

Description

Title of the invention: Sealed and thermally insulating tank

Technical field

[0001] The invention relates to the field of sealed and thermally insulated tanks, with sealed
5 membranes, and to the method for fitting of such sealed membranes. In particular, the
invention relates to the field of sealed and thermally insulating tanks for the storage
and/or transport of low-temperature liquefied gas, such as tanks for the transport of
Liquefied Petroleum Gas (also known as LPG) having for example a temperature of
10 between -50°C and 0°C, or for the transport of Liquefied Natural Gas (LNG) at
approximately -162°C at atmospheric pressure. These tanks can be installed on land
or on a floating structure. In the case of a floating structure, the tank can be designed
for the transport of liquefied gas, or to receive liquefied gas acting as fuel for the
propulsion of the floating structure.

Technological background

15 [0002] A sealed and thermally insulating tank for the storage of liquefied gas is known from
document US4021982, comprising on each of its tank walls a multilayer structure
composed of a secondary thermally insulating barrier, a secondary sealed membrane,
a primary thermally insulating barrier, and a primary sealed membrane which is
designed to be in contact with the liquefied gas. The primary sealed membrane is a
20 corrugated sealed membrane which comprises a plurality of corrugated metal plates
welded on one another.

[0003] In a running part of a tank wall, the corrugated metal plates are welded on anchorage
strips or on anchorage plates, which themselves are anchored on the insulating panels
of the thermally insulating barrier.

25 [0004] This document describes in particular fitting of the corrugated metal plates on
anchorage plates. In fact, in US4021982, the corrugated metal plates are welded on
anchorage systems which are themselves secured integrally on the primary thermally
insulating barrier. The anchorage system comprises a square metal plate on which
there are welded the corners of four adjacent corrugated metal plates, and an
30 anchorage boss on which the square metal plate is welded, and which is secured on
the insulating panel in a counter-bore by means of a boss-holder.

[0005] This type of securing facilitates the fitting of the corrugated metal plates, and makes possible certain positioning tolerances of the corrugated metal plates, since the square metal plate also has a sealing function.

5 [0006] However, in special areas of the tank, in particular in the vicinity of an opening for the passage of a duct, it is advantageous to limit the fastenings of the sealed membrane on the thermally insulating barrier, in order to allow the sealed membrane to be displaced or deformed more freely. In this case, it is however necessary to ensure that the membrane is sealed, and in particular at the corner areas.

10 [0007] The securing of the sealed membrane according to US4021982 does not allow the sealed membrane to be displaced or deformed more freely sufficiently.

[0008] Document WO2019002076 thus relates to a fitting method wherein the metal plates have corner areas with different designs from one another, and are assembled on one another in a particular order in order to assure that the sealing is provided at the intersections of metal plates.

15 [0009] A production method of this type has the advantage of not needing any additional part other than the corrugated metal plates, in order to assure the sealing at the intersection of the metal plates. However, despite these advantages, this method is not totally satisfactory. In particular, this method involves the need for a very large number of metal plates with different forms, and increases the risk of errors during the fitting.

20 **Summary of the invention**

[0010] A concept on which the invention is based consists of providing a sealed membrane which makes it possible to limit the securing of the sealed membrane on the thermally insulating barrier, in particular in special areas of the tank.

25 [0011] Another concept on which the invention is based consists of facilitating the fitting of the sealed membrane.

[0012] According to one embodiment, the invention provides a sealed and thermally insulating tank for the storage of liquefied gas, the sealed and thermally insulating tank being designed to be incorporated in a support structure, the tank comprising at least one tank wall,
30 wherein the tank wall comprises a thermally insulating barrier secured directly or indirectly on the support structure, and a sealed membrane which is supported by the thermally insulating barrier, and is designed to be in contact with the liquefied gas,

wherein the thermally insulating barrier comprises insulating panels which are
 juxtaposed on one another, the insulating panels comprising cover plates, the
 thermally insulating barrier comprising first grooves and second grooves provided in
 the cover plates of the insulating panels, the first grooves extending parallel to one
 5 another in a first direction and the second grooves extending parallel to one another
 in a second direction, the second direction being perpendicular to the first direction, a
 so-called first groove intersecting a so-called second groove at a groove nub,
 wherein the tank wall comprises a metal sealing plate, the metal sealing plate
 comprising an upper face and a lower face, the lower face of the metal sealing plate
 10 being bonded to the thermally insulating barrier (6) in said groove nub (15) by means
 of an adhesive resin,
 first and second thermal protection strips being positioned in the said first groove and
 the said second groove outside the said groove nub,
 wherein the sealed membrane comprises at least three corrugated metal plates which
 15 are adjacent to the metal sealing plate, each corrugated metal plate having a
 rectangular form and comprising a first edge extending in the first direction, and a
 second edge extending in the second direction,
 wherein the first edges of the corrugated metal plates are welded in pairs by
 overlapping in-line with the first thermal protection strip, and the second edges of the
 20 corrugated metal plates are welded in pairs by overlapping in-line with the second
 thermal protection strip,
 wherein at least two of the said corrugated metal plates comprise a corner area which
 is welded on the upper face of the metal sealing plate, the corner area connecting the
 said first edge and the said second edge, the said at least two corrugated metal plates
 25 having the first edge positioned in-line with the said first thermal protection strip, and
 the second edge positioned in-line with the said second thermal protection strip, the
 upper face of the metal sealing plate comprising a covered portion and a non-covered
 portion complementary with the covered portion, the covered portion being situated
 below the at least three corrugated metal plates, and the non-covered portion being
 30 designed to be in contact with the liquefied gas.

[0013] According to one embodiment, the invention provides a method for fitting of a sealed
 membrane on a tank wall of a sealed and thermally insulating tank for the storage of
 liquefied gas, the sealed and thermally insulating tank being incorporated in a support
 structure, wherein the fitting method comprises the following steps:
 35 - providing a tank wall comprising a thermally insulating barrier secured on the support

structure, the thermally insulating barrier comprising insulating panels which are juxtaposed on one another and comprising cover plates, the thermally insulating barrier comprising first grooves and second grooves provided in the cover plates of the insulating panels, the first grooves extending parallel to one another in a first direction and the second grooves extending parallel to one another in a second direction, the second direction being perpendicular to the first direction, a so-called first groove intersecting a so-called second groove at a groove nub, first and second thermal protection strips being positioned respectively in the said first groove and the said second groove;

- cutting the first and second thermal protection strips at the said groove nub;
- providing a metal sealing plate comprising an upper face and a lower face;
- gluing the lower face of the metal sealing plate at the said groove nub on the cover plate;
- providing four corrugated metal plates which are designed to form a sealed membrane of the tank wall, each metal plate having a rectangular form and comprising a first edge and a second edge, the first edge joining the second edge at a corner area;
- positioning and welding the four corrugated metal plates such that each first edge is positioned in-line with one of the first grooves, each second edge is positioned in-line with one of the second grooves, the first edges of the corrugated metal plates being welded in pairs by overlapping in-line with the first thermal protection strip, and the second edges of the corrugated metal plates being welded in pairs by overlapping in-line with the second thermal protection strip, the corner area of the corrugated metal plates being welded on the upper face of the metal sealing plate, the upper face of the metal sealing plate comprising a covered portion and a non-covered portion which is complementary with the covered portion, the covered portion being situated below the four corrugated metal plates, and the non-covered portion being designed to be in contact with the liquefied gas.

[0014] Thanks to these characteristics, the sealing plate makes it possible firstly to facilitate the fitting, by having a sealing role which permits more flexible arrangement of the corrugated metal plates. In addition, the design of the sealing plate is simple, and its pre-securing on the thermally insulating barrier is easy since it involves simple gluing. Finally, the gluing is not designed to last during the use of the tank, and has a function only of pre-securing of the sealing plate, such that, after separation of the sealing plate after welding of the corrugated metal plates on the sealing plate, the sealed membrane

is free to be displaced or deformed relative to the thermally insulating barrier at the sealing plate.

[0015] According to one embodiment, the invention also provides a sealed, thermally insulating tank for storing liquefied gas, the sealed, thermally insulating tank being designed to be integrated into a supporting structure, the tank comprising at least one tank wall,

wherein the tank wall comprises a thermally insulating barrier fixed directly or indirectly to the supporting structure and a sealed membrane supported by the thermally insulating barrier and intended to be in contact with the liquefied gas,

wherein the thermally insulating barrier comprises insulating panels juxtaposed to one another, the insulating panels comprising cover plates, the thermally insulating barrier comprising first grooves and second grooves formed on the cover plates of the insulating panels, the first grooves extending parallel to one another in a first direction and the second grooves extending parallel to one another in a second direction, the second direction being perpendicular to the first direction, a said first groove intersecting a said second groove at a groove nub,

wherein the tank wall comprises a metal sealing plate, the metal sealing plate comprising a top face and a bottom face, the bottom face of the metal sealing plate being left free relative to the thermally insulating barrier,

first and second thermal protection strips being arranged in said first groove and said second groove outside said groove nub,

wherein the sealing membrane comprises at least three corrugated metal plates which are adjacent to the metal sealing plate, each corrugated metal plate being rectangular in shape and comprising a first edge extending in the first direction, and a second edge extending in the second direction,

wherein the first edges of the corrugated metal sheets are welded in overlapping pairs at the first thermal protection strip and the second edges of the corrugated metal sheets are welded in overlapping pairs at the second thermal protection strip, wherein at least two of said corrugated metal sheets have a corner area welded to the top face of the metal sealing plate, the corner area connecting said first edge and said second edge, said at least two corrugated metal sheets having the first edge disposed at said first thermal protection strip and the second edge disposed at said second thermal protection strip, the upper face of the metal sealing plate comprising a covered portion and an uncovered portion complementary to the covered portion, the covered

portion being situated below the at least three corrugated metal plates and the uncovered portion being intended to be in contact with the liquefied gas.

[0016] Thanks to these features, once the metal sealing plate has been detached, the sealed membrane is free to move or deform in relation to the thermally insulating barrier in the area of the sealing plate. In addition, the sealing plate has a sealing function at the connection between several metal plates, enabling a more flexible arrangement of the corrugated metal plates.

[0017] According to some embodiments, a tank of this type or a method of this type can comprise one or a plurality of the following characteristics.

[0018] According to one embodiment, the sealed membrane has been mounted using the aforementioned assembly method, with the underside of the metal sealing plate peeled away from the thermally insulating barrier.

[0019] According to one embodiment, the sealed membrane comprises three corrugated metal plates which are adjacent to the metal sealing plate, wherein two of the said corrugated metal plates comprise a corner area which is welded on the upper face of the metal sealing plate, the said two corrugated metal plates having the first edge positioned in-line with the said first thermal protection strip, and the second edge positioned in-line with the second thermal protection strip, and wherein the first edge of a third one of the said corrugated metal plates passes through the upper face of the metal sealing plate, the covered portion being situated below the said three corrugated metal plates.

[0020] According to one embodiment, the sealed membrane comprises four corrugated metal plates which are adjacent to the metal sealing plate, wherein each corrugated metal plate comprises a corner area which is welded on the upper face of the metal sealing plate, each corrugated metal plate having the first edge positioned in-line with the said first thermal protection strip, and the second edge positioned in-line with the said second thermal protection strip, the covered portion being situated below the four corrugated metal plates.

[0021] According to one embodiment, the tank wall and the support structure have a duct passing through them, the sealed membrane comprising a closure plate situated all around the duct, the closure plate being provided with an orifice through which the duct passes, at least one of the said corrugated metal plates having an edge which is connected in a sealed manner to the closure plate.

[0022] According to one embodiment, the closure plate can be made in a single piece, or by assembly of a plurality of plates.

5 [0023] According to one embodiment, the tank wall and the support structure are interrupted locally such as to delimit an opening which is designed to have a duct passing through it, the said insulating panels being opening insulating panels adjacent to the opening.

[0024] In fact, in this area, the sealed membrane is designed in a particular manner, and is furthermore designed to be welded on the duct during the production of the tank, thus creating a special area where the sealed membrane cannot be displaced freely, in the same manner as in the tank corners, compared with the running part of a tank wall.
10 Thus, the securing of the corrugated metal plates on the metal sealing plate makes it possible to limit the securing of the sealed membrane on the thermally insulating barrier.

[0025] According to one embodiment, the first groove and the second groove each comprise a groove base, and two opposite edges which are spaced by a groove width, the first
15 and second thermal protection strips being supported against the groove base, and the metal sealing plate being positioned in the groove nub spaced from the edges of the first groove and from the edges of the second groove.

[0026] Thus, a space exists between the groove edges and the sealing plate, thus permitting relative displacement of the sealed membrane relative to the thermally insulating
20 barrier on the plane of the sealed membrane.

[0027] According to one embodiment, the groove width of the first groove is equal to the groove width of the second groove.

[0028] According to one embodiment, the metal sealing plate has a dimension in the first direction which is smaller than, or equal to, the groove width of the second groove,
25 and the metal sealing plate has a dimension in the second direction which is smaller than, or equal to, the groove width of the first groove.

[0029] Thus, the dimensions of the metal sealing plate are relatively small, de facto limiting the securing of the sealed membrane on the thermally insulating barrier.

[0030] According to one embodiment, the metal sealing plate has a dimension in the first
30 direction which is strictly smaller than the groove width of the second groove, and the metal sealing plate has a dimension in the second direction which is strictly smaller than the groove width of the first groove.

- [0031] According to one embodiment, the metal sealing plate has a rectangular form, with two first sides of the metal sealing plate extending in the first direction and two second sides of the metal sealing plate extending in the second direction, the first side joining the second side at a corner, the corners being chamfered.
- 5 [0032] Thus, the chamfered corners and/or dimensions of the metal sealing plate which are strictly smaller than those of the grooves participate in the creation of a space between the groove edges and the sealing plate, in order to permit relative displacement of the sealed membrane relative to the thermally insulating barrier on the plane of the sealed membrane.
- 10 [0033] According to one embodiment, the corner areas of the corrugated metal plates are chamfered.
- [0034] According to one embodiment, the tank wall is a ceiling wall, with the sealed and thermally insulating tank comprising the ceiling wall, a base wall opposite the ceiling wall in a direction of height, and one or a plurality of lateral walls connecting the base wall to the ceiling wall.
- 15 [0035] According to one embodiment, the tank wall is a base wall, the sealed and thermally insulating tank comprising the base wall, a ceiling wall opposite the base wall in a direction of height, and one or a plurality of lateral walls connecting the base wall to the ceiling wall.
- 20 [0036] According to one embodiment, the thermally insulating barrier is a primary thermally insulating barrier, and the sealed membrane is a primary sealed membrane, the tank wall also comprising a secondary thermally insulating barrier positioned between the primary thermally insulating barrier and the support structure, and a secondary sealed membrane positioned between the secondary thermally insulating barrier and the
- 25 primary thermally insulating barrier.
- [0037] According to one embodiment, before the step of gluing of the metal sealing plate, the method comprises the step of arrangement of a template in the said groove nub, the template comprising a border surrounding a receptacle at least partly, the receptacle having a form which is at least partly complementary with the metal sealing plate, and
- 30 wherein the step of gluing of the metal sealing plate is carried out by placing the metal sealing plate in the receptacle of the template, the template preferably being withdrawn after the step of gluing of the metal sealing plate.

[0038] Thus, the template makes it possible to assist the precise positioning of the sealing plate in the groove nub, which advantageously makes it possible to prevent the sealing plate from being glued too close to the edges of the grooves.

5 [0039] According to one embodiment, before the step of arrangement and welding of the corrugated metal plates, the method comprises the step of marking of the metal sealing plate by positioning marks, the positioning marks being configured to indicate the position of the corner areas of the corrugated metal plates to be positioned.

10 [0040] Thus, the presence of a metal element, in this case the metal sealing plate, where the corner areas must be positioned, makes possible a marking step which facilitates the fitting of the sealed membrane.

[0041] According to one embodiment, each metal plate comprises at least one first corrugation extending in the first direction, and at least one second corrugation extending in the second direction.

15 [0042] According to one embodiment, the first and second thermal protection strips are made of a composite material comprising an aluminium sheet and glass fibres.

[0043] Thus, the thermal protection strips have a material, the thermal properties of which make it possible to protect the cover plate against the heat of the welding. However, this type of material makes the positioning marking difficult and imprecise.

20 [0044] According to one embodiment, the corrugated metal plates and/or the metal sealing plates are made of stainless steel.

[0045] According to one embodiment, the cover plate is made of plywood or of composite material.

[0046] According to one embodiment, the tank wall comprises a layer of adhesive resin between the metal sealing plate and the cover plate.

25 [0047] According to one embodiment, the tank wall comprises a layer of adhesive resin, the layer of adhesive resin being arranged between the metal sealing plate and the thermally insulating barrier, in order to glue the lower face of the metal sealing plate on the thermally insulating barrier in the said groove nub, the adhesive resin being configured to withstand a load greater than, or equal to, the weight of the metal sealing plate at ambient temperature during a production time of the sealed and thermally
30 insulating tank.

[0048] Thus, the adhesive resin is selected such that these gluing properties make it possible to retain the metal sealing plate in position in the most unfavourable case, i.e. the ceiling wall, during the fitting of the metal sealing membrane. However, it is not necessary for this adhesive resin to continue to retain the metal sealing plate after the fitting of the metal sealing membrane. This adhesive resin therefore does not have gluing properties which are sufficient to retain the metal sealing plate in position at cryogenic temperatures during the use of the sealed and thermally insulating tank.

[0049] According to one embodiment, the adhesive resin is configured to withstand a load strictly lower than the weight of the metal sealing plate at cryogenic temperature during a predefined time.

[0050] A tank of this type can form part of a storage installation on land, for example in order to store LNG, or it can be installed in a floating, coastal or deepwater structure, in particular an LNG ship, a floating storage and reclassification unit (FSRU), and a floating production, storage and off-loading unit (FPSO) and others. A tank of this type can also act as a fuel tank in any type of ship.

[0051] According to one embodiment, a ship for the transport of a cold liquid product comprises a double hull, and an above-described tank positioned in the double hull.

[0052] According to one embodiment, the invention also provides a transfer system for a cold liquid product, the system comprising the aforementioned ship, insulated piping arranged such as to connect the tank installed in the hull of the ship to a floating or terrestrial storage installation, and a pump to drive a flow of cold liquid product through the insulated piping from or to the floating or terrestrial storage installation, to or from the tank of the ship.

[0053] According to one embodiment, the invention also provides a method for loading or unloading of such a ship, wherein a cold liquid product is conveyed through insulated piping from or to a floating or terrestrial storage installation, to or from the tank of the ship.

Brief description of the figures

[0054] The invention will be better understood, and other objectives, details, characteristics and advantages thereof will become more clearly apparent, during the following description of a plurality of particular embodiments of the invention, provided purely by way of non-limiting illustration, with reference to the appended drawings.

- [0055] Figure 1 represents a schematic view in cross-section of a tank wall.
- [0056] Figure 2 is a partial front view of a ceiling wall of a tank according to one embodiment, before the securing of the primary sealed membrane.
- 5 [0057] Figure 3 is a detail view III of figure 2 representing a groove nub after putting thermal protection strips into place.
- [0058] Figure 4 is a detail view III of figure 2 representing a groove nub after cutting of the thermal protection strips.
- [0059] Figure 5 is a detail view III in perspective of figure 2 representing a groove nub after the arrangement of a template.
- 10 [0060] Figure 6 is a detail view III in perspective of figure 2 representing a groove nub after gluing of the metal sealing plate on the cover plate before removal of the template.
- [0061] Figure 7 is a detail view III in perspective of figure 2 representing a groove nub after gluing of the metal sealing plate on the cover plate after removal of the template.
- 15 [0062] Figure 8 is a partial front view of a ceiling wall of a tank according to one embodiment, before the securing of the primary sealed membrane and during a step of marking for the positioning of the corrugated metal plates.
- [0063] Figure 9 is a partial front view of a ceiling wall of a tank according to one embodiment, after the securing of the primary sealed membrane.
- 20 [0064] Figure 10 is a detail view III of figure 2 representing a groove nub after the step of welding of the corrugated metal plates, the corrugated metal plates being represented in transparency.
- [0065] Figure 11 is a sectional schematic representation of an LNG ship comprising a ship's tank of a terminal for loading/unloading of this tank.

Description of the embodiments

- 25 [0066] A description will be provided hereinafter with reference to the figures of a sealed and thermally insulating tank 71 with membranes which makes it possible to store liquefied gas. The tank 71 comprises a plurality of tank walls 1 which are connected to one another and secured on a support structure 2. The tank 71 can for example have a polyhedral form, or also a cylindrical form with a circular base.
- 30 [0067] Figure 1 represents schematically the structure of a tank wall 1.

- [0068] Each tank wall 1 has a multilayer structure comprising, from the exterior towards the interior, a secondary thermally insulating barrier 3 comprising secondary insulating panels 4, and being supported against the support structure 2, a secondary sealed membrane 5 being supported against the secondary thermally insulating barrier 3, a primary thermally insulating barrier 6 comprising primary insulating panels 7, 12, and being supported against the secondary sealed membrane 5, and a primary sealed membrane 8 being supported against the primary thermally insulating barrier 6, and being designed to be in contact with the liquefied gas contained in the tank 1. The primary sealed membrane 8 defines an inner space which is designed to receive the liquefied gas. By way of example, tanks with membranes of this type are described in particular in patent applications WO2019239048, WO14057221, and FR2691520.
- [0069] Each primary insulating panel 7, 12 comprises a cover plate 10, an insulating lining 11 such as an insulating foam block, and optionally a base plate (not represented).
- [0070] The liquefied gas which is designed to be stored in the tank 71 can in particular be a liquefied natural gas (LNG), i.e. a gaseous mixture comprising mostly methane, as well as one or more other hydrocarbons. The liquefied gas can also be ethane or a liquefied petroleum gas (LPG), i.e. a mixture of hydrocarbons obtained from the refining of petroleum, comprising substantially propane and butane.
- [0071] Figure 2 represents partly a ceiling wall 1 of the tank 71. In this figure, the secondary thermally insulating barrier 3, the secondary sealed membrane 5, and the primary thermally insulating barrier 6 have already been fitted on the support structure 2, such that only the primary thermally insulating barrier 6 can be distinguished. The ceiling wall 1 and the support structure 2 are in this case interrupted locally in several places, such as to delimit three openings 9. The openings 9 are designed to have ducts (not represented) passing through them, such as a filling duct and a discharge duct. The primary thermally insulating barrier 6 comprises a plurality of primary insulating panels 7, 12 which are juxtaposed relative to one another.
- [0072] The primary insulating panels 7, 12 comprise running primary insulating panels 7 and opening primary insulating panels 12, which are situated in a manner adjacent to an opening 9.
- [0073] The primary thermally insulating barrier 6 comprises first grooves 13 and second grooves 14 provided in the cover plates 10 of the primary insulating panels 7, 12. The first grooves 13 extend parallel to one another in a first direction, and the second

grooves 14 extend parallel to one another in a second direction which is perpendicular to the first direction. The first grooves 13 intersect the second grooves 14 at groove nubs 15.

5 [0074] The primary sealed membrane 7, which is represented more particularly in figure 9, comprises corrugated metal plates 16 with a rectangular form. Each corrugated metal plate 16 comprises two first edges 17, which are parallel to one another and extend in the first direction, and two second edges 18 which are parallel to one another and extend in the second direction, each first edge joining a second edge at a corner area 19.

10 [0075] During the fitting of the corrugated metal plates 16, the first edges 17 are positioned in-line with the first grooves 13, and the second edges are positioned in-line with the second grooves 14. The corner areas 19 for their part are positioned in-line with the groove nubs 15. Each corrugated metal plate comprises at least one first corrugation (not represented) extending in the first direction, and at least one second corrugation (not represented) extending in the second direction. The first corrugations and the second corrugations are deliberately not illustrated in figure 9, in order to distinguish more easily the assembly of the different corrugated metal plates with one another.

20 [0076] With reference once more to figure 2, the running primary insulating panels 7 are equipped with metal anchorage strips 20 secured on the cover plate 10 in the interior of the first grooves 13 and the second grooves 14, in particular at the groove nubs 15. It is on these metal anchorage strips 20 that the corrugated metal plates 16 are welded and anchored on the primary thermally insulating barrier 6.

25 [0077] The opening primary insulating panels 12 for their part are equipped with thermal protection strips 21 which are positioned in the first grooves 13 and the second grooves 14.

[0078] In order to maintain freedom for deformation, the primary sealed membrane 8 is not anchored by means of the metal anchorage strips 20 in the vicinity of the openings 9, and thus at the opening primary insulating panels 12.

30 [0079] Thus, above the opening primary insulating panels 12, the first edges 17 and the second edges 18 of the corrugated metal plates 16 are welded by overlapping respectively on the first edges 17 and the second edges 18 of the adjacent corrugated metal plates 16, without being anchored on the primary thermally insulating barrier 6. The corner areas 19 for their part are welded on an upper face of a metal sealing plate

22 at a groove nub 15. The metal sealing plates 22 and their function will be described in greater detail hereinafter.

[0080] Figures 3 to 7 represent more particularly the different steps which make it possible to position the metal sealing plates 22 in the groove nubs 15.

5 [0081] Figure 3 represents the initial state in which the thermal protection strips 21 of the first groove 13 and the second groove 14 intersect at the groove nub 15. The thermal protection strips 21 are then cut, as illustrated in figure 4, in-line with the groove nub 15, such as to make a groove base of the groove nub 15 apparent.

10 [0082] A template 23 is then positioned at the groove nub 15, as represented in figure 5. This template 23 comprises a border 24 which surrounds a receptacle 25 partly. The border 24 has a plurality of branches which are connected to one another, and are positioned in the different grooves 13, 14 which constitute the groove nub 15, such as to permit centring of the receptacle 25 on the groove nub 15. The receptacle 25 is produced such as to have a form which is partly complementary to the metal sealing plate 22, in order to assist the positioning and centring thereof on the groove nub 15.

15 [0083] The metal sealing plate 22 is positioned in the receptacle 25, and is glued on the groove nub 15, as shown in figure 6. When the metal sealing plate 22 has been glued, the template is removed, as represented in figure 7. The gluing can be carried out by placing a layer of glue on the groove nub 15 or the lower face of the metal sealing plate 22, or also by gluing a double-face adhesive strip on the interior face of the metal sealing plate 22.

20 [0084] As shown in figure 7, the metal sealing plate 22 has a rectangular form, preferably square, and has two first sides 26 extending in the first direction after gluing, and two second sides 27 extending in the second direction after gluing. The first side 26 joins the second side 27 at a corner 28, which is chamfered in the example represented.

25 [0085] The metal sealing plate 22 has a dimension in the first direction which is smaller than the dimension of the second groove 14 in the first direction, and has a dimension in the second direction which is smaller than the dimension of the first groove 13 in the second direction. Thus, as represented in figure 7, thanks to these dimensions and its form, and to the centring carried out by the template, the metal sealing plate 22 is positioned spaced from the edges of the first groove 13 and from the edges of the second groove 14 forming the groove nub 15.

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[0086] The metal sealing plate 22 thus comprises a lower face glued on the cover plate 10, and an upper face designed to be welded on the corrugated metal plates 16.

[0087] After the gluing of the metal sealing plates, and in order to assist the positioning of the corrugated metal plates 16, a marking step is provided, as illustrated schematically in figure 8. In fact, during this step, positioning marks 29 are drawn precisely on the metal sealing plates 22, in order to measure and indicate where the different corrugated metal plates will be positioned.

[0088] Figure 9 represents the ceiling wall 1 after welding of the corrugated metal plates 16, such as to form the primary sealed membrane 8, without illustration of the first corrugations and the second corrugations, in order to facilitate reading of this figure.

[0089] The corrugated metal plates 16 are thus positioned such that their first edge 17 is situated in-line with one of the first grooves 13, and their second edge 18 is situated in-line with one of the second grooves 14. As they are placed on the primary thermally insulating barrier 6, the metal plates are welded to one another by overlapping, and welded by their corner area 19 on one of the metal sealing plates 21, when an opening primary insulation panel 12 is involved. The first edges 17 and the second edges 18 of the corrugated metal plates 16 are thus welded by overlapping respectively on the first edges 16 and on the second edges 17 of the adjacent corrugated metal plates 16.

[0090] All around the openings 9, flat closure plates 30 are positioned at each opening 9. The closure plates 30 have orifices 31 with the same form as the corresponding opening 9. The closure plates 30 are designed to be welded, for example via a flange, on the corresponding duct. The corrugated metal plates 16 which are situated all around the closure plate 30 are welded on the closure plate 30. The corrugations of these corrugated metal plates 16 which are interrupted by the closure plate 30 are closed by means of a corrugation cap 32, which is also welded on the closure plate 30.

[0091] According to another embodiment, not illustrated, the closure plates 30 can be corrugated such that it is not necessary to provide a corrugation cap to close the corrugations.

[0092] In order to maintain a certain flexibility of the primary sealed membrane 8, certain corrugations are diverted, by means of a diversion system 33 welded on the junction between two corrugated metal plates 16, from their original direction, in order not to be interrupted by a closure plate 30. Although the corrugations are not represented,

the diversion systems 33 and the corrugation caps 32 are represented in figure 9, such that it is possible to deduce the position of certain corrugations.

[0093] As described above, the fitting of the primary sealed membrane 9 is carried out by repeated sequences of arrangement of a corrugated metal plate 16, and welding of this corrugated metal plate on the adjacent corrugated metal plates 16, and on the metal sealing plates 22.

[0094] A sequence of this type is illustrated in particular schematically by figure 10 at the junction between four corrugated metal plates 16 at a metal sealing plate 22, and thus above an opening insulating panel 12. In this figure, the corrugated metal plates, of which there are four, i.e. the first plate 34, the second plate 35, the third plate 36 and the force plate 37, are illustrated in transparency such as to distinguish the metal sealing plate 22, the first groove 13, the second groove 14, the groove nub 15, and the cover plate 10.

[0095] In this example illustrated, the first plate 34 is firstly positioned such that one of its first edges 17 is situated in-line with the first groove 13, one of its second edges 18 is situated in-line with the second groove 14, and one of the corner areas 19 is situated in-line with the groove nub 15 and the metal sealing plate 22. The corner area 19 is then welded by means of a first welding bead 38 on the metal sealing plate 22.

[0096] The second plate 35 and the third plate 36 are positioned in a manner adjacent to the first plate 34, such that a first edge 17 of the second plate 35 is welded by overlapping on a first edge 17 of the first plate 34, and a second edge 18 of the third plate 36 is welded by overlapping on a second edge of the first plate 34. The corner area 19 of the second plate 35 is welded by means of a second welding bead 39 partly on the metal sealing plate 22 and partly on the corner area 19 of the first plate 34. The corner area 19 of the third plate is welded by means of a third welding bead 40 partly on the metal sealing plate 22, and partly on the corner area 19 of the first plate 34.

[0097] The fourth plate 37 is finally positioned in a manner adjacent to the second plate 35 and to the third plate 36, such that a first edge 17 of the fourth plate 37 is welded by overlapping on a first edge 17 of the third plate 36, and a second edge 18 of the fourth plate 37 is welded by overlapping on a second edge of the second plate 35. The corner area 19 of the fourth plate 37 is welded by means of a fourth welding bead 41 partly on the metal sealing plate 22, partly on the corner area 19 of the second plate 35, and partly on the corner area 19 of the third plate 36.

[0098] This welding sequence is described in greater detail in document US4021982. This is an example of a welding sequence. Other sequences could be carried out in order to obtain corrugated metal plates 16 welded on a metal sealing plate 22 in a sealed manner.

5 [0099] The metal sealing plate 22 thus has an upper face comprising a covered portion 42 and a non-covered portion 43 illustrated in figure 10. The covered portion 42 thus corresponds to the portion of the upper face which is below the four plates 34, 35, 36, 37. The non-covered portion 43 is designed to be in contact with the liquefied gas.

10 [0100] As shown in figure 10, the non-covered portion 43 is thus surrounded continuously by a quadrilateral of welding bead, the sides of which are each formed by first, second, third and fourth welding beads 38, 39, 40, 41. Thus, it is the assembly of the corrugated metal plates and the non-covered portions 43 of the metal sealing plates 22 which form the primary sealed membrane 8.

15 [0101] Following the welding of metal plates 34, 35, 36, 37, and after the tank has been used, the bonding of metal sealing plate 22 is expected to break. This is because the bonding is only a pre-fixing solution for welding the metal plates to the metal sealing plate 22. When the tank is in use, e.g. when liquefied gas is being filled into the tank, the sealed membrane 8 is subjected to high thermal contraction stresses, which can cause the bonding to break.

20 [0102] As a result, the metal sealing plate 22 is free to move relative to the thermally insulating barrier. However, the position of the metal sealing plate 22 can remain within a groove nub 15 or be moved out of this groove nub 15. The sealed membrane 8 is thus free to move or deform in relation to the thermally insulating barrier in the area of the sealing plate 22.

25 [0103] With reference to figure 11, a sectional view of an LNG ship 70 shows a sealed and thermally insulating tank 71 with a generally prismatic form, fitted in the double hull 72 of the ship 70. The wall of the tank 71 comprises a primary sealed membrane which is designed 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
30 the ship 70, 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.

[0104] In a known manner, loading/unloading piping 73 positioned on the upper deck of the ship can be connected, by means of appropriate connectors, to a maritime or port terminal, in order to transfer a cargo of LNG from or to the tank 71.

5 [0105] Figure 11 represents an example of a maritime terminal comprising a loading and unloading station 75, an undersea duct 76, and an installation on land 77. The loading and unloading station 75 is a fixed offshore installation comprising a mobile arm 74 and a tower 78 which supports the mobile arm 74. The mobile arm 74 supports a bundle of insulated flexible pipes 79 which can be connected to the loading/unloading piping 73. The orientable mobile arm 74 fits all tanker gauges. A connection duct, not
10 represented, extends inside the tower 78. The loading and unloading station 75 permits loading and unloading of the tanker 70 from or to the installation on land 77. This installation comprises liquefied gas storage tanks 80 and connection ducts 81 which are connected by the undersea duct 76 to the loading or unloading station 75. The undersea duct 76 permits the transfer of the liquefied gas between the loading or
15 unloading station 75 and the installation on land 77 over a long distance, for example 5 km, which makes it possible to keep the tanker 70 at a long distance from the coast during the loading and unloading operations.

[0106] In order to generate the pressure necessary for the transfer of the liquefied gas, pumps on board the ship 70 are used, and/or pumps which equip the installation on land 77,
20 and/or pumps which equip the loading and unloading station 75.

[0107] Although the invention has been described in association with a plurality of particular embodiments, it is apparent that it is in no way limited to this, 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.

25 [0108] Use of the verbs “contain”, “comprise” or “include” and their conjugated forms does not exclude the presence of elements or steps other than those described in a claim.

[0109] In the claims, any reference numeral between brackets should not be interpreted as a limitation of the claim.

CLAIMS

[Claim 1] Method for fitting a sealed membrane (8) on a tank wall (1) of a sealed and thermally insulating tank (71) for the storage of liquefied gas, the sealed and thermally insulating tank (71) being incorporated in a support structure (2), wherein the fitting method comprises the following steps:

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- providing a tank wall (1) comprising a thermally insulating barrier (6) secured on the support structure (2), the thermally insulating barrier (6) comprising insulating panels which are juxtaposed on one another and comprising cover plates (10), the thermally insulating barrier (6) comprising first grooves (13) and second grooves (14) provided in the cover plates (10) of the insulating panels, the first grooves (13) extending parallel to one another in a first direction and the second grooves (14) extending parallel to one another in a second direction, the second direction being perpendicular to the first direction, a so-called first groove (13) intersecting a so-called second groove (14) at a groove nub (15), first and second thermal protection strips (21) being positioned respectively in the said first groove (13) and the said second groove (14);

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- cutting the first and second thermal protection strips (21) at the said groove nub (15);
 - providing a metal sealing plate (22) comprising an upper face and a lower face;
 - gluing the lower face of the metal sealing plate (22) at the said groove nub (15) on the cover plate (10);

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- providing four corrugated metal plates (16) which are designed to form a sealed membrane (8) of the tank wall (1), each metal plate having a rectangular form and comprising a first edge (17) and a second edge (18), the first edge (17) joining the second edge (18) at a corner area (19);

- positioning and welding the four corrugated metal plates (16) such that each first edge (17) is positioned in-line with one of the first grooves (13), each second edge (18) is positioned in-line with one of the second grooves (14), the first edges of the corrugated metal plates (16) being welded in pairs by overlapping in-line with the first thermal protection strip, and the second edges of the corrugated metal plates (16) being welded in pairs by overlapping in-line with the second thermal protection strip, the corner area (19) of the corrugated metal plates (16) being welded on the upper face of the metal sealing plate (22), the upper face of the metal sealing plate (22) comprising a covered portion (42) and a non-covered portion (43) which is complementary with the covered portion (42), the covered portion being situated below the four corrugated metal plates

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(16), and the non-covered portion (43) being designed to be in contact with the liquefied gas.

[Claim 2] Method for fitting a sealed membrane (8) according to claim 1, wherein, before the step of gluing of the metal sealing plate (22), the method comprises the step of arrangement of a template (23) in the said groove nub (15), the template (23) comprising a border (24) surrounding a receptacle (25) at least partly, the receptacle (25) having a form which is at least partly complementary with the metal sealing plate (22), and wherein the step of gluing of the metal sealing plate (22) is carried out by placing the metal sealing plate (22) in the receptacle (25) of the template (23), the template (23) preferably being withdrawn after the step of gluing of the metal sealing plate (22).

[Claim 3] Method for fitting a sealed membrane (8) according to claim 1 or claim 2, wherein, before the step of arrangement and welding of the corrugated metal plates (16), the method comprises the step of marking of the metal sealing plate (22) by positioning marks, the positioning marks being configured to indicate the position of the corner areas of the corrugated metal plates (16) to be positioned.

[Claim 4] Sealed and thermally insulating tank (71) for the storage of liquefied gas, the sealed and thermally insulating tank (71) being designed to be incorporated in a support structure (2), the tank comprising at least one tank wall (1), wherein the tank wall (1) comprises a thermally insulating barrier (6) secured directly or indirectly on the support structure (2), and a sealed membrane (8) which is supported by the thermally insulating barrier (6), and is designed to be in contact with the liquefied gas, wherein the thermally insulating barrier (6) comprises insulating panels (7, 12) which are juxtaposed on one another, the insulating panels comprising cover plates (10), the thermally insulating barrier (6) comprising first grooves (13) and second grooves (14) provided in the cover plates (10) of the insulating panels, the first grooves (13) extending parallel to one another in a first direction and the second grooves (14) extending parallel to one another in a second direction, the second direction being perpendicular to the first direction, a so-called first groove (13) intersecting a so-called second groove (14) at a groove nub (15), wherein the tank wall (1) comprises a metal sealing plate (22), the metal sealing plate (22) comprising an upper face and a lower face, the lower face of the metal sealing plate (22) being bonded to the thermally insulating barrier (6) in said groove nub (15) by means of an adhesive resin,

first and second thermal protection strips (21) being positioned in the said first groove (13) and the said second groove (14) outside the said groove nub (15), wherein the sealed membrane (8) comprises at least three corrugated metal plates (16) which are adjacent to the metal sealing plate (22), each corrugated metal plate (16) having a rectangular form and comprising a first edge (17) extending in the first direction, and a second edge (18) extending in the second direction, wherein the first edges of the corrugated metal plates (16) are welded in pairs by overlapping in-line with the first thermal protection strip, and the second edges of the corrugated metal plates (16) are welded in pairs by overlapping in-line with the second thermal protection strip, wherein at least two of the said corrugated metal plates (16) comprise a corner area (19) which is welded on the upper face of the metal sealing plate (22), the corner area (19) connecting the said first edge (17) and the said second edge (18), the said at least two corrugated metal plates (16) having the first edge (17) positioned in-line with the said first thermal protection strip (21), and the second edge (18) positioned in-line with the said second thermal protection strip (21), the upper face of the metal sealing plate (22) comprising a covered portion (42) and a non-covered portion (43) complementary with the covered portion (42), the covered portion (42) being situated below the at least three corrugated metal plates (16), and the non-covered portion (43) being designed to be in contact with the liquefied gas.

[Claim 5] Sealed and thermally insulating tank (71) according to claim 4, wherein the lower face of the metal sealing plate (22) is bonded to the thermally insulating barrier (6) in the said groove nub (15) with adhesive resin, the adhesive resin being configured to withstand a load greater than, or equal to, the weight of the metal sealing plate (22) at ambient temperature during a production time of the sealed and thermally insulating tank (71).

[Claim 6] Sealed and thermally insulating tank (71) for the storage of liquefied gas, the sealed and thermally insulating tank (71) being designed to be incorporated in a support structure (2), the tank comprising at least one tank wall (1), wherein the tank wall (1) comprises a thermally insulating barrier (6) secured directly or indirectly on the support structure (2), and a sealed membrane (8) which is supported by the thermally insulating barrier (6), and is designed to be in contact with the liquefied gas, wherein the thermally insulating barrier (6) comprises insulating panels (7, 12) which are juxtaposed on one another, the insulating panels comprising cover plates (10), the

thermally insulating barrier (6) comprising first grooves (13) and second grooves (14) provided in the cover plates (10) of the insulating panels, the first grooves (13) extending parallel to one another in a first direction and the second grooves (14) extending parallel to one another in a second direction, the second direction being perpendicular to the first direction, a so-called first groove (13) intersecting a so-called second groove (14) at a groove nub (15),

wherein the tank wall (1) comprises a metal sealing plate (22), the metal sealing plate (22) comprising an upper face and a lower face, the lower face of the metal sealing plate (22) being left free relative to the thermally insulating barrier (6) in the said groove nub (15),

first and second thermal protection strips (21) being positioned in the said first groove (13) and the said second groove (14) outside the said groove nub (15), wherein the sealed membrane (8) comprises at least three corrugated metal plates (16) which are adjacent to the metal sealing plate (22), each corrugated metal plate (16) having a rectangular form and comprising a first edge (17) extending in the first direction, and a second edge (18) extending in the second direction,

wherein the first edges of the corrugated metal plates (16) are welded in pairs by overlapping in-line with the first thermal protection strip, and the second edges of the corrugated metal plates (16) are welded in pairs by overlapping in-line with the second thermal protection strip,

wherein at least two of the said corrugated metal plates (16) comprise a corner area (19) which is welded on the upper face of the metal sealing plate (22), the corner area (19) connecting the said first edge (17) and the said second edge (18), the said at least two corrugated metal plates (16) having the first edge (17) positioned in-line with the said first thermal protection strip (21), and the second edge (18) positioned in-line with the said second thermal protection strip (21), the upper face of the metal sealing plate (22) comprising a covered portion (42) and a non-covered portion (43) complementary with the covered portion (42), the covered portion (42) being situated below the at least three corrugated metal plates (16), and the non-covered portion (43) being designed to be in contact with the liquefied gas.

[Claim 7] Sealed and thermally insulating tank (71) according to one of claims 4 to 6, wherein the sealed membrane (8) comprises three corrugated metal plates (16) which are adjacent to the metal sealing plate (22),

wherein two of the said corrugated metal plates (16) comprise a corner area (19) which is welded on the upper face of the metal sealing plate (22), the said two corrugated

metal plates (16) having the first edge (17) positioned in-line with the said first thermal protection strip (21), and the second edge (18) positioned in-line with the second thermal protection strip (21), and wherein the first edge (71) of a third one of the said corrugated metal plates passes through the upper face of the metal sealing plate (22),
 5 the covered portion (42) being situated below the said three corrugated metal plates (16).

[Claim 8] Sealed and thermally insulating tank (71) according to one of claims 4 to 7, wherein the sealed membrane (8) comprises four corrugated metal plates (16) which are adjacent to the metal sealing plate (22), wherein each corrugated metal plate (16)
 10 comprises a corner area (19) which is welded on the upper face of the metal sealing plate (22), each corrugated metal plate (16) having the first edge (17) positioned in-line with the said first thermal protection strip (21), and the second edge (18) positioned in-line with the said second thermal protection strip (21), the covered portion (42) being situated below the four corrugated metal plates (16).

15 [Claim 9] Sealed and thermally insulating tank (71) according to one of claims 4 to 8, wherein the tank wall (1) and the support structure (2) have a duct passing through them, the sealed membrane (8) comprising a closure plate (30) situated all around the duct, the closure plate (30) being provided with an orifice (31) through which the duct passes, at least one of the said corrugated metal plates (16) having an edge which is
 20 connected in a sealed manner to the closure plate (30).

[Claim 10] Sealed and thermally insulating tank (71) according to one of claims 4 to 9, wherein the first groove (13) and the second groove (14) each comprise a groove base, and two opposite edges which are spaced by a groove width, the first and second thermal protection strips (21) being supported against the groove base, and the metal
 25 sealing plate (22) being positioned in the groove nub (15) spaced from the edges of the first groove (13) and from the edges of the second groove (14).

[Claim 11] Sealed and thermally insulating tank (71) according to one of claims 4 to 10, wherein the metal sealing plate (22) has a rectangular form, with two first sides of the metal sealing plate (22) extending in the first direction and two second sides (27) of the
 30 metal sealing plate (22) extending in the second direction, the first side (26) joining the second side (27) at a corner, the corners being chamfered.

[Claim 12] Sealed and thermally insulating tank (71) according to one of claims 4 to 11, wherein the corner areas (19) of the corrugated metal plates (16) are chamfered.

[Claim 13] Sealed and thermally insulating tank (71) according to one of claims 4 to 12, wherein the tank wall (1) is a ceiling wall, with the sealed and thermally insulating tank (71) comprising the ceiling wall, a base wall opposite the ceiling wall in a direction of height, and one or a plurality of lateral walls connecting the base wall to the ceiling wall.

5 [Claim 14] Sealed and thermally insulating tank (71) according to one of claims 4 to 13, wherein the thermally insulating barrier (6) is a primary thermally insulating barrier, and the sealed membrane (8) is a primary sealed membrane, the tank wall (1) also comprising a secondary thermally insulating barrier positioned between the primary thermally insulating barrier and the support structure (2), and a secondary sealed
10 membrane positioned between the secondary thermally insulating barrier and the primary thermally insulating barrier.

[Claim 15] Sealed and thermally insulating tank (71) according to one of claims 4 to 14, wherein the thermal protection strips (21) are made of glass wool strips or rock wool strips.

15 [Claim 16] Ship (70) for the transport of a cold liquid product, the ship comprising a double hull (72), and a sealed and thermally insulating tank (71) according to one of claims 4 to 15, positioned in the double hull.

[Claim 17] Transfer system for a cold liquid product, the system comprising a ship (70) according to claim 16, insulated piping (73, 79, 76, 81) arranged such as to connect
20 the sealed and thermally insulating tank (71) of the ship to a floating or terrestrial storage installation (77), and a pump to drive a flow of cold liquid product through the insulated piping from or to the floating or terrestrial storage installation, to or from the sealed and thermally insulating tank (71) of the ship.

[Claim 18] Method for loading or unloading of a ship (70), wherein a cold liquid product is
25 conveyed through insulated piping (73, 79, 76, 81) from or to a floating or terrestrial storage installation (77), to or from the sealed and thermally insulating tank (71) of the ship (70) according to claim 16.