

Description

Title of the invention: Sealed and thermally insulating tank

Technical field

[1] The invention relates to the field of sealed and thermally insulating membrane tanks for the storage and/or the transport of fluid, such as a liquefied gas. Sealed and thermally insulating membrane tanks are employed in particular for the storage of liquefied natural gas (LNG) which is stored at atmospheric pressure at approximately -163°C . These tanks may be installed on land or on a floating structure. In the case of a floating structure the tank may be intended for the transport of liquefied natural gas or to receive liquefied natural gas serving as fuel for the propulsion of the floating structure.

Technological background

[2] The document WO-A-89/09909 discloses a sealed and thermally insulating tank for storing liquefied natural gas arranged in a supporting structure and the walls of which have a multilayer structure, namely, from the exterior to the interior of the tank, a secondary thermally insulating barrier anchored against the supporting structure, a secondary sealed membrane that is supported by the secondary thermally insulating barrier, a primary thermally insulating barrier that is supported by the secondary sealed membrane, and a primary sealed membrane that is supported by the primary thermally insulating barrier and is intended to be in contact with the liquefied natural gas stored in the tank. The primary insulating barrier includes an assembly of rigid plates retained by means of the weld supports of the secondary sealed membrane.

[3] In one embodiment the primary sealed membrane is formed by an assembly of rectangular plates including corrugations in two perpendicular directions, said plates being welded together with an overlap and being welded by their edges to metal strips fixed in rebates along the edges of the plates of the primary sealing barrier.

[4] WO-A-2019077253 describes a sealed and thermally insulating tank wall including in a lengthwise direction: a first zone in which the insulating modules include spacers extending between the cover panel and the bottom panel so that the bottom panel and the cover panel of said insulating modules are held at a distance from one another by said spacers and a second zone in which a structural insulating foam is inserted between the cover panel and the bottom panel so that the cover panel of the insulating modules is held at a distance from the bottom panel by said structural insulating foam.

[5] It has been shown in WO-A-2019077253 that the behavior in contraction within the thickness is determined by at least one parameter chosen from the coefficient of thermal contraction and the modulus of elasticity within the thickness. The characteristics such as the coefficient of thermal contraction and the modulus of elasticity within the thickness are therefore not the same for the various insulating modules, which is liable to create thickness differences at low temperatures, reflected in height differences between the successive insulating modules, which result in flatness defects in the supporting surfaces of the sealed membranes. To limit these defects WO-A-2019077253 provides a transition zone inserted between the first zone and the second zone in which the insulating modules are constituted in such a manner that the tank wall in said transition zone has at least one parameter chosen from the coefficient of thermal contraction and the modulus of elasticity in the direction of thickness of the tank wall the value of which is between the corresponding value of the first zone and the corresponding value of the second zone inclusive.

15 **Summary**

- [6] One idea behind certain aspects of the invention consists in limiting the vulnerability of the sealing membranes to height differences between the successive insulating modules.
- [7] Another idea behind certain aspects of the invention consists in providing a tank wall combining the advantages of a secondary membrane formed of parallel strakes, the robustness of which has been proven by experience, and a corrugated primary membrane, which can have very high mechanical resistance to loads resulting for example from thermal contraction, movements of the cargo and/or deformation of the beam when the ship is at sea.
- [8] Another idea behind certain aspects of the invention consists in providing a corner structure for this kind of tank wall that is relatively easy to produce.
- [9] In accordance with one embodiment, the invention provides a sealed and thermally insulating tank integrated into a supporting structure, the tank including a first tank wall fixed to a first supporting wall and a second tank wall fixed to a second supporting wall joining the first supporting wall at the level of an edge of the supporting structure,
- 30 [10] in which each of the first and second tank walls includes at least one sealed membrane and one insulating barrier arranged between the sealed membrane and the supporting wall,
- [11] in which the sealed membrane includes a plurality of strakes made of alloy with a low coefficient of expansion, a strake including a plane central portion resting on an upper

surface of the insulating barrier and two raised edges projecting toward the interior of the tank relative to the central portion, the strakes being juxtaposed and welded together in sealed manner at the level of the raised edges,

[12] the tank wall including a metal corner beam disposed parallel to the edge and anchored to the first and second supporting walls, the corner beam including a first plane flange parallel to the first supporting wall and a second plane flange parallel to the second supporting wall, the two plane flanges being rigidly connected to one another at the level of a sealed connecting zone forming a corner of the sealed membrane, each of the first and second plane flanges including a receiving portion that extends at a distance from the edge from the connecting zone,

[13] in which a first portion of the insulating barrier is situated under a proximal portion of the receiving portions of the plane flanges and includes at least one row of first insulating panels, each of the first insulating panels including a cover plate, a bottom plate and spacers extending in the direction of thickness of the tank wall between the bottom plate and the cover plate to hold the bottom plate and the cover plate at a distance from one another,

[14] in which a second portion of the insulating barrier farther from the edge than the first portion of the insulating barrier includes at least one row of second insulating panels, each of the second insulating panels including a cover plate, a bottom plate and a block of insulating foam inserted between the bottom plate and the cover plate so that the cover plate is held at a distance from the bottom plate by the block of insulating foam,

[15] and in which an end portion of the strakes of the sealed membrane is welded to a distal portion of the receiving portions of the plane flanges extending over the second portion of the insulating barrier.

[16] Thanks to this arrangement, it is possible to use the second insulating panels based on structural insulating foam over large portions of the tank wall to benefit from the better thermal insulation properties of those panels. The first insulating panels having spacers extending in the thickness direction are nevertheless used in the vicinity of the edge and possibly in any other zone of the tank wall where the compression stresses are higher, to benefit from the better resistance to stresses of these insulating panels.

[17] Thanks to the characteristics of the corner beam, the receiving panels of the plane flanges of the corner beam extend over the first portion of the insulating barrier where the first insulating panels having a behavior in contraction within the thickness that is mainly determined by the behavior in contraction within the thickness of the supporting spacers,

the cover plates and the bottom plates and as far as the second portion of the insulating barrier, where the second insulating panels have a behavior in contraction within the thickness that is mainly determined by the behavior in contraction within the thickness of the insulating foam. The receiving portions of the plane flanges of the corner beam therefore straddle the interface between the first and second portions of the insulating barrier and the height differences if any that occur there at low temperature. The strakes with raised edges can therefore be held at a distance from this interface to rest on a supporting surface that is not affected by these possible height differences.

[18] The distal portion of the plane flanges preferably extends over the second portion of the insulating barrier over a distance greater than 100 mm, or even greater than 200 mm, in a direction perpendicular to the edge. Any height differences between the first and second portions of the insulating barrier can therefore be compensated over a sufficient length of the plane flanges in such a manner as to avoid excessively intense shear. In accordance with other advantageous embodiments this kind of tank may have one or more of the following features.

[19] The secondary beam may be anchored to the supporting structure in various ways. In accordance with one embodiment, each of the first and second plane flanges further has an anchoring portion that extends toward the supporting structure relative to the connecting zone, the anchoring portion of the first plane flange and respectively of the second plane flange being connected to the second supporting wall and respectively to the first supporting wall.

[20] The anchoring portion of a plane flange and the supporting wall may be interconnected in various ways, for example by nuts and bolts, welding, etc. In accordance with one embodiment the first supporting wall and respectively the second supporting wall carrying an anchoring flat disposed at a distance from the edge substantially equal to the thickness of the secondary insulating barrier and the anchoring portion of the first plane flange and respectively of the second plane flange is welded to the anchoring flat, preferably to the surface of the anchoring flat far from the edge.

[21] In accordance with one embodiment, an insulating material stiffener element is fixed to the corner beam between the anchoring portions of the first and second plane flanges, the stiffener element including spacing plates arranged perpendicularly to the edge to maintain the angle between the anchoring portions of the first and second plane flanges equal to an angle of the two supporting walls.

[22] In accordance with one embodiment the stiffener element further includes two insulating material supporting plates respectively fixed against a surface facing toward the

edge of the anchoring portions of the first and second plane flanges parallel to the latter, the spacing plates being arranged between the two supporting plates.

[23] The corner beam may be produced in various ways, by means of a greater or lesser number of metal parts welded together. In accordance with one embodiment, the corner beam includes a base cross having a first plane lug parallel to the first supporting wall and a second plane lug parallel to the second supporting wall, said sealed connecting zone being formed between the first flat lug and the second flat lug, the corner beam further including two plane metal strips welded in sealed manner to the first and second plane lugs respectively and extending parallel to the first and second supporting walls respectively to form the receiving portion of the plane flanges.

[24] This kind of structure may be employed in a tank wall including a single sealed membrane and a single insulating barrier or in a tank wall including a plurality of sealed membranes and/or a plurality of insulating barriers within its thickness. In accordance with a corresponding embodiment, the sealed membrane is a secondary sealed membrane and said insulating barrier is a secondary insulating barrier arranged between the secondary sealed membrane and the supporting wall and each of the first and second tank walls may further include a primary sealed membrane intended to be in contact with a product contained in the tank and a primary insulating barrier arranged between the primary sealed membrane and the secondary sealed membrane.

[25] The secondary insulating barrier may be produced in various ways. In accordance with one embodiment, the secondary insulating barrier includes a plurality of juxtaposed parallelepipedal secondary insulating panels.

[26] In accordance with one embodiment, the primary sealed membrane includes metal plates including parallel first corrugations, second corrugations perpendicular to the first corrugations and plane portions situated between the first corrugations and between the second corrugations and resting on an upper surface of the primary insulating barrier,

[27] the tank wall including a row of primary corner pieces disposed parallel to the edge, each primary corner piece including a metal angle iron to which is welded an edge portion of the primary sealed membrane of the first and second tank walls and a rigid insulating piece arranged between the metal angle iron and the corner beam,

[28] the primary corner pieces resting on an interior surface of the first and second plane flanges of the corner beam,

[29] and the corner retaining members retain said primary corner pieces on the secondary insulating barrier of the first and second tank walls or to the first and second supporting

walls, the corner retaining members being configured to pass in sealed manner through the receiving portions of the plane flanges of the corner beam.

- [30] Corner retaining members may be configured to retain the primary corner piece on the secondary insulating barrier and/or on the supporting wall of each of the two tank walls.
 5 The corner pieces can therefore advantageously be retained on the corner beam without creating a metal connection between the two sealed membranes, which makes it possible to limit the flow of heat and to render the two sealed membranes independent, unlike for example architectures employing an entirely metal, for example invar®, double connecting ring.
- 10 [31] In accordance with one embodiment, the corner retaining members include metal rods fixed to or between the first insulating panels of the secondary insulating barrier in line with the row of primary corner pieces and projecting through the receiving portions of the plane flanges of the corner beam to cooperate with the primary corner pieces.
- [32] In accordance with one embodiment, one or each corner retaining member includes a
 15 stirrup fixed under the cover plate of a first insulating panel, said stirrup including a central plate parallel to the cover plate and two fixing lugs extending perpendicularly to the central plate and fixed to two spacers of said first insulating panel, and a metal rod fixed, for example bolted or welded, to said central plate and passing through the cover plate of the first insulating panel.
- 20 [33] In accordance with one embodiment, a corner retaining member includes a base fixed to a or each supporting wall in line with the primary corner piece and a coupler retained by the base and extending through the thickness of the secondary insulating barrier and the receiving portion of a or each plane flange to cooperate with the rigid insulating piece.
- [34] This kind of coupler may cooperate with the secondary insulating panels or not. In
 25 accordance with one embodiment, said coupler includes a secondary coupler cooperating with a first insulating panel of the secondary insulating barrier to retain the first insulating panel on the supporting wall and a primary coupler carried by the secondary coupler and cooperating with the rigid insulating piece to retain the rigid insulating piece.
- [35] The primary insulating barrier may be produced in various ways. In accordance with
 30 one embodiment the primary insulating barrier includes a plurality of juxtaposed parallelepipedal primary insulating panels.
- [36] In accordance with one embodiment, a primary insulating panel adjacent to the primary corner piece includes a cover plate, a bottom plate and a structural insulating foam inserted between the bottom plate and the cover plate so that the cover plate is held at a distance

from the bottom plate by said structural insulating foam. It is also possible to use primary insulating panels based on structural insulating foam over large portions of the tank wall to benefit from the better thermal insulating properties of these panels.

- [37] In accordance with one embodiment, the second portion of the secondary insulating barrier includes a first row of the second insulating panels, said first row being adjacent to the first portion of the secondary insulating barrier,
- [38] the primary insulating barrier includes a first row of primary insulating panels adjacent to the row of primary corner pieces, and
- [39] the first row of the second insulating panels carries a row of primary retaining members for retaining the first row of primary insulating panels on the secondary insulating barrier of the first and second tank walls.
- [40] In accordance with one embodiment, the receiving portions of the plane flanges extend over the first row of the second insulating panels beyond said row of primary retaining members in a direction perpendicular to the edge and have the primary retaining members passed through them in sealed manner.
- [41] This arrangement is advantageous in that it makes it possible to localize the openings for the primary retaining members to pass through in the plane flanges rather than in the strakes with raised edges. Now the plane flanges are preferably made from plate having a greater thickness than the strakes with raised edges.
- [42] In accordance with an alternative embodiment, said row of primary retaining members is disposed on the first row of the second insulating panels beyond the receiving portions of the plane flanges in a direction perpendicular to the edge and in which the primary retaining members pass in sealed manner through the strakes of the secondary sealing membrane.
- [43] In accordance with one embodiment a or each second insulating panel includes a relaxation slot extending parallel to the edge and extending within the thickness of the second insulating panel through the cover plate and an upper portion of the block of insulating foam, the primary retaining members being carried by the second insulating panel between said relaxation slot and an end of the second insulating panel facing toward the edge, preferably approximately halfway between the relaxation slot and the end of the second insulating panel.
- [44] In accordance with an alternative embodiment, the first row of the second insulating panels carries the row of primary retaining members at a position situated at approximately half a dimension of the second insulating panel in a direction perpendicular to the edge.

[45] Thanks to these arrangements, either with a relaxation slot or with no relaxation slot but with a less wide second insulating panel, the thermal contraction of the second insulating panel in a direction perpendicular to the edge can definitely be effected in a relatively balanced manner on either side of the row of primary retaining members. This avoids the thermal contraction of the second insulating panel being able to create a traction force on the primary retaining members, which would tend to shear the secondary sealed membrane.

[46] In accordance with one embodiment, the first row of the second insulating panels includes an insulating foam having a first density and the second portion of the secondary insulating barrier includes a second row of the second insulating panels farther from the edge than the first row of the second insulating panels, and the second row of the second insulating panels includes an insulating foam having a second density lower than the first density.

[47] Thanks to these features, as the coefficient of thermal contraction and the modulus of elasticity of the insulating foam vary with its density, a height difference may also be created between the two rows of the second insulating panels because of the effect of the thermal contraction. Accordingly, by using a plurality of rows of second insulating panels having different densities, it is possible to stagger the height differences caused by thermal contraction and hydrostatic compression under load as a plurality of successive small differences, rather than localizing those differences at the interface between the first and second portions of the insulating barrier, where applicable the secondary insulating barrier.

[48] In accordance with one embodiment, in a direction perpendicular to the edge, the dimension of the primary corner pieces is greater than the dimension of the first portion of the secondary insulating barrier so that the row of the primary corner pieces straddles the first row of the second insulating panels.

[49] In accordance with an alternative embodiment, in a direction perpendicular to the edge, the dimension of the primary corner pieces is smaller than the dimension of the first portion of the secondary insulating barrier so that the first row of the primary insulating panels straddles the first portion of the secondary insulating barrier.

[50] Thanks to these arrangements the interface between the first portion of the secondary insulating barrier and the second portion of the secondary insulating barrier is straddled by elements of the primary insulating barrier, namely either the row of primary corner pieces or the first row of the primary insulating panels. The effect of this straddling is to distribute over the width of these elements of the primary insulating barrier any height difference at low temperature between the two portions of the secondary insulating barrier.

The flatness of the support surface of the primary membrane is therefore improved at this location and the shear forces on the membrane therefore reduced.

- [51] In accordance with one embodiment, the rigid insulating part of the primary corner pieces includes an insulating foam having a first density and a primary insulating panel includes a cover plate, a bottom plate and a block of insulating foam inserted between the bottom plate and the cover plate so that the cover plate is held at a distance from the bottom plate by said block of insulating foam, said block of insulating foam having a second density lower than the first density.
- [52] Thanks to these features it is possible to use the second insulating foam density over large portions of the primary insulating barrier to benefit from the better thermal insulation properties. The first insulating foam density is nevertheless used in the vicinity of the edge, and possibly in any other zone of the tank wall where the compression stresses are higher, to benefit from the improved resistance to stresses.
- [53] In accordance with a first embodiment, in a first row of primary insulating panels adjacent to the row of primary corner pieces the primary insulating panel includes a cover plate, a bottom plate and at least two blocks of insulating foam with different densities inserted between the bottom plate and the cover plate so that the cover plate is held at a distance from the bottom plate by said blocks of insulating foam. The bottom plate and the cover plate may be glued to the insulating foam blocks.
- [54] A first of the two insulating foam blocks nearer the row of corner pieces preferably has a higher density than the second block of insulating foam farther from the row of corner pieces. The first insulating foam block has for example the same density as the rigid insulating piece of the primary angle pieces or the first row of the second insulating panels.
- [55] In accordance with one embodiment said row of primary retaining members is disposed on the first row of the second insulating panels in line with the first block of insulating foam, namely the more dense one.
- [56] The secondary sealing membrane may be formed in various ways. In accordance with one embodiment, in at least one tank wall, a longitudinal direction of the strakes is perpendicular to the edge, the secondary sealed membrane further including a row of end strakes having a flat edge forming the end portion of the strakes of the secondary sealed membrane welded to the corner beam, the end strakes having raised edges parallel to said longitudinal direction of the strakes that are progressively reduced in size in the direction of the corner beam. Other details of this kind of membrane are described for example in WO-A-2012072906.

[57] The primary sealed membrane may be formed in various ways. In accordance with embodiments, the first and second corrugations may be continuous or discontinuous at the level of the intersections between first and second corrugations.

5 [58] In accordance with one embodiment, the first corrugations of the primary sealed membrane extend perpendicularly to the edge, the primary sealed membrane including cap pieces welded to the metal angle iron to close said first corrugations. The cap piece is known for example from WO-A-2014167228.

10 [59] In accordance with one embodiment, the first corrugations of the primary sealed membrane extend perpendicularly to the edge, the primary sealed membrane including a corrugated corner piece welded to the metal angle iron to connect a first corrugation of the first tank wall to a first corrugation of the second tank wall. The corrugated corner piece is known for example from FR-A-2739675.

15 [60] In accordance with one embodiment bridging elements are disposed to straddle the first row of the primary insulating panels and the row of the primary corner pieces to improve the flatness of the upper surface of the primary insulating barrier.

20 [61] The secondary beam may be produced with a greater or lesser length. In accordance with one embodiment, the secondary beam includes at least two beam segments juxtaposed with a gap along the edge and a connecting element disposed in the gap to assemble the two beam segments. It is therefore possible to produce the secondary beam as a plurality of successive parts, each having a length of 1 to 3 m for example, which facilitates handling.

[62] In accordance with one embodiment, the product contained in the tank is a liquefied gas such as liquefied natural gas.

25 [63] This kind of tank may 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.

[64] In accordance with one embodiment a ship for the transport of a cryogenic fluid includes a double hull and a tank as aforementioned disposed in the double hull.

30 [65] In accordance with one embodiment, the double hull includes an internal hull forming the supporting structure of the tank.

[66] In accordance with one embodiment the invention also provides a transfer system for a fluid, 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 floating or terrestrial storage installation and a pump for routing a fluid through the insulated pipes from or to the floating or terrestrial storage installation to or from the tank of the ship.

[67] In accordance with one embodiment, the invention also provides a method of loading
 5 or offloading a ship of the above kind, in which a fluid is routed through insulated pipes from or to a floating or terrestrial storage installation to or from the tank of the ship.

Brief description of the figures

[68] The invention will be better understood and other aims, details, features and
 10 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.

[69] [fig.1] figure 1 is a partial view in perspective of a corner zone of a sealed and thermally insulating tank in accordance with one embodiment at a first stage of production;

15 [70] [fig.2] figure 2 is a view analogous to figure 1 at a second stage of production;

[71] [fig.3] figure 3 is a view analogous to figure 1 at a third stage of production;

[72] [fig.4] figure 4 is a cutaway perspective view to a larger scale showing a detail of an insulating panel that may be used in the corner zone;

[73] [fig.5] figure 5 is a view analogous to figure 3 showing another embodiment of the
 20 corner zone;

[74] [fig.6] figure 6 is a view of the corner zone at the third stage of production, in section in a plane perpendicular to the edge;

[75] [fig.7] figure 7 is a view in perspective of a stiffener element that may be used in the corner zone;

25 [76] [fig.8] figure 8 is a view analogous to figure 1 showing the corner zone at a final stage of production with cutaway parts;

[77] [fig.9] figure 9 is a view of the corner zone in the final stage of production, in section in a plane perpendicular to the edge, and in accordance with another embodiment;

[78] [fig.10] figure 10 is a view analogous to figure 9 showing a further embodiment of the
 30 corner zone;

[79] [fig.11] figure 11 is a schematic cutaway representation of a methane tanker ship tank and a terminal for loading/offloading that tank;

- [80] [fig.12] figure 12 is a partial view in perspective of the primary membrane and of the primary insulating barrier in accordance with one embodiment;
- [81] [fig.13] figure 13 is a view analogous to figure 9 showing a further embodiment of the corner zone;
- 5 [82] [fig.14] figure 14 is a view in perspective of an insulating panel that may be used in the corner zone in accordance with one embodiment;
- [83] [fig.15] figure 15 is a partial view in perspective of a corner zone of the tank in which the insulating panel from Fig. 14 is used;
- [84] [fig.16] figure 16 is a view analogous to figure 14 showing an insulating panel in
10 accordance with another embodiment.

Detailed description of embodiments

- [85] The tank wall is attached to the wall of a supporting structure. By convention, “over” or “above” refers to a position situated close to the interior of the tank and “under” or “below” refers to a position situated closer to the supporting wall, whatever the orientation of the
15 tank wall relative to the terrestrial gravity field.
- [86] In figure 8 there has been represented the multilayer structure of two walls 1 and 101 in a corner zone of a sealed and thermally insulating tank for the storage of a liquefied fluid such as liquefied natural gas (LNG). Each wall 1, 101 of the tank includes successively, in the direction of thickness, from the exterior to the interior of the tank, a secondary thermally
20 insulating barrier 2, 102 retained on a supporting wall 3, 103, a secondary sealed membrane 4, 104 resting against the secondary thermally insulating barrier 2, 102, a primary thermally insulating barrier 5, 105 resting against the secondary sealed membrane 4, 104, and a primary sealed membrane 6, 106 intended to be in contact with the liquefied natural gas contained in the tank.
- 25 [87] The supporting structure may in particular be formed by the hull or the double hull of a ship. The supporting structure includes a plurality of supporting walls 3, 103 defining the general shape of the tank, usually a polyhedral shape. The two supporting walls 3 and 103 join at the level of an edge 100, forming a dihedral angle that could have various values. Here an angle of 90° is represented.
- 30 [88] The structure of the corner zone will now be described in more detail with reference to figures 1 to 7. Given that the structure of the two tank walls 1 and 101 is essentially symmetrical with respect to the edge 100 in the embodiments shown, it is essentially the tank wall 1 that will be described. The elements of the tank wall 101 will carry the same

reference numbers as the elements of the tank wall 1 increased by 100 and will not be described again.

[89] Referring to figure 1, a metal base cross 10 is placed parallel to the edge 100 within the thickness of the secondary insulating barrier 2, 102. The base cross 10 includes two plane pieces that extend parallel to the supporting walls 3 and 103 respectively and cross in sealed manner. Each plane piece consists of an anchoring portion 11, 111 welded to an anchoring flat 113, 13, preferably to the surface of the anchoring flat that is far away from the edge 100, and a plane lug 12, 112 that projects away from the supporting wall 103, 3 to which the anchoring portion is fixed. These two plane pieces are assembled at a right angle by a welded connection. Each of the two plane pieces may be made in one piece or in the form of a plurality of plates welded together.

[90] An insulating packing 15 is housed along the edge 100 in the gap between the two anchoring plates 13, 113, behind the base cross 10. In a first embodiment this insulating packing 15 does not withstand high forces and may be made of glass wool or other material such as insulating foam. In a second embodiment, if greater mechanical strength is required in this zone, the insulating packing 15 includes a plywood box filled with an insulating material such as glass wool or rockwool, perlite or insulating foam.

[91] Referring to figure 2, the secondary insulating barrier 2 has been represented. The secondary thermally insulating barrier 2 includes a plurality of secondary insulating panels that are anchored to the supporting wall 3 by means of retaining devices not all of which are represented. The secondary insulating panels have a parallelepipedal general shape and are disposed in rows parallel to the edge 100. Beads of mastic, not represented, are disposed between the secondary insulating panels and the supporting walls 3 to compensate departures of the supporting wall 3 from a plane reference surface. A film, not represented, for example of Kraft paper, may be inserted between beads of mastic and the supporting wall 3, 103 to prevent adhesion of the beads of mastic on the supporting wall 3, 103.

[92] This kind of film is not indispensable. Conversely, the beads of mastic may be used to stick the secondary insulating panels to the supporting wall 3.

[93] The secondary insulating panels are produced in accordance with various structures. In a first portion of the secondary insulating barrier 2 an insulating panel 21 of a first type is produced in the form of a box including a bottom plate 41, a cover plate 40 and supporting flanges 42 extending in the direction of thickness of the tank wall between the bottom plate 41 and the cover plate 40 and delimiting a plurality of compartments 43 filled

with an insulating packing 44, for example a polymer foam, in particular polyurethane foam, perlite, or glass wool or rockwool.

[94] In a variant, the supporting flanges 42 are replaced by pillars of small section compared to the overall section of the panel. A general structure of this kind is described for example
5 in WO-A-2012/127141 and WO-A-2017/103500.

[95] In an embodiment seen better in figure 4 an insulating panel 21 includes supporting webs 42 extending parallel to the edge 100. The supporting webs 42, the bottom plate 41 and the cover plate 40 may be made of plywood or composite material. They define compartments 43, represented empty in figure 4 but in fact filled with an insulating packing
10 44. In a variant embodiment represented in figures 14 to 16 and applicable to all the figures the supporting webs 42 are oriented perpendicularly to the edge 100.

[96] In a second portion of the secondary insulating barrier 2 an insulating panel 22 of a second type includes a bottom plate 23, a cover plate 24 and possibly an intermediate plate, not represented, made for example of plywood. The insulating panel 22 also
15 includes one or more layers of insulating polymer foam 25 sandwiched between the bottom plate 23 and the cover plate 24 (and where applicable the intermediate plate) and stuck to the latter. The insulating polymer foam 25 may in particular be a foam based on polyurethane, optionally reinforced by means of fibers. A general structure of this kind is described for example in WO-A- 2017/006044.

[97] The secondary insulating panels have different structures according to their location in the tank wall 1. Thus the insulating panels 21 of the first type are employed in an edge zone of the tank wall 1 situated near the edge 100 and the secondary insulating panels 22 of the second type are employed farther from the edge 100.

[98] Thus in figure 2 the secondary insulating barrier 2 includes a row of insulating panels
25 21 of the first type disposed against the base cross 10. The insulating panels 21 form a first portion of the secondary insulating barrier 2 in which the behavior in contraction within the thickness is controlled by spacers. The insulating panels 21 are disposed partly under the plane lug 12, which can be screwed into the cover plate 40 to stiffen it. The insulating panels 21 are fixed to the supporting wall 3 by retaining members 29 disposed between
30 the insulating panels 21.

[99] For example, as can be seen in figure 6, the retaining member 29 includes two studs 26 housed in bases 27 welded to the supporting wall 3 and a plate 28 bolted onto the studs 26 so as to come to be engaged on two insulating panels 21 disposed on either side of the retaining member 29. In particular, the plate 28 secures thin strips 45 formed at the edges

of the supporting webs 42. Alternatively, the thin strips 45 are independent of the supporting webs 42, for example parts mounted on the bottom plate 41.

[100] As can be seen in figure 3, a plane metal strip 30 is welded in sealed manner to the plane lug 12 of the base cross 10 and extends in line with the plane lug 12 at a distance from the edge in such a manner as to cover the row of the insulating panels 21 and to straddle the first row of the insulating panels 22. The straddling of the first row of the insulating panels 22 may have a greater or lesser dimension, as can be seen comparatively in figures 3 and 5. It is preferably greater than 100 mm.

[101] The base cross 10 and the plane strips 30 and 130 together constitute a corner beam that completes the secondary sealed membrane 4 in the corner of the tank. As for the rest, the secondary sealed membrane 44 includes a continuous layer of metal strakes with raised edges not represented as they are known in themselves. The strakes are welded by their raised edges onto parallel weld supports, not represented, that are fixed into grooves 31 formed on the cover plates 24 of the insulating panels 22. The strakes are made of Invar® for example: that is to say an alloy of iron and nickel the coefficient of expansion of which is typically between 1.2×10^{-6} and $2 \times 10^{-6} \text{ K}^{-1}$. It is also possible to use alloys of iron and manganese the coefficient of expansion of which is typically of the order of $7 \times 10^{-6} \text{ K}^{-1}$. The corner beam may be made of the same material. Other details of this kind of continuous layer of metal strakes are described for example in WO-A-2012/072906.

[102] Figure 3 shows only the end of the strakes of the secondary membrane 4, which is formed of a row of edge strakes 32 having a flat edge 33 welded in sealed manner to the plane strip 30 and raised edges extending the raised edges of the strakes and that are progressively reduced in size in the direction of the flat edge 33. The end strakes 32 are disposed on the insulating panels 22 and do not project over the insulating panels 21. Thus any height difference between the insulating panels of the two types is not transmitted to the strakes with raised edges but only to the plane strip 30 which is plane and more easily able to flex.

[103] To produce the corner beam all along the edge 100 it is preferable to employ a plurality of successive segments the length of which is matched to handling conditions, for example 1 to 3 m per segment. Figure 5 illustrates schematically two successive segments of the base cross 10.

[104] Figure 6 shows a stiffener 34 that is fixed, for example bolted, to the corner beam between the anchoring portions of the base cross 10. The stiffener 34 includes triangular spacing plates 35 that maintain the angle between the anchoring portions.

[105] As can be seen in figure 7, the stiffener 34 may be produced as an element further including two support plates 36 respectively fixed against the anchoring portions of the base cross 10, for example bolted thereto. The stiffener 34 is for example made of plywood or other insulating material.

5 [106] Figures 3, 5 and 6 represent a tank wall that may be considered as finished if only one sealed membrane is used. There will now be described in more detail the primary element of the tank, which is therefore optional.

[107] Figure 3 shows primary retaining members mounted on the insulating panels 21 and 22 to fix the primary insulating barrier 5. To be more precise, the junction between the
10 primary insulating barriers 5 and 105 is produced by means of a row of primary corner pieces 37 placed on the corner beam. The corner piece 37 includes an insulating piece 38 in the form of an angle iron having two perpendicular flanges the thickness of which is substantially equal to the thickness of the primary insulating barriers 5 and 105. A metal angle iron 39 is fixed to the upper surface of the insulating piece 38 along the corner. The
15 insulating piece 38 may be produced in various ways, for example from solid plywood; from one or more blocks of a sandwich structure consisting of one or more layers of polymer foam and one or more rigid plates, for example made of plywood; or again in the form of one or more boxes filled with insulating material.

[108] The insulating piece 38 may be produced in one piece or a plurality of pieces. Figures
20 8 to 10 illustrate an embodiment in which the primary corner piece 37 includes the angle iron 39 and an insulating piece 38 consisting of two symmetrical parts. To be more precise each symmetrical part includes a sandwich structure made from a block of a polymer foam 63 of high density, for example between 150 and 300 kg/m³, in particular approximately 210 kg/m³, and two rigid, for example plywood, plates 61 and 64.

25 [109] Threaded studs 46 are carried by the insulating panels 21 for fixing the primary corner pieces 37. As can be seen in figure 4, the stud 46 may be screwed into an insert 47 mounted in the insulating panel 21 under the cover plate 40. The insert 47 includes an inverted U-shaped stirrup 48 the flanges of which are fixed to the webs 42 and a threaded bush 49 fixed to the central plate of the stirrup 48 and housed in a hole 50 in the cover
30 plate 40.

[110] The threaded studs 46 are therefore disposed on the plane strip 30 and pass through the latter in sealed manner, which makes it possible to limit the number of holes in the strakes with raised edges, which are more fragile. The primary corner pieces 37 may be fixed by the threaded studs 46 in various ways, for example as described in WO-A-
35 2018087466.

- [111] Where it passes through the secondary membrane 4, the threaded stud 46 may bear a flange the periphery of which is welded to the secondary membrane 4 to make the seal.
- [112] To limit the thermal bridging caused by the primary retaining members, the threaded studs 46 are configured to secure a low part of the insulating piece 38 at a distance from the primary sealed membrane 6. As can be seen in figure 10 for example, a plate 60
5 secures a bottom plate 61 of the insulating piece 37 or a thin strip near that bottom panel.
- [113] Threaded studs 52 are also fixed to the first row of the insulating panels 22 and threaded studs 53 to the second row of the insulating panels 22 in order to form retaining members for the primary insulating panels 54.
- 10 [114] In figure 3, the threaded studs 52 pass through the edge strakes 32 while in figure 5 in which the plane strip 30 is wider they pass through the plane strip 30. The figure 5 configuration enables further limitation of the number of holes in the strakes with raised edges.
- [115] As can be seen in figure 8, the primary thermally insulating barrier 5 includes a plurality
15 of primary insulating panels 54 having a parallelepipedal general shape. The primary insulating panels 54 may have lengths and widths identical to or different from those of the underlying insulating panels 22.
- [116] The primary insulating panels 54 can be produced using various structures known in themselves. The primary insulating panel 54 preferably has a multilayer structure similar
20 to the insulating panel 22.
- [117] The primary insulating panels 54 are therefore retained on the underlying insulating panels 22 with the aid of the threaded studs 52 and 53, preferably situated at the level of the corners of the primary insulating panels 54 that are for example arranged to coincide with the centers of the underlying insulating panels 22.
- 25 [118] As can be seen better in figures 9 and 10, the length of the corner piece 37 is preferably different from the length of the insulating panel 21 in the direction perpendicular to the edge 100. Thus in figure 10, which corresponds to the geometry of figure 8, the corner piece 37 is longer than the insulating panel 21 so that it straddles the first row of the insulating panels 22. Conversely, in figure 9 the insulating panel 21 is longer than the
30 corner piece 37 so that it is the first row of the primary insulating panels 54 that come to straddle the row of the insulating panels 21.
- [119] In both cases the flatness of the primary insulating barrier 5 is therefore better preserved even if a height difference occurs at low temperature between insulating panels 21 and 22.

[120] To improve the flatness of the upper surface of the primary insulating barrier 5, which has to carry the primary sealed membrane 6, it is also possible to add bridging elements, not represented, for example in the form of plane plates disposed so as to straddle the first row of the primary insulating panels 54 and the row of the corner pieces 37. Further details of how to produce this kind of bridging element can be found in the publication WO-A-2016046487.

[121] Figure 8 also shows that the primary sealed membrane 6 includes a continuous layer of plate that features two mutually perpendicular series of corrugations. The first series of corrugations 55 extends perpendicularly to the edge 100. The second series of corrugations 56 extends parallel to the edge 100. The two series of corrugations may have a regular spacing or a periodic irregular spacing.

[122] In the embodiment illustrated the corrugations 55 and 56 are continuous and form intersections between the two series of corrugations. In another embodiment the primary sealed membrane 6 may also feature two mutually perpendicular series of corrugations with discontinuities of some corrugations at the level of the intersections between the two series. For example, in this case the interruptions may be distributed alternately in the first series of corrugations and the second series of corrugations and, in one series of corrugations, the interruptions of one corrugation are offset relative to the interruptions of an adjacent parallel corrugation. This offset may be equal to the spacing between two parallel corrugations.

[123] The primary sealed membrane 6 may be formed of rectangular metal plates welded together, forming small zones of overlap along their edges, using the known technique. The primary membrane 6 is fixed to the primary insulating barrier 5 by any appropriate means. Metal anchoring strips 58 may be fixed to the cover plates of the primary insulating panels 54 at the locations of the contours of the rectangular plates. The edges of the rectangular plates can therefore be fixed by welding along the anchoring strips 58. The anchoring strip is fixed in a recess on the cover plate by any appropriate means, for example screws or rivets. The anchoring strips 58 may be disposed at various locations on the primary insulating panels 54.

[124] For example, in figure 8 the anchoring strips 58 of a primary insulating panel 54 follow two lines that intersect perpendicularly near a central zone of the primary insulating panel 54. In an embodiment illustrated in figure 12 the anchoring strips 58 are disposed along the edges of the primary insulating panel 54, all around the latter. The anchoring strips 58 along two adjacent primary insulating panels 54 are directly connected by a plane portion 69 of the primary membrane 6. The plane portion 69 opposes mutual separation

movement of the two adjacent primary insulating panels 54 in a stiffer manner than would a corrugated portion of the primary membrane 6.

[125] Example of dimensions

[126] In one embodiment the corner beam 10, 30 is made of metal plate, for example of
5 Invar®, the thickness of which is between 1 and 2 mm inclusive, for example 1.5 mm.

[127] The strakes of the secondary sealing membrane 4 may have a thickness less than 1 mm, for example 0.7 mm. The edge strakes 32 may have a greater thickness but one less than 1.5 mm, for example 1 mm.

[128] In one embodiment the primary sealed membrane 6 has a greater thickness than the
10 secondary sealed membrane 4, for example between 1 and 1.5 mm and in particular 1.2 mm.

[129] The thickness of the anchoring flaps 13, 113 is between 5 and 12 mm for example, in particular approximately 8 mm.

[130] The edge of the primary sealed membrane 6 is welded in sealed manner to the metal
15 angle iron 39. A plurality of solutions exist for sealing the corrugations 55, 155 perpendicular to the edge 100. In the figure 8 embodiment corrugated corner pieces 57 welded to the metal angle iron 39 each time connect a corrugation 55 to a corrugation 155. The corrugated corner piece 57 is known for example from FR-A-2739675.

[131] In an embodiment that is not represented, cap parts are welded to the metal angle iron
20 39 to close the end of the corrugations 55, 155. The cap piece is known for example from WO-A-2014167228.

[132] In the figure 10 embodiment identical reference digits designate elements identical or similar to those of figure 8. In this case, the retaining members 29 are replaced by retaining members 62 that also retain the primary corner piece 37 directly on the supporting wall 3.
25 To this end a retaining member 62 includes a secondary coupler, in one or more parts, the base of which is connected to the supporting wall 3, for example by means of a base forming a ball-joint and that itself carries a primary coupler securing the insulating piece 38 or two insulating pieces 38 to clamp it against the secondary membrane 4. Other details of the retaining member 62 can be found for example in FR-A-2798358.

[133] Figures 9 and 10 also illustrate various possibilities for the first row of the insulating panels 22. In figure 9 a relaxation slot 65 is cut into the upper half of the insulating panel 22 in such a manner that the threaded stud 52 is at equal distances from the relaxation slot 65 and the edge of the insulating panels 22 in the direction perpendicular to the edge
30

100. In figure 10 the insulating panel 22 of the first row is much shorter so that the threaded stud 52 is at equal distances from the two edges of the insulating panels 22 in the direction perpendicular to the edge 100.

[134] These dispositions enable symmetrical effects on the position of the threaded stud 52 of the effect of the thermal contraction and therefore prevent undesirable tension on the secondary membrane 4.

[135] Moreover, the first row of the insulating panels 22 in Figs. 9 and 10 can be made with a foam of higher density than the following rows, to produce a transition zone as described in WO-A-2019077253. A similar embodiment is illustrated in Fig. 13, which is a view analogous to Fig. 9 in which the same reference numbers designate elements identical or analogous to those from Fig. 9. Here the first row 122 of the secondary insulating panels of the second type is produced in a foam having a density, for example between 170 and 210 kg/m³, greater than the following rows of the insulating panels 22, for example 130 kg/m³.

[136] Figure 13 also illustrates another embodiment of the first row of the primary insulating panels. Here, the primary insulating panel 154 of the first row includes between the cover plate and the bottom plate two blocks of foam 66 and 67 in succession in the lengthwise direction perpendicular to the edge 100. The two blocks of foam 66 and 67 have different densities. The block of foam 66 is made from a foam having a density, for example between 170 and 210 kg/m³, greater than the block of foam 67, for example 130 kg/m³. In particular the block of foam 66 can be made with the same density as the polymer foam 63 or the foam of the first row 122 of the secondary insulating panels. The interface 68 between the two blocks of foam 66 and 67 is preferably free, that is to say not glued. The interface 68 is vertically in line with the first row 122 of the secondary insulating panels. This favors a progressive transition between the zones of the tank wall having differences of stiffness in compression and/or contraction differences.

[137] The bottom plate and the cover plate of the primary insulating panel 154 may be stuck onto the blocks of foam 66 and 67.

[138] Here also the threaded stud 52 is carried by the first row 122 of the secondary insulating panels, for example at equal distances from the two edges of the secondary insulating panel in the direction perpendicular to the edge 100. The threaded stud 52 secures the primary insulating panel 154 at the level of the block of foam 66 that is the most dense. Alternatively, the threaded stud 52 could secure the primary insulating panel 154 at the level of the block of foam 67.

[139] Another embodiment of the corner zone of the tank is now described with reference to figures 14 and 15. This embodiment differs mainly in the structure of the secondary insulating panels 121 of the first type. Elements analogous or identical to those from figures 1 to 3 bear the same reference number as in those figures.

5 [140] The secondary insulating panels 121 are designed so that the threaded studs 46 intended for fixing the primary corner pieces 37 are fixed between two secondary insulating panels 121. To that end the secondary insulating panels 121 are disposed in the form of a row parallel to the edge situated partly under the plane lug 12 as before. The secondary insulating panels 121 are fixed to the supporting wall 3 by retaining members 29 disposed
10 between the secondary insulating panels 121 as before.

[141] As can be seen better in figure 14, a secondary insulating panel 121 has a parallelepipedal shape and includes two lateral supporting webs 87 and a central supporting web 88 extending perpendicularly to the edge 100. The lateral supporting webs 87 and the central supporting web 88, the bottom plate 41 and the cover plate 40 may be
15 made of plywood or composite material. They define compartments filled with an insulating packing 92, for example glass wool. The cover plate 40 features a recess 91 to receive the plane lug 12.

[142] Windows 85 are formed at the top of the lateral supporting webs 87 to enable the insertion of the edges of a preferably metal supporting plate 83 that extends between two
20 adjacent secondary insulating panels 121 above the anchoring members 29. A block of insulating material that is not represented is preferably accommodated between the two adjacent secondary insulating panels 121, between the anchoring members 29 and the support plate 83, in such a manner as to reduce the spaces available for convection. This block of insulating material enables the support plate 83 to be supported during assembly
25 of the tank.

[143] Thanks to the windows 85, the support plate 83 secures all the thickness of the lateral supporting webs 87 at the upper edge of the windows 85, which enables an anchorage to be assured that is resistant to tearing off. In a similar manner to the insert 47, the support plate 83 enables fixing of two threaded studs 46.

30 [144] In this embodiment windows 86 are formed at the bottom of the lateral supporting webs 87 to enable securing of the retaining members 29 with all the thickness of the lateral supporting webs 87 at the lower edge of the windows 86. Thus the absence of thin strips 45 allows a relative reduction of the spacings between the secondary insulating panels 121.

[145] Alternatively, the windows 85 and/or the windows 86 may be formed in a portion of the thickness of the lateral supporting webs 87. The contours of the windows 85 and of the windows 86 may be different, as represented, or identical. For example the window 85 may be replaced by two windows similar to the window 86 provided that a notch is provided in the edge of the supporting plate 83 to receive the zone of the lateral supporting web 87 situated between the two windows.

[146] In the figure 15 embodiment the secondary insulating panel 221 has a parallelepipedal shape similar to that of the secondary insulating panel 121. The same reference numbers designate elements analogous or identical to those of the secondary insulating panel 121. Instead of the windows 85 the lateral supporting webs 87 carry upper thin strips 93, for example stuck and/or stapled to the lateral supporting webs 87, extending parallel to the upper edge of the lateral supporting webs 87. The lower surface of the upper thin strips 93 enable securing of the support plate 83 in a similar manner to the windows 85.

[147] Instead of the windows 86 the lateral supporting webs 87 bear lower thin strips 45, for example stuck and/or stapled to the lateral supporting webs 87, to cooperate with the retaining members 29, as described above.

[148] The secondary insulating panels 121 or 221 therefore allow fixing of the threaded studs 46 intended to fix the primary corner pieces 37 in line with the interface between two secondary insulating panels 121 or 221.

[149] Referring to figure 11, a cutaway of a methane tanker ship 70 shows a sealed and insulated tank 71 of prismatic general shape mounted in the double hull 72 of the ship. The wall of the tank 71 includes a primary sealed barrier intended to be in contact with the LNG contained in the tank, a secondary sealed barrier arranged between the primary sealed barrier and the double hull 72 of the ship, and two insulating barriers respectively arranged between the primary sealed barrier and the secondary sealed barrier and between the secondary sealed barrier and the double hull 72.

[150] In a manner known in itself loading/offloading pipes 73 disposed on the top deck of the ship may be connected by means of appropriate connectors to a maritime or harbor terminal to transfer a cargo of LNG from or to the tank 71.

[151] Figure 11 shows an example of a maritime terminal including a loading and offloading station 75, an underwater pipe 76 and a terrestrial installation 77. The loading and offloading station 75 is a fixed off-shore installation including a mobile arm 74 and a tower 78 that supports the mobile arm 74. The mobile arm 74 carries a bundle of insulated flexible tubes 79 that can be connected to the loading/offloading pipes 73. The orientable

mobile arm 74 adapts to all methane tanker loading gauges. A connecting pipe that is not shown extends inside the tower 78. The loading and offloading station 75 enables loading and offloading of the methane tanker 70 from or to the terrestrial installation 77. The latter includes liquefied gas storage tanks 80 and connecting pipes 81 connected via the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 enables transfer of the liquefied gas between the loading or offloading station 75 and the terrestrial installation 77 over a great distance, for example 5 km, which enables the methane tanker ship 70 to remain at a great distance from the coast during loading and offloading operations.

10 [152] Pumps onboard the ship 70 and/or pumps equipping the terrestrial installation 77 and/or pumps equipping the loading and offloading station 75 are used to generate the pressure necessary to transfer the liquefied gas.

15 [153] 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.

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

20 [155] In the claims, any reference sign between parentheses should not be interpreted as a limitation of the claim.

Claims

[Claim 1] A sealed and thermally insulating tank integrated with a supporting structure, the tank including a first tank wall (1) fixed to a first supporting wall (3) of the supporting structure and a second tank wall (101) fixed to a second supporting wall (103) of the supporting structure, the second supporting wall (103) joining the first supporting wall at the level of an edge (100) of the supporting structure, in which each of the first and second tank walls includes at least one sealed membrane (4, 104) and an insulating barrier (2, 102) arranged between the sealed membrane and the supporting wall, in which the sealed membrane (4, 104) includes a plurality of strakes made of alloy with a low coefficient of expansion, each of the plurality of strakes including a plane central portion resting on an upper surface of the insulating barrier and two raised edges projecting toward the interior of the tank relative to the central portion, the strakes being juxtaposed and welded together in sealed manner at the level of the raised edges,

the tank including a metal corner beam (10, 30) disposed parallel to the edge (100) and anchored to the first and second supporting walls (3, 103), the corner beam including a first plane flange parallel to the first supporting wall and a second plane flange parallel to the second supporting wall, the two plane flanges being rigidly connected to one another at the level of a sealed connecting zone forming a corner of the sealed membrane, each of the first and second plane flanges having a receiving portion (12, 30) that extends at a distance from the edge from the connecting zone,

in which a first portion of the insulating barrier is situated under a proximal portion of the receiving portions of the plane flanges (12, 30) and includes at least one row of first insulating panels (21, 121, 221), each of the first insulating panels (21, 121, 221) including a cover plate (40), a bottom plate (41) and spacers (42, 87, 88) extending in the direction of thickness of the insulating barrier between the bottom plate and the cover plate to hold the bottom plate and the cover plate at a distance from one another,

in which a second portion of the insulating barrier farther from the edge than the first portion of the insulating barrier includes at least one row of second insulating panels (22, 122), each of the second insulating panels including a cover plate (24), a bottom plate (23) and a block of insulating foam (25) inserted between the bottom plate and the cover plate so that the cover plate is held at a distance from the bottom plate by the block of insulating foam,

characterized in that an end portion of the strakes (32) of the sealed membrane (4,

104) is welded to a distal portion of the receiving portions (30) of the plane flanges extending over the second portion of the insulating barrier.

[Claim 2] The tank as claimed in claim 1, in which each of the first and second plane flanges further includes an anchoring portion (11, 111) that extends toward the supporting structure relative to the connecting zone, the anchoring portion of the first plane flange and respectively of the second plane flange being connected to the second supporting wall (103) and respectively to the first supporting wall (3).

[Claim 3] The tank as claimed in either one of claims 1 or 2, in which said sealed membrane is a secondary sealed membrane (4, 104) and said insulating barrier is a secondary insulating barrier (2, 102) arranged between the secondary sealed membrane and the supporting wall and in which each of the first and second tank walls further includes a primary sealed membrane (6, 106) intended to be in contact with a product contained in the tank and a primary insulating barrier (5, 105) arranged between the primary sealed membrane and the secondary sealed membrane.

[Claim 4] The tank as claimed in claim 3, in which the primary sealed membrane (6, 106) includes metal plates including parallel first corrugations (56, 156), second corrugations (55, 155) perpendicular to the first corrugations and plane portions situated between the first corrugations and between the second corrugations and resting on an upper surface of the primary insulating barrier,
the tank including a row of primary corner pieces (37) disposed parallel to the edge, each primary corner piece including a metal angle iron (39) to which is welded an edge portion of the primary sealed membrane (6, 106) of the first and second tank walls and a rigid insulating piece (38) arranged between the metal angle iron (39) and the corner beam (10, 30),
the primary corner pieces resting on an interior surface of the first and second plane flanges of the corner beam,
and in which corner retaining members (46, 62) retain said primary corner pieces (37) on the secondary insulating barrier (2, 102) of the first and second tank walls or to the first and second supporting walls (3, 103), the corner retaining members (46, 62) being configured to pass in sealed manner through the receiving portions (30) of the plane flanges of the corner beam.

[Claim 5] The tank as claimed in claim 4, in which the corner retaining members (46) include metal rods (46) fixed to or between the first insulating panels (21, 121, 221) of the secondary insulating barrier in line with the row of primary corner pieces (37) and

projecting through the receiving portions (30) of the plane flanges of the corner beam to cooperate with the primary corner pieces.

[Claim 6] The tank as claimed in claim 5, in which a corner retaining member includes a stirrup (48) fixed under the cover plate of a first insulating panel (21), said stirrup including a central plate parallel to the cover plate and two fixing lugs extending perpendicularly to the central plate and fixed to two spacers (42) of said first insulating panel, and a metal rod (49, 46) fixed to said central plate and passing through the cover plate (40) of the first insulating panel.

[Claim 7] The tank as claimed in claim 4 in which a corner retaining member (62) includes a base fixed to a supporting wall in line with the primary corner piece and a coupler retained by the base and extending through the thickness of the secondary insulating barrier (2, 102) and the receiving portion (30) of a plane flange to cooperate with the rigid insulating piece (38).

[Claim 8] The tank as claimed in claim 7, in which said coupler (62) includes a secondary coupler cooperating with a first insulating panel of the secondary insulating barrier to retain the first insulating panel on the supporting wall and a primary coupler carried by the secondary coupler and cooperating with the rigid insulating piece (38) to retain the rigid insulating piece (38).

[Claim 9] The tank as claimed in any one of claims 4 to 8, in which the second portion of the secondary insulating barrier includes a first row of second insulating panels (22, 122), said first row being adjacent to the first portion of the secondary insulating barrier, in which the primary insulating barrier (5) includes a first row of primary insulating panels (54, 154) adjacent to the row of primary corner pieces (37), and in which the first row of the second insulating panels (22, 122) carries a row of primary retaining members (52) for retaining the first row of primary insulating panels (54, 154) on the secondary insulating barrier (2, 102) of the first and second tank walls.

[Claim 10] The tank as claimed in claim 9, in which the receiving portions (30) of the plane flanges extend over the first row of the second insulating panels (22) beyond said row of primary retaining members (52) in a direction perpendicular to the edge and have the primary retaining members (52) passed through them in sealed manner.

[Claim 11] The tank as claimed in claim 9, in which said row of primary retaining members (52) is disposed on the first row of the second insulating panels (22, 122) beyond the receiving portions (30) of the plane flanges in a direction perpendicular to the edge and

in which the primary retaining members pass in sealed manner through the strakes (32) of the secondary sealing membrane.

[Claim 12] The tank as claimed in any one of claims 9 to 11, in which a second insulating panel (22) features a relaxation slot (65) extending parallel to the edge (100) and extending within the thickness of the second insulating panel through the cover plate (24) and an upper portion of the block of insulating foam (25), the primary retaining members (52) being carried by the second insulating panel between said relaxation slot (65) and an end of the second insulating panel facing toward the edge (100).

[Claim 13] The tank as claimed in any one of claims 9 to 11, in which the first row of the second insulating panels (22, 122) carries the row of primary retaining members (52) at a position situated at approximately half a dimension of the second insulating panel in a direction perpendicular to the edge (100).

[Claim 14] The tank as claimed in any one of claims 9 to 13, in which the first row of the second insulating panels (122) includes an insulating foam (25) having a first density and in which the second portion of the secondary insulating barrier includes a second row of the second insulating panels (22) farther from the edge (100) than the first row of the second insulating panels, and in which the second row of the second insulating panels includes an insulating foam (25) having a second density lower than the first density.

[Claim 15] The tank as claimed in any one of claims 9 to 14, in which, in a direction perpendicular to the edge, the dimension of the primary corner pieces (37) is greater than the dimension of the first portion of the secondary insulating barrier so that the row of the primary corner pieces (37) straddles the first row of the second insulating panels (22, 122).

[Claim 16] The tank as claimed in any one of claims 9 to 14, in which, in a direction perpendicular to the edge, the dimension of the primary corner pieces (37) is smaller than the dimension of the first portion of the secondary insulating barrier so that the first row of the primary insulating panels (54) straddles the first portion of the secondary insulating barrier.

[Claim 17] The tank as claimed in any one of claims 9 to 16, in which the rigid insulating part (38) of the primary corner pieces (37) includes an insulating foam (63) having a first density and in which a primary insulating panel (54) includes a cover plate, a bottom plate and a block of insulating foam inserted between the bottom plate and the cover plate so that the cover plate is held at a distance from the bottom plate by said

block of insulating foam, said block of insulating foam having a second density lower than the first density.

[Claim 18] The tank as claimed in any one of claims 1 to 17, in which, in at least one of the first and second tank walls, a longitudinal direction of the strakes is perpendicular to the edge (100), the secondary sealed membrane further including a row of edge strakes (32) having a flat edge (33) forming the end portion of the strakes of the secondary sealed membrane welded to the corner beam (10, 30), the end strakes having raised edges parallel to said longitudinal direction of the strakes and that are progressively reduced in size in the direction of the corner beam (10, 30).

[Claim 19] The tank as claimed in any one of claims 1 to 18, in which the corner beam includes a base cross (10) having a first plane lug (12) parallel to the first supporting wall and a second plane lug (112) parallel to the second supporting wall, said sealed connecting zone being formed between the first plane lug and the second plane lug, the corner beam further including two plane metal strips (30, 130) welded in sealed manner to the first and second plane lugs (12, 112) respectively and extending parallel to the first and second supporting walls respectively to form the receiving portion of the plane flanges.

[Claim 20] A ship (70) for the transport of a fluid, the ship including the tank (71) as claimed in any one of claims 1 to 19 and a double hull (72) forming the supporting structure, wherein the tank is disposed in the double hull (72).

[Claim 21] A transfer system for a fluid, the system including a ship (70) as claimed in claim 20, insulated pipes (73, 79, 76, 81) arranged in such a manner as to connect the tank (71) of the ship to a floating or terrestrial storage installation (77) and a pump for routing a fluid through the insulated pipes from or to the floating or terrestrial storage installation to or from the tank of the ship.

[Claim 22] A method of loading or offloading a ship (70) as claimed in claim 20, in which a fluid is routed through insulated pipes (73, 79, 76, 81) from or to a floating or terrestrial storage installation (77) to or from the tank (71) of the ship.