Description

Title of the invention: Sealed and thermally insulating tank

Technical field

[0001] The invention relates to the field of sealed and thermally insulating membrane-type tanks. In particular, the invention relates to the field of sealed and thermally insulating tanks for storing and/or transporting liquefied gas at low temperature, such as tanks 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 case of a floating structure, the tank may be intended to transport liquefied gas or receive liquefied gas serving as fuel for the propulsion of the floating structure.

Technological background

[0002] A sealed and thermally insulating membrane-type tank integrated in a load-bearing structure is known from the prior art. The tank has, in succession, in a direction of thickness of the tank, a secondary insulating barrier, a secondary sealed membrane, a primary insulating barrier and a primary sealed membrane. At a corner of such a tank, the secondary insulating barrier has secondary insulating corner panels disposed along the edge corner.

[0003] Nevertheless, these secondary insulating corner panels, which are panels having small dimensions, are laid individually, one after the other, by one or more operators during the assembly. As a result, such an assembly takes a long time to perform and involves a very large number of operators. Furthermore, laying each panel individually may cause offsets in the positioning of the secondary thermally insulating panels with respect to one another, both in the longitudinal direction of the tank and in its transverse direction. Such offsets are likely to lead to premature damage to the secondary membrane of the tank and to be detrimental to the final properties of the tank.

Summary of the invention

[0004] The inventors have found during confidential tests that increasing the dimensions of the secondary insulating corner panels in a tank causes additional thermodynamic problems. Specifically, when the tank is loaded with liquefied gas, i.e. when the tank is cooled, the secondary sealed membrane and the secondary insulating corner panels contract under the effect of the temperature changes. The elements that make up the tank, in particular the secondary sealed membrane and the secondary insulating corner panels, do not have the same coefficient of thermal expansion and therefore do not exhibit the same thermodynamic behavior in response to these temperature changes, and this generates significant stresses in the secondary insulating corner panels and in the secondary sealed membrane. Such stresses are likely to damage the tank prematurely. Thus, the inventors have found that the dimension of the secondary insulating corner panels in relation to the number and position of the anchorings of the secondary membrane that are borne by the secondary insulating panels is important for minimizing mechanical stresses and avoiding early damage to the tank.

[0005] One idea underlying the invention is that of providing a tank that solves the problems mentioned above.

[0006] One idea underlying the invention is that of providing a tank comprising a thermally insulating barrier having secondary insulating corner panels allowing the tank to be manufactured quickly and reliably.

[0007] One idea underlying the invention is that of providing a tank with a thermally insulating barrier having secondary insulating corner panels making it possible to obtain a tank that is particularly adapted to significant temperature changes, at the interface between the secondary insulating corner panels and the secondary sealed membrane.

[0008] According to one embodiment, the invention provides a sealed and thermally insulating tank for storing and/or transporting liquefied gas, the tank having a first tank wall fastened to a first load-bearing wall of a load-bearing structure and a second tank wall fastened to a second load-bearing wall of the load-bearing structure, the second load-bearing wall meeting the first load-bearing wall at an edge corner of the load-bearing structure,

wherein the first tank wall comprises a multilayer structure comprising, from the outside toward the inside of the tank, a secondary thermally insulating barrier

anchored against the load-bearing structure, a secondary sealed membrane that is borne by the secondary thermally insulating barrier, a primary thermally insulating barrier and a primary sealed membrane that is borne by the primary thermally insulating barrier and that is intended to be in contact with the liquefied gas contained in the tank,

wherein the secondary thermal insulating barrier has a secondary insulating corner panel that extends along the edge corner and is adjacent to the edge corner,

the secondary insulating corner panel has an insulating foam block sandwiched between a bottom plate and cover plates that are each situated facing the bottom plate, the cover plates being spaced apart from one another by relaxation slots that extend in a direction of thickness of the insulating foam block and in a direction transverse to the edge corner,

wherein the relaxation slots have a depth of at least half the thickness of the insulating foam block.

[0009] By virtue of these features, the tank has excellent thermodynamic properties. Specifically, such an arrangement, by virtue in particular of the presence of the relaxation slots, makes it possible to increase the flexibility of the secondary insulating corner panel. As a result, the stresses exerted in the corner of the secondary membrane at the secondary insulating corner panel and the secondary membrane are reduced and better distributed. Thus, the elements of the tank that are situated at the interface between the secondary insulating corner panel and the secondary sealed membrane are better preserved than in a tank that does not comprise such a secondary insulating corner panel.

[0010] According to embodiments, such a tank may have one or more of the following features.

[0011] According to one embodiment, the secondary insulating corner panel has the overall shape of a rectangular parallelepiped that has a length extending in the direction of the edge corner and a width extending in the direction transverse to the edge corner, the width being smaller than the length.

[0012] According to one embodiment, at least one or each of the cover plates is formed of a single piece across the width of the secondary insulating corner panel between two opposite edges of the secondary insulating corner panel.

[0013] According to a corresponding embodiment, the secondary insulating corner panel does not have a relaxation slot parallel to the edge corner.

[0014] According to one embodiment, the secondary insulating corner panel comprises at least three cover plates.

[0015] According to one embodiment, the secondary insulating corner panel has exactly three cover plates.

[0016] According to one embodiment, the relaxation slots extend over at least 60% of the thickness of the insulating foam block, for example at least 70%, and preferentially over at least 80% of the thickness of the insulating foam block. According to one embodiment, the relaxation slots extend over at least a thickness of 90%, 95% or 99% of the insulating foam block.

[0017] According to one embodiment, the relaxation slots extend over the entire thickness of the insulating foam block, as far as the bottom plate.

[0018] According to one embodiment, the relaxation slots extend in a direction transverse to the edge corner, over the entire foam block.

[0019] According to one embodiment, the relaxation slots separate the foam block into three distinct portions that are spaced apart from one another by the relaxation slots.

[0020] According to one embodiment, the depth of the relaxation slots is identical.

[0021] According to one embodiment, the relaxation slots have a width of between 0.1 mm and 30 mm. The thickness of a relaxation slot corresponds to the distance between two surfaces of the foam block that face one another and are formed by the relaxation slot. According to a first variant embodiment, the relaxation slots have a width of between 0.1 mm and 5 mm. According to a second variant embodiment, the relaxation slots have a width of between 10 mm and 30 mm, for example 20 mm, and this allows a material to be put in place in said slots.

[0022] According to one embodiment, the insulating foam block has n internal faces spaced apart from one another by the relaxation slots, and wherein the secondary insulating corner panel has n cover plates each covering one of said internal faces; where n is an integer, preferably between 2 and 10, for example n = 3.

[0023] According to one embodiment, the insulating foam block has internal faces spaced apart from one another by the relaxation slots,
wherein the internal faces are each covered by a cover plate.

[0024] According to one embodiment, the secondary insulating corner panel has at least one insulating seal that is housed in one of the relaxation slots.

[0025] Thus, the phenomena of convection in the relaxation slot are reduced

[0026] According to one embodiment, the insulating seal fills the entire relaxation slot.

[0027] According to one embodiment, the secondary insulating corner panel has an insulating seal in each relaxation slot.

[0028] According to one embodiment, the insulating seal is a flat element.

[0029] According to one embodiment, the insulating seal is made of an elastically compressible material.

[0030] According to one embodiment, the insulating seal is made of a material chosen from glass wool, rock wool and polyester wadding, synthetic foams for example made of polyurethane.

[0031] According to one embodiment, the insulating seal has one or more elements chosen from: a sheet of cardboard, a sheet of corrugated paper, a plate of hard fibers based on wood, a plate of expanded or non-expanded polyurethane or propylene or polyethylene.

[0032] According to one embodiment, the secondary insulating corner panel has a first anchoring well and a second anchoring well that pass through a thickness of the secondary insulating corner panel, the first anchoring well passes through the cover plate that is situated at a first end of the secondary insulating corner panel, and the second anchoring well passes through the cover plate that is situated at a second end of the secondary insulating corner panel,
and having a first and a second wall anchoring device each having an external portion fastened to the load-bearing structure and an internal portion respectively situated in the first and second anchoring wells and fastening the secondary insulating corner panel to the load-bearing structure.

[0033] The second end of the secondary insulating corner panel is situated opposite the first end of the secondary insulating corner panel.

[0034] According to one embodiment, the first anchoring well and the second anchoring well pass through the thickness of the secondary insulating corner panel in the direction of thickness of the secondary insulating corner panel.

[0035] According to one embodiment, the secondary insulating corner panel has a pair of anchoring wells per cover plate, each of the anchoring wells of said pair passing through a thickness of the secondary insulating corner panel.

[0036] According to one embodiment, the secondary insulating corner panel has thermally insulating packing in each anchoring well. According to one embodiment, the thermally insulating packing fills each anchoring well. According to one embodiment, the thermally insulating packing is chosen from: glass wool, rock wool, polyester wadding, polystyrene, which may be expanded polystyrene (EPS), polyurethane foam (PU) which may be reinforced and which may comprise fibers.

[0037] According to one embodiment, the secondary insulating corner panel has only the first anchoring well that passes through the cover plate that is situated at a first end of the secondary insulating corner panel, and the second anchoring well that passes through the cover plate that is situated at a second end of the secondary insulating corner panel.

[0038] Thus, there are no additional anchoring wells situated between the first anchoring well and the second anchoring well. As a result, the thermal bridges are reduced and therefore the secondary insulating corner panel has better thermal insulation than a secondary insulating corner panel having a larger number of anchoring wells. In addition, when beads of mastic on an external surface of the bottom plate are necessary, the laying of the beads of mastic is made easier and less restrictive. Specifically, the fewer anchoring wells there are, the less the beads of mastic will have to be interrupted at said anchoring wells. Another consequence is that it is faster to install the secondary insulating panel because it has fewer anchors for the implementation on the secondary insulating panel than in the case of a multitude of smaller secondary insulating panels.

[0039] According to one embodiment, the secondary insulating corner panel has metal plaques that are each fastened to the insulating foam block, the metal plaques each being situated in a recess formed in one of the cover plates. According to one embodiment, the metal plaques are flush with an internal face of the cover plate.

[0040] According to one embodiment, the secondary insulating corner panel has metal plaques that are each fastened to one of the cover plates.

[0041] According to one embodiment, the metal plaques each have a first tapped bore.

[0042] According to one embodiment, primary fastening devices, having for example threaded studs, anchor primary thermally insulating corner panels of the primary thermally insulating barrier to the secondary insulating corner panel.

[0043] According to one embodiment, the primary fastening devices are fastened to the first tapped bores.

[0044] According to one embodiment, the threaded studs have a flange and a through-portion that passes in a sealed manner through the secondary sealed membrane; a first end that is fastened in the first tapped bore retaining the flange against an internal surface of the secondary sealed membrane at the metal plaque and a second end that is equipped with a bearing member retaining the primary thermally insulating corner panel on the secondary insulating corner panel. According to one preferred embodiment, the secondary sealed membrane is welded to the flange of the threaded studs in a sealed manner. According to one embodiment, the secondary sealed membrane has an orifice passed through by the through-portion of a threaded stud, the flange of the threaded stud being welded to the secondary sealed membrane all around the orifice in order to ensure the sealing of the secondary sealed membrane at the orifice. According to one embodiment, the secondary sealed membrane is welded to said metal plaques, optionally around the threaded studs.

[0045] By virtue of these features, the thermodynamic stresses are better distributed, in particular the mechanical stresses at the welds of the threaded studs are reduced, and this increases the lifetime of the tank.

[0046] According to one embodiment, at least one of the threaded studs has a flange extending radially with respect to the longitudinal axis of said stud.

[0047] According to one embodiment, the threaded studs have a flange extending radially with respect to the longitudinal axis of the stud.

[0048] According to one embodiment, the metal plaques each have a second tapped bore spaced apart from the first tapped bore.

[0049] According to one embodiment, threaded studs have a first end that is fastened in the second tapped bore, a through-portion that passes in a sealed manner through the secondary sealed membrane and a second end that is equipped with a bearing member retaining the primary thermally insulating corner panel on the secondary insulating corner panel.

[0050] According to one embodiment, the secondary insulating corner panel has a metal plaque fastened to each cover plate.

[0051] According to one embodiment, the two anchoring wells of each pair of anchoring wells are disposed on either side of the metal plaque.

[0052] According to one embodiment, the metal plaques are situated at the center of the cover plates.

[0053] By virtue of this arrangement, the movement of the metal plaques that is associated with thermal contraction/expansion phenomena is reduced. Thus, the stresses are reduced in this zone.

[0054] According to one embodiment, the secondary sealed membrane has metal strakes having a planar portion resting on an upper surface of the secondary insulating barrier, at least one corrugation and two edges, the strakes being juxtaposed with one another and welded together in a sealed manner at the edges,
wherein the secondary sealed membrane has a metal corner strip having a portion welded to an adjacent metal strake. According to one embodiment, the metal corner strip has a portion welded to each of the metal plaques of the secondary insulating corner panel.

[0055] According to one embodiment, the secondary sealed membrane has metal strakes having a planar portion resting on an upper surface of the secondary insulating barrier and two raised edges projecting toward the inside of the tank relative to the central portion, the strakes being juxtaposed and welded together in a sealed manner at the raised edges. According to one embodiment, the secondary sealed membrane has a metal corner strip having a portion welded to an adjacent metal strake and a portion welded to each of the metal plaques of the secondary insulating corner panel.

[0056] By virtue of these features, the thermodynamic stresses are better distributed, in particular the mechanical stresses at the welds of the threaded studs are reduced, and this increases the lifetime of the tank even further.

[0057] Such an arrangement exhibits synergy, in particular via the relaxation slots, the metal plaques, the metal corner strip and the strakes. Specifically, when filling the tank with liquefied gas, the secondary insulating corner panel undergoes a thermal contraction effect, and this modifies the distance between the metal anchoring plaques that are housed in the cover plates. Such a thermal contraction is therefore passed on to the metal strakes of the secondary sealed membrane, and this has the consequence of

mechanically stressing the sealing welds of the secondary sealed membrane at the threaded studs. However, by virtue of the abovementioned features, the mechanical stresses on the sealing welds are reduced, and this increases the lifetime of the tank, especially that of the secondary sealing membrane at the welds formed around the threaded studs.

[0058] According to one embodiment, the metal corner strip is welded to the metal strake, over the entire length of the metal corner strip.

[0059] Thus, the advantages of such a tank are increased because the thermal stresses of the metal corner strip at the welds are further reduced in comparison with a tank not comprising such a secondary corner panel.

[0060] According to one embodiment, the relaxation slots extend in a direction orthogonal to the edge corner.

[0061] According to one embodiment, the primary sealed membrane is a corrugated metal membrane.

[0062] According to one embodiment, the primary sealed membrane has a first series of corrugations having first corrugations that are parallel to one another and a second series of corrugations having second corrugations that are parallel to one another and perpendicular to the first corrugations.

[0063] According to one embodiment, the primary sealed membrane has a plurality of planar zones that are each defined between two adjacent first corrugations and between two adjacent second corrugations.

[0064] According to one embodiment, the secondary sealed membrane is made of metal.

[0065] According to one embodiment, the secondary sealed membrane is made of Invar®, i.e. an alloy of iron and nickel of which the coefficient of expansion is typically between 1.2×10^{-6} and 2×10^{-6} K^{-1}, or an alloy of iron and manganese of which the coefficient of expansion is typically between 7×10^{-6} and 9×10^{-6} K^{-1}.

[0066] According to one embodiment, the cover plates and the bottom plate are rigid. According to one embodiment, the cover plates and the bottom plate are made of plywood.

[0067] In one embodiment, the secondary insulating corner panel has beads of mastic positioned against an external surface of the bottom plate.

[0068] According to one embodiment, the beads of mastic are not positioned at the anchoring wells.

[0069] According to one embodiment, the secondary insulating corner panel has the following dimensions:

- A length of between 640 and 3400 mm; preferably 660 mm, 1000 mm or 3040 mm,

- A width of between 280 and 530 mm, for example 300 mm in the direction Y; and

- A height of between 250 and 400 mm, for example 300 mm.

The length of the secondary insulating corner panel of the secondary thermal insulating barrier extends in the direction of the edge corner.

[0070] The dimensions of the secondary insulating corner panel have to be considered with a tolerance of ± 20 mm.

[0071] Thus, they are secondary insulating corner panels having larger dimensions than in the prior art. As a result, a smaller number of secondary insulating corner panels are required. Thus, the construction of the tank is accelerated and made easier. In addition, when it is necessary to position beads of mastic, the laying thereof is made easier and accelerated because the beads of mastic are to be applied to a smaller number of bottom plates of secondary insulating corner panels. According to one embodiment, the first tank wall has a plurality of abovementioned secondary insulating corner panels.

[0072] According to embodiments, the second tank wall has one, a number or all of the features of the first tank wall.

[0073] According to one embodiment, the first and second tank walls have the same abovementioned features.

[0074] According to one embodiment, the secondary sealed membrane of the second tank wall has metal strakes having a planar portion resting on an upper surface of the secondary insulating barrier and two raised edges projecting toward the inside of the tank relative to the central portion, the strakes being juxtaposed and welded together in a sealed manner at the raised edges,

wherein the secondary sealed membrane of the second tank wall has a metal corner strip having a portion welded to an adjacent metal strake and a portion welded to each of the metal plaques of the secondary insulating corner panel,

wherein the metal corner strips of the first and second walls meet at an edge corner and form a metal angle bar.

[0075] According to one embodiment, the metal angle bar forms an angle of between 80° and 145°, preferentially the angle is 90° or 135°.

[0076] According to one embodiment, the angle formed by the intersection between the first load-bearing wall and the second load-bearing wall is between 80° and 145°, preferentially the angle is 90° or 135°.

[0077] In one embodiment, the liquefied gas is LNG, namely a mixture with a high methane content stored at a temperature of approximately -162°C at atmospheric pressure. Other liquefied gases may also be envisaged, in particular ethane, propane, butane or ethylene. Liquefied gases may also be stored under pressure, for example at a relative pressure of between 2 and 20 bar, and in particular at a relative pressure of around 2 bar. The tank may be produced using various techniques, in particular in the form of an integrated membrane-type tank or a self-supporting tank.

[0078] Such a tank may form part of an onshore storage facility, for example for storing LNG, or be installed in a floating, coastal or deep water structure, in particular a methane tanker, a floating storage and regasification unit (FSRU), a floating production storage and offloading unit (FPSO), and the like. Such a tank can also be used as a fuel reservoir in any type of ship.

[0079] According to one embodiment, a ship for transporting a liquefied gas has a double hull and an abovementioned tank, the double hull having the load-bearing structure.

[0080] According to one embodiment, the invention also provides a system for transferring a liquefied gas, the system having the abovementioned ship, insulated pipelines arranged so as to connect the tank installed in the hull of the ship to a floating or onshore storage facility and a pump for driving a stream of liquefied gas through the insulated pipelines from or to the floating or onshore storage facility to or from the tank of the ship.

[0081] According to one embodiment, the invention also provides a method for loading or offloading from such a ship, wherein a liquefied gas is conveyed through the insulated pipelines from or to a floating or onshore storage facility to or from the tank of the ship.

Brief description of the figures

[0082] The invention will be better understood, and further aims, details, features and advantages thereof will become more clearly apparent in the course of the following description of a number of particular embodiments of the invention, which are given solely by way of illustration and without limitation, with reference to the appended drawings.

[0083] Figure 1 shows a schematic cut-away perspective view of a load-bearing structure intended to support a sealed and thermally insulating tank for storing a liquefied gas.

[0084] Figure 2 illustrates a view in cross section of a corner of a sealed and thermally insulating tank.

[0085] Figure 3 illustrates a perspective view of a secondary insulating corner panel according to a first embodiment.

[0086] Figure 4 illustrates a perspective view of a secondary insulating corner panel according to a second embodiment.

[0087] Figure 5 is a cut-away schematic depiction of a methane tanker tank and of a terminal for loading/offloading from this tank.

[0088] Figure 6 illustrates a primary panel anchoring device that also ensures a strake anchoring function.

Description of the embodiments

[0089] 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 inside and to the outside of the tank.

[0090] A load-bearing structure 1 intended to support a sealed and thermally insulating tank for storing a liquefied gas is shown in figure 1. The load-bearing structure 1 may in particular be formed of self-supporting metal sheets or, more generally, of any type of rigid partition having suitable mechanical properties. The load-bearing structure 1 is, for example, formed by the double hull of a ship. In figure 1, the load-bearing structure 1 has a polyhedral overall shape. It has two load-bearing walls, front and rear 2, in this case of octagonal shape, of which only the rear load-bearing wall 2 is shown. The front and rear walls 2 are, for example, cofferdam walls of the ship that extend transversely to the longitudinal direction of the ship. The load-bearing structure 1 also has a load-bearing upper wall 3, a load-bearing lower wall 4, and load-bearing lateral walls 5, 6, 7, 8, 9, 10.

[0091] Figure 2 illustrates a corner of a membrane-type tank making it possible to store liquefied gas. The tank has a first tank wall fastened to a first load-bearing wall 104 of a load-bearing structure 101 and a second tank wall fastened to a second load-bearing wall 107 of the load-bearing structure 101, the second load-bearing wall 107 meeting the first load-bearing wall 104 at an edge corner of the load-bearing structure 101, forming an angle of approximately 135° in the embodiment shown.

[0092] The first tank wall and the second tank wall each have a multi-layered structure having, at the corner, from the outside toward the inside of the tank:

- a secondary thermally insulating barrier 20 resting against the load-bearing structure 101,
- a secondary sealed membrane 11 resting against the secondary thermally insulating barrier 20,
- a primary thermally insulating barrier 30 that rests against the secondary sealed membrane 11, and
- a primary sealed membrane 12 intended to be in contact with the liquefied gas contained in the tank.

[0093] The primary sealed membrane 12 defines an internal space of the tank, intended to receive the liquefied gas. The liquefied gas intended to be stored in the tank can in particular be liquefied natural gas (LNG), i.e. a gaseous mixture containing predominantly methane and one or more other hydrocarbons. The liquefied gas may also be ethane or a liquefied petroleum gas (LPG), i.e. a mixture of hydrocarbons derived from the refining of petroleum, essentially containing propane and butane.

[0094] The secondary thermally insulating barrier 20 has secondary insulating corner panels 21 according to a first embodiment, disposed along the edge corner, in a manner adjacent to the edge corner and resting against the load-bearing structure 101. The first embodiment of a secondary insulating corner panel 21 is illustrated in greater detail in figure 3.

[0095] The secondary thermally insulating barrier 20 also has insulating elements 22 that are positioned so as to fill a space situated between the secondary insulating corner panels 21 of the first wall and the secondary insulating corner panels 21 of the second wall. The insulating elements 22 are for example made of compressible material chosen from: glass wool, rock wool, and polyester wadding, polystyrene, which may be expanded polystyrene (EPS), polyurethane foam (PU) which may be reinforced and which may comprise fibers.

[0096] The primary thermally insulating barrier 30 has primary thermally insulating corner panels 31.

[0097] The primary sealed membrane 12 is, for example, a corrugated stainless steel membrane (not shown) having two series of corrugations in two directions perpendicular to one another. Other details of such a membrane are described in particular in document WO2010040922A1.

[0098] The secondary sealed membrane 11 is for example made of Invar®, i.e. an alloy of iron and nickel of which the coefficient of expansion is typically between 1×10^{-6} and 2×10^{-6} K^{-1}, or an alloy of iron and manganese of which the coefficient of expansion is typically between 7×10^{-6} and 9×10^{-6} K^{-1}. The secondary sealed membrane 11 mainly has metal strakes (shown in dotted lines in figure 2). Central metal strakes 60 have a planar portion 62 resting on an upper surface of the secondary insulating barrier and two raised edges 63, 64 projecting toward the inside of the tank with respect to the planar portion 62. The central metal strakes 60 are juxtaposed and welded together in a sealed manner at the raised edges 63, 64.

[0099] The first embodiment of a secondary insulating corner panel 21 is described in greater detail below, with figures 2 and 3.

[0100] The secondary insulating corner panel 21 has the overall shape of a rectangular parallelepiped having a length of approximately 1000 mm. The secondary insulating corner panel 21 has an insulating foam block 23 sandwiched between a bottom plate 24 and a first cover plate 25a, a second cover plate 25b and a third cover plate 25c that are situated next to one another and facing the bottom plate 24. The insulating foam block 23 is, for example, made of polyurethane reinforced with fibers. The foam block is, for example, adhesively bonded to the first bottom plate 24 and adhesively bonded to the first, second and third cover plates 25a, 25b, 25c. The foam block may have three pieces of foam adhesively bonded to the first bottom plate 24 and to the three cover plates 25a, 25b, 25c.

[0101] The adhesive is chosen, for example, from: cyanoacrylates, neoprenes, epoxides and polyurethanes.

[0102] The bottom plate 24 and the cover plates 25a, 25b, 25c are rigid and made, for example, of plywood or of a composite containing resin and fibers.

[0103] The second cover plate 25b is spaced apart from the first cover plate 25a by a first relaxation slot 50 and the second cover plate 25b is spaced apart from the third cover plate 25c by a second relaxation slot 51.

[0104] In other words, the first cover plate 25a is spaced apart from the second cover plate 25b by the first relaxation slot 50 and the third cover plate 25c is spaced apart from the second cover plate 25b by the second relaxation slot 51.

[0105] The first and second relaxation slots 50, 51 extend in a direction E of thickness of the insulating foam block 23 over a depth of approximately 51% of the thickness of the insulating foam block 23. This depth may be adapted and may be, for example, between 55% and 80%, for example 60% or 70%, of the thickness of the insulating foam block 23.

[0106] The first and second relaxation slots 50, 51 also extend in a direction Y orthogonal to the edge corner, over the entire foam block.

[0107] The first and second relaxation slots 50, 51 have, for example, a width L of between 0.1 mm and 5 mm, for example 4 mm. In this case, the relaxation slots are for example made via a cut in the secondary insulating corner panel 21 using, for example, a saw. According to one variant, in the case in which the width L is between 0.1 mm and 1 mm and the relaxation slots extend over the entire foam block, said foam block is made by adhesively bonding pieces of foam against the bottom plate 24, side by side. In this case, the pieces of foam may already have their cover plates before they are adhesively bonded to the bottom plate 24.

[0108] As can be seen in fig. 3, each of the cover plates 25a, 25b and 25c is formed of a single piece and extends over the entire width of the secondary insulating corner panel 21 between its two longitudinal edges 52 and 53.

[0109] The secondary insulating corner panel 21 also has a metal anchoring plaque 40 that is housed in a recess of each of the first, second and third cover plates 25a, 25b, 25c, at the center of the first, second and third cover plates 25a, 25b, 25c. The secondary insulating corner panel 21 has a first anchoring well 170 and a second anchoring well 171.

[0110] The first anchoring well 170 passes through the secondary insulating corner panel 21 at the first cover plate 25a, between the anchoring plaque 40 and the end of the first cover plate 25a that is opposite the first relaxation slot 50.

[0111] The second anchoring well 171 passes through the secondary insulating corner panel 21 at the third cover plate 25c, between the anchoring plaque 40 and the end of the first cover plate 25a that is opposite the second relaxation slot 51.

[0112] Preferentially, the second cover plate 25b does not have an anchoring well, as shown in figure 3.

[0113] Each secondary insulating corner panel 21 is fastened to one of the load-bearing walls 104, 107 via a first fastening device (not shown) that is housed in the first anchoring well 170 and a second fastening device 80 that is housed in the second anchoring well 171 to fasten the secondary insulating panel 21 to the load-bearing wall 104, 107.

[0114] The fastening device 80 has in particular a threaded stud 43 that is welded to one of the load-bearing walls 104, 107 and a bearing plaque 81 passed through by the threaded stud 43 and positioned against an internal surface of the bottom plate 24 by means of a bolt 82 screwed onto the threaded stud 43 in order to fasten the secondary insulating corner panel 21 to the load-bearing wall 104, 107. Optionally, Belleville washers, not shown, can also be mounted on the threaded stud 43 and interposed between the bearing plate 81 and the bolt 82. Such wells and fastening devices are, for example, illustrated in figure 1 of document FR2724623.

[0115] The cover plates 25 of the secondary insulating corner panels 21 each have a recess 125 in which is housed an anchoring plaque 40 that is preferably made of metal.

[0116] The recess 125 is, for example, situated at the center of a cover plate 25. It has an internal section having a first dimension and an external section having a second dimension larger than the first dimension so as to form a shoulder. The anchoring plaque 40 has a shape complementary to that of the recess 125.

[0117] Thus, the internal face of the anchoring plaque 40 is flush with the internal face of the cover plate 25 of the secondary insulating corner panel 21 so as to form a planar surface on which a metal corner strip 13 of the secondary sealed membrane 11 is disposed and welded. Furthermore, the anchoring plaque 40 has an external section having a dimension larger than its internal section such that the external section of said anchoring plaque 40 is in abutment against the shoulder of the recess. The anchoring plaque 40 can also be adhesively bonded to the secondary insulating corner panel 21.

[0118] The metal anchoring plaques 40 each have a first tapped bore 41 and a second tapped bore 42 that are spaced apart from one another in a transverse direction Y orthogonal

to the direction of the edge corner. In the embodiment shown, the metal anchoring plaques 40 have an oblong shape with a larger dimension that is oriented in a transverse direction Y orthogonal to the direction of the edge corner. A circular shape could also be suitable for the metal anchoring plaques 40.

[0119] The metal corner strips 13 of the first and second tank walls meet at a first edge and form a metal angle bar with an angle corresponding to the angle formed between the first and second load-bearing walls 104, 107, namely approximately 135° in the embodiment shown. The secondary sealed membrane 11 further comprises corner strakes 65 that each have a first raised edge 66 that is welded to a raised edge 64 of a central strake 60 and a second planar edge 67 that is opposite the first raised edge 66 and that is welded to a metal corner strip 13.

[0120] The primary thermally insulating corner panels 31 have an insulating foam 32 sandwiched between a bottom plate 33 and a cover plate 34.

[0121] Furthermore, the bottom plate 33 has two orifices 35 spaced apart from one another by a distance corresponding to the spacing between the first and second tapped bores 41, 42.

[0122] Each primary thermally insulating corner panel 31 is positioned on the metal corner strip 13 of the secondary sealed membrane 11, straddling two adjacent cover plates 25 belonging to one and the same secondary insulating corner panel 21 or to two adjacent secondary insulating corner panels 21.

[0123] Each primary thermally insulating corner panel 31 is fastened to the secondary insulating corner panel 21 or to the adjacent secondary insulating corner panels 21 via two primary fastening devices 83 each having two threaded studs 84 that are each fastened to a tapped bore 41, 42 of the anchoring plaque 40. The two threaded studs 84 pass through the metal corner strip 13 of the secondary sealed membrane 11 and the bottom plate 33. The metal corner strip 13 is welded to said metal plaques 40 all around the threaded studs 84.

[0124] Optionally, Belleville washers, not shown, can also be mounted on the threaded stud 83 and interposed between the bearing plate 85 and the bolt 86.

[0125] Optionally, the primary fastening devices are as illustrated in figure 6. A primary fastening device 183 has a dual function, i.e. it ensures both the anchoring of the primary insulating corner panels 31 and also the anchoring of the metal corner strip 13. The primary fastening device 183 has a stud 184 like the primary fastening device

83 has a peg 91 that is intended to pass through an orifice provided in the metal corner strip 13. The peg 91 has a threaded end, not illustrated, which is intended to be screwed into a tapped bore of an anchoring plaque. Furthermore, the peg 91 has a flange 92 extending radially with respect to the axis of the peg 91. The flange 92 is intended to press the metal corner strip 13 against the secondary insulating corner panel 21 when the peg 92 is screwed into the tapped bore 41 or 42 of the anchoring plaque 40. Furthermore, the flange 92 is welded in a sealed manner to an internal surface of the metal corner strip 13 all around the orifice, and this makes it possible to ensure the sealing of the passage of the peg 91 through the secondary sealing membrane 11.

[0126] Each primary fastening device 83 also has a primary bearing plaque 85 that is passed through by the threaded studs 84 and positioned against an internal surface of the bottom plate 33 by means of a bolt 86 screwed onto the threaded stud 84 in order to fasten the first primary thermally insulating corner panel 31 against the metal corner strip 13 of the secondary sealed membrane 11.

[0127] The cover plates 34 have metal inserts (not shown) onto which a metal angle bar of a primary metal sealed membrane 12 is welded.

[0128] A secondary corner panel according to a second embodiment is described below with reference to figure 4.

[0129] In figure 4, the reference numerals relating to elements identical or similar to those in figure 3 have the same reference, incremented by 100.

[0130] The secondary insulating corner panel 121 differs from the secondary insulating corner panel 21 in that the first slot 150 and the second slot 151 extend over the entire thickness E of the insulating foam block 123 as far as the bottom plate 124, without passing through the bottom plate 124. In other words, the first and second relaxation slots 150, 151 separate the foam block 123 into three distinct pieces of foam, which are spaced apart from one another by the first and second relaxation slots 150, 151.

[0131] Such a secondary corner panel 121 has a total length of approximately 1000 mm, i.e. three pieces of foam each approximately 320 mm long with the first and second relaxation slots 150, 151 that each have a width L of approximately 20 mm.

[0132] Flat seals made of thermally insulating compressible material (not shown) may be housed in the first and second relaxation slots 150, 151.

[0133] Furthermore, the secondary insulating corner panel 121 has three pairs of anchoring wells 172, 173, 174, 175, 270, 271. Each of the pairs passes through the thickness E of the insulating panel at a cover plate.

[0134] The first pair of wells has a first and a second well 175, 270 that are disposed on either side of the anchoring plaque 40 of the first cover plate 125a.

[0135] The second pair of wells has a first and a second well 173, 174 that are disposed on either side of the anchoring plaque 40 of the second cover plate 125b.

[0136] The third pair of wells has a first and a second well 172, 271 that are disposed on either side of the anchoring plaque 140 of the third cover plate 125c.

[0137] With reference to figure 5, a cut-away view of a methane tanker 70 shows a sealed and thermally insulating tank 71 of prismatic overall shape mounted in the double hull 72 of the ship. The wall of the tank 71 has a primary sealed membrane intended to be in contact with the LNG contained in the tank, a secondary sealed membrane arranged between the primary sealed membrane and the double hull 72 of the ship, and two thermally insulating barriers arranged respectively between the primary sealed membrane and the secondary sealed membrane and between the secondary sealed membrane and the double hull 72.

[0138] In a manner known per se, loading/offloading pipelines 73 disposed on the upper deck of the ship can be connected, by means of appropriate connectors, to a maritime or port terminal in order to transfer a cargo of LNG from or to the tank 71.

[0139] Figure 5 shows an example of a maritime terminal having a loading and offloading station 75, an underwater pipe 76 and an onshore facility 77. The loading and offloading station 75 is a fixed offshore facility having a mobile arm 74 and a tower 78 that supports the mobile arm 74. The mobile arm 74 bears a bundle of insulated flexible hoses 79 that can be connected to the loading/offloading pipelines 73. The orientable mobile arm 74 adapts to all sizes of methane tanker. A connecting pipe, not shown, extends inside the tower 78. The loading and offloading station 75 allows the methane tanker 70 to be loaded and offloaded from or to the onshore facility 77. The latter has liquefied gas storage tanks 80 and connecting pipes 81 that are connected via the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 allows the transfer of the liquefied gas between the loading or offloading station 75 and the onshore facility 77 over a long distance, for example 5 km, and this makes it

possible to keep the methane tanker 70 at a long distance from the coast during the loading and offloading operations.

[0140] In order to generate the pressure necessary for the transfer of the liquefied gas, pumps on board the ship 70 and/or pumps with which the onshore facility 77 is equipped and/or pumps with which the loading and offloading station 75 is equipped are implemented.

[0141] Although the invention has been described in connection with a number of particular embodiments, it is obvious that it is in no way limited thereto and that it comprises all the technical equivalents of the means described and the combinations thereof, if these fall within the scope of the invention.

[0142] The use of the verb “to have” or “to comprise” and of the conjugated forms thereof does not exclude the presence of elements or of steps other than those mentioned in a claim.

[0143] In the claims, any reference sign between parentheses should not be interpreted as limiting the claim.

CLAIMS

[Claim 1] A sealed and thermally insulating tank for storing and/or transporting liquefied gas, the tank having a first tank wall fastened to a first load-bearing wall (104) of a load-bearing structure (101) and a second tank wall fastened to a second load-bearing wall (107) of the load-bearing structure, the second load-bearing wall meeting the first load-bearing wall at an edge corner of the load-bearing structure, wherein the first tank wall comprises a multilayer structure comprising, from the outside toward the inside of the tank, a secondary thermally insulating barrier (20) anchored against the load-bearing structure, a secondary sealed membrane (11) that is borne by the secondary thermally insulating barrier, a primary thermally insulating barrier (30) and a primary sealed membrane (12) that is borne by the primary thermally insulating barrier and that is intended to be in contact with the liquefied gas contained in the tank, wherein the secondary thermal insulating barrier has a secondary insulating corner panel (21, 121) that extends along the edge corner and is adjacent to the edge corner, the secondary insulating corner panel has an insulating foam block (23, 123) sandwiched between a bottom plate (24, 124) and cover plates (25a, 25b, 25c, 125a, 125b, 125c) that are each situated facing the bottom plate, the cover plates being spaced apart from one another by relaxation slots (50, 51, 150, 151) that extend in a direction (E) of thickness of the insulating foam block and in a direction (Y) transverse to the edge corner, wherein the relaxation slots have a depth of at least half the thickness of the insulating foam block.

[Claim 2] The tank as claimed in claim 1, wherein the secondary insulating corner panel comprises at least three cover plates (25a, 25b, 25c, 125a, 125b, 125c).

[Claim 3] The tank as claimed in claim 1 or 2, wherein the relaxation slots extend over at least 60% of the thickness of the insulating foam block, preferentially over at least 80% of the thickness of the insulating foam block.

[Claim 4] The tank as claimed in one of claims 1 to 3, wherein the relaxation slots (150, 151) extend over the entire thickness of the insulating foam block, as far as the bottom plate (124).

[Claim 5] The tank as claimed in one of claims 1 to 4, wherein the depth of the relaxation slots is identical.

[Claim 6] The tank as claimed in one of claims 1 to 5, wherein the insulating foam block has n internal faces spaced apart from one another by the relaxation slots, and wherein

the secondary insulating corner panel has n cover plates each covering one of said internal faces; where n is an integer.

[Claim 7] The tank as claimed in one of claims 1 to 6, wherein the secondary insulating corner panel has a first anchoring well (170, 175, 270) and a second anchoring well (171, 172, 271) that pass through a thickness of the secondary insulating corner panel, the first anchoring well passes through the cover plate that is situated at a first end of the secondary insulating corner panel, and the second anchoring well passes through the cover plate that is situated at a second end of the secondary insulating corner panel, and having a first and a second wall anchoring device (80) each having an external portion (43) fastened to the load-bearing structure and an internal portion respectively situated in the first and second anchoring wells and fastening the secondary insulating corner panel to the load-bearing structure.

[Claim 8] The tank as claimed in one of claims 1 to 7, wherein the secondary insulating corner panel has metal plaques (40, 140) each fastened to one of the cover plates, wherein the metal plaques each have a first tapped bore (41, 141), wherein threaded studs (84) anchor primary thermally insulating corner panels of the primary thermally insulating barrier to the secondary insulating corner panel, the threaded studs having a flange and a through-portion that passes in a sealed manner through the secondary sealed membrane; a first end that is fastened in the first tapped bore retaining the flange against an internal surface of the secondary sealed membrane at the metal plaque and a second end that is equipped with a bearing member (85, 86) retaining the primary thermally insulating corner panel on the secondary insulating corner panel.

[Claim 9] The tank as claimed in claim 8, wherein the secondary sealed membrane is welded to the flange of the threaded studs in a sealed manner.

[Claim 10] The tank as claimed in claim 8 or 9, wherein the secondary sealed membrane is welded to said metal plaques around the threaded studs.

[Claim 11] The tank as claimed in one of claims 1 to 10, wherein the secondary sealed membrane has metal strakes (60) having a planar portion resting on an upper surface of the secondary insulating barrier and two raised edges projecting toward the inside of the tank relative to the central portion, the strakes being juxtaposed and welded together in a sealed manner at the raised edges (63, 64),

wherein the secondary sealed membrane has a metal corner strip (13) having a portion welded to an adjacent metal strake.

[Claim 12] The tank as claimed in one of claims 1 to 10, wherein the secondary sealed membrane has metal strakes (60) having a planar portion resting on an upper surface

of the secondary insulating barrier, at least one corrugation and two edges, the strakes being juxtaposed with one another and welded together in a sealed manner at the edges,

wherein the secondary sealed membrane has a metal corner strip (13) having a portion welded to an adjacent metal strake.

[Claim 13] The tank as claimed in one of claims 1 to 12, wherein the secondary insulating corner panel (21) has the overall shape of a rectangular parallelepiped that has a length extending in the direction of the edge corner and a width extending in the direction (Y) transverse to the edge corner, the width being smaller than the length, at least one of the cover plates (25a, 25b, 25c, 125a, 125b, 125c) being formed of a single piece across the width of the secondary insulating corner panel (21) between two opposite edges of the secondary insulating corner panel.

[Claim 14] A ship (70) for transporting a liquefied gas, the ship having a double hull (72) and a tank (71) as claimed in one of claims 1 to 13, the double hull having the load-bearing structure.

[Claim 15] A system for transferring a liquefied gas, the system having a ship (70) as claimed in claim 14, insulated pipelines (73, 79, 76, 81) arranged so as to connect the tank (71) installed in the hull of the ship to a floating or onshore storage facility (77) and a pump for driving a stream of liquefied gas through the insulated pipelines from or to the floating or onshore storage facility to or from the tank of the ship.

[Claim 16] A method for loading or offloading from a ship (70) as claimed in claim 14, wherein a liquefied gas is conveyed through the insulated pipelines (73, 79, 76, 81) from or to a floating or onshore storage facility (77) to or from the tank (71) of the ship (70).