

DESCRIPTION

Title: Sealed and thermally insulating tank

The present invention relates to the field of liquefied natural gas storage tanks, in particular onshore liquefied natural gas storage tanks.

5 Liquefied natural gas is generally transported by sea in storage tanks fitted on transport ships. Natural gas is kept in liquid form to increase the amount of natural gas transported per tank, the volume of one liter of natural gas in liquid form being much lower than the volume of one liter of natural gas in gaseous form. These tanks keep the liquefied natural gas at a very low temperature, and more precisely at a
10 temperature below -163°C , the temperature at which natural gas is in liquid form at atmospheric pressure.

To load and/or unload the tanks of these liquefied natural gas transport ships, an onshore liquefied natural gas storage tank is installed at a port. This is generally fitted out such that liquefied natural gas transport ships can come and restock and/or
15 unload their cargo of liquefied natural gas. Such onshore storage tanks are equipped with elements passing through one of the walls of these onshore tanks, such as for example a pipe, thus allowing communication between a liquefied natural gas loading and/or unloading facility and an internal volume of the onshore tank in which the liquefied natural gas is stored.

20 As is known, the walls of such tanks include a sealed and thermally insulating secondary space and a sealed and thermally insulating primary space resting on the secondary space and configured to be in contact with the liquefied natural gas contained in the tank. However, when a through element is fitted passing through one of the walls of the tank, it is necessary to create a first seal for the secondary
25 space and a second seal for the primary space. These seals represent an extra cost in addition to the cost of the facility, in particular as regards their design, their manufacture and their installation, especially with regard to the thermal insulation which they involve. These through elements are sometimes grouped together, thus complicating the seals to be created and the arrangement of the equipment above the
30 tanks.

In this context, the present invention proposes an alternative to the already existing solutions by virtue of a tank comprising a wall which has a first portion composed of

the secondary space and the primary space and a second portion comprising a sealed and thermally insulating layer in communication with the primary space, it being possible to fit a through element in the second portion more easily and at lower cost.

- The main subject matter of the present invention is thus a sealed and thermally
- 5 insulating tank comprising at least a storage structure for storing a fluid and a supporting structure surrounding the storage structure, the storage structure comprising a plurality of walls including at least a ceiling wall, a bottom wall and a plurality of side walls extending between the ceiling wall and the bottom wall, at least the ceiling wall comprising a first portion and a second portion, the first portion
- 10 comprising, successively in the thickness direction from the outside toward the inside of the tank, a sealed and thermally insulating secondary space and a sealed and thermally insulating primary space, the secondary space being configured to be in contact with the supporting structure, the primary space delimiting an internal volume configured to receive the fluid contained in the tank, the second portion
- 15 comprising a sealed and thermally insulating layer, characterized in that the sealed and thermally insulating layer of the second portion is in contact with the supporting structure while helping to delimit the internal volume of the tank, a ratio of the surface area of the second portion of the ceiling wall to the total surface area of the ceiling wall being between 5% and 60%.
- 20 The tank reduces heat loss so as to keep the fluid at a temperature below its boiling point, for example when the fluid is natural gas, the tank keeps it in liquid form at a temperature below -163°C .

The first portion and the second portion of the ceiling wall advantageously extend in the same plane, this plane being the main plane of extension of the ceiling wall, each

25 portion thus extending the other portion in this plane.

The primary space rests on the secondary space, the latter itself resting on the supporting structure of the tank. The sealed and thermally insulating layer for its part extends between the supporting structure and the internal volume of the tank.

A ratio of the surface area of the second portion of between 5% and 60% of the total

30 surface area of the ceiling wall makes it possible to minimize the heat loss from the ceiling wall of the tank, while greatly facilitating the installation of one or more through pipes through the ceiling wall. Note that with a second portion extending over 5% of the total surface area of the ceiling wall, the heat loss is minimal while

freeing up enough space to allow the installation of one or more pipes through the ceiling wall, while with a second portion extending over 60% of the total surface area of the ceiling wall, the heat loss is still acceptable, and the installation of one or more pipes through the ceiling wall is greatly facilitated.

- 5 According to an optional feature of the invention, the ratio is calculated by comparing the surface area of the sealed and thermally insulating layer with the total surface area of the ceiling wall, these two surface areas being projected onto a horizontal plane.

According to another optional feature of the invention, the ratio of the surface area of
10 the second portion of the ceiling wall to the total surface area of the ceiling wall is between 7% and 30%. This affords a compromise which offers high-level thermal insulation performance, while concentrating the through pipe(s) in a necessary but sufficient surface area.

According to another optional feature of the invention, the storage structure
15 comprises at least one closure device for the secondary space arranged at at least one junction between the first portion and the second portion of the ceiling wall.

The closure device is arranged in the thickness of the secondary space, to close off the latter and keep it sealed.

The closure device comprises a first closure member and at least one second closure
20 member, these closure members being secured to one another, as well as to the secondary space and to the supporting structure to seal the secondary space.

According to another feature of the invention, the primary space and the sealed and thermally insulating layer are in aeraulic communication with one another.

Note that a gas circulating in the primary space also circulates in the sealed and
25 thermally insulating layer.

According to another optional feature of the invention, the secondary space comprises, successively in the thickness direction from the outside toward the inside of the tank, a secondary thermally insulating barrier adapted to be in contact with the supporting structure and a secondary sealing membrane carried by the secondary
30 thermally insulating barrier, the primary space comprising, successively in the thickness direction from the outside toward the inside of the tank, a primary thermally insulating barrier resting against the secondary sealing membrane and a

primary sealing membrane carried by the primary thermally insulating barrier and intended to be in contact with the fluid contained in the tank, the sealed and thermally insulating layer comprising a thermally insulating wall resting against the supporting structure and an impermeable membrane carried by the thermally insulating wall and intended to be in contact with the fluid contained in the tank.

According to another optional feature of the invention, the primary thermally insulating barrier is in aeraulic communication with the thermally insulating wall.

According to another optional feature of the invention, a thickness of the thermally insulating wall measured in the second portion is at least equal to the sum of the thickness of the primary thermally insulating barrier and the thickness of the secondary space measured in the first portion.

The thickness is measured in a direction perpendicular to the main plane of extension of each of the portions.

According to another optional feature of the invention, the primary sealing membrane and the impermeable membrane extend in a common plane.

The impermeable membrane of the sealed and thermally insulating layer extends the primary sealing membrane of the primary space, that is to say in continuity with one another.

According to another optional feature of the invention, the ceiling wall is composed of at least two distinct facets, each of these facets extending in a plane secant to a or to the planes in which the other facets lie.

Note that the two facets each extend in a plane secant to the planes in which the plurality of side walls lie.

Furthermore, the ceiling wall may comprise a first facet extending in a plane perpendicular to the planes in which the plurality of side walls lie and two other facets each extending in a plane secant to one another, and to the plane in which the first facet lies and the planes in which the plurality of side walls lie. In other words, it could be envisaged, without thereby departing from the scope of the invention, that the ceiling wall extends mainly or at least partially in a plane perpendicular to the planes in which the plurality of side walls lie, the ceiling wall comprising two chamfers arranged on either side of the ceiling wall and connecting the ceiling wall to

two side walls each extending substantially in a plane parallel to the plane in which the other side wall lies.

According to another optional feature of the invention, the ceiling wall is composed of at least four distinct facets, each of these facets extending in a plane secant to the planes in which the other facets lie.

According to another optional feature of the invention, the four facets of the ceiling wall are symmetrical in pairs, forming two central facets and two outer facets.

In other words, the ceiling wall comprises two outer facets and two central facets, each outer facet comprising at least a first edge in contact with one of the side walls and a second edge in contact with one of the central facets, each central facet having a central edge in common with the other central facet, the plane of symmetry passing through the central edge common to the central facets.

According to another optional feature of the invention, the second portion of the ceiling wall is formed in at least one of the central facets of the ceiling wall.

According to another optional feature of the invention, the second portion of the ceiling wall is formed only in the central facets of the ceiling wall.

According to another optional feature of the invention, the supporting structure is composed at least partially of a material chosen from a metal, a metal alloy, concrete and/or a mixture thereof.

The present invention also relates to a transport and/or storage unit comprising at least one tank according to any one of the preceding features, the transport and/or storage unit consisting of a ship transporting a fluid, a barge, a reliquefaction unit, a gasification unit, an onshore structure or a gravity platform.

A ship transporting a fluid means a ship comprising a tank according to the invention loaded with fluid, such as liquefied natural gas for example, the ship transporting this fluid from one port to another.

The term “barge” means a category of ship transporting a fluid which is notable in that it has a flat bottom, facilitating the travel of such a barge in the various waterways, such as on rivers for example, or in a port.

“Gravity platform” means that the tank is at least partially submerged, in a port for example, and that a reliquefaction and/or gasification unit is installed in the ceiling of

the tank. More specifically, the tank may interact with the reliquefaction and/or gasification unit such that the tank stores liquefied gas coming from the liquefaction unit and/or supplies the gasification unit with liquefied gas.

The present invention also relates to a method for loading or unloading liquefied gas contained in a tank according to any one of the preceding features, in which a cold liquid product is conveyed through insulated pipelines from or to a floating or onshore storage facility, to or from a tank of a ship.

Further features, details and advantages of the invention will become more clearly apparent from reading the following description, and from a number of exemplary embodiments provided by way of non-limiting indication, with reference to the appended schematic drawings, in which:

[Fig. 1] is a perspective view of a tank according to the invention;

[Fig. 2] is a cross section through the tank according to figure 1;

[Fig. 3] is a perspective view of a first portion and a second portion of a ceiling wall of the tank according to figure 1;

[Fig. 4] is a cross section through a junction between the first portion and the second portion of the ceiling wall of the tank according to figure 3.

The features, variants and different embodiments of the invention may be combined with one another, in various combinations, as long as they are not mutually

incompatible or mutually exclusive. In particular, variants of the invention can be contemplated that only comprise a selection of features that are described hereafter independently of the other features described, if this selection of features is sufficient to provide a technical advantage and/or to differentiate the invention from the prior art.

In the description below, the designations “longitudinal”, “transverse” and “vertical” refer to the orientation of a sealed and thermally insulating tank according to the invention. A longitudinal direction corresponds to a main direction of extension of the sealed and thermally insulating tank, this longitudinal direction being parallel to a longitudinal axis L of a coordinate system L, V, T shown in the figures. A transverse direction corresponds to a direction parallel to a transverse axis along which an end wall of the sealed and thermally insulating tank mainly extends, this transverse direction being parallel to a transverse axis T of the coordinate system L, V, T and this

transverse axis T being perpendicular to the longitudinal axis L. Lastly, a vertical direction corresponds to a direction parallel to a vertical axis V of the coordinate system L, V, T, this vertical axis V being perpendicular to the longitudinal axis L and the transverse axis T.

5 Figure 1 shows a sealed and thermally insulating tank 1 generally in the shape of a rectangular parallelepiped. The tank 1 comprises a storage structure 2 and a supporting structure 4 surrounding the storage structure 2. The storage structure 2 is configured to contain and/or store a fluid, and more particularly a cryogenic liquid, such as for example liquefied natural gas or liquefied petroleum gas. The storage
10 structure 2 comprises a plurality of walls resting against the supporting structure 4. The latter is configured to support the plurality of walls when the tank 1 is at least partially filled with this fluid, this fluid exerting pressure on each of the walls of the plurality of walls.

According to a non-limiting example, this type of tank 1 is used in the onshore storage
15 of liquefied natural gas to contain liquefied natural gas and/or as a point of loading and/or unloading of a maritime transport vessel, such as for example a gravity platform. “Gravity platform” means that the tank is at least partially submerged, in a port for example, and that a liquefaction and/or gasification unit is installed in the ceiling of the tank. More specifically, the tank 1 may interact with the liquefaction
20 and/or gasification unit such that the tank stores liquefied gas coming from the liquefaction unit and/or supplies the gasification unit with liquefied gas.

Advantageously, the supporting structure 4 is formed by a concrete structure inside which the storage structure 2 is arranged. Note that, in this case, the walls of the supporting structure 4 comprise concrete, optimizing the structural support for the
25 tank 1 when it is installed at a dock, for example. Note that, in this case, the tank 1 may be an onshore tank, for example installed at a seaport to allow, on the one hand, a ship to be able to load/unload fluid from or to the tank 1, and on the other hand to allow access to the tank 1 from the land.

Furthermore, this tank 1 may also be used as a tank 1 for transporting liquefied
30 natural gas, or even as a fuel tank for a ship and/or a barge. Lastly, this tank 1 may also be used in maritime transport, as a tank 1 for transporting liquefied natural gas.

As shown here in figure 1, the tank 1 extends mainly in a longitudinal direction L. The plurality of walls of the storage structure 2 comprises a ceiling wall 6 and a bottom

wall 8 each extending generally in a plane parallel to the longitudinal direction L and to a transverse direction T, the latter being perpendicular to the longitudinal direction L. The storage structure 2 also comprises a plurality of side walls 10a, 10b extending at least in a vertical direction V perpendicular to the longitudinal direction L and to the transverse direction T between the bottom wall 8 and the ceiling wall 6. The plurality of side walls 10a, 10b in this case comprises two longitudinal walls 10a parallel to one another and two end walls 10b parallel to one another. The longitudinal walls 10a extend in the longitudinal direction L, the end walls 10b extending for their part in the transverse direction T between the two longitudinal walls 10a.

The supporting structure 4 takes the shape of the storage structure 2, surrounding the latter. To this end, the supporting structure 4 comprises a plurality of partitions 12, each of its partitions 12 advantageously extending parallel to one of the walls of the plurality of walls.

To facilitate understanding of the invention, one of the two end walls 10b of the supporting structure 4, and the partition of the supporting structure 4 adjacent to this end wall are marked in figure 1.

According to the invention and as shown in figure 1, the ceiling wall 6 comprises two distinct portions, a first portion 46 of which is composed of at least two spaces which are sealed relative to one another, and a second portion 48 being composed of at least a sealed and thermally insulating layer 50 in contact with the supporting structure 4 while contributing to defining an internal volume 44 of the tank 1.

The tank 1, and more particularly the storage structure 2, is configured to keep the liquefied natural gas at a temperature of no higher than -163°C . To this end, and as shown in figure 2, each wall of the storage structure 2, along with the first portion 46 of the ceiling wall 6, comprise successively in the thickness direction from the outside toward the inside of the tank 1, a sealed secondary space 28 and primary space 30, thermally insulating and sealed relative to one another.

The composition of each of the primary 30 and secondary 28 spaces as well as the composition of the sealed and thermally insulating layer 50 will now be described with reference to figure 2, which is a section through the tank 1 along a plane P advantageously parallel to the transverse T and vertical V directions.

More specifically, the secondary space 28 in the first portion 46 of the ceiling wall comprises, successively from the supporting structure 4 toward the primary space 30, a secondary thermally insulating barrier 32 and a secondary sealing membrane 34, the primary space 30 for its part comprising, successively from the secondary space
 5 28 toward the inside of the tank 1, a primary thermally insulating barrier 36 and a primary sealing membrane 38.

The secondary thermally insulating barrier 32 is a juxtaposition of heat-insulating self-supporting panels, each heat-insulating self-supporting panel comprising, successively from the supporting structure 4 toward the secondary sealing membrane
 10 34, a first plywood panel, a thermal insulation block and a second plywood panel. The thermal insulation block extends between the plywood panels and may be made of a synthetic alveolar material, such as polyurethane foam for example, allowing efficient and homogeneous thermal insulation. The secondary thermally insulating barrier 32, and more particularly the second plywood panel, is secured to the secondary sealing
 15 membrane 34, for example by adhesive bonding.

According to one alternative, the secondary thermally insulating barrier 32 comprises only the first plywood panel and the thermal insulation block, the latter extending between the first plywood panel and the secondary sealing membrane 34.

The secondary sealing membrane 34 comprises a rigid secondary sealing membrane
 20 40 and a flexible secondary sealing membrane 42, as can be seen more particularly in figure 4.

As shown in figure 2, the primary thermally insulating barrier 36 has the same components as the secondary thermally insulating barrier 32, these same components being superimposed in a similar manner. There is thus a thermal
 25 insulation block surmounted, in the thickness direction, by a plywood panel facing the sealing membrane 38. Reference may be made to the foregoing for the composition and function of each of these elements.

During assembly of the sealed and thermally insulating tank 1, the walls of the storage structure 2 are assembled by juxtaposition of the heat-insulating self-
 30 supporting panels. These assembly panels are then covered with the primary sealing membrane 38, which may be made of corrugated stainless steel. Note that, alternatively, the primary sealing membrane is for example made of sheet Invar®.

The primary sealing membrane 38 is intended to be in contact with the fluid contained in the tank 1 while helping to define the internal volume 44 of the tank 1.

The second portion 48 comprises, in the thickness direction from the supporting structure 4 toward the internal volume 44 of the tank 1, a thermally insulating wall 52 resting against the supporting structure 4 and an impermeable membrane 54 carried by the thermally insulating wall 52 and intended to be in contact with the fluid contained in the tank 1.

The thermally insulating wall 52 has the same composition as the primary and secondary thermally insulating barriers 32, 36 of the primary and secondary spaces 28, 30, and therefore comprises at least one thermal insulation block and a plywood panel secured to the supporting structure 4, by adhesive bonding for example.

The thermally insulating wall 52 of the sealed and thermally insulating layer 50 has a thickness at least equal to the sum of the thickness of the primary thermally insulating barrier 36 and the thickness of the secondary space 28 measured in the first portion 46. The thickness of the thermally insulating wall 52 is measured along an axis perpendicular to a plane in which the second portion 48 mainly extends, the thickness of the primary thermally insulating barrier 36 and the thickness of the secondary space 28 being measured in a direction perpendicular to a plane in which the first portion 46 mainly extends. In other words, the thickness of the thermally insulating wall 52 is the sum of the thicknesses of the secondary thermally insulating barrier 32, the secondary sealing membrane 34 and the primary thermally insulating barrier 36.

Furthermore, and according to the example shown here, the thermally insulating wall 52 of the sealed and thermally insulating layer 50 is in aeraulic communication with the primary thermally insulating barrier 36 of the primary space 30. To be specific, an inerting fluid circulates in the primary thermally insulating barrier 36 of the primary space 30 and may also pass through the thermally insulating wall 52 of the sealed and thermally insulating layer 50.

The impermeable membrane 54 is secured to the thermally insulating wall 52 and has the same composition as the primary sealing membrane 38, that is to say corrugated stainless steel or sheet Invar®. The impermeable membrane 54 is welded at at least one of its ends to the primary sealing membrane 38, ensuring continuity of the ceiling wall 6 between the first portion 46 and the second portion 48.

According to the example shown in figure 2, the impermeable membrane 54 of the sealed and thermally insulating layer 50 and the primary sealing membrane 38 of the primary space 30 extend at least partially in a common plane, the impermeable membrane 54 extending the primary sealing membrane 38 of the primary space 30 onto the sealed and thermally insulating layer 50 in the second portion 48.

According to the example shown in figure 2, the storage structure also comprises at least one closure device 58 for the secondary space 28 arranged at at least one junction between the first portion 46 and the second portion 48 of the ceiling wall 6. The closure device 58 is described with reference to figure 4.

The shape of the ceiling wall 6 of the supporting structure 2 will now be described with reference to figures 1, 2 and 3.

The ceiling wall 6 is composed of at least four distinct facets 14, 16, 18, 20, each of these facets 14, 16, 18, 20 extending in a plane secant to the planes in which the other facets 14, 16, 18, 20 lie. In other words, the plane of one of the facets 14, 16, 18, 20 is secant to the other three planes in which the other facets 14, 16, 18, 20 extend. Each facet extends longitudinally between each end wall 10b of the supporting structure 4.

The four facets 14, 16, 18, 20 of the ceiling wall 6 are symmetrical in pairs, forming two central facets 14, 16 and two outer facets 18, 20. The storage structure 2 comprises a plane of symmetry which passes through a vertex 26 of the tank and which extends in a longitudinal and vertical plane, one central facet and one outer facet being symmetrical with the other central facet and the other outer facet. Thus, the ceiling wall 6 comprises a first outer facet 18 and a second outer facet 20 flanking, in the transverse direction T, a first central facet 14 and a second central facet 16.

Each outer facet 18, 20 extends between a first edge 22 and a second edge 24, the first edge 22 being in contact with one of the longitudinal walls 10a of the supporting structure 4, the second edge 24 being for its part in contact with one of the central facets 14, 16. Each outer facet 18, 20 extends in a plane secant to one of the main planes of extension of one of the longitudinal walls 10a, the angle formed having a value between 0° and 30° .

Each central facet 14, 16 extends between the second edge 24 of one of the outer facets 18, 20 and a vertex 26, the vertex 26 being common to the two central facets 14, 16. The first central facet 14 extends in a plane secant to the plane in which the

second central facet 16 lies, the angle formed having a value between 0° and 30° , and preferably between 5° and 15° . Furthermore, the plane of symmetry of the facets 14, 16, 18, 20 of the ceiling wall 6 mentioned above passes through the vertex 26 common to the two central facets 14, 16.

5 In the example shown in figure 2, the second portion 48 of the ceiling wall 6 is formed in at least one of the central facets 14, 16 of the ceiling wall 6. However, a second portion 48 extending only over one of the central facets 14, 16 or only over one of the outer facets 18, 20 would not depart from the scope of the invention and would constitute an embodiment that has not been shown.

10 In another alternative embodiment, the two central facets 14, 16 form a single same facet extending in a plane secant to the planes in which the outer facets 18, 20 lie.

The tank 1 comprises a pipe 60 passing through at least the supporting structure 4 and the storage structure 2 in the second portion 48 of the ceiling wall 6. More specifically, the through pipe 60 extends at the vertex 26 of the central facets 14, 16, 15 passing through, successively from the outside of the tank 1 toward the internal volume 44 of the tank 1, a partition 12 of the supporting structure 4, the thermally insulating wall 52 and the impermeable membrane 54. A sealing device is installed between the through pipe 60 and the sealed and thermally insulating layer 50 to prevent any infiltration of the fluid contained in the tank 1 into the ceiling wall 6, 20 while limiting heat loss.

This figure clearly illustrates the advantage gained from the invention. It can be clearly seen here that it is necessary to design, manufacture and assemble a single sealing device since the through pipe 60 passes through one, and only one, layer. The means are therefore simpler and more economical.

25 According to the invention and as shown in figure 3, a ratio of the surface area of the second portion 48 of the ceiling wall 6 to the total surface area of the ceiling wall 6 is between 5% and 60%.

To calculate this ratio, the surface area of the second portion 48 is compared with the total surface area of the ceiling wall 6. In this case, the second portion 48 extends 30 over part of the central facets 14, 16 and takes on a rectangular shape. A first length D1 of the ceiling wall 6 and a second length D1' of the second portion 48 are measured, each of these lengths D1, D1' being measured in the longitudinal direction

L between, respectively, the longitudinal ends of the ceiling wall 6 and the longitudinal ends of the second portion 48.

A first width D2 of the ceiling wall 6 and a second width D2' of the second portion 48 are also measured. More specifically, the first width D2 is a sum of the widths of each of the facets 14, 16, 18, 20, the widths of the outer facets 18, 20 being measured perpendicular to the longitudinal direction L between their first edges 22 and their second edges 24, the widths of the central facets 14, 16 being measured perpendicular to the longitudinal direction L between their second edges 24 common with the outer facets 18, 20 and the vertex 26.

The second width D2' of the second portion 48 is the sum of the widths of the second portion 48 measured along each of the central facets 14, 16 between a transverse end of the second portion 48, corresponding to a join between the first portion 46 and the second portion 48, and the vertex 26 common to the two central facets 14, 16.

The surface area of the ceiling wall 6 is then calculated, taking the product of the first length D1 and the first width D2, as is the surface area of the second portion 48, taking the product of the second length D1' and the second width D2'. The ratio of the surface area of the second portion 48 to the total surface area of the ceiling wall 6 is then calculated, this ratio being expressed as a percentage.

The calculation of this ratio may be summarized by the following equation, where R corresponds to the ratio of the second portion 48 relative to the total surface area of the ceiling wall 6 and is expressed as a percentage (%), each of the lengths D1, D1' and widths D2, D2' being expressed in the same unit, for example in meters (m):

$$[\text{MATH } 1]: R = \frac{D1' * D2'}{D1 * D2} * 100$$

the ratio R according to the invention being between 5% and 60%, and advantageously between 7% and 30%.

The closure device 58 for the secondary space 28 at the junction between the first and second portions 46, 48 will now be described with reference to figure 4, in the plane U.

The closure device 58 comprises a first closure member 62 and at least one second closure member 64 configured to interact with one another in such a way as to

separate the secondary space 28 of the first portion 46 from the sealed and thermally insulating layer 50 constituting the second portion 48.

Each of the closure members 62, 64 has an “L” profile seen in a vertical cross-sectional plane of the ceiling wall 6. Each closure member 62, 64 comprises a first part 66 and at least one second part 68 extending in secant planes. In this case, each closure member 62, 64 comprises a bent part 70 connecting the first parts 66 to the respective second parts 68 of each of the closure members 62, 64.

The first part 66 of the first closure member 62 extends in this case at least partially between the secondary space 28 and the primary space 30 of the first portion 46. The secondary thermally insulating barrier 32 has an area for securing the first part 66 of the first closure member 62 in which a portion of the secondary sealing membrane 34 is extended by a plate 72 formed between the secondary space 28 and the primary space 30. More specifically, the plate 72 in this case extends the rigid secondary sealing membrane 40, the flexible secondary sealing membrane 42 at least partially covering the plate 72, in such a way as to ensure a seal between the plate 72 and the rigid secondary sealing membrane 40.

The plate 72 is secured by a first securing device 74, such as a screw or a rivet for example, to the secondary thermally insulating barrier 32. The first part 66 of the first closure member 62 is secured to the plate 72, for example by means of a weld bead, such that the first part 66 of the first closure member 62 is formed at least between the plate 72 and the primary space 30.

More specifically, and as shown in figure 4, the secondary thermally insulating barrier 32 comprises at least one thermally insulating self-supporting panel 71 having an external face 78 secured to the supporting structure 4 by a securing element 80, such as mastic for example, an internal face 82 to which the plate 72 of the secondary space 28 is secured, and a thickness face 84 extending between the external face 78 and the internal face 82 and facing the second portion 48 of the ceiling wall. Each of the faces 78, 82, 84 of the self-supporting panel 71 includes a plywood plate 81. It is on or in these plywood plates 81 that the first and/or second securing devices 74, 76 are secured, in particular by screwing or riveting.

Furthermore, the secondary thermally insulating barrier 32 has a chamfer 86 connecting the internal face 82 to the thickness face 84 of the secondary barrier. The bent part 70 of the first closure member 62 is arranged in line with the chamfer 86.

According to one alternative of the invention, the plywood plate 81 on the internal face 82 of the secondary thermally insulating barrier 32 may be placed only at the plate 72, such that the first securing device 74 can be secured in the plywood plate 81. The thermal insulation block constituting the secondary thermally insulating barrier 32 is thus directly covered by the secondary sealing membrane 34 on the internal face 82 of the secondary thermally insulating barrier 32.

The first closure member 62 is positioned against the secondary thermally insulating barrier 32 such that the second part 68 of the first closure member 62 extends along the thickness face 84 of the secondary thermally insulating barrier 32. The second part 68 of the first closure member 62 is secured to the secondary thermally insulating barrier 32 on the thickness face 84 by a second securing device 76 such as, for example, a screw or a rivet.

According to the example shown here in figure 4, the second part 68 of each closure member 62, 64 extends in a plane perpendicular to the planes in which the first parts 66 of the first and second closure member 62, 64 extend. The second part 68 of the first closure member 62 thus extends from the bent part 70 of the first closure member 62 toward the supporting structure 4, the second part 68 of the second closure member 64 extending from the bent part 70 of the second closure member 64 toward the internal volume of the tank. In this arrangement, the second parts 68 of each of the closure members 62, 64 are welded together in a sealed manner.

The first closure member 62 and the second closure member 64 are positioned head to tail.

The first part 66 of the second closure member 64 extends for its part at least partially between the sealed and thermally insulating layer 50 of the second portion 48 and the supporting structure 4. The first part 66 of the second closure member 64 is secured to the supporting structure 4. To this end, the supporting structure 4 comprises an insert, such as a plate for example, in the area where the first part 66 of the second closure member 64 has to be secured. According to one example of the invention, the insert of the supporting structure 4 is metal, the first part 66 of the second securing device 76 being secured to the insert of the supporting structure 4 by at least one weld bead.

According to the example shown here, the second parts 68 of the closure members 62, 64, part of the thermally insulating wall 52 and part of the primary thermally

insulating barrier 36 help delimit a space 92 filled with a thermally insulating component, such as glass wool or rock wool, or flexible polymer foam, for example.

Moreover, at least the first closure member 62 and the second closure member 64 of the closure device 58 are elastically deformable. The various components of the ceiling wall may be caused to contract and/or expand, for example owing to the movements of the swell or owing to a sudden change in temperature. The first closure member 62 and the second closure member 64 of the closure device 58 are configured to be able to match these contraction or expansion movements of the components of the ceiling wall 6. More specifically, the fact that the first parts 66 and the second parts 68 of each of the closure members 62, 64 extend in secant planes allows each of the closure members 62, 64 to open or close around a point formed at the intersection of these secant planes.

The invention also relates to a method for loading or unloading liquefied gas contained in the tank described above, in which a cold liquid product is conveyed through insulated pipelines from or to a floating or onshore storage facility, to or from a tank of a ship.

The invention should not be limited to the means and configurations described and illustrated herein, however, but also extends to any equivalent means and any equivalent configuration described and illustrated herein and to any technically functional combination of such means. In particular, the position of the second portion, in this case on the central facets of the ceiling wall, may in another embodiment be formed on at least one other facet. Furthermore, a ceiling wall may comprise two or more areas where a second portion as described above extends without thereby departing from the scope of the invention. Lastly, a plurality of through pipes 60, like that shown in figure 2, may pass through the second portion.

CLAIMS

1. A sealed and thermally insulating tank (1) comprising at least a storage structure (2) for storing a fluid and a supporting structure (4) surrounding the storage structure (2), the storage structure (2) comprising a plurality of walls including at least a ceiling wall (6), a bottom wall (8) and a plurality of side walls (10a, 10b) extending between the ceiling wall (6) and the bottom wall (8), at least the ceiling wall (6) comprising a first portion (46) and a second portion (48), the first portion (46) comprising, successively in the thickness direction from the outside toward the inside of the tank (1), a sealed and thermally insulating secondary space (28) and a sealed and thermally insulating primary space (30), the secondary space (28) being configured to be in contact with the supporting structure (4), the primary space (30) delimiting an internal volume (44) configured to receive the fluid contained in the tank (1), the second portion (48) comprising a sealed and thermally insulating layer (50), characterized in that the sealed and thermally insulating layer (50) of the second portion (48) is in contact with the supporting structure (4) while helping to delimit the internal volume (44) of the tank (1), a ratio of the surface area of the second portion (48) of the ceiling wall (6) to the total surface area of the ceiling wall (6) being between 5% and 60%.
2. The tank (1) as claimed in claim 1, wherein the ratio of the surface area of the second portion (48) of the ceiling wall (6) to the total surface area of the ceiling wall (6) is between 7% and 30%.
3. The tank (1) as claimed in any one of the preceding claims, wherein the storage structure (2) comprises at least one closure device (58) for the secondary space (28) arranged at at least one junction between the first portion (46) and the second portion (48) of the ceiling wall (6).
4. The tank (1) as claimed in any one of the preceding claims, wherein the primary space (28) and the sealed and thermally insulating layer (50) are in aeraulic communication with one another.
5. The tank (1) as claimed in any one of the preceding claims, wherein the secondary space (28) comprises, successively in the thickness direction from the outside toward the inside of the tank (1), a secondary thermally insulating barrier (32) adapted to be in contact with the supporting structure (4) and a secondary sealing membrane (34) carried by the secondary thermally insulating barrier (32), the

primary space (30) comprising, successively in the thickness direction from the outside toward the inside of the tank (1), a primary thermally insulating barrier (36) resting against the secondary sealing membrane (34) and a primary sealing membrane (38) carried by the primary thermally insulating barrier (36) and intended to be in contact with the fluid contained in the tank (1), the sealed and thermally insulating layer (50) comprising a thermally insulating wall (52) resting against the supporting structure (4) and an impermeable membrane (54) carried by the thermally insulating wall (52) and intended to be in contact with the fluid contained in the tank (1).

10 **6.** The tank (1) as claimed in claim 5, wherein a thickness of the thermally insulating wall (52) measured in the second portion (48) is at least equal to the sum of the thickness of the primary thermally insulating barrier (36) and the thickness of the secondary space (28) measured in the first portion (46).

15 **7.** The tank (1) as claimed in either of claims 5 or 6, wherein the primary sealing membrane (38) and the impermeable membrane (54) extend in a common plane.

8. The tank (1) as claimed in any one of the preceding claims, wherein the ceiling wall (6) is composed of at least two distinct facets (14, 16, 18, 20), each of these facets (14, 16, 18, 20) extending in a plane secant to the planes in which the other facet or facets (14, 16, 18, 20) lie.

20 **9.** The tank (1) as claimed in any one of the preceding claims, wherein the ceiling wall (6) is composed of at least four distinct facets (14, 16, 18, 20), each of these facets (14, 16, 18, 20) extending in a plane secant to the planes in which the other facets (14, 16, 18, 20) lie.

25 **10.** The tank (1) as claimed in claim 9, wherein the four facets (14, 16, 18, 20) of the ceiling wall (6) are symmetrical in pairs, forming two central facets (14, 16) and two outer facets (18, 20).

11. The tank (1) as claimed in claim 10, wherein the second portion (48) of the ceiling wall (6) is formed in at least one of the central facets (14, 16) of the ceiling wall (6).

30 **12.** The tank (1) as claimed in any one of the preceding claims, wherein the supporting structure (4) is composed at least partially of a material chosen from a metal, a metal alloy, concrete and/or a mixture thereof.

13. A transport and/or storage unit comprising at least one tank (1) as claimed in any one of the preceding claims and consisting of a ship transporting a fluid, a barge, a reliquefaction unit, a gasification unit, an onshore structure or a gravity platform.

14. A method for loading or unloading liquefied gas contained in a tank (1) as
5 claimed in any one of claims 1 to 12, in which a cold liquid product is conveyed through insulated pipelines from or to a floating or onshore storage facility, to or from a tank of a ship.