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(54) Titre :
INSULATING ELEMENT FOR A SEALED AND THERMALLY INSULATING TANK WALL

(55) Titre :
FLIMENT CALORIFUGÉ POUR PAROI D'ÉCUVE/ETANCHE/ET THERMIQUEMENT ISOLANTE

(57) Abstract : In a sealed and insulating tank wall, a retaining member (31-35) collaborates with edge pieces (21) of the four insulating elements (13) of the insulating barrier in order to hold the four insulating elements directly or indirectly against the bearing structure. Cut-outs at the adjacent corners of the four insulating elements delimit an opening (50) through the cover panels (14) to provide access to the retaining member. A closure plate (55) is positioned in the opening in line with the retaining member (31-35) to complete the substantially continuous planar bearing surface of the sealed membrane. Each cut-out at the corner of a cover panel is bordered by a flat rim (51) formed in the thickness of the cover panel (14) and parallel to the upper surface of the cover panel. The closure plate (52) rests on the flat rims (51).

(57) Abrégé : Dans une paroi de cuve étanche et isolante, un organe de retenue (31-35) coopère avec des pièces de bord (21) des quatre éléments calorifuges (13) de la barrière isolante pour retenir les quatre éléments calorifuges directement ou indirectement contre la structure portante. Des découpages des coins adjacents des quatre éléments calorifuges définissent [Suite sur la page suivante]
une fenêtre (50) à travers les panneaux de couvercle (14) pour donner accès à l'organe de retenue. Une plaque de fermeture (52) est disposée dans la fenêtre au droit de l'organe de retenue (31-35) pour compléter la surface d'appui plane sensiblement continue de la membrane étanche. La découpe du coin d'un panneau de couvercle est à chaque fois bordée d'un rebord plan (51) ménagé dans l'épaisseur du panneau de couvercle (14) et parallèle à la surface supérieure du panneau de couvercle. La plaque de fermeture (52) est reçue en appui sur les rebords plans (51).
The invention relates to the field of sealed and thermally insulating tanks arranged in a bearing structure to contain a fluid, notably to the membrane-lined tanks for containing hot or cold liquids, notably liquefied gases.

Sealed and thermally insulated tanks arranged in the hull of a ship for transporting a liquefied natural gas (LNG) with a high methane content are known. Such a tank is disclosed for example in FR-A-2798902. An insulating caisson comprises a cover panel made of plywood. This cover panel has no flat rim formed within its thickness and parallel to the upper surface of the cover panel. The recesses 111 and 121 are used to accommodate fasteners, not a closure plate.

US-A-3990382 describes another insulating caisson comprising a cover panel made of plywood. This cover panel has no flat rim formed in its thickness and parallel to the upper surface of the cover panel. The aperture 7 in figure 1 is intended to provide a space through which a tubular member 13 can pass.

According to one embodiment, the invention provides a sealed and thermally insulating tank arranged in a bearing structure to contain a fluid, in which a wall of the tank comprises at least one insulating barrier and at least one sealing membrane held on the insulating barrier, in which the insulating barrier is made up of a set of substantially parallelepipedal
insulating elements each comprising a flat cover panel, the cover panel of an insulating element having a rectangular overall shape and comprising at least two opposite sides which protrude beyond the corresponding lateral walls of the insulating element, the corners of the cover panel of the insulating element each having a cutout formed in the projecting part of the cover panel, in which the insulating elements are juxtaposed in such a way that the projecting sides of the cover panels are substantially edge to edge, the upper surface of the cover panels forming a substantially continuous planar bearing surface for the sealing membrane, a clearance being formed in each instance between the lateral walls of the insulating elements in line with the protruding sides of the cover panels, a retaining member secured directly or indirectly to the bearing structure, being arranged at the adjacent corners of four adjacent insulating elements in the clearance between the lateral walls and collaborating with edge pieces of the four insulating elements in order to hold the four insulating elements of the insulating barrier directly or indirectly against the bearing structure, the cutouts at the adjacent corners of the four insulating elements delimiting an opening through the bearing surface in order to provide access to the retaining member, a closure plate being positioned in the opening in line with the retaining member to complete the substantially continuous planar bearing surface, characterized in that the cutout in the corner of a cover panel is, in each instance, bordered by a flat rim formed in the thickness of the cover panel and parallel to the upper surface of the cover panel, the closure plate being housed such that
it rests on the flat rims of the adjacent corners of the four insulating elements.

According to some embodiments, such a tank may have one or more of the following features.

According to one embodiment, the flat rims of the adjacent corners of the four insulating elements completely surround the opening to support an edge part of the closure plate over the entire periphery of the closure plate.

According to one embodiment, the cutout in the corner of a cover panel has a re-entrant corner shape, the flat rim having an L-shaped flat strip running along two sides of the re-entrant corner.

According to one embodiment, the edge piece of an insulating element comprises a cleat fixed to a bottom panel of the insulating element at a rim of the bottom panel that protrudes beyond the lateral wall.

According to one embodiment, an insulating element comprises in each instance a box comprising a bottom panel parallel to the cover panel and spaced away therefrom and lateral webs arranged between the bottom panel and the cover panel to delimit an interior space of the box, which space is filled with an insulating packing, the lateral webs forming the lateral walls of the insulating element, the lateral web parallel to a projecting side of the cover panel having two end portions arranged in each in line with the flat rim of a corner of the cover panel.
Such an arrangement allows the lateral web to contribute to reacting to the pressure load applied by the closure plate under the effect of the filling of the tank, and this reinforces the flat rims of the cover panel.

According to one embodiment, the cover panel of an insulating element comprises two superposed sheets of plywood, the upper sheet comprising a more extensive cutout than the lower sheet so as to uncover portions of the upper surface of the lower sheet of the cover panel at the corners, the uncovered portions constituting the flat rims that accept the closure plate.

Such a tank may form part of an on-shore storage facility, for example for storing LNG, or may be installed in a floating, shallow-water or deep-water structure, notably a methane tanker, a floating storage and regasification unit (FSRU), a floating production, storage and offloading (FPSO) unit, and others.

According to one embodiment, a ship for transporting a cold liquid product comprises a double hull and an aforementioned tank arranged in the double hull.

According to one embodiment, the invention also provides a method for loading or unloading such a ship, in which a cold liquid product is conveyed through insulated piping from or to a floating or on-shore storage facility to or from the tank of the ship.

According to one embodiment, the invention also provides a system for transferring a cold liquid
product, the system comprising the aforementioned ship, insulated piping arranged in such a way as to connect the tank installed in the hull of the ship to a floating or on-shore storage facility and a pump for driving a flow of cold liquid product through the insulated piping from or to the floating or on-shore storage facility to or from the tank of the ship.

According to one embodiment, the invention also provides a substantially parallelepipedal insulating element suited to creating an insulating barrier in a tank wall, the insulating element comprising a flat cover panel of rectangular overall shape, the cover panel comprising at least two opposite sides which protrude beyond the corresponding lateral walls of the insulating element, the corners of the cover panel of the insulating element each having a cutout formed in the projecting part of the cover panel, the lateral walls corresponding to the two opposite sides of the insulating element bearing edge pieces able to collaborate with a retaining member, characterized in that the cutout in a corner of the cover panel is, in each instance, bordered by a flat rim formed in the thickness of the cover panel and parallel to the upper surface of the cover panel, the insulating element being able to be juxtaposed with another three identical insulating elements which are adjacent at a corner so that the cutouts in the adjacent corners of the four insulating elements delimit an opening through the surface of the cover panels in line with the edge pieces of the four insulating elements, the flat rims of the adjacent corners of the four insulating elements being able to accept a flat closure plate that closes said opening.
A concept underlying the invention is that of improving support of a sealed membrane by the cover panels of a series of juxtaposed insulating elements.

Certain aspects of the invention set out from the idea of extending the upper surface of the cover panels in the region of the access to the insulating element retaining members in order to offer the sealing membrane a substantially uniform bearing surface. Certain aspects of the invention set out from the concept of performing this extension in a way that is simple and independent of the shape of the retaining members and that is able to withstand pressure.

The invention will be better understood, and other objects, details, features and advantages thereof will become more clearly apparent during the course of the following description of a number of particular embodiments of the invention, which are provided solely by way of nonlimiting illustration with reference to the attached drawings.

In these drawings:

- Figure 1 is a cutaway partial view of a tank wall.
- Figure 2 is an exploded perspective view of a fastener that can be used in the wall of figure 1.
- Figure 3 is a perspective view of detail V of the wall of figure 1.
Figure 4 is a cutaway schematic depiction of a methane tanker tank and of a terminal for loading/unloading this tank.

Figure 1 depicts a sealed and thermally insulating wall which has been depicted in cutaway perspective in order to show the structure of this wall. Such a structure can be employed over wide surfaces of various orientations, for example to cover bottom, top and side walls of a reservoir. Hence the orientation shown in figure 1 is nonlimiting in this respect.

The tank wall is attached to the wall of a bearing structure 1. By convention, a position situated closer toward the inside of the reservoir will be referred to as "on top of" and a position situated closer to the bearing structure 1 will be referred to as "underneath" regardless of the orientation of the tank wall with respect to the earth's gravitational field.

The tank wall comprises a secondary insulating barrier 2, a secondary sealing barrier 3 held on top of the secondary insulating barrier 2, a primary insulating barrier 4 held on the secondary sealing barrier 3 and a primary sealing barrier 5 held on the primary insulating barrier 4.

The secondary insulating barrier 2 is made up of a plurality of parallelepipedal secondary insulating caissons 6 which are positioned side by side so that they substantially cover the internal surface of the bearing structure 1. Each secondary insulating caisson 6 is made up of a parallelepipedal box made of plywood which internally comprises partitions 7 interposed
between a bottom panel made of plywood and a top panel made of plywood. The bottom wall of the caissons projects laterally along the two short sides of the caisson so that in each corner of the caisson, on this protruding part, are attached pleats which collaborate with fasteners that attach the caissons to the bearing structure. Each caisson is filled with an insulating particulate substance, for example pearlite. The bottom plate of each caisson rests on wads of polymerizable resin which themselves rest on the bearing structure. The wads of polymerizable resin are there to make good any discrepancies between the theoretical surface intended for the bearing structure and the imperfect surface that results from the manufacturing tolerances and to spread the load of the caissons across the bearing structure in a relatively uniform manner. A sheet of paper, not depicted, is inserted between the wads of resin and the bearing structure to prevent the caissons from becoming bonded to the bearing structure. The top panels of the secondary insulating caissons further comprise a pair of parallel grooves substantially in the shape of an inverted T so that they can accommodate the angle-bracket-shaped welding flanges. That part of the welding flanges that projects toward the top of the panels allows the secondary sealing barrier to be anchored. The secondary sealing barrier is made up of a plurality of Invar strakes with turned-up edges, having a thickness of the order of 0.7 mm. The turned-up edges of each strake are welded to the abovementioned welding flanges.

Mounted on the secondary sealing barrier is the primary insulating barrier which is made up of a
plurality of primary insulating caissons 13 that have a structure similar to that of the secondary insulating caissons 6. Each primary insulating caisson 13 is made up of a rectangular parallelepipedal box made of plywood of a height smaller than the caisson 6, which is filled with particulate substance such as perlite. The primary insulating caissons 13 also have internal partitions 15, a bottom panel and a top panel 14. The top panel 14 has two grooves 16 in the overall shape of an inverted T which likewise accept a welding flange (not depicted) to which the turned-up edges of the strakes 17 of the primary sealing barrier are welded. The separation between two grooves 11 or 11 of one and the same caisson 6 or 13 corresponds to the width of a strake 12 or 17. The separation between the grooves and the adjacent edge of the same caisson corresponds to half the width of a strake, such that a strake straddles two adjacent caissons.

Furthermore, the bottom panel of a primary insulating caisson 13 projects on its short sides so that cleats rest on the protruding part of the bottom panel to collaborate with the fasteners as explained below.

Reference is now made to figure 2 in order to describe a fastener used to attach the primary and secondary insulating barriers to the bearing structure. A fastener comprises a bushing 22 the base of which is welded to the bearing structure 1 in a position which corresponds to a clearance space at the corners of four adjacent secondary insulating caissons 6. The bushing bears a first rod 23 screwed to it. The rod 23 passes between the adjacent caissons 6. The spaces in between the caissons 6 are filled with a glass wool
wadding in order to ensure the continuity of the secondary insulating barrier. A metal bearer 24 is mounted on the rod 23 to clamp the cleats 9 against the bearing structure 1 by means of a nut (not depicted). A piece made of plywood 25 is mounted on the bearer 24 to act as spacer piece between the bearer 24 and an upper bearer 26 and reduce the thermal bridge to the bearing structure. The piece of wood 25 has a housing 28 intended to accept the threaded end of the rod 23 and its nut, and also has two drillings through which fixing screws that have not been depicted are intended to pass. The head of each fixing screw rests in a counterbore 27 provided in the upper bearer 26. The height of this arrangement is determined in such a way that the upper bearer 26 lies flush with the top panels 8 of the secondary insulating caissons 6.

The upper bearer 26 also has a threaded central bore 29 intended to accept a threaded base 30 of a connector 31. In service, the threaded base 30 also passes through a drilling made through a strake 17 of the secondary sealing barrier. The connector 31 has a flange 32 which is welded at its periphery to strake 11 around the drilling in order to re-establish the sealing of the secondary sealing barrier. The connector 31 is extended by an upper rod 33 onto which an upper nut 34 is screwed in order to clamp a metal platelet 35 to the cleats 21 of the primary insulating caissons 13. One or more washers 36 may also be interposed between the upper nut 34 and the platelet 35. Here again, the space in between the faces of the primary insulating caissons 13 that are fitted with cleats 21 is filled with a glass wool wadding in order to ensure the continuity of the primary insulating barrier.
Figure 3 depicts another detail of the primary insulating barrier, still in the region of a fastener at the interface between four primary insulating caissons 13. Only two caissons 13 have been partially depicted, for the sake of the clarity of the depiction, the other two being symmetric.

As can be seen, on the two shortest parallel sides of the caisson 13, the bottom panel 40 and the cover panel 14 project beyond the lateral web 45 of the caisson. The cover panel 14 is made up of two superposed sheets 46 and 47. At the corner of the caisson 13, a rectangular cutout 48 is made in the lower sheet 47 and a rectangular cutout 49 of a larger size is made in the upper sheet 46. Thus are formed a rectangular opening 50 centered on the fastener which provides access to the nut 34 when the four caissons 13 are positioned on the secondary sealing membrane, and a rectangular counterbore 51 surrounding the four sides of the opening 50. The counterbore 51 is used for positioning and holding a closure plate 52 of the same thickness as the upper sheet 46. The closure plate 52 is there to complete the upper surface of the primary insulating barrier 4 once the nut 34 has been correctly tightened. This then yields a bearing surface that is substantially uniform to accept the primary sealing barrier 5. Because the counterbore 51 bares the upper surface of the lower sheet 47 along the four sides of the opening 50, the closure plate 52 is held in place firmly and stably.

In figure 3, the line 53 represents the upper edge corner of the lateral web 45 which is under the
counterbore 51 and thus supports the lower sheet 47 at the long side of this counterbore. As a result, the closure plate 52 is held firmly and in a way that is even more able to withstand the pressure obtaining in the tank in service.

The techniques described hereinabove for creating a sealed and insulated wall can be used in various types of reservoir, for example to form the wall of an LNG reservoir in an on-shore facility or in a floating one such as a methane tanker or the like.

With reference to figure 4, a cutaway view of a methane tanker 70 shows a sealed and insulated tank 71 of prismatic overall shape mounted in the double hull 72 of the ship. The wall of the tank 71 comprises 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 72 of the ship, and two insulating barriers arranged respectively between the primary sealing barrier and the secondary sealing barrier and between the secondary sealing barrier and the double hull 72.

In a way known per se, loading/unloading piping 73 arranged on the upper deck of the ship can be connected, using suitable connectors to a maritime or harbour terminal in order to transfer a cargo of LNG from or to the tank 71.

Figure 4 depicts one example of a maritime terminal comprising a loading and unloading station 75, an underwater pipe 76 and an on-shore facility 77. The
loading and unloading station 75 is a fixed off-shore installation comprising a mobile arm 74 and a tower 78 supporting the mobile arm 74. The mobile arm 74 bears a bundle of insulated flexible pipes 79 which can be connected to the loading/unloading piping 73. The mobile orientable arm 74 adapts to suit all sizes of methane tanker. A connecting pipe, not depicted, extends along inside the tower 78. The loading and unloading station 75 allows the methane tanker 70 to be loaded and unloaded from or to the on-shore facility 77. The latter comprises liquefied-gas storage tanks 80 and connecting pipes 81 connected by the underwater pipe 76 to the loading or unloading station 75. The underwater pipe 76 allows the liquefied gas to be transferred between the loading or unloading station 75 and the on-shore facility 77 over a long distance, for example 5 km, allowing the methane tanker 70 to be kept a long way off the coast during the loading and unloading operations.

In order to generate the pressure needed to transfer the liquefied gas, use is made of pumps carried on board the ship 70 and/or pumps with which the on-shore facility 77 is equipped and/or pumps with which the loading and unloading station 75 is equipped.

Although the invention has been described in conjunction with a number of particular embodiments, it is quite obvious that it is not in any way restricted thereto and that it comprises all technical equivalents of the means described and combinations thereof where these fall within the scope of the invention.
The use of the verb "to have", "to comprise" or "to include" and of its conjugated forms does not exclude the presence of elements or of steps other than those listed in a claim. The use of the indefinite article "a/an" or "one" in respect of an element or a step does not, unless mentioned otherwise, exclude there being a plurality of such elements or steps.

In the claims, any reference symbol between parentheses cannot be interpreted as implying any restriction on the claim.
1. A sealed and thermally insulating tank arranged in a bearing structure to contain a fluid, in which a wall of the tank comprises at least one insulating barrier (4) and at least one sealing membrane (5) held on the insulating barrier, in which the insulating barrier (4) is made up of a set of substantially parallelepipedal insulating elements (13) each comprising a flat cover panel (14), the cover panel of an insulating element having a rectangular overall shape and comprising at least two opposite sides which protrude beyond the corresponding lateral walls (45) of the insulating element, the corners of the cover panel of the insulating element each having a cutout (50, 51) formed in the projecting part of the cover panel, in which the insulating elements (13) are juxtaposed in such a way that the projecting sides of the cover panels are substantially edge to edge, the upper surface of the cover panels forming a substantially continuous planar bearing surface for the sealing membrane (5), a clearance being formed in each instance between the lateral walls (45) of the insulating elements in line with the protruding sides of the cover panels, a retaining member (31-36) secured directly or indirectly to the bearing structure (1), being arranged at the adjacent corners of four adjacent insulating elements (13) in the clearance between the lateral walls and collaborating with edge pieces (21) of the four insulating elements in order to hold the four insulating elements of the insulating barrier directly or indirectly against the bearing structure,
the cutouts at the adjacent corners of the four insulating elements delimiting an opening (50) through the bearing surface in order to provide access to the retaining member,
a closure plate (52) being positioned in the opening in line with the retaining member (31-36) to complete the substantially continuous planar bearing surface, characterized in that the cutout in the corner of a cover panel is, in each instance, bordered by a flat rim (51) formed in the thickness of the cover panel (14) and parallel to the upper surface of the cover panel, the closure plate (52) being housed such that it rests on the flat rims (51) of the adjacent corners of the four insulating elements (13).

2. The tank as claimed in claim 1, in which the flat rims (51) of the adjacent corners of the four insulating elements completely surround the opening (50) to support an edge part of the closure plate over the entire periphery of the closure plate (52).

3. The tank as claimed in claim 2, in which the cutout (50) in the corner of a cover panel has a re-entrant corner shape, the flat rim (51) having an L-shaped flat strip running along two sides of the re-entrant corner (50).

4. The tank as claimed in one of claims 1 to 3, in which the edge piece of an insulating element comprises a cleat (21) fixed to a bottom panel (40) of the insulating element at a rim of the bottom panel that protrudes beyond the lateral wall (45).
5. The tank as claimed in one of claims 1 to 4, in which an insulating element (13) comprises in each instance a box comprising a bottom panel (40) parallel to the cover panel (14) and spaced away therefrom and lateral webs (45) arranged between the bottom panel and the cover panel to delimit an interior space of the box, which space is filled with an insulating packing, the lateral webs forming the lateral walls of the insulating element, the lateral web (45, 53) parallel to a projecting side of the cover panel having two end portions arranged in each instance in line with the flat rim (51) of a corner of the cover panel (14).

6. The tank as claimed in one of claims 1 to 5, in which the cover panel (14) of an insulating element comprises two superposed sheets of plywood, the upper sheet (46) comprising a more extensive cutout (51) than the lower sheet (47) so as to uncover portions of the upper surface of the lower sheet of the cover panel at the corners, the uncovered portions constituting the flat rims (51) that accept the closure plate (52).

7. A ship (70) for transporting a cold liquid product, the ship having a double hull (72) and a tank (71) as claimed in one of claims 1 to 6 arranged in the double hull.

8. A method for loading or unloading a ship (70) as claimed in claim 7, in which a cold liquid product is conveyed through insulated piping (73, 79, 76, 81) from or to a floating or on-shore storage facility (77) to or from the tank of the ship (71).
9. A system for transferring a cold liquid product, the system comprising a ship (70) as claimed in claim 7, insulated piping (73, 79, 76, 81) arranged in such a way as to connect the tank (71) installed in the hull of the ship to a floating or on-shore storage facility (77) and a pump for driving a flow of cold liquid product through the insulated piping from or to the floating or on-shore storage facility to or from the tank of the ship.

10. A substantially parallelepipedal insulating element (13) suited to creating an insulating barrier in a tank wall, the insulating element comprising a flat cover panel (14) of rectangular overall shape, the cover panel (14) comprising at least two opposite sides which protrude beyond the corresponding lateral walls (45) of the insulating element, the corners of the cover panel of the insulating element each having a cutout (50, 51) formed in the projecting part of the cover panel,

the lateral walls (45) corresponding to the two opposite sides of the insulating element (13) bearing edge pieces (21) able to collaborate with a retaining member, characterized in that the cutout in a corner of the cover panel is, in each instance, bordered by a flat rim (51) formed in the thickness of the cover panel (14) and parallel to the upper surface of the cover panel,

the insulating element (13) being able to be juxtaposed with another three identical insulating elements (13) which are adjacent at a corner so that the cutouts in the adjacent corners of the four insulating elements delimit an opening (50) through the surface of the
cover panels in line with the edge pieces (21) of the
four insulating elements,
the flat rims of the adjacent corners of the four
insulating elements being able to accept a flat closure
plate (52) that closes said opening (50).