Description

Title of the invention: Leaktight and thermally insulating wall

Technical field

[0001] The invention relates to the field of sealed tanks with a corrugated metal membrane for storing and/or transporting a liquefied gas.

[0002] In particular, the invention relates to the field of sealed and thermally insulating tanks for storing and/or transporting liquefied gas, such as tanks for transporting liquefied petroleum gas (LPG) for example at a temperature of between -50°C and 0°C, or for transporting ammonia at approximately -33°C, or for transporting liquefied natural gas (LNG) at approximately -162°C at atmospheric pressure. These tanks may be installed on land or on a floating structure. In the case of a floating structure, the tank may be intended to transport liquefied gas or receive liquefied gas serving as fuel for the propulsion of the floating structure.

Technological background

[0003] In the prior art, sealed and thermally insulating tanks for storing a liquefied gas are known, comprising a corrugated primary sealing membrane which is intended to be in contact with the liquefied gas contained in the tank and which is reinforced with the aid of reinforcing elements. The reinforcing elements are disposed under the corrugations of the primary sealing membrane, between said primary sealing membrane and the primary thermally insulating barrier supporting it. Such reinforcing elements make it possible to reduce the stresses which are liable to be exerted in the primary sealing membrane, notably under the effect of hydrostatic pressures and dynamic pressures caused by the movement of the cargo in the tank, as a result of the swell.

[0004] Different types of reinforcing element are known. There are notably tanks with reinforcing elements in the form of plywood wedges and others with reinforcing elements in the form of metal profiled elements. The choice of the type of reinforcer to be used is notably guided by the hydrostatic and dynamic pressures liable to be exerted on the primary sealing membrane. Thus, the use of metal profiled elements is generally preferred for large tanks, for example when the maximum pressure on the waves of the membrane is of the order of 80 to 100 bar, whereas the use of plywood

wedges is preferred for tanks of a standard size, for example when the maximum pressure is of the order of 50 bar.

[0005] However, there is no reinforcing system that is suitable for intermediate pressure ranges between the two aforementioned pressure ranges, that is to say that is sufficiently robust to withstand such pressures without being oversized, which would lead to an unnecessary increase in the cost and complexity of the sealed and thermally insulating tank. This is, for example, the case for intermediate-sized or standard-sized tanks when they are intended to store ethane or ammonia because the latter have higher densities than methane, namely 544 kg/m^3 for ethane and 681 kg/m^3 for ammonia, compared with 423 kg/m^3 for methane.

Summary of the invention

[0006] One idea behind the invention is therefore to propose a wall for a sealed and thermally insulating tank that is optimally reinforced, notably for intermediate pressure ranges.

[0007] According to one embodiment, the invention provides a sealed and thermally insulating wall for a tank intended for the storage of a liquefied gas, said wall comprising:

a primary sealing membrane intended to be in contact with the fluid contained in the tank and resting against a primary thermally insulating barrier, the sealing membrane comprising at least a first series of corrugations comprising first corrugations which are parallel to one another and a second series of corrugations comprising second corrugations which are parallel to one another, perpendicular to the first corrugations and intersect the first corrugations in node zones; the first corrugations having a height in a thickness direction of the wall that is greater than a height of the second corrugations; the wall comprising at least one reinforcing system comprising first reinforcing elements which are positioned bearing against the primary thermally insulating barrier, inside one of the first corrugations, on either side of one of the node zones, and a second reinforcing element which is positioned bearing against the primary thermally insulating barrier, in line with the node zone, and extends into one of the second corrugations on either side of the node zone, the first reinforcing elements being profiled hollow elements and the second reinforcing element having a solid cross section and being made of wood, for example plywood.

[0008] By virtue of these features, the reinforcing system can be optimized for intermediate pressure ranges since the tallest corrugation or corrugations, that is to say those which

are subjected to the greatest loads, are reinforced with profiled hollow elements, whereas the lowest corrugation or corrugations, that is to say those which are subjected to the lowest loads, are reinforced only with reinforcing elements made of wood, for example plywood.

[0009] According to embodiments, such a sealed and thermally insulating wall may have one or more of the following features.

[0010] According to one embodiment, the reinforcing system comprises a connecting member which is disposed inside the first corrugation and which is fastened to the first reinforcing elements and to the second reinforcing element. The connecting member ensures a relative positioning of the reinforcing elements with respect to one another. The connecting member also prevents the first reinforcers from coming into contact with the node.

[0011] According to one embodiment, the connecting member comprises a metal strip which is fastened to the first reinforcing elements and to the second reinforcing element.

[0012] According to one embodiment, the strip is engaged in a slot which is provided in each of the first reinforcing elements, the strip being fastened in said slot. Thus, the strip and the slot in the first reinforcing elements form a sliding connection which facilitates the placing of the connecting member before the strip is fastened to the first reinforcing elements.

[0013] According to one embodiment, the slot is locally deformed in order to pinch the strip inside said slot.

[0014] According to one embodiment, the strip is fastened to the first reinforcing elements by means of fastening members, such as screws, for example self-drilling screws.

[0015] According to one embodiment, the strip comprises holes, preferably oblong holes.

[0016] According to one embodiment, the strip is fastened by clip-fastening to the first reinforcing elements.

[0017] According to one embodiment, the strip is fastened to the first reinforcing elements by an assembly mechanism, such as a quarter-turn assembly mechanism.

[0018] According to one embodiment, the strip is engaged in a groove which is provided in the second reinforcing element, transversely to a longitudinal direction of said second reinforcing element, the strip being fastened in said groove by at least one fastening member, such as a clip or a screw, for example a self-drilling screw.

[0019] According to one embodiment, the reinforcing system comprises a plurality of second reinforcing elements which are disposed in a plurality of adjacent node zones and which are connected to one another by the connecting member, the node zones being formed at intersections of the first corrugation with a plurality of the second corrugations.

[0020] According to one embodiment, the connecting member is a first connecting member and the first reinforcing elements to which the first connecting member is fastened are a first plurality of first reinforcing elements positioned inside a first one of the first corrugations,

the reinforcing system further comprising a second plurality of first reinforcing elements which are positioned bearing against the primary thermally insulating barrier, inside a second one of the first corrugations, and a second connecting member which is disposed inside the second one of the first corrugations and which is fastened to the second plurality of first reinforcing elements and to said or to each second reinforcing element, said or each second reinforcing element extending into the second corrugation between the first and the second of the first corrugations and on either side of the node zones formed at intersections of the second corrugation with the first and the second of the first corrugations.

[0021] By virtue of these features, the reinforcing system can be in the form of a lattice.

[0022] According to one embodiment, the reinforcing system comprises a plurality of first reinforcing elements, which are spaced apart from one another, in at least one inter-corrugation gap positioned between two node zones. This makes it possible to further limit the cost and the weight of the reinforcing system.

[0023] According to one embodiment, the sealed and thermally insulating wall comprises a plurality of reinforcing systems such that second reinforcing elements are disposed in each of the node zones of the sealing membrane and extend on either side of said node zone in one of the second corrugations and such that first reinforcing elements are disposed in each inter-corrugation gap of the second corrugations positioned between two node zones.

[0024] According to one embodiment, the first reinforcing elements are made of a metallic material, preferably selected from aluminium and aluminium alloys, or of a polymer material, preferably selected from polyethylene, polycarbonate, polystyrene and polyetherimide.

[0025] According to one embodiment, the wood of the second reinforcing element is solid wood, plywood or wood fibres impregnated with polymer resin.

[0026] According to one embodiment, the plywood of the second reinforcing element has fibres oriented perpendicularly to a thickness direction of the wall.

[0027] According to another embodiment, the plywood of the second reinforcing element has fibres oriented parallel to a thickness direction of the wall. Thus, the compression strength of the second reinforcing elements is greatest in the direction in which the compressive loads are predominantly exerted.

[0028] According to one embodiment, the profiled hollow elements comprise a lower flange which is intended to rest against the inner surface of the primary thermally insulating barrier and an upper support portion. According to one embodiment, the support portion has a shape corresponding to the shape of the inside of the first corrugation.

[0029] According to one embodiment, the support portion comprises intersecting reinforcing webs which extend from one edge of the profiled hollow element to the other and which intersect at the plane of symmetry thereof.

[0030] According to one embodiment, the second reinforcing element has a lower flange which is intended to rest against the inner surface of the primary thermally insulating barrier.

[0031] According to one embodiment, the second reinforcing element has lateral faces which do not extend as far as the top of the second corrugation and a planar upper face which connects the two lateral faces.

[0032] According to one embodiment, the invention also provides a sealed and thermally insulating tank comprising at least one sealed and thermally insulating wall of the aforementioned type.

[0033] According to one embodiment, the invention also provides a sealed and thermally insulating tank comprising two thermally insulating barriers and two sealing membranes.

[0034] A facility according to one of the aforementioned embodiments may be an onshore storage facility, for example for storing LNG, or 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 to receive liquefied natural gas serving as fuel for the propulsion of the floating structure.

[0035] According to one embodiment, the invention relates to a ship for transporting a fluid, comprising a facility of the aforementioned type.

[0036] According to one embodiment, the ship has a double hull which forms the load-bearing structure.

[0037] According to one embodiment, the invention also provides a transfer system for a fluid, the system comprising the aforementioned ship, insulated pipelines arranged so as to connect the tank of the ship to a floating or onshore storage facility, and a pump for causing fluid to flow through the insulated pipelines from or to the floating or onshore storage facility to or from the tank of the ship.

[0038] According to one embodiment, the invention also provides a method for loading onto or offloading from such a ship, wherein a fluid is conveyed through insulated pipelines from or to a floating or onshore storage facility to or from the tank of the ship.

[0039] According to one embodiment, the invention relates to a ship for transporting a fluid, comprising a facility of the aforementioned type.

Brief description of the figures

[0040] The invention will be better understood, and further aims, details, features and advantages thereof will become more clearly apparent, in the course of the following description of several particular embodiments of the invention, which are given solely by way of non-limiting illustration, with reference to the appended drawings.

[0041] Figure 1 is an exploded perspective view of a tank wall.

[0042] Figure 2 is a perspective view of a corrugated metal plate intended for the construction of a sealed membrane.

[0043] Figure 3 is a view from above of a reinforcing system according to a first embodiment intended to be disposed under the corrugations of the primary sealing membrane.

[0044] Figure 4 is a partial perspective view of the reinforcing system in Figure 3.

[0045] Figure 5 is a sectional view illustrating a mode for fastening a connecting member to a first reinforcing element, intended to be disposed under a tall corrugation, according to a first variant.

[0046] Figure 6 is a schematic view illustrating a mode for fastening a connecting member to a second reinforcing element, intended to be disposed under a low corrugation, according to the first variant in Figure 5.

[0047] Figure 7 is a schematic view illustrating a mode for fastening a connecting member to a first reinforcing element, intended to be disposed under a tall corrugation, according to a second variant.

[0048] Figure 8 is a schematic view illustrating a mode for fastening a connecting member to a second reinforcing element, intended to be disposed under a low corrugation, according to the second variant in Figure 7.

[0049] Figure 9 is a schematic view illustrating a mode for fastening a connecting member to a first reinforcing element, intended to be disposed under a tall corrugation, according to a third variant.

[0050] Figure 10 is a view from below of a first reinforcing element, intended to be disposed under a tall corrugation, according to a fourth variant.

[0051] Figure 11 is a schematic view of a first reinforcing element and of a connecting member according to the fourth variant before they are fastened to one another.

[0052] Figure 12 is a cut-away schematic depiction of a methane tanker tank and of a terminal for loading/offloading from this tank.

[0053] Figure 13 is a perspective view of a reinforcing system according to a second embodiment.

Description of the embodiments

[0054] By convention, the terms "outer" and "inner" are used to define the position of one element relative to another, with reference to the inside and to the outside of the tank. Moreover, the terms "upper" and "lower" are also used to define the position of one element relative to another, the term "upper" denoting an element closer to the inside of the tank and, by contrast, the term "lower" denoting an element further from the inside of the tank; and this regardless of the position of said elements relative to the direction of the gravity field.

[0055] In relation to Figure 1, a wall 1 is described for a sealed and thermally insulating tank intended for the storage of a liquefied gas.

[0056] Each wall 1 comprises a multilayer structure which has successively, from the outside to the inside, in the thickness direction of the wall 1: a secondary thermally insulating barrier 3 retained on the load-bearing structure 2, a secondary sealing membrane 4 bearing against the secondary thermally insulating barrier 3, a primary thermally insulating barrier 5 bearing against the secondary sealing membrane 4 and a primary sealing membrane 6 bearing against the primary thermally insulating barrier 5 and intended to be in contact with the liquefied natural gas contained in the tank.

[0057] The load-bearing structure 2 is, for example, formed by the double hull of a ship, but can more generally be formed by any type of rigid partition having appropriate mechanical properties.

[0058] The primary sealing membrane 6 comprises a plurality of metal sheets 7 which are lap-welded to one another in a sealed manner. The metal sheets 7 are also anchored to the primary thermally insulating barrier 5. To do this, in the embodiment shown, the metal sheets 7 are welded, for example by spot welds, along their edges, to anchoring strips 8. The anchoring strips 8 are housed and fastened in cutouts provided in the inner surface of the primary thermally insulating barrier 5 in such a way that the anchoring strips 8 lie flush with the inner surface of the primary thermally insulating barrier 5.

[0059] As shown in Figure 2, each metal sheet 7 comprises a first series of parallel corrugations, referred to as tall corrugations 9, and a second series of parallel corrugations, referred to as low corrugations 10, which extend perpendicularly to the corrugations of the first series. Note that the terms "high" and "low" here have a relative meaning and mean that the low corrugations 10 are smaller in height than the tall corrugations 9. At each intersection between two corrugations 9, 10, the primary sealing membrane 6 comprises a node zone 36. The node zone 36 comprises a central portion having a top projecting towards the inside of the tank. Moreover, the central portion is bordered, for the one part, by a pair of concave corrugations formed in the crest of the tall corrugation 9 and, for the other part, by a pair of indentations that the low corrugation 10 penetrates. The corrugations 9, 10 of the metal sheets 7 allow the primary sealing membrane 6 to be flexible so that it can deform under the effect of the thermal and mechanical stress loadings generated by the liquefied gas stored in the tank.

[0060] By way of example, the tall corrugations 9 have a height between 45 and 70 mm depending on the thickness of the insulation and the low corrugations 10 have a height between 20 and 44 mm depending on the thickness of the insulation.

[0061] By way of example, the metal sheets 7 may notably be made of stainless steel, of aluminium, of Invar®, namely an alloy of iron and nickel with an expansion coefficient typically between 1.10^{-6} and 2.10^{-6} K^{-1}, or of an iron alloy with a high manganese content, the expansion coefficient of which is typically of the order of 7.10^{-6} to 9.10^{-6} K^{-1}. However, other metals or alloys are also conceivable. By way of example, the metal sheet has a thickness between 1 and 1.5 mm, for example 1.2 mm. Other thicknesses are also conceivable, in the knowledge that a thickening of the metal sheet leads to an increase in its cost and generally increases the stiffness of the corrugations.

[0062] In the embodiment shown, the tank wall 1 is similar to that described in application FR2691520 which targets the Mark III® products and to which reference may be made for further details regarding the primary and secondary thermally insulating barriers and the secondary sealing membrane 4. Alternatively, the walls 1 of the tank may also be produced according to other technologies, and notably those described in patent applications WO14057221 and FR3125323 which respectively target the Mark V and GTT NEXT1® products.

[0063] It will be noted that the reinforcing system is most particularly optimized for use in combination with insulating panels of the primary and secondary thermally insulating barriers which comprise a layer of insulating polymer foam, advantageously made of polyurethane foam reinforced with fibres, such as glass fibres, and the density of which is between 130 and 210 kg/m^3, preferably between 150 and 170 kg/m^3.

[0064] In relation to Figures 3 to 11, a reinforcing system 11 is described, intended to be disposed under the corrugations 9, 10 of the primary sealing membrane 6, according to a first embodiment.

[0065] The reinforcing system 11 comprises, for the one part, reinforcing elements, hereinafter denoted "first reinforcing elements 12", which are intended to be placed inside tall corrugations 9 of the primary sealing membrane 6, and, for the other part, reinforcing elements, hereinafter denoted "second reinforcing elements 13", which are intended to be placed inside low corrugations 10 of the primary sealing membrane 6. The reinforcing system 11 further comprises a connecting member 14 which is fastened to the first and second reinforcing elements 12, 13 and thus ensures the

relative positioning of said first and second reinforcing elements 12, 13 with respect to one another.

[0066] The first reinforcing elements 12 are profiled hollow elements. They are made of a metallic material, such as aluminium or an aluminium alloy for example, or of a polymer material, such as polyethylene, polycarbonate, polystyrene or polyetherimide, advantageously reinforced with fibres, such as glass fibres.

[0067] As illustrated for example in Figures 4 and 5, the profiled hollow elements comprise a lower flange 15 which is intended to rest against the inner surface of the primary thermally insulating barrier 5 and an upper support portion 16.

[0068] The support portion 16 may be produced according to various geometries, as illustrated for example in document FR2936784. Preferably, the outer shape of the support portion 16 corresponds to the shape of the inside of the tall corrugation 9, so as to offer effective support of substantially the entire surface of the tall corrugation 9. In the embodiment shown, the general cross section of the support portion 16 is a semi-elliptical dome. Moreover, the flange 15 has a lower wall which is planar and which rests against the inner surface of the primary thermally insulating barrier 5. The support portion 16 comprises intersecting reinforcing webs 17 which extend from one edge of the profiled hollow element to the other and which intersect at the plane of symmetry thereof.

[0069] In the embodiment shown, the reinforcing system 11 comprises a plurality of first reinforcing elements 12 which are spaced apart in each inter-corrugation gap between two low corrugations 10. Moreover, as described in publication FR2861060, reinforcing ribs (not shown) can be provided on the lateral faces of the tall corrugations 9. In this case, the reinforcing ribs are preferably located between the first reinforcing elements 12 which are spaced apart in each inter-corrugation gap between two low corrugations 10.

[0070] However, in another embodiment (not shown), the reinforcing system 11 may also comprise only a single first reinforcing element disposed in each inter-corrugation gap between two low corrugations 10. In such a case, the longitudinal dimension of the single reinforcing element 12 is adapted accordingly in order to exert effective support over a major part of the length of the inter-corrugation gap between two low corrugations 10.

[0071] Moreover, the second reinforcing elements 13 have a solid cross section and are made of plywood. The second reinforcing elements 13 have a lower flange 18 which is intended to rest against the inner surface of the primary thermally insulating barrier 5. The second reinforcing elements 13 have lateral faces 19 which do not extend as far as the top of the low corrugation 10 and the second reinforcing elements 13 have a planar upper face which connects the two lateral faces 19. The second reinforcing elements 13 therefore have a cross section in the form of an isosceles trapezium. Thus, gas can circulate between the top of the wave and the upper face 20. The second reinforcing elements 13 have a shape complementary to that of the lower portion of the low corrugations 10. In the embodiment illustrated, each second reinforcing element 13 is disposed in line with one of the node zones 36 and extends into the low corrugation 10, on either side of the node zone 36.

[0072] Advantageously, the fibres of the plywood of which the second reinforcing elements 13 are formed are oriented parallel to the thickness direction of the wall 1. Thus, the compression strength of the second reinforcing elements 13 is greatest in the thickness direction of the wall 1, which corresponds to the direction in which the compressive loads are predominantly exerted on the second reinforcing elements 13.

[0073] The connecting members are formed by strips 21 which are advantageously made of metal and, for example, of stainless steel.

[0074] In a first embodiment variant illustrated in Figures 3, 5 and 6, the strip 21 has a rectangular cross section. Furthermore, as shown in Figure 5, the strip 21 is engaged in a slot 22 which is provided in each of the first reinforcing elements 12 and passes through the first reinforcing elements 12 in the longitudinal direction thereof. The slot 22 has a rectangular cross section complementary to that of the strip 21 and thus forms a sliding connection. Thus, the mounting of the first reinforcing elements 12 on the strip 21 is simple to implement by causing said first reinforcing elements 12 to slide along the strip 21. Furthermore, to fasten the first reinforcing elements 12 to the strip 21 in a determined position, the first reinforcing elements 12 can be punched in order to locally deform the slot 22 so as to pinch the strip 21. Alternatively, the fastening of the strips 21 to the first reinforcing elements 12 may also be carried out by means of fastening members, such as screws, for example self-drilling screws, thereby avoiding prior drilling operations. Alternatively, the strip 21 may comprise holes to facilitate the use of a fastening screw or rivet, preferably the hole may be oblong.

[0075] Moreover, as shown in Figure 6, the second reinforcing elements 13 have a groove 23 in which the strip 21 is engaged. The groove 23 is provided in the second reinforcing elements 13 in a transverse direction perpendicular to the longitudinal direction of the second reinforcing elements 13. The strip 21 is fastened to the second reinforcing elements 13 by fastening members, such as clips 24, one of which is shown schematically in Figure 6, or screws, for example self-drilling screws.

[0076] In a second embodiment variant, shown in Figures 7 and 8, the strip 21 is fastened by clip-fastening to the first reinforcing elements 12. The strip 21 has an L-shaped cross section, one of the branches of which has a curved end 25. As shown in Figure 7, the slot 26 provided in the first reinforcing elements 12 also has an L-shaped cross section and opens into the flange 15. The curved end 23 of the branch of the strip 21 is shaped to deform when the strip 21 is engaged in the slot 26 and to generate a reaction force which presses said curved end 23 against one of the walls of the slot 26. This makes it possible to fasten the first reinforcing elements 12 to the strip 21.

[0077] As shown in Figure 8, the groove 27 provided in the second reinforcing elements 13 is also L-shaped. The curved end 23 can also deform and be pressed against the walls of the groove 27. Alternatively or additionally, the strip 21 is fastened to the second reinforcing elements 13 by fastening members, such as clips 28, one of which is shown schematically in Figure 8, or self-drilling screws for example.

[0078] Figure 9 shows a first reinforcing element 12 and a connecting member 14 according to a third embodiment variant. The connecting member 14 is a profiled metal strip 29 with a cross section that has a male element 30 having a shape complementary to that of the slot 31 provided in the first reinforcing element 12. Thus, the male element 30 and the slot 31 form a sliding connection allowing the first reinforcing elements 12 to slide along the connecting member 14 when they are being put into place. Moreover, as in the first embodiment variant, the first reinforcing elements 12 are advantageously punched in order to locally deform the slot 31 so as to pinch the male element 30 of the connecting member inside the slot 31.

[0079] Figures 10 and 11 illustrate another variant for fastening the first reinforcing elements 12 to the connecting member 14. In this embodiment variant, the first reinforcing elements 12 are fastened to the connecting member 14 by an assembly mechanism, for example a quarter-turn assembly mechanism. Such an assembly mechanism comprises a male part 32, visible in Figures 11 and 12, which is secured here to the strip 21 of the connecting member 14, and a female part 33 which here corresponds

to an opening provided in the flange of the first reinforcing elements 12. In the embodiment shown, the male part 32 is provided on a wedge 35, for example made of aluminium or stainless steel, which is fastened to the strip 21.

[0080] The male part 32 has lugs (not shown) which are intended to engage in notches 34 provided in the opening of the female part 33. Thus, to fasten the first reinforcing elements 12 to the connecting member 14, the reinforcing elements 12 are firstly positioned with respect to the connecting member in a relative position, shown in Figure 11, in which the lugs of the male part 32 each pass through one of the notches 34 of the female part 33. Secondly, the first reinforcing elements 12 are rotated about an axis parallel to the thickness direction of the wall as far as an assembled position, shown in Figure 12, in which the profile direction of the first reinforcing elements 12 is aligned with the longitudinal direction of the strip 21 of the connecting member 14.

[0081] In the reinforcing system 111 according to the second embodiment shown in Figure 13, the elements that are identical or similar to those of the first embodiment bear the same reference numeral increased by 100 and will only be described insofar as they differ from the first embodiment.

[0082] The reinforcing system 111 comprises a plurality of reinforcing frames 50 intended to be positioned inside a plurality of successive tall corrugations 9 of the primary sealing membrane 6. Each reinforcing frame 50 comprises, similarly to the reinforcing system 11, a plurality of first reinforcing elements 112 intended to be positioned inside one of the tall corrugations 9 and a connecting member 114 fastened to the first reinforcing elements 112 of the reinforcing frame 50. Three reinforcing frames 50 are present in the reinforcing system 111 in Figure 13 by way of illustration.

[0083] The reinforcing frames 50 of the reinforcing system 111 are attached to one another by second reinforcing elements 113 intended to be placed inside the low corrugations 10 of the primary sealing membrane 6. For this purpose, the connecting members 114 of all the reinforcing frames 50 of the reinforcing system 111 are fastened to each of the second reinforcing elements 113. The second reinforcing element 113 is therefore sufficiently long to extend through at least two successive node zones 36 along a low corrugation 10. The second reinforcing element 113 is sufficiently long to extend through three successive node zones 36 in the reinforcing system 111 in Figure 13 by way of illustration. Thus, the reinforcing system 111 forms a reinforcement lattice intended to be positioned in the tall corrugations 9 and the low corrugations 10 of an entire rectangular zone of the primary sealing membrane 6. Depending on the size of

the lattice, that is to say depending on the number of reinforcing frames 50 in a width direction of the reinforcing system 111 and depending on the number of second reinforcing elements 113 in a length direction of the reinforcing system 111, the rectangular zone can correspond to a corrugated metal plate, a plurality of corrugated metal plates or a portion of a corrugated metal plate.

[0084] At each of the longitudinal ends thereof, the reinforcing system 111 may be terminated by a second reinforcing element 113 or by first reinforcing elements 112. The two possibilities are illustrated in Figure 13, in which the reinforcing system 111 has different structures at the two longitudinal ends thereof. In a variant, the reinforcing system 111 could have an identical structure at the two longitudinal ends thereof.

[0085] According to one embodiment, the second reinforcing element 113 is formed of a plurality of components assembled together, each component being similar to the second reinforcing element 13 of the first embodiment. In this case, the reinforcing system 111 can be obtained by assembling a plurality of reinforcing systems 11.

[0086] With reference to Figure 12, a cut-away view of a methane tanker 70 shows a sealed and thermally insulating tank 71 of prismatic overall shape mounted in the double hull 72 of the ship. The wall of the tank 71 has a primary sealed membrane intended to be in contact with the LNG contained in the tank, a secondary sealed membrane arranged between the primary sealed membrane and the double hull 72 of the ship, and two thermally insulating barriers arranged respectively between the primary sealed membrane and the secondary sealed membrane and between the secondary sealed membrane and the double hull 72.

[0087] As is known per se, loading/offloading pipelines 73 disposed on the upper deck of the ship can be connected, by means of appropriate connectors, to a sea or port terminal in order to transfer a cargo of LNG from or to the tank 71.

[0088] Figure 12 shows an example of a sea terminal comprising a loading and offloading station 75, an underwater pipe 76 and an onshore facility 77. The loading and offloading station 75 is a fixed offshore facility having a mobile arm 74 and a tower 78 that supports the mobile arm 74. The mobile arm 74 bears a bundle of insulated flexible hoses 79 that can be connected to the loading/offloading pipelines 73. The orientable mobile arm 74 is suitable for all sizes of methane tanker. A connecting pipe (not shown) extends inside the tower 78. The loading and offloading station 75 allows the methane tanker 70 to be loaded and offloaded from or to the onshore facility 77. The

latter has liquefied gas storage tanks 80 and connecting pipes 81 that are connected via the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 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.

[0089] In order to generate the pressure needed for transferring the liquefied gas, use is made of pumps carried on board the ship 70 and/or pumps with which the onshore facility 77 is equipped and/or pumps with which the loading and offloading station 75 is equipped.

[0090] Although the invention has been described in connection with a number of particular embodiments, it is obvious that it is in no way limited thereto and that it comprises all the technical equivalents of the means described and the combinations thereof where these fall within the scope of the invention.

[0091] The use of the verbs "have", "comprise" or "include" and conjugated forms thereof does not exclude the presence of elements or steps other than those stated in a claim.

[0092] In the claims, any reference sign between parentheses should not be interpreted as a limitation of the claim.

CLAIMS

[Claim 1] Sealed and thermally insulating wall (1) for a tank intended for the storage of a liquefied gas, said wall (1) comprising:

a primary sealing membrane (6) intended to be in contact with the fluid contained in the tank and resting against a primary thermally insulating barrier (5), the primary sealing membrane (6) comprising at least a first series of corrugations comprising first corrugations (9) which are parallel to one another and a second series of corrugations comprising second corrugations (10) which are parallel to one another, perpendicular to the first corrugations (9) and intersect the first corrugations (9) in node zones (36); the first corrugations (9) having a height in a thickness direction of the wall that is greater than a height of the second corrugations (10); the wall (1) comprising at least one reinforcing system (11, 111) comprising first reinforcing elements (12, 112) which are positioned bearing against the primary thermally insulating barrier (5), inside one of the first corrugations (9), on either side of one of the node zones (36), and a second reinforcing element (13, 113) which is positioned bearing against the primary thermally insulating barrier (5), in line with the node zone (36), and extends into one of the second corrugations (10) on either side of the node zone (36), the first reinforcing elements (12, 112) being profiled hollow elements and the second reinforcing element (13, 113) having a solid cross section and being made of wood.

[Claim 2] Sealed and thermally insulating wall (1) according to Claim 1, wherein the reinforcing system (11, 111) comprises a connecting member (14, 114) which is disposed inside the first corrugation (9) and which is fastened to the first reinforcing elements (12, 112) and to the second reinforcing element (13, 113).

[Claim 3] Sealed and thermally insulating wall (1) according to Claim 2, wherein the connecting member (14) comprises a metal strip (21, 30) which is fastened to the first reinforcing elements (12, 112) and to the second reinforcing element (13, 113).

[Claim 4] Sealed and thermally insulating wall (1) according to Claim 3, wherein the strip (21, 30) is engaged in a slot (22, 26, 31) which is provided in each of the first reinforcing elements (12, 112) and wherein the strip (21, 30) is fastened in said slot (22, 26, 31).

[Claim 5] Sealed and thermally insulating wall (1) according to Claim 4, wherein the slot (22, 26, 31) is locally deformed in order to pinch the strip (21, 30) inside said slot (22, 26, 31).

[Claim 6] Sealed and thermally insulating wall (1) according to Claim 4 or 5, wherein the strip (21, 30) is fastened to the first reinforcing elements (12, 112) by means of fastening members, such as screws.

[Claim 7] Sealed and thermally insulating wall (1) according to any one of Claims 4 to 6, wherein the strip (21) is fastened by clip-fastening to the first reinforcing elements (12, 112).

[Claim 8] Sealed and thermally insulating wall (1) according to Claim 4, wherein the strip (21) is fastened to the first reinforcing elements (12) by an assembly mechanism, such as a quarter-turn assembly mechanism.

[Claim 9] Sealed and thermally insulating wall (1) according to any one of Claims 4 to 8, wherein the strip (21, 30) is engaged in a groove (23) which is provided in the second reinforcing element (13, 113), transversely to a longitudinal direction of said second reinforcing element (13, 113), and wherein the strip (21, 30) is fastened in said groove (23) by at least one fastening member (24), such as a clip or a screw.

[Claim 10] Sealed and thermally insulating wall (1) according to any one of Claims 2 to 9, wherein the reinforcing system (11, 111) comprises a plurality of second reinforcing elements (13, 113) which are disposed in a plurality of adjacent node zones (36) and which are connected to one another by the connecting member (14, 114), the node zones being formed at intersections of the first corrugation (9) with a plurality of the second corrugations (10).

[Claim 11] Sealed and thermally insulating wall (1) according to any of Claims 2 to 10, wherein the connecting member is a first connecting member (114) and the first reinforcing elements to which the first connecting member (114) is fastened are a first plurality of first reinforcing elements (112) positioned inside a first one of the first corrugations (9),

the reinforcing system (111) further comprising a second plurality of first reinforcing elements (112) which are positioned bearing against the primary thermally insulating barrier (5), inside a second one of the first corrugations (9), and a second connecting member (114) which is disposed inside the second one of the first corrugations (9) and which is fastened to the second plurality of first reinforcing elements (12) and to said or to each second reinforcing element (113), said or each second reinforcing element (113) extending into the second corrugation (10) between the first and the second of the first corrugations (9) and on either side of the node zones (36) formed at intersections of the second corrugation (10) with the first and the second of the first corrugations (9).

[Claim 12] Sealed and thermally insulating wall (1) according to any one of Claims 1 to 11, wherein the reinforcing system (11) comprises a plurality of first reinforcing elements (12), which are spaced apart from one another, in at least one inter-corrugation gap positioned between two node zones (36).

[Claim 13] Sealed and thermally insulating wall (1) according to any one of Claims 1 to 12, wherein the first reinforcing elements (12) are made of a metallic material, preferably selected from aluminium and aluminium alloys, or of a polymer material, preferably selected from polyethylene, polycarbonate, polystyrene and polyetherimide.

[Claim 14] Sealed and thermally insulating wall (1) according to any one of Claims 1 to 13, wherein the wood of the second reinforcing element (13) is plywood and has fibres oriented parallel to a thickness direction of the wall.

[Claim 15] Sealed and thermally insulating tank comprising at least one sealed and thermally insulating wall (1) according to any one of Claims 1 to 14.

[Claim 16] Ship (70) for transporting a liquefied gas, the ship comprising a double hull (72) and a tank (71) according to Claim 15, the double hull comprising the load-bearing structure.

[Claim 17] Transfer system for a liquefied gas, the system comprising a ship (70) according to Claim 16, 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 causing liquefied gas to flow through the insulated pipelines from or to the floating or onshore storage facility to or from the tank of the ship.

[Claim 18] Method for loading onto or offloading from a ship (70) according to Claim 16, wherein a liquefied gas is conveyed through insulated pipelines (73, 79, 76, 81) from or to a floating or onshore storage facility (77) to or from the tank (71) of the ship (70).