

Description

Title of the invention: Liquefied gas storage facility with a tensioned secondary membrane

Technical field

5 [0001] The invention relates to the field of liquefied gas storage facilities comprising a sealed and thermally insulating tank with a sealing membrane.

[0002] In particular, the invention relates to the field of sealed and thermally insulating tanks for storing and/or transporting liquefied gas at low temperature, such as tanks for transporting liquefied petroleum gas (LPG) having for example a temperature of between
10 -50°C and 0°C, or for transporting liquefied natural gas (LNG) at approximately -162°C at atmospheric pressure. These tanks may be installed onshore or on a floating structure. In the case of a floating structure, the tank may be intended to transport liquefied gas or to receive liquefied gas that is used as fuel to propel the floating structure.

[0003] The storage facility can be installed onshore or on a floating structure. In the case of
15 a floating structure, the facility may be intended to transport liquefied gas or to receive liquefied gas that is used as fuel to propel the floating structure.

Technological background

[0004] Document WO2023/001678 describes a liquefied gas storage facility comprising a tank incorporated in the load-bearing structure of a carrier. The walls of the tank have a
20 multilayer structure comprising, in the thickness direction, from the outside to the inside: a secondary thermally insulating barrier retained on the load-bearing structure, a secondary sealing membrane fixed to the secondary thermally insulating barrier, a primary thermally insulating barrier fixed to the secondary thermally insulating barrier via the secondary sealing membrane, and a primary sealing membrane which is fixed to the primary thermally
25 insulating barrier and is intended to be in contact with the liquefied gas stored inside the tank. The secondary sealing membrane has a plurality of parallel strakes. Each strake has a flat central portion which extends in the longitudinal direction of the tank and two turned-up edges arranged one on each side of the flat central portion and protruding toward the inside of the tank with respect to the central portion. Such a secondary sealing membrane,
30 usually denoted "tensioned membrane", does not make it possible to take up the tensile and compressive loads in the longitudinal direction, by contrast to a corrugated membrane.

[0005] The ceiling wall of the tank is interrupted at a loading/offloading opening through which pipes for loading and/or offloading the liquefied gas pass. The secondary sealing membrane is stopped and is attached directly to the supporting structure by means of secondary attachment brackets so as to take up the tensile and compressive forces resulting in particular from the thermal contraction of the secondary sealing membrane and from the deformation of the hull of the carrier related to the deflection of the carrier beam. In order to relieve the secondary attachment brackets, the secondary thermally insulating barrier has, along the front transverse edge, a particular arrangement notably comprising a plurality of secondary fixing supports, made of metal, to which are fixed secondary stop beams against which the corresponding secondary attachment bracket rests. The secondary fixing supports comprise a secondary base having two branches which are anchored to the load-bearing structure and a secondary cap which is welded to the secondary base.

[0006] The secondary stop beams are prevented from moving translationally in the longitudinal direction. To this end, the secondary fixing supports have stop devices which are fixed to the secondary cap of said secondary fixing supports. Each of the ends of the secondary stop beams is thus held in position in the longitudinal direction between a stop device and an end of one of the branches of the secondary base.

Summary of the invention

[0007] An idea on which the invention is based is to provide a liquefied gas storage facility of the type mentioned above in which the secondary stop beams are straightforwardly and reliably prevented from moving translationally in the longitudinal direction.

[0008] According to one embodiment, the invention provides a liquefied gas storage facility comprising a load-bearing structure and a sealed and thermally insulating tank supported by the load-bearing structure, the load-bearing structure having an upper load-bearing wall and the tank having a ceiling wall which is fixed to the upper load-bearing wall, said ceiling wall comprising, in a thickness direction, from the outside to the inside of the tank: a secondary thermally insulating barrier fixed to the upper load-bearing wall, a secondary sealing membrane resting against the secondary thermally insulating barrier, a primary thermally insulating barrier resting against the secondary sealing membrane, and a primary sealing membrane resting against the primary thermally insulating barrier and intended to be in contact with the liquefied gas, said ceiling wall being interrupted locally so as to delimit a loading/offloading opening intended to have loading/offloading pipes passing through it, said loading/offloading opening being defined by a first and a second transverse edge,

which are parallel to a transverse direction, and a first and a second longitudinal edge, which are parallel to a longitudinal direction perpendicular to the transverse direction;

the secondary thermally insulating barrier of the ceiling wall having:

- 5 - at least one first and one second secondary fixing support positioned along the first transverse edge; the first and second secondary fixing supports each comprising a secondary base which is anchored to the upper load-bearing wall, a secondary cap which is welded to the secondary base and which extends parallel to the longitudinal direction, in a plane parallel to the upper load-bearing wall, and a holding plate which is fixed to the
- 10 secondary cap by fixing members;
- at least one secondary insulating edging block which is arranged along the first transverse edge, between the first and the second secondary fixing supports; and
- at least one secondary stop beam which extends along the first transverse edge and rests at least against the secondary cap of each of the first and second secondary fixing supports
- 15 and against one of the secondary insulating edging blocks, said secondary stop beam being immobilized, in the thickness direction of the ceiling wall, between the holding plate and the secondary cap of each of the first and second secondary fixing supports; the secondary stop beam comprising support brackets which are fixed to the secondary stop beam;
- 20 each of the first and second secondary fixing supports comprising a stop device which is configured to press the secondary stop beam against a stop surface of said first or second secondary fixing support in order to prevent the secondary stop beam from moving translationally in the longitudinal direction; each stop device comprising a support fixed to the secondary cap and a set screw which is mounted for movement in the longitudinal
- 25 direction in a tapped bore provided in said support and which bears against one of the support brackets.

[0009] As a result, since the support brackets are positioned between the set screw and the stop beam, they make it possible to prevent the beam from being dented in the zone in contact with the set screws. In addition, since the support brackets are fixed to the

30 secondary stop beam and preassembled thereon, while the secondary stop beam is being fitted they are positioned at the same time, and this makes it easier to realize the function of preventing the secondary stop beam from moving translationally in the longitudinal direction of installation. Another advantage of the set screws is to allow adjustment of the position of the secondary stop beam in the longitudinal direction.

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

[0011] According to one embodiment, each support bracket has a first tab which is arranged against an outer face of the secondary stop beam and a second tab which is perpendicular
5 to the first tab and against which the set screw of the stop device of one of the first and second secondary fixing supports bears.

[0012] According to one embodiment, the outer face of the secondary stop beam rests against the secondary cap of the secondary support devices and against the secondary insulating edging block.

10 [0013] According to an advantageous embodiment, mastic is positioned between the outer surface of the secondary stop beam and the secondary cap of the secondary support devices, and also between the outer surface of the secondary stop beam and the secondary insulating edging block. This makes it possible to adjust the position of the secondary stop beam in the thickness direction of the ceiling wall.

15 [0014] According to one embodiment, the outer face of the secondary stop beam has recesses in which the first tabs of the support brackets are embedded. This makes it possible to ensure the flatness of the bearing surface of the secondary stop beam with which the latter bears against the secondary cap of the secondary fixing supports and the secondary insulating edging block.

20 [0015] According to one embodiment, the secondary stop beam has at least two cutouts which respectively accommodate the stop device of the first and of the second secondary fixing support, the second tab of each of the support brackets being positioned against an edge of one of the cutouts.

[0016] According to one embodiment, the support brackets are made of metal. As a result,
25 the support brackets have sufficient mechanical strength to withstand the forces exerted by the set screws.

[0017] According to one embodiment, the support brackets are fixed to the secondary stop beam by fixing members, such as screws for example. This ensures a straightforward and reliable fixing of the support brackets to the secondary stop beam.

30 [0018] According to one embodiment, the secondary stop beam is equipped with at least one metal stiffening strip which extends in the transverse direction along said secondary stop

beam. Such a stiffening strip makes it possible to reinforce the secondary stop beam and increase its stiffness.

[0019] According to one embodiment, the metal stiffening strip is fixed against an inner surface of the secondary stop beam.

5 [0020] According to one embodiment, the inner face of the secondary stop beam has a recess in which the metal stiffening strip is embedded.

[0021] According to one embodiment, the support of the stop devices comprises a plate which is welded to the secondary cap, perpendicularly thereto, and a reinforcement in the form of a gusset which is welded between the plate and the secondary cap.

10 [0022] According to one embodiment, the secondary base has two branches connected to one another by a central web, the branches extending in planes that are parallel to the transverse direction.

[0023] According to one embodiment, the stop surface of the first and second secondary fixing supports is formed by an end of one of the branches of the secondary base that
15 protrudes inward beyond the secondary cap.

[0024] According to one embodiment, the facility comprises a first and a second primary anchoring device which are fixed to the first and to the second secondary fixing supports, respectively, each of the first and second primary anchoring devices having a threaded shank which passes tightly through an orifice provided in the secondary sealing membrane,
20 a bearing element which is fitted on the threaded shank and which bears, in the direction of the upper load-bearing wall, against a bearing zone of one or more insulating elements of the primary thermally insulating barrier, and a nut which is screwed onto the threaded shank so as to hold the bearing element against the bearing zone(s) of the insulating elements of the primary thermally insulating barrier; said threaded shank being fixed to the
25 holding plate of one of the first and second secondary fixing supports.

[0025] The holding plate thus provides a dual functionality, namely: immobilizing the secondary stop beam in the thickness direction of the ceiling wall and fixing the primary anchoring device to the secondary fixing supports, thereby allowing the structure of the ceiling wall in the zone of the loading/offloading opening to be even further simplified.

30 [0026] According to one embodiment, the primary thermally insulating barrier comprises primary insulating edging blocks which are arranged along the first longitudinal edge and which have a bearing zone, each bearing element bearing against a bearing zone of two

adjacent primary insulating edging blocks. This makes it possible to limit the number of primary anchoring devices necessary for the fixing of the primary thermally insulating barrier and therefore the number of leaktight passages through the secondary sealing membrane.

- 5 [0027] According to one embodiment, the bearing zones of the primary insulating edging blocks are formed by battens.

[0028] According to one embodiment, the holding plate is fixed to the secondary cap by adjustable fixing members in order to allow the holding plate to move relative to the secondary cap, in the thickness direction of the ceiling wall.

- 10 [0029] According to one embodiment, the secondary stop beam has an end provided with a recess which receives the holding plate in such a way that said holding plate lies flush with an inner surface of the secondary stop beam. This makes it possible to ensure the flatness of the support surface against which the first wing of the secondary attachment bracket and the secondary sealing membrane are positioned.

- 15 [0030] According to one embodiment, the first transverse edge is in front of or behind the loading/offloading opening.

- [0031] A facility according to one of the aforementioned embodiments may be an onshore storage facility, for example for storing LNG, or be installed in a floating, inshore or offshore structure, in particular an LNG or ethane carrier, a floating storage and regasification unit (FSRU), a floating production storage and offloading (FPSO) unit, and the like. In the case of a floating structure, the tank may be intended to receive liquefied natural gas that is used as fuel to propel the floating structure.
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[0032] According to one embodiment, the invention relates to a carrier for transporting a fluid, the carrier comprising a facility of the aforementioned type.

- 25 [0033] According to one embodiment, the carrier has a double hull which forms the load-bearing structure.

- [0034] According to one embodiment, the invention also provides a system for transferring a fluid, the system comprising the aforementioned carrier, insulated pipelines arranged in such a way that they connect the tank of the carrier to a floating or onshore storage facility, and a pump for driving a stream of fluid through the insulated pipelines to or from the floating or onshore storage facility from or to the tank of the carrier.
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[0035] According to one embodiment, the invention also provides a method for loading or offloading such a carrier, wherein a fluid is conveyed through insulated pipelines from or to a floating or onshore storage facility to or from the tank of the carrier.

Brief description of the figures

5 [0036] The invention will be better understood, and further aims, details, features and advantages thereof will become more clearly apparent, throughout the following description of several particular embodiments of the invention, which are provided solely by way of a non-limiting illustration, with reference to the appended drawings.

[0037] Figure 1 is a schematic view of a carrier comprising a storage facility.

10 [0038] Figure 2 is a partial perspective view from below of a ceiling wall according to a first embodiment, in a zone close to a loading/offloading opening interrupting the ceiling wall of the tank, said view corresponding to detail II in Figure 1.

[0039] Figure 3 is a view in longitudinal section of the ceiling wall, close to the rear cofferdam wall.

15 [0040] Figure 4 is a partial perspective view of the secondary thermally insulating barrier, along the rear transverse edge of the loading/offloading opening.

[0041] Figure 5 is a perspective view of a secondary fixing support.

[0042] Figure 6 is a partial transverse view of the secondary thermally insulating barrier, along the rear transverse edge of the loading/offloading opening.

20 [0043] Figure 7 is a perspective view of a beam intended to rest against the secondary fixing supports.

[0044] Figure 8 is a cut-away schematic depiction of a tank of an LNG carrier and a terminal for loading/offloading this tank.

Description of the embodiments

25 [0045] By convention, the terms "outer" and "inner" are used to define the position of one element relative to another, with reference to the outside and to the inside of the tank. In addition, in the figures, the arrows L and T correspond to the longitudinal and transverse directions, respectively, of the tank, which are perpendicular to one another. By extension, in the embodiments shown, the arrows L and T also correspond to the longitudinal and
30 transverse directions of the carrier since, in these embodiments, the tanks have the same orientation as the carrier.

[0046] Figure 1 shows a carrier 70, for example an LNG carrier, for storing and transporting liquefied gas. The carrier 70 comprises a storage facility 1 comprising multiple tanks 71 arranged in the inner hull of the carrier. For this purpose, the inner hull has a plurality of polyhedral compartments which are defined by a plurality of load-bearing walls and which are each intended to form a load-bearing structure receiving one of the tanks 71 of the carrier 1. The inner hull has load-bearing cofferdam walls which extend transversely to the longitudinal direction L of the carrier and which delimit cofferdam spaces segmenting the inner hull into multiple compartments.

[0047] Each tank 71 is polyhedral and has a plurality of tank walls joined to one another and fixed against the load-bearing walls, and in particular a ceiling wall 4, a rear cofferdam wall 82 and a front cofferdam wall 83. The front cofferdam wall 82 and rear cofferdam wall 83 are spaced apart in the longitudinal direction L of the carrier 70 and are fixed against one and the other of the two load-bearing cofferdam walls.

[0048] In order to load the liquefied gas into the tank and offload it, there is a loading/offloading opening (not shown in Figure 1) which is formed in the ceiling wall 4 and through which pipes intended for the loading and/or offloading of the liquefied gas pass. The loading/offloading opening is provided in the ceiling wall 4 close to the rear cofferdam wall 82 (zone II in Figure 1).

[0049] The upper load-bearing wall of the load-bearing structure 2 also has orifices allowing the pipes to pass through the load-bearing structure 2. The loading/offloading opening serves as an entry point for various pieces of equipment for handling the liquefied natural gas, and in particular one or more of the following pieces of equipment: a filling line, an emergency pumping line, offloading lines connected to offloading pumps, a spray line, a feed line connected to a spray pump, etc. According to one embodiment, a loading/offloading tower (not shown) passes through the loading/offloading opening. The loading tower has vertical masts which are fixed to one another by crossbars. The vertical masts are hollow and thus each define a loading line, a loading line or a relief well allowing the descent of a relief well.

[0050] Figure 2 shows a perspective view of a ceiling wall 4 from the inside of the tank in a zone close to the loading/offloading opening 14. The loading/offloading opening 14 has a rectangular shape and is defined by two longitudinal edges 5, parallel to the longitudinal direction L of the tank, and two transverse edges 6, parallel to the transverse direction.

[0051] In relation to Figure 3, the multilayer structure of the ceiling wall 4 can be observed.

The ceiling wall 4 comprises successively, in the thickness direction, from the outside to the inside of the tank: a secondary thermally insulating barrier 7 held on the upper load-bearing wall 8, a secondary sealing membrane 9 bearing against the secondary thermally insulating barrier 7, a primary thermally insulating barrier 10 bearing against the secondary sealing membrane 9 and a primary sealing membrane 11 bearing against the thermally insulating barrier 10 and intended to be in contact with the liquefied natural gas contained in the tank.

[0052] The secondary thermally insulating barrier 7 has a plurality of secondary insulating panels 12 which are anchored to the upper load-bearing wall 8 by means of secondary anchoring devices (not shown in Figure 3). Additionally or alternatively, the secondary insulating panels 12 are adhesively bonded to the upper load-bearing wall 8 by strips of mastic. The secondary insulating panels 12 have a parallelepipedal overall shape and are, for example, arranged in parallel rows, in the longitudinal direction L and in the transverse direction T.

[0053] The secondary sealing membrane 9 of the ceiling wall 4 has a continuous layer of metal strakes, with turned-up edges. Each strake extends in the longitudinal direction L and has a flat central portion resting on the secondary insulating panels 12. Each strake also has two turned-up edges arranged one on each side of the flat central portion and protruding toward the inside of the tank with respect to the central portion. The strakes are welded by their turned-up edges to parallel welding supports which are fixed in grooves provided in the inner surface of the secondary insulating panels 12, which is to say the surface in contact with the secondary sealing membrane 9. The strakes are, for example, made of Invar®: that is to say an alloy of iron and nickel of which the coefficient of expansion is typically between 1.10^{-6} and 2.10^{-6} K^{-1} , or an alloy of iron and manganese of which the coefficient of expansion is typically between 7.10^{-6} and 9.10^{-6} K^{-1} .

[0054] The primary thermally insulating barrier 10 has a plurality of primary insulating panels 13 which are anchored to the secondary insulating panels 12 by means of primary anchoring devices (also not shown in Figure 3). The primary insulating panels 13 have a parallelepipedal overall shape. The primary insulating panels 13 can in particular be positioned offset with respect to the secondary insulating panels 12 in the longitudinal direction L, and optionally also in the transverse direction T.

[0055] According to one embodiment, the secondary insulating panels 12 and the primary insulating panels 13 comprise a baseplate, a cover plate and one or more layers of

insulating polymer foam sandwiched between the baseplate and the cover plate and adhesively bonded thereto. The insulating polymer foam can in particular be a polyurethane-based foam optionally reinforced with fibres, in particular glass fibres.

5 [0056] The primary sealing membrane 11 has a plurality of corrugated metal plates juxtaposed in the longitudinal direction L and in the transverse direction T, and welded to one another along their edges. The primary sealing membrane 11 has corrugations extending parallel to the longitudinal direction L and corrugations extending parallel to the transverse direction T.

10 [0057] In order to delimit the loading/offloading opening 14, the ceiling wall 4 is locally interrupted. As a result, the primary sealing membrane 11 and secondary sealing membrane 9, and the primary thermally insulating barrier 10 and secondary thermally insulating barrier 7, are interrupted all the way around the loading/offloading opening 14.

15 [0058] Returning to Figure 2, a cover 15 arranged in the loading/offloading opening 14 can be seen. The cover 15 has a metal sealing wall 16 and a thermal insulation structure 17 located between the metal sealing wall 16 and the upper load-bearing wall 8. The cover 15 is fixed to the upper load-bearing wall 8. The metal sealing wall 16 continues the sealing provided by the primary sealing membrane 11 of the ceiling wall 4 whereas the thermal insulation structure 17 continues the insulation.

20 [0059] The thermal insulation structure 17 may comprise one or more insulating cover blocks, produced for example in the form of boxes having a baseplate, a cover plate and load-bearing spacers extending, in the thickness direction, between the baseplate 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(s) have holes (not shown) for the passage of the unloading/offloading pipes.

25 [0060] The metal sealing wall 16 of the cover 14 has, for example, a plurality of metal plates welded to one another. The metal sealing wall 16 also has a plurality of cover orifices (not shown) intended to have the loading/offloading pipes passing through them. A metal connecting strip 18 makes it possible to tightly connect the metal sealing wall 16 of the cover 14 and the primary sealing membrane 11 of the ceiling wall 4, as shown in Figure 2.

30 [0061] Although, at the loading/offloading opening 14, the primary sealing membrane 11 is attached to the metal sealing wall 16 of the cover 14, the secondary sealing membrane 9 for its part is interrupted at the longitudinal edges 5 and transverse edges 6 of the loading/offloading opening 14 and is directly and tightly attached to the upper load-bearing

wall 8 in order to make the separation between the secondary thermally insulating barrier 7 and the cover 14 leaktight. This attachment is realized by means of a secondary attachment bracket 19, as shown in Figure 3. The secondary attachment bracket 19 has a first wing 20 and a second wing 21 connected to the first wing 20. The first wing 20 extends in a horizontal plane and is attached to the secondary sealing membrane 9 whereas the second flange 21 extends in a vertical plane and is welded to a flat anchoring surface 22 integral with the upper load-bearing wall 8. As a result, some of the strakes of the secondary sealing membrane 9 are interrupted by the loading/offloading opening 14 and are attached to the upper load-bearing wall 8.

10 [0062] At this attachment to the upper load-bearing wall 8, the secondary sealing membrane 9 is capable of transmitting, to the secondary attachment bracket 19, tensile forces associated with the functioning of the secondary sealing membrane 9, in particular when the tank cools. Hence, in order to relieve the secondary attachment bracket 19 and the weld thereof with the secondary sealing membrane 9, the secondary thermally insulating barrier 7 has a particular arrangement along the transverse edges 6 of the loading/offloading opening 14.

[0063] The particular arrangement of the secondary thermally insulating barrier 7, along one of its edges 6, is partially shown in Figure 4. The secondary thermally insulating barrier 7 has a plurality of secondary fixing supports 23 which are evenly placed along said transverse edge 6 of the loading/offloading opening 14, at a distance from one another in the transverse direction T, and welded to the upper load-bearing wall 8.

[0064] One of said secondary fixing supports 23 is shown in Figure 5. It has a secondary cap 24 which extends parallel to the longitudinal direction, in a plane parallel to the ceiling wall 4. The secondary cap 24 is welded to a secondary base 25 which is anchored to the upper load-bearing wall 8, for example by welding. The secondary base 25 has two branches 26, 27 connected to one another by a central web 28. The two branches 26, 27 are welded to the two ends of the secondary cap 24 and extend, parallel to one another, in planes parallel to the transverse direction and to the thickness direction of the ceiling wall 4. The central web 28 for its part extends in a plane parallel to the longitudinal direction and to the thickness direction of the ceiling wall 4. The central web 28 is welded to the secondary cap 24 and to the two branches 26, 27. In the embodiment shown, the central web 28 has a U shape. The spacing in the longitudinal direction L between the two branches 26, 27 defines a base length and makes it possible to oppose rocking and bending of the secondary attachment bracket 19 in this direction.

[0065] The secondary fixing support 23 bears a primary anchoring device 29 intended to anchor the primary thermally insulating barrier 10. The primary anchoring device 29 is fixed to a holding plate 30 which is itself fixed to the secondary cap 24 by fixing members 31, such as screws. The longitudinal direction of the holding plate 30 is parallel to the longitudinal direction of the tank.

[0066] In addition, a threaded shank 32 is fixed to said holding plate 30 and extends in the thickness direction toward the inside of the tank. The threaded shank 32 is intended to pass tightly through an orifice provided in the secondary sealing membrane 9. The primary anchoring device 29 also has a bearing element 33 which is intended to bear against bearing zones of primary insulating edging blocks 51 of the primary thermally insulating barrier 10, these being in particular shown in Figure 3, which are arranged along the transverse edges 6 of the loading/offloading opening 14. In the embodiment shown, the bearing zones of the primary insulating edging blocks 51 are, for example, formed by battens which are fixed to the ends of said primary insulating edging blocks 51.

[0067] In addition, the primary anchoring device 25 also has a nut 34, visible in particular in Figure 5, which cooperates with the thread of the threaded shank 32 in such a way as to fix the bearing element 33 on the threaded shank 32 and also Belleville washers 35 which are mounted on the threaded shank 32 between the nut 34 and the bearing element 33. The primary anchoring device 25 also has a flange 36 which is positioned around the threaded shank 32 and is intended to be welded tightly to the secondary sealing membrane 9 all the way around the orifice through which the threaded shank 32 passes.

[0068] Returning to Figure 4, it can be seen that the secondary thermally insulating barrier 7 also has, along the transverse edges 6, secondary insulating edging blocks 37. Each secondary insulating edging block 37 is interposed between two adjacent secondary fixing supports 23. The secondary insulating edging blocks 37 are advantageously adhesively bonded to the upper load-bearing wall 8, for example by means of mastic. According to another embodiment (not shown), the secondary insulating edging blocks are fixed to the upper load-bearing wall by means of mechanical anchoring devices. The secondary insulating edging blocks 37 are, for example, formed by a wooden box inside which is placed an insulating packing, such as perlite, glass wool or rock wool for example.

[0069] The secondary thermally insulating barrier 7 also has secondary stop beams 38 against which is fixed the first wing 20 of the secondary attachment bracket 19. The secondary stop beams 38 are, for example, made of wood. The secondary stop beams 38 also contribute to retaining the secondary insulating edging blocks 37 against the upper

load-bearing wall 8. The secondary stop beams 38 are thus positioned, in the thickness direction, between the secondary insulating edging blocks 37 and the first wing 20 of the secondary attachment bracket 19.

5 [0070] The secondary stop beams 38 are each fixed in a straddling manner between two secondary fixing supports 23. In the embodiment shown, the secondary stop beams 38 also rest, in their median part, on a secondary fixing support 23. To fix the secondary stop beams 38 in place, the ends of the secondary stop beams 38 are sandwiched between the holding plate 30 and the secondary cap 24. Since the fixing members 31 are adjustable, the ends of the secondary stop beams 38 are thus immobilized, in the thickness direction
10 of the ceiling wall, between the holding plate 30 and the secondary cap 24.

[0071] As illustrated in Figure 7, the secondary stop beams 38 have recesses 39 which receive the holding plates 30 in such a way that said holding plates 30 lie substantially flush with the inner surface of the secondary stop beam 38. This makes it possible to ensure the flatness of the support surface against which the first wing 20 of the secondary attachment
15 bracket 19 and the secondary sealing membrane 9 are positioned.

[0072] Advantageously, the secondary stop beams 38 also incorporate, in the form of prefabs, one or more metal reinforcements for increasing their stiffness. The metal reinforcements are, for example, metal stiffening strips 40 which are oriented parallel to the length of said secondary stop beams 38, which is to say in the transverse direction of
20 the tank. The metal reinforcements can be fixed to the secondary stop beam 38 by any means, and in particular by fixing screws, by adhesive bonding or by riveting.

[0073] According to an advantageous embodiment, beads or strips of mastic (not illustrated) are positioned between the secondary stop beams 38 and the secondary insulating edging blocks 37 and/or the secondary caps 24 of the secondary fixing supports 23. This makes
25 it possible to adjust the position of the secondary stop beams 38 in the thickness direction of the ceiling wall 4.

[0074] As illustrated in Figure 7, the secondary stop beams 38 also incorporate support brackets 41, in an L shape and made of metal, which serve as a bearing surface for stop devices 42, shown in particular in Figures 4 to 6, and described hereinafter. Since the
30 support brackets 41 are harder than the secondary stop beam 38, they make it possible to prevent the secondary stop beams 38 from being dented in their zones in contact with the stop devices 42. The secondary stop beams 38 also have cutouts 43 which make it possible to receive the stop devices 42 when the secondary stop beams 38 are placed

against the secondary fixing supports 23. The support brackets 41 each have a first tab 52 which is positioned against the outer face of the secondary stop beam 38 and a second tab 45 which is positioned against an edge of one of the aforementioned cutouts 43. The support brackets 41 can be fixed to the secondary stop beams 38 by any means, and in particular by fixing screws, by adhesive bonding or by riveting. Advantageously, the first tab 52 is embedded in a recess provided in the inner surface of the secondary stop beam 38.

[0075] In addition, as illustrated in Figure 6, each secondary stop beam 38 is prevented from moving translationally, in the longitudinal direction L, on the secondary fixing supports 23 with which they cooperate. For this purpose, each secondary fixing support 23 has a stop device 42 which is fixed to the secondary cap 24. The stop device 42 has a plate 43 fixed in place, by welding, perpendicularly to the secondary cap 24. In the embodiment shown, in order to increase the stiffness of the stop device 42, a reinforcement in the form of a gusset 46 is welded between the plate 43 and the secondary cap 24. The plate 43 has two tapped orifices of which the axes are oriented parallel to the longitudinal direction L of the tank and which each has a set screw 44 passing through it. Each set screw 44 is intended to bear against one of the bearing brackets 41, the effect of which is to press the corresponding secondary stop beam 38 against an end 45 of a branch 27, thereby making it possible to prevent it from moving translationally in the longitudinal direction L and to adjust the position of the stop beam 38 in the longitudinal direction L.

[0076] As a result, the secondary stop beams 38 are rigidly supported by the secondary fixing supports 23, both in the longitudinal direction L and in the thickness direction of the ceiling wall 4, thereby making it possible to take up the tensile or compressive forces that can be exerted by the secondary sealing membrane 9 in operation.

[0077] As illustrated in Figure 4, the secondary thermally insulating barrier 7 has covering plates 47 which are received in ledges provided in the secondary stop beams 38 and covering the cutouts 43 that receive the stop devices 42. The covering plates 47 ensure the flatness of the support surface of the secondary sealing membrane 9.

[0078] With reference to Figure 8, a cut-away view of an LNG carrier 70 shows a sealed and insulated tank 71 having a prismatic overall shape assembled in the double hull 72 of the carrier. The wall of the tank 71 comprises a primary sealing barrier intended to be in contact with the LNG contained in the tank, a secondary sealing barrier arranged between the primary sealing barrier and the double hull 72 of the carrier, and two thermally insulating

barriers arranged between the primary sealing barrier and the secondary sealing barrier and between the secondary sealing barrier and the double hull 72, respectively.

[0079] As is known per se, loading/offloading pipelines 73 arranged on the upper deck of the carrier can be connected, by means of appropriate connectors, to a maritime or harbour terminal in order to transfer a cargo of LNG from or to the tank 71.

[0080] Figure 8 shows an example of a maritime terminal comprising a loading and offloading station 75, an underwater pipe 76 and an onshore facility 77. The loading/offloading station 75 is a fixed offshore facility including a mobile arm 74 and a tower 78 which supports the mobile arm 74. The mobile arm 74 carries a bundle of flexible insulated hoses 79 that can be connected to the loading/offloading pipelines 73. The orientable mobile arm 74 can be adapted to all sizes of LNG carriers. A connecting pipe (not shown) extends inside the column 78. The loading/offloading station 75 is used to load and offload the LNG carrier 70 to or from the onshore facility 77. This facility has liquefied-gas storage tanks 80 and connecting pipes 81 connected via the underwater pipe 76 to the loading/offloading station 75. The underwater pipe 76 is used to transfer the liquefied gas between the loading/offloading station 75 and the onshore facility 77 over a long distance, for example 5 km, allowing the LNG carrier 70 to be kept a long way from the coast during the loading and offloading operations.

[0081] Pumps carried on board the carrier 70 and/or pumps in the onshore facility 77 and/or pumps in the loading/offloading station 75 are used to generate the pressure required to transfer the liquefied gas.

[0082] Although the invention has been described in connection with several particular embodiments, it is evident that it is in no way limited thereto and that it comprises all the technical equivalents of the means described and the combinations thereof where these fall within the scope of the invention, as defined by the claims.

[0083] Use of the verbs “have” or “comprise” or “include” and their conjugated forms does not exclude the presence of elements or steps other than those set forth in a claim.

[0084] In the claims, any reference sign between parentheses should not be interpreted as a limitation of the claim.

CLAIMS

[Claim 1] Liquefied gas storage facility comprising a load-bearing structure (2) and a sealed and thermally insulating tank (71) supported by the load-bearing structure (2), the load-bearing structure (2) having an upper load-bearing wall (8) and the tank (71) having a ceiling wall (4) which is fixed to the upper load-bearing wall (8), said ceiling wall (4) comprising, in a thickness direction, from the outside to the inside of the tank: a secondary thermally insulating barrier (7) fixed to the upper load-bearing wall (8), a secondary sealing membrane (9) resting against the secondary thermally insulating barrier (7), a primary thermally insulating barrier (10) resting against the secondary sealing membrane (9), and a primary sealing membrane (11) resting against the primary thermally insulating barrier (10) and intended to be in contact with the liquefied gas, said ceiling wall (4) being interrupted locally so as to delimit a loading/offloading opening (14) intended to have loading/offloading pipes passing through it, said loading/offloading opening (14) being defined by a first and a second transverse edge (6), which are parallel to a transverse direction (T), and a first and a second longitudinal edge (5), which are parallel to a longitudinal direction (L) perpendicular to the transverse direction (T);

the secondary thermally insulating barrier (7) of the ceiling wall (4) having:

- at least one first and one second secondary fixing support (23) positioned along the first transverse edge (T); the first and second secondary fixing supports (23) each comprising a secondary base (25) which is anchored to the upper load-bearing wall (8), a secondary cap (24) which is welded to the secondary base (25) and which extends parallel to the longitudinal direction, in a plane parallel to the upper load-bearing wall (8), and a holding plate (30) which is fixed to the secondary cap (24) by fixing members (31);
- at least one secondary insulating edging block (37) which is arranged along the first transverse edge (T), between the first and the second secondary fixing supports (23);

and

- at least one secondary stop beam (38) which extends along the first transverse edge (T) and rests at least against the secondary cap (24) of each of the first and second secondary fixing supports (23) and against one of the secondary insulating edging blocks (37), said secondary stop beam (38) being immobilized, in the thickness direction of the ceiling wall, between the holding plate (30) and the secondary cap (24) of each of the first and second secondary fixing supports; the secondary stop beam

(38) comprising support brackets (41) which are fixed to the secondary stop beam (38); each of the first and second secondary fixing supports (23) comprising a stop device (42) which is configured to press the secondary stop beam (38) against a stop surface of said first or second secondary fixing support (23) in order to prevent the secondary stop beam (38) from moving translationally in the longitudinal direction; each stop device (42) comprising a support fixed to the secondary cap (24) and a set screw (44) which is mounted for movement in the longitudinal direction in a tapped bore provided in said support and which bears against one of the support brackets (41).

[Claim 2] Liquefied gas storage facility according to Claim 1, wherein each support bracket (41) has a first tab (52) which is arranged against an outer face of the secondary stop beam (38) and a second tab (45) which is perpendicular to the first tab (52) and against which the set screw (44) of the stop device (42) of one of the first and second secondary fixing supports (23) bears.

[Claim 3] Liquefied gas storage facility according to Claim 2, wherein the outer face of the secondary stop beam (38) has recesses in which the first tabs (52) of the support brackets (41) are embedded.

[Claim 4] Liquefied gas storage facility according to Claim 2 or 3, wherein the secondary stop beam (38) has at least two cutouts (43) which respectively accommodate the stop device (42) of the first and of the second secondary fixing support (23) and wherein the second tab (45) of each of the support brackets (41) is positioned against an edge of one of the cutouts (43).

[Claim 5] Liquefied gas storage facility according to any one of Claims 1 to 4, wherein the support brackets (41) are made of metal.

[Claim 6] Liquefied gas storage facility according to any one of Claims 1 to 5, wherein the support brackets (41) are fixed to the secondary stop beam (38) by fixing members.

[Claim 7] Liquefied gas storage facility according to any one of Claims 1 to 6, wherein the secondary stop beam (38) is equipped with at least one metal stiffening strip (40) which extends in the transverse direction along said secondary stop beam (38).

[Claim 8] Liquefied gas storage facility according to any one of Claims 1 to 7, wherein the support of the stop devices (42) comprises a plate (43) which is welded to the secondary cap (24), perpendicularly thereto, and a reinforcement in the form of a gusset (46) which is welded between the plate (43) and the secondary cap (24).

[Claim 9] Liquefied gas storage facility according to any one of Claims 1 to 8, wherein the secondary base (25) has two branches (26, 27) connected to one another by a

central web (28), the branches (26, 27) extending in planes that are parallel to the transverse direction.

[Claim 10] Liquefied gas storage facility according to Claim 9, wherein the stop surface of the first and second secondary fixing supports (23) is formed by an end of one of the branches (26, 27) of the secondary base (25) that protrudes inward beyond the secondary cap (24).

[Claim 11] Liquefied gas storage facility according to any one of Claims 1 to 10, comprising a first and a second primary anchoring device (29) which are fixed to the first and to the second secondary fixing supports (23), respectively, each of the first and second primary anchoring devices (29) having a threaded shank (32) which passes tightly through an orifice provided in the secondary sealing membrane (9), a bearing element (33) which is fitted on the threaded shank (32) and which bears, in the direction of the upper load-bearing wall, against a bearing zone of one or more insulating elements (51) of the primary thermally insulating barrier (10), and a nut which is screwed onto the threaded shank (32) so as to hold the bearing element (33) against the bearing zone(s) of the insulating elements (51) of the primary thermally insulating barrier (10); said threaded shank being fixed to the holding plate (30) of one of the first and second secondary fixing supports (23).

[Claim 12] Carrier (70) for transporting a liquefied gas, the carrier comprising a liquefied gas storage facility according to any one of Claims 1 to 11.

[Claim 13] System for transferring a liquefied gas, the system comprising a carrier (70) according to Claim 12 and insulated pipelines (73, 79, 76, 81) arranged in such a way as to connect the tank (71) installed in the hull of the carrier to a floating or onshore storage facility (77).

[Claim 14] Method for loading or offloading a carrier (70), wherein a liquefied gas is conveyed through insulated pipelines (73, 79, 76, 81) from or to a floating or onshore storage facility (77) to or from the tank (71) of the carrier (70) according to Claim 12.