

Description

Title of the invention: Sealed and thermally insulating tank

Technical field

[0001] The invention relates to the field of sealed and thermally insulating tanks for storing and/or transporting a liquefied gas, such as tanks for transporting liquefied petroleum gas (also referred to as LPG) having for example a temperature of between -50°C and 0°C , or for transporting liquefied natural gas (LNG) at approximately -163°C at atmospheric pressure.

[0002] These tanks can be installed on shore or on a floating structure. In the case of a floating structure, the tank can be intended for transporting liquefied gas or for receiving liquefied gas used as a fuel to propel the floating structure.

Technological background

[0003] A sealed and thermally insulating tank comprising a tank wall held on a bearing structure is known from the prior art, the tank wall including, in the thickness direction from the outside toward the inside of the tank, a secondary thermally insulating barrier held on the bearing structure, a secondary sealing membrane held on the secondary thermally insulating barrier, a primary thermally insulating barrier held on the secondary sealing membrane and a corrugated primary sealing membrane held on the primary thermally insulating barrier. Such a sealed and thermally insulating tank may notably be used in the transport of liquefied gas, such as liquefied natural gas (LNG), notably on board a floating structure such as a ship.

[0004] It is known practice to produce the primary sealing membrane by assembling a plurality of corrugated sheets, the corrugations of which advantageously run perpendicular to one another. The corrugations give the primary sealing membrane a certain flexibility that allows it to deform under the effect of thermal and mechanical stresses, and notably those generated by the liquefied gas stored in the tank and those associated with the deformation of the bearing structure. The primary sealing membrane is anchored on the insulating panels of the primary thermally insulating barrier.

[0005] The applicant company has observed that, in a tank of the above-mentioned type, the corrugations of the primary sealing membrane are not stressed uniformly. In particular, because the primary thermally insulating barrier is discontinuous, which is to say made up of insulating panels juxtaposed with one another, it does not behave uniformly when the bearing structure deforms under the effect of the swell and/or under the effect of the

thermal and mechanical stresses generated by the liquefied gas stored in the tank. Thus, the applicant company has observed that the corrugations positioned in a zone straddling a first anchoring element fixed to a first insulating panel and a second anchoring element fixed to a second insulating panel are more highly stressed than the other corrugations. Now, it is important to ensure that the stresses are distributed as uniformly as possible between the corrugations of the primary sealing membrane, notably so as to optimize the life of the primary sealing membrane.

Summary

[0006] One idea behind the invention is that of proposing a sealed and thermally insulating tank in which the stresses experienced by the primary sealing membrane are more uniformly distributed.

[0007] According to one embodiment, the invention relates to a wall of a sealed and thermally insulating tank for storing a liquefied gas, comprising at least one thermally insulating barrier and one sealing membrane which is anchored to said thermally insulating barrier and is intended to be in contact with the liquefied gas contained in the tank, the thermally insulating barrier comprising insulating panels which are juxtaposed with one another in mutually parallel rows and columns, each insulating panel comprising an internal face supporting the sealing membrane and being connected to the adjacent insulating panels by means of bridging elements, each bridging element being arranged straddling two of the adjacent insulating panels and being fixed to the internal face of one of the two adjacent insulating panels and to the internal face of the other of the two adjacent insulating panels, the insulating panels comprising relaxation slots which are each formed in a thickness direction of the wall, each bridging element being fixed to one of the insulating panels between an edge of said insulating panel and a relaxation slot that is adjacent and parallel to said edge.

[0008] Thus, the bridging elements provide a mechanical connection between the insulating panels that limits or prevents the mutual separation of said panels in a plane parallel to the surface of the insulating panels.

[0009] Advantageously, in order to prevent the insulating panels from separating from one another, the insulating panels need to be able to deform and their stiffness therefore needs to be lower than that of the elements causing the deformation, namely the bridging elements. Now, by virtue of the relaxation slots, the stiffness of the insulating panels is lower than that of the bridging elements. Thus, the bridging elements cause the insulating panels to deform. The aforementioned features thus contribute to the more uniform

distribution of the deformation of the bearing structure over the primary thermally insulating barrier. The corrugations of the sealing membrane are therefore stressed more uniformly.

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

[0011] According to one embodiment, the bridging elements are metal plates. This makes it possible to provide a robust mechanical connection between the insulating panels so that the panels can be made to deform.

[0012] According to one embodiment, each bridging element is fixed in a recess formed in the internal face of one of the two adjacent insulating panels and in a recess formed in the internal face of the other of the two adjacent insulating panels.

[0013] According to one embodiment, at least one of the bridging elements comprises a central portion and two bent-over edges positioned respectively at two ends of the central portion, each bent-over edge being set into a respective groove housed in one of the recesses, the grooves having a length greater than the width of the bent-over edges, at least one of the two grooves being inclined, in a plane orthogonal to the thickness direction of the wall, by an angle α_1 with respect to the adjacent edge of the insulating panel in which said recess is formed. Such an arrangement is advantageous in that it allows the bent-over edges to be set into the grooves present on the internal face of the insulating panels or of the metal mounting plates even if the separation e_1 between the primary panels does not correspond to its nominal value, this being so long as it remains within a determined tolerance band. This arrangement therefore makes it possible to provide simple, rapid and precise positioning of the bridging elements even when the separation e_1 between the insulating panels differs from its nominal value.

[0014] According to one embodiment, the other of the two grooves is inclined, in a plane orthogonal to the thickness direction of the wall, by an angle α_2 with respect to the adjacent edge of the insulating panel in which the recess housing said groove is formed, the angles α_1 and α_2 being oriented angles having opposite directions from one another.

[0015] According to one embodiment, the angles α_1 and α_2 have a value of between 5 and 10°.

[0016] According to one embodiment, the angles α_1 and α_2 have the same value.

[0017] According to one embodiment, the angles α_1 and α_2 and the lengths of the grooves are configured in such a way as to cover a tolerance band, on the spacing e_1 between the insulating panels, that is between 1 and 10 mm and for example of the order of 3 mm.

- [0018]** According to one embodiment, each groove is formed in a metal mounting plate which is fixed in one of the recesses.
- [0019]** According to another embodiment, each groove is formed in a zone of the insulating panel that defines the bottom of one of the recesses. In this way it is possible to dispense with a metal mounting plate.
- [0020]** According to one embodiment, the central portion of the bridging element is fixed to the two insulating panels by fasteners, for example screws. According to an alternative embodiment or in addition, the bridging element is welded to the metal mounting plates in which the grooves are formed. According to one embodiment, the welding between the bridging element and the metal mounting plates is along the edges of the central portion of the bridging element.
- [0021]** According to one embodiment, grooves extending along the one same edge of a primary panel are alternately inclined, with respect to said edge of the primary panel, in one direction and then the other.
- [0022]** According to one embodiment, each bent-over edge has an inclination with respect to the edge of the adjacent insulating panel which corresponds to the inclination of the groove into which said bent-over edge is set.
- [0023]** According to one embodiment, each recess is arranged between an edge of one of the insulating panels and one of the relaxation slots which is adjacent and parallel to said edge.
- [0024]** According to one embodiment, each metal plate is welded to two metal mounting plates which are respectively fixed in one of the recesses of each of the two adjacent insulating panels. Thus the fixing of the bridging elements is simple because the metal mounting plates can be fixed to the insulating elements at the workshop, the bridging elements therefore being able to be fixed, during assembly of the tank, by the means of the welding equipment that already needs to be present inside the tank, notably for welding the sheets of the sealing membrane to one another, and which the operators tasked with manufacturing the tank are fully competent to operate.
- [0025]** According to another embodiment, each metal plate is riveted into one of the recesses of each of the two adjacent insulating panels. This too provides simple fixing of the bridging elements.
- [0026]** According to one embodiment, the sealing membrane is welded to at least some of the metal plates. Thus, the bridging elements perform two functions, namely, on the one hand, that of providing a mechanical connection between the insulating panels and, on the other hand, that of anchoring the sealing membrane to the thermally insulating barrier.

[0027] According to one embodiment, the sealing membrane comprises metal sheets, each metal sheet having edges which are arranged in alignment with at least some of the metal plates and each form an overlapping edge or an overlapped edge respectively welded to an overlapped edge or an overlapping edge of an adjacent metal sheet, each overlapped edge being further welded to at least one of the metal plates in line with which said overlapped edge is situated.

[0028] According to one embodiment, the insulating panels have a parallelepipedal shape and have two first edges parallel to a first direction and two second edges parallel to a second direction perpendicular to the first direction, the metal sheets having two first edges parallel to the first direction and having a dimension that is equal to or an integer multiple of that of the first edges of the insulating panels and two second edges parallel to the second direction and having a dimension that is equal to or an integer multiple of that of the second edges of the insulating panels, the first edges of the metal sheets running along at least some of the two first edges of the insulating panels so as to be situated in line with some of the metal plates and the second edges of the metal sheets running along at least some of the second edges of the insulating panels so as to be situated in line with some of the metal plates.

[0029] According to one embodiment, the two first edges of the metal sheets have a dimension that is an integer multiple of the first edges of the insulating panels so that the metal sheets fully cover some of the metal plates, the metal sheets being welded to said fully covered metal plates by plug welding or by through-transmission welding.

[0030] According to one embodiment, the bridging elements lie flush with the internal surface of the insulating panels so as to ensure continuity of support of the sealing membrane.

[0031] According to another embodiment, the bridging elements project, toward the sealing membrane, beyond the internal surface of the insulating panels, advantageously by an amount less than 3 mm and for example of between 1.2 and 3 mm.

[0032] According to one embodiment, the sealing membrane comprises two mutually perpendicular series of corrugations.

[0033] According to one embodiment, the relaxation slots of the insulating panels are formed facing each of the corrugations of the two series of corrugations of the sealing membrane. Such relaxation slots make it possible to reduce the stiffness of the insulating panels so that the bridging elements cause the insulating panels to deform and so that the thermally insulating barrier deforms more uniformly.

[0034] According to one embodiment, the insulating panels have relaxation slots the number and depth of which are such that said insulating panels have tensile stiffnesses in a first direction and a second direction that are orthogonal to the thickness direction of the wall and respectively parallel to the rows and columns of insulating panels that are respectively lower, and advantageously a factor of more than 3 times lower, than the stiffnesses of the bridging element in the first and second directions.

[0035] According to one advantageous embodiment, the depth of the slots is defined in such a way as to obtain the most uniform possible opening-up of the various slots under the effect of the deformation of the bearing structure, thus obtaining the most uniform possible deformation of the corrugations.

[0036] According to one embodiment, the relaxation slots have a depth in the thickness direction of the wall that is greater than 60 mm.

[0037] According to one embodiment, the insulating panels each have a first series of relaxation slots, for example three slots, which are formed in the internal face of said insulating panel and are parallel to two opposite first edges of said insulating panel, and a second series of relaxation slots, for example three slots, which are formed in the internal face of said insulating panel and parallel to two opposite second edges of said insulating panel.

[0038] According to one embodiment, said relaxation slots have a depth of between 80 and 150 mm and preferably between 115 and 150 mm in the thickness direction of the wall.

[0039] According to one embodiment, at least one of the two series of relaxation slots has at least a central relaxation slot and two edge relaxation slots extending on each side of the central relaxation slot, the central relaxation slot having a depth greater than that of each of the two edge relaxation slots.

[0040] According to one embodiment, the relaxation slots are formed in the internal face of the insulating panels, the insulating panels further comprising external relaxation slots which are formed in the external face of the insulating panels parallel to the relaxation slots formed on the internal face and which are positioned to alternate, in a direction perpendicular to said external relaxation slots, with the relaxation slots formed on the internal face. In other words, each external relaxation slot is arranged between two relaxation slots formed on the internal face, in the direction perpendicular to the external relaxation slots.

[0041] According to one embodiment, the external relaxation slots have a depth greater than 60 mm and for example of between 115 and 150 mm.

- [0042]** According to one embodiment, each insulating panel has two relaxation slots passing respectively through each of the two median axes of said insulating panel.
- [0043]** According to one embodiment, the relaxation slots are separated from one another by a constant spacing.
- [0044]** According to one embodiment, the relaxation slots are separated by a spacing that corresponds to the spacing between the corrugations parallel to said relaxation slots.
- [0045]** According to one embodiment, the internal sheet of the insulating panels has four edges each comprising a plurality of recesses, said recesses being arranged on each side of each relaxation slot.
- [0046]** According to one embodiment, the sealing membrane is a primary sealing membrane and the thermally insulating barrier is a primary thermally insulating barrier, the wall further comprising a secondary thermally insulating barrier held against a bearing structure and a secondary sealing membrane fixed to the secondary thermally insulating barrier and arranged between the secondary thermally insulating barrier and the primary thermally insulating barrier.
- [0047]** According to one embodiment, the invention relates to a sealed and thermally insulating tank having an abovementioned wall.
- [0048]** A tank according to one of the abovementioned embodiments may form part of an onshore storage facility, for example for storing LNG, or may be installed in an inshore or offshore floating structure, in particular an ethane or methane tanker, a floating storage and regasification unit (FSRU), a floating production storage and offloading (FPSO) unit and the like. In the case of a floating structure, the tank may be intended for receiving liquefied natural gas serving as fuel for propulsion of the floating structure.
- [0049]** According to one embodiment, the invention provides a ship for transporting a fluid, which ship has a hull, such as a double hull, and an abovementioned tank arranged in the hull.
- [0050]** According to one embodiment, the invention also provides a method for loading or unloading such a ship, wherein a fluid is conveyed through insulated pipelines from or to a floating or onshore storage facility to or from the ship's tank.
- [0051]** According to one embodiment, the invention also provides a transfer system for transferring a fluid, the system comprising the aforesaid 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 fluid through the insulated pipelines from or to the floating or onshore storage facility to or from the ship's tank.

Brief description of the figures

[0052] The invention will be better understood and further aims, details, features and advantages thereof will become more clearly apparent during the following description of a plurality of particular embodiments of the invention, given merely for illustration and without limitation, with reference to the attached drawings.

[0053] [Fig. 1] Figure 1 is a schematic view in cross section of the multilayer structure of a tank wall.

[0054] [Fig. 2] Figure 2 is a cutaway partial view of a tank wall.

[0055] [Fig. 3] Figure 3 is a perspective view of a corrugated metal sheet of a primary sealing membrane.

[0056] [Fig. 4] Figure 4 is a partial view, from above, of the primary thermally insulating barrier of the tank wall of figure 2.

[0057] [Fig. 5] Figure 5 is a cutaway top view of a tank wall according to another embodiment.

[0058] [Fig. 6] Figure 6 is a partial view, in section, of a primary anchoring device according to one embodiment.

[0059] [Fig.7] Figure 7 is a cutaway schematic depiction of a ship having a tank for storing liquefied natural gas and of a terminal for loading/offloading from this tank.

[0060] [Fig. 8] Figure 8 is a view from above depicting in detail the recesses, the bridging elements and the metal plates according to one embodiment.

[0061] [Fig. 9] Figure 9 is a perspective view of a bridging element according to one embodiment.

[0062] [Fig. 10] Figure 10 is a view from above depicting in detail the recesses, the bridging elements and the metal plates according to another embodiment.

[0063] [Fig. 11] Figure 11 is a schematic depiction of primary insulating elements and of bridging elements according to another embodiment.

[0064] [Fig.12] Figure 12 is a sectional view of a primary thermally insulating barrier and of a primary sealing membrane according to another embodiment.

[0065] [Fig.13] Figure 13 is a sectional view of a primary thermally insulating barrier and of a primary sealing membrane according to another embodiment.

[0066] [Fig. 14] Figure 14 is a schematic depiction of primary insulating elements and of bridging elements according to another embodiment.

Description of the embodiments

[0067] By convention, the terms “external” and “internal” are used to define the relative position of one element relative to another, with reference to the outside and inside of the tank.

[0068] Figure 1 schematically depicts the multilayer structure of a wall 1 of a sealed and thermally insulating tank for storing a liquefied gas. Each wall 1 comprises, from the outside toward the inside of the tank, a secondary thermally insulating barrier 2 comprising secondary panels 3 anchored to a bearing structure 4, a secondary sealing membrane 5 resting against the secondary thermally insulating barrier 2, a primary thermally insulating barrier 6 comprising primary panels 7 resting against the secondary sealing membrane 5 and anchored to the secondary panels 3 and a primary sealing membrane 8 which rests against the primary thermally insulating barrier 6 and which is intended to be in contact with the liquefied gas contained in the tank.

[0069] The bearing structure 4 may notably be formed by the hull or double hull of a ship. The bearing structure 4 comprises a plurality of walls defining the overall shape of the tank, usually a polyhedral shape.

[0070] In connection with figure 2, it may be seen that the secondary thermally insulating barrier 2 comprises a plurality of secondary panels 3. The secondary panels 3 are anchored to the bearing structure 4 by means of secondary anchoring devices, not depicted. The secondary panels 3 have a parallelepipedal overall shape and are arranged in mutually parallel secondary rows. By way of example, in the embodiment illustrated, the secondary panels 3 have an insulating polymer foam layer 9 sandwiched between an external sheet 10 and an internal sheet 11. The external sheet 10 and the internal sheet 11 are, for example, made of plywood and bonded to the insulating polymer foam layer 9. The insulating polymer foam can in particular be a polyurethane-based polymer foam, optionally glass-fiber reinforced. The structure of the secondary panel 3 is described hereinabove by way of example. Also, in another embodiment, the secondary panels 3 are able to adopt another overall structure, for example that described in document WO2012/127141. Also, the secondary panels 3 are for example made up of a parallelepipedal wood box which internally has partitions and is filled with an insulating packing. In another embodiment, the secondary thermally insulating barrier 2 comprises secondary panels 3 having at least two different types of structure, for example the two aforementioned structures, depending on whereabouts in the tank they are installed.

[0071] The secondary sealing membrane 5, illustrated partially in figure 2, comprises a continuous layer of metal strakes 12, having two parallel turned-up edges. The strakes 12

are welded by their turned-up edges to parallel welding supports which are housed in grooves made in the internal sheet 11 of the secondary panels 3. The strakes 12 are for example made of Invar®: i.e. an alloy of iron and nickel, the coefficient of expansion of which is typically between 1.2×10^{-6} and $2 \times 10^{-6} \cdot K^{-1}$. It is also possible to use alloys of iron and manganese the coefficient of expansion of which is typically of the order of 7 to $9 \times 10^{-6} \cdot K^{-1}$. In another embodiment, the metal membrane has corrugations and may for example be made from the same alloys as the strakes.

[0072] Moreover, the primary thermally insulating barrier 6 comprises a plurality of primary panels 7 which are anchored to the secondary thermally insulating barrier 2 by means of primary anchoring devices, as described later on in connection with figure 5. The primary panels 7 have a rectangular parallelepipedal overall shape and are arranged in mutually parallel rows.

[0073] The primary panels 7 may have a multilayer structure similar to the structure of the secondary panels 3. Thus, according to the embodiment depicted, the primary panels 7 comprise, in succession, in the thickness direction of the wall 1, an external sheet 13, for example of plywood, an insulating polymer foam layer 14, and an internal sheet 15, for example of plywood. The insulating polymer foam layer 14 is, for example, a polyurethane-based foam, optionally glass-fiber reinforced. The structure of the primary panel 7 is described hereinabove by way of example.

[0074] In the embodiment depicted, the external sheet 13 and the internal sheet 15 are square in shape. In other words, the primary panels 7 have four edges of the same dimension.

[0075] As illustrated in figure 2, the external sheet 13 of the primary panels 7 has grooves which accept the turned-up edges of the strakes 12 of the secondary sealing membrane 5.

[0076] Moreover, the primary sealing membrane 8 is obtained by assembling a plurality of corrugated metal sheets 16, one of which is depicted in figure 3. The corrugated metal sheets 16 are, for example, made of stainless steel or of aluminum. Each corrugated metal sheet 16 has two mutually perpendicular series of corrugations 17, 18. The corrugations 17, 18 are separated from one another by planar portions 19. In this embodiment, the corrugations 17, 18 are continuous and intersect one another. In a variant embodiment which has not been depicted, each of the corrugations 17, 18 has corrugated portions interspersed with planar portions. The corrugations are therefore discontinuous. Advantageously, the corrugated portions do not intersect one another.

[0077] The corrugated metal sheets 16 are rectangular and therefore have two opposite first edges 20, 21 which are parallel to one another and two opposite second edges 22, 23

which are parallel to one another and perpendicular to the two first edges 20, 21. The corrugated metal sheets 16 preferably have width and length dimensions which are entire values or integer multiples of a spacing between corrugations and also integer multiples of the dimensions of the primary panels 7.

[0078] Thus, in the embodiment illustrated in figure 2, the two first edges 20, 21 have a length which is substantially equal to three times the side length of the primary panels 7, while the second edges 22, 23 have a length which is substantially equal to the side length of the primary panels 7.

[0079] The internal sheet of the primary panels 7 has relaxation slots 24 each extending facing a respective corrugation 17, 18 of the primary sealing membrane 8. The relaxation slots 24 delimit, along the edges of each primary panel 7, a plurality of edge zones. The relaxation slots 24 pass through the internal sheet 15 and extend in the thickness direction of the wall through the insulating polymer foam layer 14 of the primary panels 7. Advantageously, the depth of the relaxation slots 24 and the number thereof are determined in such a way that the tensile stiffnesses of the primary panels 7 in directions orthogonal to the thickness direction of the wall and parallel to the edges of the primary panels 7 are less than the tensile stiffness of the bridging elements 26 in the corresponding direction. Thus, the relaxation slots 24 advantageously have a depth greater than 60 mm, preferably of between 115 and 150 mm. By way of example, the primary panels 7 have a thickness of 230 mm while the relaxation slots 24 have a depth of 115 mm. The aforementioned ranges of values preferably correspond to primary panels 7 having an insulating polymer foam layer 14 made from a polyurethane-based foam of a density of between 110 and 150 kg/m³ and more particularly 130 kg/m³. For foams of greater densities, for example of between 150 and 210 kg/m³, the depth of the relaxation slots 24 will advantageously be greater than those corresponding to the above-mentioned ranges of values and, for example, 40% greater in the case of a 210 kg/m³ foam compared with a 130 kg/m³ foam. The relationship between the depth of the relaxation slots 24 and the density of the foam will advantageously be a linear relationship.

[0080] In the embodiment depicted in figures 2 and 4, each primary panel 7 faces three corrugations 17 running parallel to a first direction and three corrugations 18 running parallel to a second direction perpendicular to the first direction. Also, each primary panel 7 comprises three relaxation slots 24 running parallel to the first direction and each arranged facing one of the corrugations 17 and three relaxation slots 24 running parallel to the second direction and each arranged facing one of the corrugations 17, 18. The primary panels 7 therefore comprise two relaxation slots passing respectively through each of the two median axes of said insulating panel 7, which is to say through the axes

that are parallel to two edges of the insulating panel 7 and which divides it into two equal parts.

[0081] The relaxation slots 24 are therefore separated by a spacing corresponding to the spacing between the corrugations 17, 18 parallel to said relaxation slots 24. However, each relaxation slot 24 adjacent to one of the edges of a primary panel 7 is separated from said edge by a distance corresponding substantially to half the spacing between the corrugations parallel to said relaxation slot 24.

[0082] The internal sheet 15 of the primary panels 7 defines a support surface for the primary sealing membrane 8. The primary panels 7 have, along each of their edges, recesses 25, depicted in figures 2 and 4, intended to accept a bridging element 26 and arranged on each side of each relaxation slot 14. In other words, each edge zone defined by the relaxation slots 24 along the edges of the primary panels 7 has a recess 25.

[0083] The bridging elements 26 are each arranged straddling at least two adjacent primary panels 7, spanning the gap between the two adjacent primary panels 7. Each bridging element 26 comprises an end that is fixed into the recess 25 of one of the two adjacent primary panels 7 and another end that is fixed into the recess 25 of the other of the two adjacent primary panels 7. The bridging elements 26 thus provide a mechanical connection between the primary panels 7 that prevents the mutual separation of said panels. This, in combination with the presence of the relaxation slots 24, contributes to distributing the deformation of the bearing structure 4 more uniformly over the primary thermally insulating barrier 6 and thus allows the primary sealing membrane 8 to be stressed more uniformly.

[0084] In order to fix the bridging elements 26, each recess 25 is equipped with a metal mounting plate 27 which is fixed to the internal sheet 15 inside the recess 25. The metal mounting plate 27 is, for example, fixed to the internal sheet 15 of the primary panels 7, by bonding and/or by using fasteners, such as rivets for example. Furthermore, the bridging elements 26 are metal plates that are welded to the metal mounting plates 27.

[0085] The bridging elements 26 lie flush with the internal surface of the internal sheet 15 of the primary elements 7. In order to achieve that, in the embodiment depicted, the depth of the recesses 25 is equal or substantially equal to the sum of the thickness of a metal mounting plate 27 and of a bridging element 26. Thus, the bridging elements 26 are able to ensure continuity in the support of the primary sealing membrane 8.

[0086] The corrugated metal sheets 16 of the primary sealing membrane 8 are lap welded along their edges 20, 21, 22, 23. Furthermore, the corrugated metal sheets 16 are anchored to the primary thermally insulating barrier 6.

[0087] In the embodiment depicted in figure 2, the corrugated metal sheets 16 are anchored to some of the metal plates that form the bridging elements 26. To achieve that, the edges 20, 21, 22, 23 of the corrugated metal sheets 16 are each arranged along some of the edges of the primary panels 7 and situated in line with the bridging elements 26.

[0088] According to one embodiment, the edge 21, 23 of a first corrugated metal sheet 16 which is intended to be overlapped by the edge 20, 22 of an adjacent second corrugated metal sheet 16 is welded to the bridging element 26, for example using spot welding, and then the edge 20, 22 of the second corrugated metal sheet 16 which overlaps the edge 21, 23 of the first corrugated metal sheet 16 is welded continuously, advantageously as a fillet weld, to said edge 20, 22 of the first corrugated metal sheet 16.

[0089] According to one embodiment which has not been depicted, outside of the recesses 25, the edges of the primary panels 7 have thermal protection strips which are positioned facing the line of welding-together of the corrugated metal sheets 16 and which are aimed at protecting the primary panels 7, and notably the insulating polymer foam layer 14 thereof, against temperatures liable to damage them during the operations of welding the corrugated metal sheets 16 to one another along their edges 20, 21, 22, 23.

[0090] When the corrugated metal sheets 16 have edges 20, 21 the dimension of which is substantially an integer multiple of that of the edges of the primary panels 7, as is the case in the embodiment illustrated in which the edges 20, 21 of the corrugated metal sheets 16 have a length substantially equal to three times the dimension of an edge of a primary panel 7, the corrugated metal sheets 16 are, in an optional embodiment variant, welded to the bridging elements 26 that they fully cover. In order to achieve that, in the embodiment illustrated in figure 2, the corrugated metal sheets 16 are anchored to the bridging elements 26 using plug welds 28. In order to achieve that, the corrugated metal sheets 16 have at least one through-hole, in the form of a slot in the embodiment depicted, which is formed in a planar portion of said corrugated metal sheets 16 in line with said bridging element 26. Each of said holes is filled with weld material in order to make the connection between the primary sealing membrane 8 and the bridging element 26. Alternatively, to anchor the corrugated metal sheets 16 to the bridging elements 26 that they cover, the method employed is through-transmission welding, namely welding using a laser source with no filler material.

[0091] According to another embodiment depicted in figure 5, each corrugated metal sheet 16 is positioned straddling several primary panels 7 so that its edges 20, 21, 22, 23 are offset relative to the edge of the primary panels 7. Thus, only those portions of the edges of the corrugated metal sheets 16 that are situated at the junction between two adjacent

primary panels 7 and, therefore, in line with one of the bridging elements 26, are welded to said bridging element 26.

[0092] The other parts of the edges 20, 21, 22, 23 of the corrugated metal sheets 16 then fall in line with the thermal protection elements 29 depicted in figure 5. The thermal protection elements 29 are, for example, formed of a sheet of aluminum or a composite film containing at least one aluminum foil associated with at least one glass-fiber mat. The thermal protection elements 29 are advantageously housed in bores formed in the internal sheet 15 of the primary panels 7 and are arranged in each gap between two relaxation slots 24 along the edges 20, 21, 22, 23 of the corrugated metal sheets 16. The thermal protection elements 29 are fixed to the internal sheet 15 of the primary panels 7 by bonding and/or stapling. The thermal protection elements 29 protect the primary panels 7 and notably the insulating polymer foam layer 14 thereof against temperatures liable to damage them during the operations of welding the corrugated metal sheets 16 to one another along their edges 20, 21, 22, 23.

[0093] According to another embodiment, the thermal protection elements 29 depicted in figure 5 are replaced by metal mounting plates housed in bores formed in the internal sheet 15 of the primary panels 7 and to which the edges of the corrugated metal sheets 16 which are overlapped by an edge of an adjacent corrugated metal sheet 16 are welded, for example using spot welds or fillet welds.

[0094] Figure 8 depicts in detail the recesses 25, the bridging elements 26 and the metal plates 27 according to one embodiment. In this embodiment, the metal plates 27 are each fixed in one of the recesses 25 by means of four rivets, two of which are depicted in figure 8. As depicted, the ends of the bridging elements 26 are separated from the end of the recesses 25 by enough space to uncover a surface of the metal plates 27 that allows said ends of the bridging elements 26 to be welded to the metal plates 27.

[0095] According to another embodiment depicted in figure 9, each bridging element 26 is anchored to each of two metal plates 27 using a plug weld. In order to achieve this, the bridging element 26 has two through-orifices 38, for example in the form of slots in figure 9, which are filled with weld material in order to make the connection between the bridging element 26 and each of the two metal plates 27.

[0096] Figure 10 depicts in detail recesses 25, bridging elements 26 and metal plates 27 according to another variant embodiment. According to this variant embodiment, the recesses 25 formed at the corners of the primary panels 7, and the metal plates 27 accepted into said recesses 25, are each oriented along the diagonal to the internal face of the primary panels 7. Furthermore, the bridging element 26 which is fixed to the four

metal plates 27 respectively belonging to the four adjacent primary panels 7 is shaped as an octagon.

[0097] In an embodiment which has not been depicted, the metal plates 27 are omitted and the bridging elements 26 are fixed directly by riveting to the inside of the recesses 25.

[0098] Figure 11 depicts another embodiment. In this embodiment, the bridging elements 26 do not lie flush with the internal surface of the insulating panels and are not coplanar either. The bridging elements 26 comprise two ends which are welded to metal plates 27 fixed in recesses 25 formed in the internal face of the primary panels 7. The two ends of the bridging elements 26 project slightly above the internal face of the primary panels 7, for example by an amount of between 1.2 and 3 mm. This makes it easier to weld the bridging elements 26 to the metal plates 27 without too great an impact on the behavior of the primary sealing membrane 8. Moreover, in the embodiment depicted, the bridging element 26 comprises a central part which does not extend in the plane of the two ends of said bridging element 26 and which projects into the gap formed between the two adjacent primary panels 7.

[0099] As depicted in figure 6, the primary panels 7 have cutouts 30 at their corners, such that their external sheet 13 extends beyond the insulating polymer foam layer 14 and the internal sheet 15 thereof. Thus, the external sheet 13 forms, at the corners of the primary panels 7, a bearing zone 31 that is intended to collaborate directly or indirectly with a hold-down plate 32 of a primary anchoring device 33. Furthermore, in the embodiment depicted, a block 34 is added to the external sheet 13, said block 34 having a shape similar to that of the bearing zone 31 and collaborating with the hold-down plate 32 to anchor the primary panel 7. Each primary anchoring device 33 collaborates with four bearing zones 31 belonging respectively to the corners of four adjacent primary panels 7. Each primary anchoring device 33 comprises a stud 35 which projects from one of the secondary panels 3, a hold-down plate 32 which is fixed to the end of the stud 35 and which bears against the four bearing zones of the four adjacent primary panels 7 so as to hold them against the secondary thermally insulating barrier 2. The hold-down plate 32 has a bore slipped over the stud 35. A nut 36 engages with a threaded end of the stud 35 so as to secure the hold-down plate 32. Furthermore, according to one advantageous embodiment, elastic Belleville washers are slipped over the stud 35, between the nut 36 and the hold-down plate 32, thereby elastically anchoring the primary panels 7 on the secondary thermally insulating barrier 2.

[0100] The stud 35 is fixed to a base 37 which is itself fixed to the internal sheet 11 of the secondary panels 3. In order to achieve this, the base 37 comprises, for example, a screw

thread which engages with a complementing threaded end of the stud 35. Furthermore, the internal sheet 11 of the secondary panels 3 has a cutout in which the base 37 is housed. The cutout has an internal section of a first diameter and an external section of a second diameter greater than the first diameter so as to create a stepped shoulder. The base 37 has a shape that complements that of the cutout. Thus, the internal face of the base 37 lies flush with the internal face of the internal sheet 11 of the secondary panels 3 so as to form a planar support surface supporting the secondary sealing membrane 5. Furthermore, the base 37 has an external section of a greater diameter than its internal section such that the external section of said base 37 is in abutment against the shoulder of the cutout. The base 37 is also bonded to the secondary panel 3.

[0101] Moreover, the stud 35 passes in a sealed manner through an orifice formed in the secondary sealing membrane 5.

[0102] In the embodiment depicted in figure 12, the primary panels 7 differ from the primary panels described hereinabove in that they also comprise relaxation slots 39 opening onto the external face of the primary panels 7. Advantageously, the primary panels 7 also have two series of such relaxation slots 39 which are respectively parallel to two opposite first edges of the primary panels and to two opposite second edges of the primary panels 7. As illustrated in this figure, the relaxation slots 39 are not arranged facing a corrugation 17, 18 but midway between two parallel corrugations 17, 18. Thus, the relaxation slots 39 are positioned so that they alternate with the relaxation slots 24. The depth of the relaxation slots is greater than 60 mm, preferably between 115 and 150 mm, and for example of the order of 115 mm.

[0103] In the embodiment depicted in figure 13, the relaxation slots 24 do not all have the same depth. Specifically, the depth of the relaxation slots 24 increases toward the center of the primary panels 7 and decreases toward the edges thereof. In other words, the central relaxation slot has a depth greater than that of the two edge relaxation slots which extend on each side of the central relaxation slot. This has the effect of obtaining a better distribution of the stresses within each primary insulating panel 7, making it possible for the corrugations 17, 18 of the primary sealing membrane 8 to be stressed even more uniformly. By way of example, the depth of the central relaxation slot may be 115 mm while the depths of the edge relaxation slots are 80 mm. According to another example, the depth of the central relaxation slot may be 150 mm while the depths of the edge relaxation slots are 115 mm.

[0104] Figure 14 depicts a bridging element 26 according to another embodiment. As in the preceding embodiments, in order to fix the bridging element 26, each recess 25 is

equipped with a metal mounting plate 27. The metal mounting plates 27 are fixed to the primary panels 7 for example by means of fasteners, not depicted, such as rivets or screws, which pass through orifices 40 made in the metal mounting plates 7.

[0105] The bridging element 26 comprises a central portion 41 and two bent-over edges 42, 43 which are respectively set into a groove 44, 45 formed in each of the two metal mounting plates 27. The bridging element 26 is made for example of bent sheet metal of the order of 1 to 2 mm thick.

[0106] According to one embodiment, each of the recesses 25 of the primary panels 7 has a groove, not illustrated, of the same shape as the groove 44, 45 of the corresponding metal mounting plate 27 and facing same. Thus, the bent-over edges 42, 43 of the bridging element 26 are also set into the grooves formed in the recesses 25.

[0107] At least one of the grooves 44, 45 of the two metal mounting plates 27 is angled, which is to say not formed parallel to the adjacent edge 47, 48 of the primary panel 7 that bears it but is inclined, in a plane orthogonal to the thickness direction, by an angle α_1 , α_2 with respect to said edge 47, 48. In the advantageous embodiment depicted in figure 14, the grooves 44, 45 of both the metal mounting plates 27 are angled and respectively inclined by an angle α_1 and α_2 with respect to the adjacent edge 47, 48 of the respective primary panel 7. The angles α_1 and α_2 are oriented angles having opposite directions to one another. Furthermore, as a preference, the angles α_1 and α_2 have identical values.

[0108] In order to be able to be inserted into one of the grooves 44, 45, each bent-over edge 42, 43 of the bridging element 26 extends in a plane which is perpendicular to the plane of the central portion 26 but which is inclined with respect to the edge 47, 48 of the adjacent primary panel 7 by the same angle α_1 and α_2 as the angled groove 44, 45 into which it is set.

[0109] Furthermore, the grooves 44, 45 have a length greater than the width of the bent-over edges 42, 43 so as to create some clearance for the positioning of the bent-over edges 42, 43 inside the grooves 44, 45.

[0110] Such an arrangement is advantageous in that it allows the bent-over edges 42, 43 to be set into the grooves 42, 43 of the metal mounting plates 27 even if the separation e_1 between the primary panels 7 does not correspond to its nominal value, this being so long as it remains within a determined tolerance band. Thus, in figure 14, the bent-over edges 42, 43 will be closer to the left-hand end of the grooves 44, 45 than to the right-hand end thereof if the separation e_1 between the two adjacent primary panels 7 is greater than its nominal value. Conversely, as depicted in figure 14, the bent-over edges 42, 43 will be

closer to the right-hand end of the grooves 44, 45 than to the left-hand end thereof if the separation e_1 is less than its nominal value.

[0111] Advantageously, the angles α_1 and α_2 and the clearance for the positioning of the bent-over edges 42, 43 in the grooves 44, 45 are such that it is possible to cover a tolerance band of between 1 and 10 mm and for example of the order of 3 mm. Advantageously, the tolerance band is centered on the nominal value for the separation e_1 .

[0112] The recesses 25 advantageously have a depth substantially equal to the sum of the thickness of a metal mounting plate 27 and of the central portion 41 of the bridging element 26, thereby allowing the central portion 41 of the bridging element 26 to lie flush with the internal surface of the primary panels 7 so as to ensure continuity of support of the primary sealing membrane 8.

[0113] The bridging element 26 is fixed to the primary panel 7 so as to fix the relative position of the bent-over edges 42, 43 in the grooves 44, 45 and avoid the bent-over edges 42, 43 becoming disengaged from the grooves 44, 45. In order to achieve this, in the embodiment depicted, the central portion 41 of the bridging element 26 comprises orifices 49 intended to accept fasteners, not depicted, such as screws or rivets, for fixing the bridging element 26 to the primary panels 7. As an alternative or in addition, the bridging element 26 is welded to the metal mounting plates 27. In that case, the bridging element 26 is preferably welded to the metal mounting plates 27 along the edges of the central portion 41.

[0114] Advantageously, the surface finish of the grooves 44, 45 and of the bent-over edges 42, 43 is rough, so as to limit the shear forces applied to the fasteners that fasten the bridging element 26 to the primary panels 7.

[0115] In one embodiment, not illustrated, the grooves 44 of the metal mounting plates 27 extending along the one same edge 47 of a primary panel 7 are alternately inclined, with respect to said edge 47 of the primary panel 7, in one direction and then the other. In other words, the inclination of the grooves 44 of two adjacent metal mounting plates 27 along an edge 47 is reversed so that when the separation e_1 between the primary panels 7 is greater than the nominal value, one of the bridging elements 26 set into the groove 44 of one of the metal mounting plates 27 is closer to the right-hand end of said groove 44 and the other bridging element 26 set into the groove 44 of the other metal mounting plate 27 is closer to the left-hand end of said groove 44.

[0116] Another embodiment, not depicted, differs from the embodiment described hereinabove in connection with figure 14, in that the primary panels 7 do not have metal mounting plates 27, thereby making it possible to simplify the mounting of the bridging

elements 26 still further. Therefore, the bent-over edges 42, 43 of the bridging elements 26 are set directly into angled grooves formed in the recesses 25 of the primary panels 7. The angled grooves formed in the recesses 325 have characteristics similar to those of the grooves 44, 45 described hereinabove, particularly as regards their inclination with respect to the adjacent edges 47, 48 of the primary panels 7. Moreover, the depth of the recesses 25 is substantially equal to the thickness of the central portion 41 of the bridging element 26, thereby allowing the central portion 41 of the bridging element 26 to lie flush with the internal surface of the primary panels 7.

[0117] With reference to figure 7, a cut-away view of a methane carrier 70 shows a sealed and insulated tank 71 with a generally prismatic shape assembled in the double hull 72 of the ship. The wall of the tank 71 has a primary sealing membrane 8 intended to be in contact with the LNG contained in the tank, a secondary sealing membrane 5 arranged between the primary sealing membrane 8 and the double hull 72 of the ship, and two thermally insulating barriers arranged between the primary sealing membrane 8 and the secondary sealing membrane and between the secondary sealing membrane and the double hull 72, respectively.

[0118] In a manner known *per se*, loading/offloading pipelines 73 arranged on the upper deck of the ship can be connected, by means of appropriate connectors, to a maritime or harbor terminal in order to transfer a cargo of LNG from or to the tank 71.

[0119] Figure 7 also 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 carries a bundle of insulated flexible hoses 79 that can be connected to the loading/offloading pipelines 73. The orientable mobile arm 74 is suitable for all sizes of methane carrier. A connecting pipe, not shown, extends inside the tower 78. The loading and offloading station 75 makes it possible to load and offload from the methane carrier 70 from or to the onshore facility 77. The latter has liquefied-gas storage tanks 80 and connecting pipes 81 connected by the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 makes it possible to transfer the liquefied gas between the loading or offloading station 75 and the onshore facility 77 over a long distance, for example 5 km, allowing the methane tanker 70 to be kept standing off shore by a long distance during the loading and offloading operations.

[0120] In order to generate the pressure needed for transferring the liquefied gas, use is made of the pumps carried on board the ship 70 and/or of the pumps with which the onshore

facility 77 is equipped and/or of the pumps with which the loading and offloading station 75 is equipped.

[0121] Although the invention has been described in connection with several particular embodiments, it is quite obvious that it is in no way limited thereto and that it comprises all the technical equivalents of the means described as well as their combinations, if these come within the scope of the invention.

[0122] In the claims, any reference sign in brackets should not be interpreted as a limitation on the claim.

[0123] Although the invention has been described in connection with several particular embodiments, it is quite obvious that it is in no way limited thereto and that it comprises all the technical equivalents of the means described as well as their combinations, if these come within the scope of the invention.

[0124] In particular, while the above description describes a tank comprising two thermally insulating barriers and two sealing membranes, the invention is not restricted to such a multilayer structure and may for example comprise just one thermally insulating barrier and one sealing membrane.

[0125] The use of the verb "have", "comprise" or "include" and conjugated forms thereof does not exclude the presence of elements or steps other than those stated in a claim.

[0126] In the claims, any reference sign in brackets should not be interpreted as a limitation on the claim.

Claims

[Claim 1] A wall (1) of a sealed and thermally insulating tank for storing a liquefied gas, comprising at least one thermally insulating barrier (6) and one sealing membrane (8) which is anchored to said thermally insulating barrier (6) and is intended to be in contact with the liquefied gas contained in the tank, the thermally insulating barrier (6) comprising insulating panels (7) which are juxtaposed with one another in mutually parallel rows and columns, each insulating panel (7) comprising an internal face supporting the sealing membrane (8) and being connected to the adjacent insulating panels (7) by means of bridging elements (26), each bridging element (26) being arranged straddling two of the adjacent insulating panels (7) and being fixed to the internal face of one of the two adjacent insulating panels (7) and to the internal face of the other of the two adjacent insulating panels (7), the insulating panels (7) comprising relaxation slots (24) which are each formed in a thickness direction of the wall, each bridging element (26) being fixed to one of the insulating panels (7) between an edge of said insulating panel (7) and that one of the relaxation slots (24) that is adjacent and parallel to said edge.

[Claim 2] The wall (1) as claimed in claim 1, wherein the bridging elements (26) are metal plates.

[Claim 3] The wall (1) as claimed in claim 1 or 2, wherein each bridging element (26) is fixed in a recess (25) formed in the internal face of one of the two adjacent insulating panels (7) and in a recess (25) formed in the internal face of the other of the two adjacent insulating panels (7).

[Claim 4] The wall (1) as claimed in claim 3, wherein at least one of the bridging elements (26) comprises a central portion (41) and two bent-over edges (42, 43) positioned respectively at two ends of the central portion (41), each bent-over edge (42; 43) being set into a respective groove (44, 45) housed in one of the recesses (25), the grooves having a length greater than the width of the bent-over edges (42, 43), at least one of the two grooves (44) being inclined, in a plane orthogonal to the thickness direction of the wall, by an angle α_1 with respect to the adjacent edge of the insulating panel (7) in which said recess (25) is formed.

- [Claim 5] The wall (1) as claimed in claim 4, wherein the other of the two grooves (45) is inclined, in a plane orthogonal to the thickness direction of the wall, by an angle α_2 with respect to the adjacent edge of the insulating panel (7) in which the recess (25) housing said groove (45) is formed, the angles α_1 and α_2 being oriented angles having opposite directions from one another.
- [Claim 6] The wall (1) as claimed in claim 5, wherein the angles α_1 and α_2 have a value of between 5 and 10°.
- [Claim 7] The wall (1) as claimed in any one of claims 3 to 6, wherein each metal plate is welded to two metal mounting plates (27) which are respectively fixed in one of the recesses (25) of each of the two adjacent insulating panels (7).
- [Claim 8] The wall as claimed in claim 3, wherein each metal plate is riveted into one of the recesses (25) of each of the two adjacent insulating panels (7).
- [Claim 9] The wall (1) as claimed in any one of claims 2 to 8, wherein the sealing membrane (8) is welded to at least some of the metal plates.
- [Claim 10] The wall (1) as claimed in claim 9, wherein the sealing membrane (8) comprises metal sheets (16), each metal sheet (16) having edges (20, 21, 22, 23) which are arranged in alignment with at least some of the metal plates and each form an overlapping edge or an overlapped edge respectively welded to an overlapped edge or an overlapping edge of an adjacent metal sheet (16), each overlapped edge being further welded to at least one of the metal plates in line with which said overlapped edge is situated.
- [Claim 11] The wall (1) as claimed in claim 10, wherein the insulating panels (7) have a parallelepipedal shape and have two first edges parallel to a first direction and two second edges parallel to a second direction perpendicular to the first direction, the metal sheets (16) having two first edges (20, 21) parallel to the first direction and having a dimension that is equal to or an integer multiple of that of the first edges of the insulating panels (7) and two second edges (22, 23) parallel to the second direction and having a dimension that is equal to or an integer multiple of that of the second edges of the insulating panels (7), the first edges (20, 21) of the metal sheets (16) running along at least some of the two first edges of the insulating panels (7) so as to be situated in line with some of the metal plates and the second edges (22, 23) of the metal

sheets (16) running along at least some of the second edges of the insulating panels (7) so as to be situated in line with some of the metal plates.

[Claim 12] The wall (1) as claimed in claim 11, wherein the two first edges (20, 21) of the metal sheets (16) have a dimension that is an integer multiple of the first edges of the insulating panels (7) so that the metal sheets (16) fully cover some of the metal plates, the metal sheets (16) being welded to said fully covered metal plates by plug welding (28) or by through-transmission welding.

[Claim 13] The wall (1) as claimed in any one of claims 1 to 12, wherein the bridging elements (26) lie flush with the internal surface of the insulating panels (7) so as to ensure continuity of support of the sealing membrane (8).

[Claim 14] The wall (1) as claimed in any one of claims 1 to 13, wherein the bridging elements (25) project, toward the sealing membrane (8), beyond the internal surface of the insulating panels (7).

[Claim 15] The wall (1) as claimed in any one of claims 1 to 14, wherein the sealing membrane (8) comprises two mutually perpendicular series of corrugations.

[Claim 16] The wall (1) as claimed in claim 15, wherein the relaxation slots (24) of the insulating panels (7) are formed facing each of the corrugations (17, 18) of the two series of corrugations of the sealing membrane (8).

[Claim 17] The wall (1) as claimed in claim 15 or 16, wherein the internal sheet of the insulating panels (7) has four edges each comprising a plurality of recesses (25), said recesses (25) being arranged on each side of each relaxation slot (24).

[Claim 18] The wall (1) as claimed in any one of claims 1 to 17, wherein the insulating panels (7) have relaxation slots the number and depth of which are such that said insulating panels have tensile stiffnesses in a first direction and a second direction that are orthogonal to the thickness direction of the wall and respectively parallel to the rows and columns of insulating panels (7) that are respectively lower than the stiffnesses of the bridging element in the first and second directions.

[Claim 19] The wall (1) as claimed in claim 18, wherein the relaxation slots (24) have a depth in the thickness direction of the wall that is greater than 60 mm.

[Claim 20] The wall (1) as claimed in any one of claims 1 to 19, wherein the insulating panels each have a first series of relaxation slots which are formed in the internal face of said insulating panel (7) and parallel to two opposite first edges (20, 21) of said insulating panel (7), and a second series of relaxation slots which are formed in the internal face of said insulating panel (7) and parallel to two opposite second edges (20, 21) of said insulating panel (7), said relaxation slots (24) having a depth of between 80 and 150 mm and preferably between 115 and 150 mm in the thickness direction of the wall.

[Claim 21] The wall (1) as claimed in claim 20, wherein at least one of the two series of relaxation slots has at least a central relaxation slot and two edge relaxation slots extending on each side of the central relaxation slot, the central relaxation slot having a depth greater than that of each of the two edge relaxation slots.

[Claim 22] The wall (1) as claimed in any one of claims 1 to 21, wherein the relaxation slots (24) are formed in the internal face of the insulating panels (7), the insulating panels (7) further comprising external relaxation slots (39) which are formed in the external face of the insulating panels (7) parallel to the relaxation slots (24) formed on the internal face and which are positioned to alternate, in a direction perpendicular to said external relaxation slots (39), with the relaxation slots formed on the internal face.

[Claim 23] The wall (1) as claimed in any one of claims 1 to 22, wherein the sealing membrane (8) is a primary sealing membrane and the thermally insulating barrier (6) is a primary thermally insulating barrier, the wall (1) further comprising a secondary thermally insulating barrier (2) held against a bearing structure (4) and a secondary sealing membrane (5) fixed to the secondary thermally insulating barrier and arranged (2) and arranged between the secondary thermally insulating barrier (2) and the primary thermally insulating barrier.

[Claim 24] A sealed and thermally insulating tank comprising a wall (1) as claimed in any one of claims 1 to 23.

[Claim 25] A ship (70) for transporting a fluid, the ship comprising a hull (72) and a tank (71) as claimed in claim 24, arranged in the hull.

[Claim 26] A transfer system for transferring a fluid, the system comprising a ship (70) as claimed in claim 25, 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 fluid through the insulated pipelines from or to the floating or onshore storage facility to or from the ship's tank.

[Claim 27] A method for loading or unloading a ship (70) as claimed in claim 25, wherein a fluid is conveyed through insulated pipelines (73, 79, 76, 81) from or to a floating or onshore storage facility (77) to or from the ship's tank (71).