

Description

Title of the invention: Storage facility for liquefied gas

Technical field

[0001] The invention relates to the field of storage facilities for liquefied gas comprising a
5 sealed and thermally insulating tank with sealed membranes. In particular, the invention
relates to the domain of sealed and thermally insulating tanks for storing and/or
transporting liquefied gas at low temperatures, such as tanks for transporting liquefied
petroleum gas (LPG) for example at a temperature between -50°C and 0°C, or for
10 transporting liquefied natural gas (LNG) at approximately -162°C at atmospheric pressure.
These tanks can be installed on shore or on a floating structure. In a floating structure, the
tank can be used to transport liquefied gas or to receive the liquefied gas used as fuel to
power the floating structure.

Technological background

[0002] Sealed and thermally insulating tanks built into the load-bearing structure of a ship,
15 including a secondary thermally insulating barrier, a secondary sealing membrane, a
primary thermally insulating barrier and a primary sealing membrane are known from the
prior art, for example WO2019234360. The tank has a plurality of tank walls assembled
together. The secondary sealing membrane has a plurality of parallel strakes. Each strake
has a flat central portion extending in a first direction and two raised edges arranged on
20 the two sides of the flat central portion and projecting toward the inside of the tank in
relation to the central portion. The strakes are therefore juxtaposed in a second direction
in a repeating pattern and welded together at the raised edges. Such a secondary sealing
membrane, commonly referred to as stretched membranes, have no zones in the first
direction able to absorb compressive and tractive forces, unlike a corrugated membrane.

25 [0003] In this type of structure, the secondary sealing membrane is interrupted by an opening,
for example to enable the passage of loading/unloading lines. Therefore, at these
interruptions, the secondary sealing membrane is stopped and is directly connected to the
load-bearing structure notably to absorb the compressive and tractive forces caused by
thermal contraction of the sealing membranes, deformation of the hull related for example
30 to the bending of the ship girder, and the filling state of the tanks.

[0004] Document KR20200144178 describes a tank wall at such an interruption formed by a
liquid dome.

Summary

[0005] One idea at the heart of the invention is to enable the simple assembly of the primary thermally insulating barrier close to the opening.

[0006] Another idea at the heart of the invention is to limit the number of anchor points.

[0007] Another idea at the heart of the invention is to improve the support for the primary
5 sealing membrane close to the opening.

[0008] According to one embodiment, the invention provides a storage facility for liquefied gas comprising a metal load-bearing structure and a sealed and thermally insulating tank arranged inside the load-bearing structure,
the tank comprising, in the thickness direction from the outside toward the inside of the
10 tank, a secondary thermally insulating barrier fastened to the load-bearing structure, a metal secondary sealing membrane arranged on the secondary thermally insulating barrier, a primary thermally insulating barrier arranged on the secondary sealing membrane, and a primary sealing membrane arranged on the primary thermally insulating barrier and intended to be in contact with the liquefied gas,
15 the load-bearing structure having an upper load-bearing wall, the tank having a ceiling wall fastened to the upper load-bearing wall, the ceiling wall being interrupted locally to delimit a loading/unloading opening that is intended to be traversed by loading/unloading lines,
in which the secondary sealing membrane of the ceiling wall includes a plurality of parallel
20 strakes extending in a first direction, each strake including a flat central portion and two raised edges projecting toward the inside of the tank in relation to the central portion, the strakes being juxtaposed in a second direction in a repeating pattern and welded together sealingly at the raised edges, the first direction being perpendicular to the second direction,
25 in which the secondary thermally insulating barrier of the ceiling wall includes an end secondary insulating block adjacent to an edge of the loading/unloading opening, and a secondary insulating panel juxtaposed with the end secondary insulating block in the second direction, said edge of the loading/unloading opening extending in the first direction,
30 in which the primary thermally insulating barrier of the ceiling wall includes an end primary insulating block adjacent to said edge of the loading/unloading opening, and a primary insulating panel juxtaposed with the end primary insulating block in the second direction,
in which the end primary insulating block extends in line with a first portion of the end
35 secondary insulating block and is fastened to the end secondary insulating block, and the

primary insulating panel extends in line with a second portion of the end secondary insulating block, the second portion being adjacent to the first portion in the second direction, the primary insulating panel being fastened to the end secondary insulating block.

5 [0009] These features make the primary thermally insulating barrier of the ceiling wall relatively simple to build along the edge of the loading/unloading opening extending in the first direction. Furthermore, the end primary insulating block and an end portion of the primary insulating panel turned toward the end primary insulating block are both carried by the end secondary insulating block, which limits the probability and amplitude of a difference in thickness, i.e. a step, at an interface between the primary insulating panel
10 and the end primary insulating block.

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

[0011] According to one embodiment, the end primary insulating block is more rigid than the primary insulating panel in the thickness direction.

15 [0012] According to one embodiment, the end primary insulating block has a lower coefficient of thermal contraction than the primary insulating panel in the thickness direction, preferably between the coefficient of thermal contraction of the strakes and the coefficient of thermal contraction of the primary insulating panel.

20 [0013] According to one embodiment, the end primary insulating block and the primary insulating panel are fastened to the end secondary insulating block using a shared anchoring device.

25 [0014] According to one embodiment, an interface between the end secondary insulating block and the secondary insulating panel is positioned further away from the edge of the loading/unloading opening in the second direction than an interface between the end primary insulating block and the primary insulating panel.

[0015] According to one embodiment, the end primary insulating block is made in the form of a box comprising a bottom plate, a cover plate parallel to the bottom plate, and load-bearing spacer plates holding the cover plate away from the bottom plate, the box being filled with insulating packing.

30 [0016] According to one embodiment, the end secondary insulating block is made in the form of a box comprising a bottom plate, a cover plate parallel to the bottom plate, and load-bearing spacer plates holding the cover plate away from the bottom plate, the box being filled with insulating packing.

[0017] The insulating packing is for example perlite, glass wool, or rock wool. The bottom plate, the cover plate, and the load-bearing spacer plates are for example made of plywood.

[0018] According to one embodiment, the primary insulating panel includes, successively in the thickness direction, at least one layer of insulating foam and at least one rigid plate.

5 [0019] According to one embodiment, the insulating foam is a polymer foam, for example a polyurethane foam. According to one embodiment, this insulating foam has a density greater than 100 kg/m^3 , preferably equal to or greater than 120 kg/m^3 , notably equal to 130 or 210 kg/m^3 .

10 [0020] According to one embodiment, the structural insulating foam is a reinforced foam, for example reinforced with fibers such as glass fibers.

[0021] According to one embodiment, the bottom panel is a panel made of plywood or composite material. According to one embodiment, the cover panel is a panel made of plywood or composite material.

15 [0022] According to one embodiment, the coefficient of thermal contraction of the end primary insulating block in said thickness direction is lower than the coefficient of thermal contraction in said thickness direction of the primary insulating panel.

[0023] According to one embodiment, the end primary insulating block is parallelepipedic and has two lateral faces perpendicular to the first direction, at least one of the lateral faces being fastened to the end secondary insulating block.

20 [0024] According to one embodiment, the end primary insulating block has a bearing surface and the anchoring device has a base fastened to the end secondary insulating block, a pin fastened to said base and extending in the thickness direction and passing sealingly through an orifice in the secondary sealing membrane, and a bearing element mounted on the pin and bearing against the bearing surface of the end primary insulating block to
25 hold it against the end secondary insulating block.

[0025] According to one embodiment, at least one of the lateral faces of the end primary insulating block has a protuberance, the bearing surface being formed on the protuberance.

[0026] According to one embodiment, the protuberance is formed by a plywood shim.

30 [0027] According to one embodiment, the primary insulating panel has a bearing surface and the bearing element bears against the bearing surface of the primary insulating panel to hold the primary insulating panel against the end secondary insulating block.

[0028] According to one embodiment, the bearing surface of the primary insulating panel is positioned at a corner of the primary insulating panel.

[0029] According to one embodiment, the anchoring device further includes a flange integral with the pin, the flange projecting radially outwards from the pin and being fastened sealingly to the secondary sealing membrane about the orifice in the secondary sealing membrane.

5 [0030] According to one embodiment, the anchoring device further includes a sealing washer that is engaged on the pin and that has a flange fastened sealingly to the secondary sealing membrane about the orifice in the secondary sealing membrane.

[0031] According to one embodiment, the anchoring device includes a deformable seal sealingly joining the flange to the pin to enable a relative movement between the flange
10 and the pin.

[0032] According to one embodiment, the end secondary insulating block is parallelepipedic and has two lateral faces perpendicular to the first direction, at least one of the lateral faces being fastened to the load-bearing structure using a fastening device, the base of the anchoring device being fastened to said lateral face such that the anchoring device is
15 positioned in line with the fastening device in the thickness direction.

[0033] According to one embodiment, said lateral face has a lower protuberance comprising a bearing surface and an upper protuberance, the fastening device having at least one threaded rod extending in the thickness direction and fastened to the upper load-bearing wall, and a retaining plate mounted on the threaded rod and bearing against the bearing
20 surface of the lower protuberance, the base of the anchoring device having a lower plate and an upper plate sandwiching the upper protuberance.

[0034] According to one embodiment, the primary thermally insulating barrier of the ceiling wall has a row of end primary insulating blocks adjacent to the edge of the loading/unloading opening, the end primary insulating blocks being juxtaposed with one
25 another in the first direction, and has a row of primary insulating panels juxtaposed with one another in the first direction.

[0035] According to one embodiment, the row of end primary insulating blocks has a first end primary insulating block and a second end primary insulating block adjacent to the first end primary insulating block and the row of primary insulating panels has a first primary
30 insulating panel adjacent to the first end primary insulating block, and a second primary insulating panel adjacent to the second end primary insulating block, the first and second end primary insulating blocks and the first and second primary insulating panels being fastened to the end secondary insulating block using a shared anchoring device.

[0036] According to one embodiment, the secondary thermally insulating barrier of the ceiling wall has a row of end secondary insulating blocks adjacent to the edge of the loading/unloading opening, the end secondary insulating blocks being juxtaposed with one another in the first direction, the base of the anchoring device being fastened to two adjacent end secondary insulating blocks at an interface formed between the end secondary insulating blocks.

[0037] According to one embodiment, the secondary thermally insulating barrier includes the end secondary insulating block and secondary insulating panels, the secondary insulating panel adjacent to the end secondary insulating block in the first direction having a different structure to the other secondary insulating panels, for example so as to be more rigid in the thickness direction than the other secondary insulating panels or to have a lower coefficient of thermal contraction.

[0038] According to one embodiment, the deformable seal includes a deformable boot, said deformable boot being hollow and extending about and axially along the pin. The deformable boot is for example made of stainless steel.

[0039] According to one embodiment, the anchoring device includes a shell covering the deformable seal, the shell being cylindrical.

[0040] The primary sealing membrane can be made in different ways. According to one embodiment, the primary sealing membrane of the ceiling wall includes a plurality of corrugated metal plates juxtaposed in the first direction and the second direction, and welded to one another, the primary sealing membrane having a first series of corrugations extending in the first direction and a second series of corrugations extending in the second direction.

[0041] According to one embodiment, the tank has a cover arranged in the loading/unloading opening, the cover having a metal sealing wall and a thermally insulating structure positioned between the sealing wall and the upper load-bearing wall, the cover being fastened to the upper load-bearing wall for example by welding, the metal sealing wall being sealingly connected to the primary sealing membrane by a metal joining strip.

[0042] According to one embodiment, the thermally insulating structure of the cover has a plurality of insulating cover blocks, each insulating cover block being made in the form of a box comprising a cover plate and a bottom plate kept apart by load-bearing spacer plates and the sides of the box, the box being filled with insulating packing.

[0043] According to one embodiment, the secondary sealing membrane, the sealing wall of the cover and/or the joining strip are made of a metal with a low coefficient of expansion,

for example an alloy of iron and nickel with a coefficient of thermal expansion of between $0.5 \cdot 10^{-6}$ and $2 \cdot 10^{-6} \text{ K}^{-1}$. It is also possible to use alloys of iron and manganese with a typical coefficient of expansion of around $7 \cdot 10^{-6} \text{ K}^{-1}$.

5 [0044] According to one embodiment, the secondary sealing membrane is made of stainless steel.

[0045] According to one embodiment, the load-bearing structure has a rear cofferdam wall and a front cofferdam wall that are positioned on the two sides of the tank in the first direction, and two longitudinal walls positioned on the two sides of the tank in the second direction, the loading/unloading opening being formed close to one of the cofferdam walls,
10 for example the rear cofferdam wall.

[0046] According to one embodiment, the edge of the loading/unloading opening is a transverse end edge of the loading/unloading opening that is located between the opening and one of the longitudinal walls in the second direction.

[0047] Such a storage facility may be an onshore storage facility, for example for storing LNG,
15 or be a coastal or deep-water floating structure, notably a liquefied natural gas carrier, a floating storage and regasification unit (FSRU), a floating production, storage and unloading (FPSO) unit, inter alia. Such a facility can also be used as a fuel tank in any type of ship.

[0048] According to one embodiment, the storage facility is made in the form of a floating
20 structure, said load-bearing structure being formed by a double hull of the floating structure, and the first direction is a longitudinal direction of the floating structure.

[0049] According to one embodiment, the floating structure is a ship for transporting a cold liquid product.

[0050] According to one embodiment, the invention also provides a transfer system for a cold
25 liquid product, the system including a storage facility as described above, insulated pipes arranged to connect the tank installed in the hull of the ship to an external onshore or floating storage facility and a pump for driving a flow of cold liquid product through the insulated pipes to or from the external onshore or floating storage facility to or from the tank on the ship.

30 [0051] According to one embodiment, the invention also provides a method for loading or unloading a storage facility as described above, in which a cold liquid product is channeled through insulated pipes to or from an external onshore or floating storage facility to or from the tank on the ship.

Brief description of the figures

[0052] The invention will be better understood, and further aims, details, features and advantages thereof will become more clearly apparent in the course of the following description of a number of particular embodiments of the invention, which are given solely by way of illustration and without limitation, with reference to the appended drawings.

[0053] [Fig. 1] Figure 1 is a schematic view of a ship including a storage facility.

[0054] [Fig. 2] Figure 2 is a partial perspective view from the inside of a ceiling wall according to a first embodiment, in a zone close to a loading/unloading opening of the tank, said view corresponding to detail II in figure 1.

10 [0055] [Fig. 3] Figure 3 shows detail III in figure 2, and more specifically the anchoring of the insulating elements of the secondary thermally insulating barrier close to the transverse end edge.

[0056] [Fig. 4] Figure 4 is a perspective view of the zone in figure 3 showing the secondary sealing membrane and the primary thermally insulating barrier.

15 [0057] [Fig. 5] Figure 5 is a cross-section view of figure 4 at an anchoring device in a plane normal to the first direction.

[0058] [Fig. 6] Figure 6 is a view similar to figure 5 in which the primary sealing membrane has been added.

20 [0059] [Fig. 7] Figure 7 is a magnified view of figure 6 specifically showing the anchoring device according to one embodiment.

[0060] [Fig. 8] Figure 8 is a view similar to figure 7 specifically showing an anchoring device according to another embodiment.

[0061] [Fig. 9] Figure 9 is a cut-away schematic view of a tank in a liquefied natural gas carrier ship and of a loading/unloading terminal for this tank.

25 Description of the embodiments

[0062] By convention, the terms “above” or “upper” refer to a position closer to the inside of the tank, and “below” or “lower” refer to a position closer to the load-bearing structure, regardless of the orientation of the tank wall in relation to the Earth’s gravitational field. Thus, figures 2 to 7 are shown in an inverted orientation in relation to their actual position in a storage facility.

30

[0063] Figure 1 shows a liquefied natural gas carrier ship 70 for storing and transporting liquefied gas. However, the invention is not limited to this type of ship.

[0064] The ship 70 shown in figure 1 includes a storage facility 1 with four tanks 71 arranged in the load-bearing structure 2 formed by the inner hull of the ship 70 and fastened thereto. Each tank 71 is polyhedral and has a plurality of tank walls assembled together such as to form an internal space 3, and notably a ceiling wall 4, a rear cofferdam wall 5 and a front cofferdam wall 6. The front cofferdam wall 6 and the rear cofferdam wall 5 are spaced apart in the longitudinal direction L of the ship 70 and are fastened at the top to the ceiling wall 4. For the correct loading and unloading of these tanks 71, a loading/unloading opening 7 is provided in the ceiling wall 4 to enable the passage of loading/unloading lines. The ceiling wall 4 is fastened to an upper load-bearing wall 8 of the load-bearing structure 2. The upper load-bearing wall 8 is also provided with orifices enabling the loading/unloading lines to pass through the load-bearing structure 2.

[0065] The loading/unloading opening 7 is an entry point for miscellaneous LNG handling equipment, such as a filling line, an emergency pumping line, unloading lines linked to unloading pumps, a spray line, a feed line linked to a spray pump, etc. Operation of such equipment is already known.

[0066] The loading/unloading opening 7 is provided in the ceiling wall 4 close to the rear cofferdam wall 5.

[0067] Figure 2 is a perspective view of a ceiling wall 4 from inside the tank according to one embodiment, in a zone close to a loading/unloading opening 7. In this figure, only the secondary thermally insulating barrier 10 of the ceiling wall 4 is shown.

[0068] The multi-layer structure of the ceiling wall 4 is described below in greater detail.

[0069] The multi-layer structure of the ceiling wall 4 of a sealed and thermally insulating tank 71 for storing a liquefied gas, such as liquefied natural gas (LNG), has, arranged successively in the thickness direction from the outside toward the inside of the tank, a secondary thermally insulating barrier 10 fastened to the upper load-bearing wall 8, a secondary sealing membrane 11 bearing against the secondary thermally insulating barrier 10, a primary thermally insulating barrier 12 bearing against the secondary sealing membrane 11 and a primary sealing membrane 13 resting on the primary thermally insulating barrier 12 intended to be in contact with the liquefied natural gas contained in the tank 71.

[0070] The secondary thermally insulating barrier 10 has a plurality of secondary insulating panels 14 that are anchored to the upper load-bearing wall 8 using fastening devices. The secondary insulating panels 14 have an overall parallelepipedic shape and are for example

arranged in parallel rows in the longitudinal direction L and in the transverse direction T perpendicular to the longitudinal direction L.

[0071] The secondary sealing membrane 11 of the ceiling wall 4 has a continuous layer of metal strakes with raised edges. The strakes have a flat central portion resting on the secondary insulating panels 14 of the secondary thermally insulating barrier 10 and also have two raised edges arranged on the two sides of the flat central portion in the transverse direction T and projecting toward the inside of the tank in relation to the central portion. The strakes are welded via the raised edges thereof to parallel welding supports that are fastened in slots formed in the surface of the secondary insulating panels 14 in contact with the secondary sealing membrane 11. The strakes are for example made of Invar®, i.e. an alloy of iron and nickel with a coefficient of expansion typically between $1.2 \cdot 10^{-6}$ and $2 \cdot 10^{-6} \text{ K}^{-1}$.

[0072] Figure 4 shows that the primary thermally insulating barrier 12 of the ceiling wall 4 has a plurality of primary insulating panels 18 that are anchored to the secondary insulating panels 14 using couplers 9. The primary insulating panels 18 have an overall parallelepipedic shape. Furthermore, the dimensions thereof may be substantially identical to or different from the dimensions of the secondary insulating panels 14. In the embodiment shown in figure 2, the primary insulating panels 18 are offset in relation to the secondary insulating panels 14 in the longitudinal direction L, and in the transverse direction T.

[0073] As shown notably in figure 5, the secondary insulating panels 14 and the primary insulating panels 18 have a bottom plate 15, a cover plate 16 and one or more layers of insulating polymer foam 17 sandwiched between the bottom plate 15 and the cover plate 16, and bonded thereto. The insulating polymer foam 17 can in particular be a polyurethane-based polymer foam, optionally reinforced with fibers, notably glass fibers.

[0074] As shown in figure 6, the primary sealing membrane 13 has a plurality of corrugated metal plates juxtaposed in the longitudinal direction L and the transverse direction T, and welded together. The primary sealing membrane 13 has a first series of corrugations 27 extending in the longitudinal direction L and a second series of corrugations 28 extending in the transverse direction T. The corrugations of the second series of corrugations 28 interrupted by the opening 7 are closed by a corrugation cap 29.

[0075] In order to delimit the loading/unloading opening 7, the ceiling wall 4 is interrupted locally to enable the passage of loading/unloading lines. Thus, the sealing membranes 11, 13 and the thermally insulating barriers 10, 12 are interrupted about the entire perimeter of the loading/unloading opening 7, as shown in figure 2.

- [0076] To ensure the continuity of the seal and of the insulation at the opening, the tank 71 has a cover (not shown) placed in the loading/unloading opening 7. The cover has a metal sealing wall and a thermally insulating structure positioned between the metal sealing wall and the upper load-bearing wall 8. The cover is fastened to the upper load-bearing wall by welding, thereby ensuring the continuity of the upper load-bearing wall throughout the tank. The metal sealing wall ensures the continuity of the seal with the primary sealing membrane 13 of the ceiling wall 4, while the thermally insulating structure ensures the continuity of the insulation.
- [0077] The thermally insulating structure may have one or more insulating cover blocks, for example in the form of boxes with a bottom plate, a cover plate and load-bearing spacer plates extending in the thickness direction between the bottom plate and the cover plate and delimiting a plurality of compartments filled with an insulating packing such as perlite, glass wool or rock wool. The insulating cover block or blocks have through-holes (not shown) enabling the passage of the loading/unloading lines.
- [0078] The sealing wall of the cover for example has a plurality of flat metal plates welded to one another. The sealing wall also has a plurality of cover orifices (not shown) intended to be traversed by the loading/unloading lines. The storage facility 1 also includes a metal joining strip (not shown) enabling the sealing wall of the cover to be joined sealingly to the primary sealing membrane 13 of the ceiling wall 4.
- [0079] If at the loading/unloading opening 7 the primary sealing membrane 13 is connected to the sealing wall of the cover, the secondary sealing membrane 11 is interrupted at the edges of the loading/unloading opening 7 and is directly and sealingly connected to the upper load-bearing wall 8 to seal the separation between the secondary thermally insulating barrier 10 and the cover. This connection is made using a secondary connection angle iron 36 including a first secondary flange 37 and a second secondary flange 38 connected to the first secondary flange 37, the first secondary flange 37 being connected to the secondary sealing membrane 11 and the second secondary flange 38 being welded to an anchoring plate 69 rigidly connected to the upper load-bearing wall 8, as shown notably in figure 5 and figure 6.
- [0080] The anchoring of the secondary thermally insulating barrier 10 and of the primary thermally insulating barrier 12 close to the transverse end edge 25 of the loading/unloading opening 7, i.e. one of the edges of the opening 7 extending in the longitudinal direction L, is described in detail below.
- [0081] The secondary thermally insulating barrier 10 of the ceiling wall 4 has a row of end secondary insulating blocks 34 adjacent to the transverse end edge 25, as shown in figure

3. The end secondary insulating blocks 34 are juxtaposed with one another in the longitudinal direction L and are anchored to the upper load-bearing wall 8 using fastening devices 41. Furthermore, the end secondary insulating blocks 34 are staggered with the secondary insulating panels 14 of the row directly adjacent to the end secondary insulating blocks 34. Indeed, the interface between two adjacent end secondary insulating blocks 34 is not aligned with the interface between two adjacent secondary insulating panels 14.

[0082] The end secondary insulating blocks 34 have an overall parallelepipedic shape and each have two lateral faces perpendicular to the longitudinal direction L. Each lateral face has a lower protuberance 46 comprising a bearing surface and an upper protuberance 47, as shown notably in figures 5 and 6. The lower protuberance 46 is positioned in a lower portion of the lateral face near to the upper load-bearing wall 8, while the upper protuberance 47 is positioned in an upper portion of the lateral face so as to be close to the secondary sealing membrane 11. The lower and upper protuberances 46, 47 are for example made of plywood or composite material.

[0083] The fastening device 41 has two threaded rods 42 that are adjacent to one another in the transverse direction T and extend in the thickness direction. The threaded rods 42 of the fastening device 41 are fastened to the upper load-bearing wall 8. The fastening device 41 also has a retaining plate 43 mounted on the threaded rod 42 and held on the threaded rod by a nut. The retaining plate 43 bears against a bearing surface of the lower protuberance 46, as shown notably in figure 5, so as to press the end secondary insulating block 34 against the upper load-bearing wall 8.

[0084] As shown in figure 3, a single fastening device 41 is used at the interface between two end secondary insulating blocks 34 such that the retaining plate 43 bears against the lower protuberance 46 of the two end secondary insulating blocks 34 adjacent to one another.

[0085] The primary thermally insulating barrier 12 of the ceiling wall 4 has, similarly to the secondary thermally insulating barrier 10, a row of end primary insulating blocks 39 adjacent to the transverse end edge 25 of the loading/unloading opening 7. The end primary insulating blocks 39 are positioned in line with a first portion of the end secondary insulating blocks 34. Indeed, the dimension of the end primary insulating blocks 39 in the transverse direction is less than the dimension of the end secondary insulating blocks 34. The end primary and secondary insulating blocks 34, 39 are thus aligned at the faces thereof that are turned toward the opening 7.

[0086] As shown notably in figures 5 and 6, the end primary insulating block 39 has two lateral walls perpendicular to the longitudinal direction L, each having a protuberance 44 formed on a lower portion of the lateral wall of the end primary insulating block 39.

[0087] The end primary insulating block 39 is anchored at each of these lateral walls by an anchoring device 45 to an end secondary insulating block 34. Furthermore, the primary insulating panel 18 directly adjacent to the end primary insulating block 39 is also anchored using the same anchoring device 45 to said end primary insulating block 39. Indeed, the primary insulating panel 18 is also positioned in line with a second portion of the end secondary insulating block 34, the first portion and the second portion being adjacent.

[0088] Thus, the primary and secondary insulating barriers are staggered in the transverse direction T, which means that the interface between the end secondary insulating block 34 and the secondary insulating panel 14 is not aligned in the transverse direction T with the interface between the end primary insulating block 39 and the primary insulating panel 18. This arrangement makes it possible to distribute any differences in thickness caused by differences in contraction, in service, between the end insulating blocks on the one hand and the insulating panels on the other hand. These differences in contraction may result from differences in rigidity and/or differences in thermal behavior. Spacing apart the interfaces prevents all of the differences from accumulating at one point, which helps to maintain the flatness of the membranes.

[0089] Furthermore and as evidenced by comparing figures 3 and 4, the primary insulating panels 18 and the secondary insulating panels 14 are also staggered in the longitudinal direction L, which means that the interface between two adjacent secondary insulating panels 14 in the longitudinal direction L is not aligned with the interface between two adjacent primary insulating panels 18 in the longitudinal direction L.

[0090] As shown more specifically in figure 7, the anchoring device 45 comprises a base 48 fastened to the upper protuberance 47 of the end secondary insulating block 34, a pin 49 fastened to said base 48 and extending in the thickness direction and passing sealingly through an orifice in the secondary sealing membrane 11, and a bearing element 50 mounted on the pin 49 and bearing against a bearing surface formed on the protuberance 44 of the end primary insulating block 39 to hold it against the end secondary insulating block 34. The bearing element 50 is for example provided in the form of a plate held on the pin 49 by a nut.

[0091] The base 48 has a lower plate 60 and an upper plate 61 that are held together by a screw 62. The lower plate 60 is placed beneath and in contact with the upper protuberance 47 of the end secondary insulating block 34, while the upper plate 61 is placed above and in contact with the upper protuberance 47 so as to sandwich it.

[0092] With regard to the anchoring of the primary insulating panel 18 adjacent to the end primary insulating block 39 and as also shown in figures 5 and 6, the primary insulating

panel 18 has a recess formed in the foam 17 and the cover panel 16 at a lower corner 58 of said primary insulating panel 18 adjacent to the end primary insulating block 39. The lower corner 58 is provided with a batten 59. The bearing element 50 of the anchoring device 45 also bears against a bearing surface formed on the batten 59. Thus, a shared anchoring device 45 enables the end primary insulating block 39 and the primary insulating panel 18 to be anchored to the end secondary insulating block 34.

[0093] Furthermore, advantageously as shown in figure 4, the anchoring device 45 may be shared by four elements of the primary thermally insulating barrier 12, specifically two end primary insulating blocks 39 adjacent to one another, and the two primary insulating panels 18 directly adjacent to the end primary insulating blocks 39.

[0094] Similarly and as shown in figure 3, the base 48 is formed at the interface between two end secondary insulating blocks 34 so as to be fastened to the upper protuberance 47 of each of these two end secondary insulating blocks 34.

[0095] The anchoring device 45 also has a sealing washer 51 that is arranged on the pin 49 and includes a flange 54 fastened sealingly to the secondary sealing membrane 11 about the orifice in the secondary sealing membrane 11 and a deformable seal 55 sealingly joining the sealing washer to the pin such as to enable a relative movement between the sealing washer 51 and the pin 49.

[0096] The flange 54 is for example fastened sealingly to the secondary sealing membrane 11 about the orifice in said secondary sealing membrane 11. Furthermore, the pin 49 has an anchoring shoulder 56 projecting radially outwards from the pin 49. Furthermore, the deformable seal 55 is welded sealingly firstly to the sealing washer 51 and secondly to the anchoring shoulder 56 of the pin 49 to guarantee the seal of the pin 49 passing through the secondary sealing membrane 11. In the embodiment shown, the deformable seal 55 is a boot, for example made of stainless steel. The sealed join between the secondary sealing membrane 11 and the pin 49 is then flexible, which enables relative movement between the end primary insulating block 39 and the primary insulating panel 18 adjacent to the secondary sealing membrane 11, thereby helping to limit the risk of damage being caused to the seal of said secondary sealing membrane 11.

[0097] In order to protect the deformable seal 55, the anchoring device 45 is also provided with a shell 57 that has an orifice into which the pin 49 is inserted and that covers said deformable seal 55. In the embodiment shown, the shell 57 has an overall cylindrical shape.

[0098] Figure 8 shows another embodiment of the anchoring device 45.

[0099] Unlike in the embodiment in figure 7, in this embodiment the anchoring device 45 has a flange 54 integral with the pin 49, i.e. the flange 54 is formed simultaneously from the same material as the rest of the pin 49 to form a single part. The flange 54 thus projects radially outwards from the pin 49 and is welded sealingly to the secondary sealing membrane 11 about the orifice in the secondary sealing membrane 11. In this embodiment, the anchoring device 45 does not have a deformable seal, or a shell, or an anchoring shoulder.

[0100] Similarly to the secondary sealing membrane 11 and in order to seal the separation between the secondary thermally insulating barrier 10 and the cover, the primary sealing membrane 13 is connected sealingly to the secondary connection angle iron 36. This connection is made using a primary connection angle iron 63 including a first primary flange 64 and a second primary flange 65 connected to the first primary flange 64, the first primary flange 64 being connected to the primary sealing membrane 13 and the second primary flange 65 being welded to the second secondary flange 38.

[0101] With reference to figure 9, a cut-away view of a liquefied natural gas carrier ship 70 shows a sealed and insulating tank 71 having an overall prismatic shape mounted in the double hull 72 of the ship. The wall of the tank 71 has a primary sealed barrier intended to be in contact with the LNG contained in the tank, a secondary sealed barrier arranged between the primary sealed barrier and the double hull 72 of the ship, and two insulating barriers arranged respectively between the primary sealed barrier and the secondary sealed barrier, and between the secondary sealed barrier and the double hull 72.

[0102] In a known manner, the loading/unloading pipes 73 arranged on the upper deck of the ship can be connected, using appropriate connectors, to a sea or port terminal to transfer a cargo of LNG to or from the tank 71.

[0103] Figure 9 shows an example of a sea terminal comprising a loading/unloading point 75, an undersea line 76 and an onshore facility 77. The loading/unloading point 75 is a static offshore facility comprising a moveable arm 74 and a column 78 holding the moveable arm 74. The moveable arm 74 carries a bundle of insulated hoses 79 that can be connected to the loading/unloading pipes 73. The orientable moveable arm 74 can be adapted to all sizes of liquefied natural gas carrier ships. A connecting line (not shown) extends inside the column 78. The loading/unloading point 75 makes loading and unloading of the liquefied natural gas carrier ship 70 possible to or from the onshore facility 77. This facility has liquefied gas storage tanks 80 and connection lines 81 connected via the undersea line 76 to the loading/unloading point 75. The undersea line 76 enables liquefied gas to be transferred between the loading/unloading point 75 and the onshore facility 77 over a large

distance, for example 5 km, which makes it possible to keep the liquefied natural gas carrier ship 70 a long way away from the coast during loading and unloading operations.

5 [0104] To create the pressure required to transfer the liquefied gas, pumps carried on board the ship 70 and/or pumps installed at the onshore facility 77 and/or pumps installed at the loading/unloading point 75 are used.

[0105] Although the invention has been described in relation to several specific embodiments, it is evidently in no way limited thereto and it includes all of the technical equivalents of the means described and the combinations thereof where these fall within the scope of the invention.

10 [0106] Use of the verb “comprise” or “include” or “have”, including when conjugated, does not exclude the presence of other elements or other steps in addition to those mentioned in a claim.

[0107] In the claims, reference signs between parentheses should not be understood to constitute a limitation to the claim.

Claims

[Claim 1] A storage facility (1) for liquefied gas comprising a metal load-bearing structure (2) and a sealed and thermally insulating tank (71) arranged inside the load-bearing structure,

5 the tank comprising, in the thickness direction from the outside toward the inside of the tank, a secondary thermally insulating barrier (10) fastened to the load-bearing structure (2), a metal secondary sealing membrane (11) arranged on the secondary thermally insulating barrier (10), a primary thermally insulating barrier (12) arranged on the secondary sealing membrane (11), and a primary sealing membrane (13) arranged

10 on the primary thermally insulating barrier (12) and intended to be in contact with the liquefied gas,

the load-bearing structure having an upper load-bearing wall (8),

the tank (71) having a ceiling wall (4) fastened to the upper load-bearing wall (8),

the ceiling wall (4) being interrupted locally to delimit a loading/unloading opening (7)

15 that is intended to be traversed by loading/unloading lines,

in which the secondary sealing membrane (11) of the ceiling wall (4) includes a plurality of parallel strakes extending in a first direction (L), each strake including a flat central portion and two raised edges projecting toward the inside of the tank in relation to the central portion, the strakes being juxtaposed in a second direction (T) in a repeating

20 pattern and welded together sealingly at the raised edges, the first direction being perpendicular to the second direction (T),

in which the secondary thermally insulating barrier (10) of the ceiling wall (4) includes an end secondary insulating block (34) adjacent to an edge (25) of the loading/unloading opening (7), and a secondary insulating panel (14) juxtaposed with

25 the end secondary insulating block (34) in the second direction (T), said edge of the loading/unloading opening extending in the first direction (L),

in which the primary thermally insulating barrier (12) of the ceiling wall (4) includes an end primary insulating block (39) adjacent to said edge of the loading/unloading opening (7), and a primary insulating panel (18) juxtaposed with the end primary

30 insulating block (39) in the second direction (T), in which the end primary insulating block (39) extends in line with a first portion of the end secondary insulating block (34) and is fastened to the end secondary insulating block (34), and the primary insulating panel (18) extends in line with a second portion of the end secondary insulating block (34), the second portion being adjacent to the first portion in the second direction (T),

35 the primary insulating panel (18) being fastened to the end secondary insulating block (34).

[Claim 2] The storage facility as claimed in claim 1, in which the end primary insulating block (39) and the primary insulating panel (18) are fastened to the end secondary insulating block (34) using a shared anchoring device (45).

5 [Claim 3] The storage facility as claimed in either of claims 1 and 2, in which an interface between the end secondary insulating block (34) and the secondary insulating panel (14) is positioned further away from the edge of the loading/unloading opening (7) in the second direction (T) than an interface between the end primary insulating block (39) and the primary insulating panel (18).

10 [Claim 4] The storage facility as claimed in one of claims 1 to 3, in which the end primary insulating block (39) is made in the form of a box comprising a bottom plate, a cover plate parallel to the bottom plate, and load-bearing spacer plates holding the cover plate away from the bottom plate, the box being filled with insulating packing.

15 [Claim 5] The storage facility as claimed in one of claims 1 to 4, in which the primary insulating panel (18) includes, successively in the thickness direction, at least one layer of insulating foam (17) and at least one rigid plate (15, 16).

[Claim 6] The storage facility as claimed in one of claims 1 to 5, in which the end primary insulating block (39) is parallelepipedic and has two lateral faces perpendicular to the first direction (L), at least one of the lateral faces being fastened to the end secondary insulating block (34).

20 [Claim 7] The storage facility as claimed in claim 2, in which the end primary insulating block (39) has a bearing surface and in which the anchoring device (45) has a base (48) fastened to the end secondary insulating block (34), a pin (49) fastened to said base and extending in the thickness direction and passing sealingly through an orifice in the secondary sealing membrane (11), and a bearing element (50) mounted on the
25 pin and bearing against the bearing surface of the end primary insulating block (39) to hold it against the end secondary insulating block (34).

[Claim 8] The storage facility as claimed in claims 6 and 7 in combination, in which at least one of the lateral faces of the end primary insulating block (39) has a protuberance (44), the bearing surface being formed on the protuberance.

30 [Claim 9] The storage facility as claimed in either of claims 7 and 8, in which the primary insulating panel (18) has a bearing surface and in which the bearing element (50) bears against the bearing surface of the primary insulating panel to hold the primary insulating panel against the end secondary insulating block (34).

35 [Claim 10] The storage facility as claimed in claim 9, in which the bearing surface of the primary insulating panel (18) is positioned at a corner (58) of the primary insulating panel (18).

[Claim 11] The storage facility as claimed in one of claims 7 to 10, in which the anchoring device further includes a flange (54) integral with the pin (49), the flange projecting radially outwards from the pin and being fastened sealingly to the secondary sealing membrane (11) about the orifice in the secondary sealing membrane (11).

5 [Claim 12] The storage facility as claimed in one of claims 7 to 10, in which the end secondary insulating block (39) is parallelepipedic and has two lateral faces perpendicular to the first direction (L), at least one of the lateral faces being fastened to the load-bearing structure using a fastening device (41), the base (48) of the anchoring device (45) being fastened to said lateral face such that the anchoring
10 device (45) is positioned in line with the fastening device (41) in the thickness direction.

[Claim 13] The storage facility as claimed in claim 12, in which said lateral face has a lower protuberance (46) comprising a bearing surface and an upper protuberance (47), the fastening device (41) having at least one threaded rod (42) extending in the thickness direction and fastened to the upper load-bearing wall (8), and a retaining plate (43)
15 mounted on the threaded rod (42) and bearing against the bearing surface of the lower protuberance (46), the base of the anchoring device (45) having a lower plate (60) and an upper plate (61) sandwiching the upper protuberance (47).

[Claim 14] The storage facility as claimed in one of claims 1 to 13, in which the primary thermally insulating barrier (12) of the ceiling wall (4) has a row of end primary
20 insulating blocks (39) adjacent to the edge (25) of the loading/unloading opening (7), the end primary insulating blocks (34) being juxtaposed with one another in the first direction (L), and has a row of primary insulating panels (18) juxtaposed with one another in the first direction (L).

[Claim 15] The storage facility as claimed in claim 14, in which the row of end primary
25 insulating blocks (39) has a first end primary insulating block (39) and a second end primary insulating block (39) adjacent to the first end primary insulating block (39) and the row of primary insulating panels (18) has a first primary insulating panel (18) adjacent to the first end primary insulating block (39), and a second primary insulating panel (18) adjacent to the second end primary insulating block (39), the first and
30 second end primary insulating blocks (39) and the first and second primary insulating panels (18) being fastened to the end secondary insulating block (34) using a shared anchoring device (45).

[Claim 16] The storage facility as claimed in one of claims 7 to 13 and 15, in which the secondary thermally insulating barrier (10) of the ceiling wall (4) has a row of end
35 secondary insulating blocks (34) adjacent to the edge of the loading/unloading opening (7), the end secondary insulating blocks (34) being juxtaposed with one another in the

first direction (L), the base of the anchoring device being fastened to two adjacent end secondary insulating blocks (34) at an interface formed between the end secondary insulating blocks (39).

5 [Claim 17] The storage facility as claimed in one of claims 1 to 16, in which the end primary insulating block (39) is more rigid than the primary insulating panel (18) in the thickness direction.

10 [Claim 18] The storage facility (1) as claimed in one of claims 1 to 16 in the form of a floating structure, in which said load-bearing structure comprises a double hull (72) of the floating structure, and in which the first direction (L) is a longitudinal direction (L) of the floating structure, the floating structure preferably being a ship (70) for transporting a cold liquid product.

15 [Claim 19] A transfer system for a cold liquid product, the system including a storage facility as claimed in claim 18, insulated pipes (73, 79, 76, 81) arranged to connect the tank (71) installed in the hull of the floating structure to an external onshore or floating storage facility (77) and a pump for driving a flow of cold liquid product through the insulated pipes to or from the external onshore or floating storage facility to or from the tank on the floating structure.

20 [Claim 20] A method for loading or unloading a storage facility as claimed in claim 18, in which a cold liquid product is channeled through insulated pipes (73, 79, 76, 81) to or from an external onshore or floating storage facility (77) to or from the tank (71) on the floating structure.