft paper is referred to for producing the support film 81.
 30 Other materials may also be employed to produce the support film 81. Those materials are for example polymer films, composite films including mineral fibers and a polymer matrix, composite films including mineral fibers stuck to a paper or polymer film, and combinations thereof. The polymer may be a resin selected in the group consisting of polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PTE) and polyvinyl chloride (PVC).

The above description is given with reference to a secondary insulating barrier 3. However, the same technique may be employed to produce the primary insulating barrier of a tank or the only insulating barrier of a tank including only one sealing membrane.

5 The technique described hereinabove for producing a sealed and thermally insulating tank may be used in different types of tank, for example in a terrestrial installation or in a floating structure such as a methane tanker or other ship.

Referring to figure 9, a cutaway of a methane tanker ship 100 shows a sealed and insulated tank 1 of prismatic general shape mounted in the double hull 101 of the ship. The tank 1 includes a primary sealing barrier intended to be in contact with the LNG contained in the tank, a secondary sealing barrier arranged between the primary sealing barrier and the double hull 101 of the ship, and two insulating barriers respectively arranged between the primary sealing barrier and the secondary sealing barrier and between the secondary sealing barrier and the double hull 101.

Figure 9 shows an example of a maritime terminal including a loading and offloading station 103, an underwater pipe 104 and a terrestrial installation 105. The loading and offloading station 103 is a fixed off-shore installation including a mobile arm 106 and a tower 107 that supports the mobile arm 106. The mobile arm 106 carries a bundle of insulated flexible tubes 108 that can be connected to the loading/offloading pipes 109. The orientable mobile arm 106 adapts to all methane tanker loading gauges. A connecting pipe that is not shown extends inside the tower 107. The loading and offloading station 103 enables loading and offloading of the ship 100 from or to the terrestrial installation 105. The latter includes liquefied gas tanks 110 and connecting pipes 111 connected via the underwater pipe 104 to the loading and offloading station 103. The underwater pipe 104 enables transfer of the liquefied gas between the loading and offloading station 103 and the terrestrial installation 105 over a great distance, for example 5 km, which enables the ship 100 to remain at a great distance from the coast during loading and offloading operations.

Pumps onboard the ship 100 and/or pumps equipping the terrestrial installation 105 and/or pumps equipping the loading and offloading station 103 are used to generate the pressure necessary to transfer the liquefied gas.

30 Although the invention has been described in connection with a plurality of particular embodiments, it is obvious that it is in no way limited to them and that it encompasses all technical equivalents and combinations of the means described if the latter fall within the scope of the invention.

The use of the verb "to include" or "to comprise" and conjugate forms thereof does not exclude the presence of elements or steps other than those stated in a claim.

In the claims, any reference sign between parentheses should not be interpreted as a limitation of the claim.

Claims

1. A sealed and thermally insulated tank (1) for the storage of a fluid, integrated into a supporting structure (2), including, in succession in a thickness direction:

5 a thermally insulating barrier (3) retained on the supporting structure (2), and
a sealing membrane (4) supported by the thermally insulating barrier (3),
the thermally insulating barrier (3) including insulating panels (5) arranged in the
form of at least two parallel rows (51, 52), the two rows (51, 52) of insulating panels
(5) being separated by a gap (6) having a small width (E) compared to the
10 dimensions of the insulating panels,
the thermally insulating barrier (3) further including gaskets (7), the gaskets being
arranged in the gap (6) in such a manner that they are compressed between the two
rows (51, 52) of insulating panels (5),
the thermally insulating barrier (3) further including at least one insert (8) arranged in
15 a contiguity zone (9) where a first gasket (7) and a second gasket (74) are
contiguous in such a manner as to compress the insert (8) between the gaskets (7)
in a longitudinal direction of the gap (6).

2. The tank (1) as claimed in the preceding claim, in which the gaskets (7)
20 include a compressible insulating material (72) covered partly or entirely by a sheet material
envelope (71).

3. The tank (1) as claimed in either one of the preceding claims, in which the
insert (8) includes a support film (81) folded into and thus forming a pleat (83) and a layer of
25 compressible insulating material (82) arranged at least in part inside said pleat (83).

4. The tank (1) as claimed in the preceding claim, in which the insert (8) extends
in the direction of thickness of said tank (1), the pleat (83) being oriented toward the support
structure (2).

5. The tank (1) as claimed in the preceding claim, in which the support structure (2) includes a first support wall (21) and a second support wall (22) forming an angle (A) and joining at the level of an edge (10), the two rows (51, 52) being oriented transversely to the edge (10), the first gasket (7, 75, 77) being arranged in a first portion of the gap (6) separating at least two insulating panels (5) situated on the first support wall (21), the second gasket (7, 76, 78) being arranged in a second portion of the gap (6) separating at least two insulating panels (5) situated on the second support wall (22).

6. The tank (1) as claimed in the preceding claim, in which the contiguity zone (9) is situated in line with the edge (10).

7. The tank (1) as claimed in any one of the preceding claims, in which the gasket (7) has a longitudinal end face (75) inclined relative to the longitudinal direction of the gap (6).

8. The tank as claimed in either one of claims 5 to 6 with claim 7, in which the inclined longitudinal end face (75) of the gasket (7) is substantially parallel to a bisector of the angle (A) between the first and second support walls (21, 22).

9. The tank (1) as claimed in either one of claims 7 or 8, in which the inclination between the end face (75) and the longitudinal direction of the gap (6) is between 45° and 68° inclusive.

10. The tank (1) as claimed in any one of the preceding claims, in which the compressible insulating material (72) of the gasket includes a laminated glass wool.

11. A method of manufacturing a sealed and thermally insulating tank (1) for storing a fluid, including the following steps:

- depositing insulating panels (5) arranged in the form of at least two parallel rows (51, 52) on a support structure (2), the two rows (51, 52) of insulating panels (5) being separated by a gap (6) having a width (E) that is small compared to the dimensions of the insulating panels (5);

- inserting gaskets (7) in the gap (6) so as to compress the gaskets between the two rows (51, 52) of insulating panels (5);
- interleaving an insert (8) in a contiguity zone (9) between two flat gaskets (7, 75, 76, 77, 78) in such a manner as to compress the insert (8) between the gaskets (7, 75, 76, 77, 78) in a longitudinal direction of the gap (6).

12. The method as claimed in the preceding claim, in which the gaskets (7, 73, 74) include a compressible insulating material (72) entirely covered by a film material envelope (71) and in which a reduced pressure is applied in the envelope in such a manner as to reduce the thickness of said gaskets (7, 75, 76, 77, 78) when inserting the gaskets (7, 75, 76, 77, 78) in the gap (6).

13. The method as claimed in either one of claims 11 or 12, in which the insert (8) is folded in two before being inserted in the contiguity zone (9) by exerting a thrust in a bottom part of the pleat.

14. The method as claimed in claim 13, in which the insert (8) is inserted in the continuity zone (9), in which the insert (8) is forcibly inserted in the contiguity zone (9).

15. A ship (100) for transporting a cold liquid product, the ship including a double hull (101) and a tank disposed in the double hull, the tank being a tank (1) as claimed in any one of claims 1 to 10.

16. A system for transferring a cold liquid product, the system including a ship (100) as claimed in claim 15, insulated pipes (104, 108, 109, 111) arranged in such a manner as to connect the tank (1) installed in the hull of the ship to a floating or terrestrial storage installation (105) and a pump for driving a flow of cold liquid product through the insulated pipes from or to the floating or terrestrial storage installation to or from the tank of the ship.

17. A method of loading or offloading a ship (100) as claimed in claim 15, in which a cold liquid product is routed through insulated pipes (104, 108, 109, 111) from or to a floating or terrestrial storage installation (105) to or from the tank of the ship (1).