

## FLUIDTIGHT AND THERMALLY INSULATED TANK COMPRISING A METAL MEMBRANE THAT IS CORRUGATED IN ORTHOGONAL FOLDS

5 The present invention relates to a fluidtight and thermally insulated tank, and in particular the present invention relates to tanks designed to contain cold liquids, for example tanks for storing and/or transporting liquefied gases by sea.

10 Fluid tight and thermally insulated tanks can be used in different industries to store hot or cold products. For example, in the energy domain, liquefied natural gas (LNG) is a liquid that can be stored at atmospheric pressure at approximately -163°C in onshore storage tanks or in tanks carried on board floating structures.

Such a tank is for example described in document FR-A-2724623.

15 According to one embodiment, the invention provides a fluidtight and thermally insulated tank built into a structure that includes a load-bearing wall, said tank having a tank wall attached to said load-bearing wall, the tank wall comprising:

20 - a thermal insulation barrier held on the load-bearing wall and made up of right-angled parallelepiped insulating blocks, juxtaposed in parallel rows separated from one another by gaps.

- a fluidtight barrier carried by the thermal insulation barrier, said fluidtight barrier comprising a metal membrane formed of metal sheets welded together sealingly,

25 - each insulating block of a thermal insulation barrier carrying, on the face of same opposite the load-bearing wall, at least two substantially orthogonal metal connecting strips, arranged parallel to the sides of the insulating block, the sheets of the metal membrane carried by said insulating block being welded to said

strips, said connecting strips being rigidly connected to the insulating block bearing same,

- a plurality of sheets of the metal membrane each having at least two orthogonal folds parallel to the sides of the thermal insulating blocks, said folds being inserted in the gaps formed between the insulating blocks.

According to the embodiments, such a tank may have one or more of the following features.

According to one embodiment, the sheets of the metal membrane each have at least two orthogonal folds parallel to the sides of the thermal insulating blocks, inserted into the gaps formed between the insulating blocks.

According to one embodiment, the tank wall has a primary element and a secondary element arranged between the load-bearing wall and the primary element, both the primary element and the secondary element including a thermal insulation barrier made up of right-angle parallelepiped insulating blocks, juxtaposed in parallel rows and a fluidtight barrier arranged on the thermal insulation barrier, the thermal insulation barrier of the secondary element being rigidly connected to the load-bearing wall, the thermal insulation barrier of the primary element being rigidly connected using attachment means connected to the thermal insulation barrier of the secondary element.

According to one embodiment, the fluidtight barrier of the secondary element is formed by the metal membrane comprising a plurality of sheets each having at least two orthogonal folds parallel to the sides of the thermal insulating blocks, inserted in the gaps formed between the insulating blocks of the secondary element.

According to one embodiment, the sheets of the metal membrane of the secondary element are made of an alloy of iron

with nickel or manganese, having a coefficient of expansion not exceeding  $7 \times 10^{-6} \text{ K}^{-1}$ .

According to one embodiment, the folds of the metal sheets of the secondary fluidtight barrier are inserted into the gaps between the insulating blocks of the thermal insulation barrier of the secondary element.

According to one embodiment, the folds of the metal sheets of the primary fluidtight barrier are inserted into the gaps between the insulating blocks of the thermal insulation barrier of the primary element. According to other embodiments, the primary membrane may have a different design from the secondary membrane, for example with folds projecting into the tank. In other words, the fluidtight barrier of the primary element is formed of metal sheets welded together sealingly, with folds oriented towards the inside of the tank.

According to one embodiment, an insulating block of the thermal insulation barrier has a base plate on which is arranged a foam layer, in particular of polyurethane foam, the base plate overhanging the foam. The plates may be made of plywood. The secondary element is pressed against the load-bearing wall using fixtures welded to the load-bearing wall and cooperating with the overhanging zones of the plates of the insulating block, a resin bead being interposed to make good any local imperfections in the load-bearing wall where necessary.

According to one embodiment, an insulating block of the thermal insulation barrier of the secondary element is held on the load-bearing wall by bonding.

Numerous different arrangements of the connecting strips on the insulating blocks are possible, in particular with regard to the

position and the number of connecting strips on an insulating block. In this regard, the insulating blocks are not necessarily all identical.

According to one embodiment, the connecting strips of each insulating block of the thermal insulation barrier of the secondary element carries two connecting strips that are arranged along the two axes of symmetry of the rectangle defined by a large face of said insulating block.

According to one embodiment, the connecting strips of each insulating block of the thermal insulation barrier of the primary element are arranged in the vicinity of the edges of a large face of said insulating block.

According to one embodiment, an insulating block has three connecting strips arranged on the cover plate.

According to one embodiment, the connecting strips of an insulating block are seated in recesses formed in the plate or the foam layer bearing same so as not to increase the thickness on the corresponding face of the insulating block.

According to one embodiment, a connecting strip of an insulating block is attached to the recess of same by screwing, stapling, riveting or bonding.

According to one embodiment, the attachment means of the thermal insulation barrier of the primary element include a continuous metal plate arranged at the crossing of two connecting strips of each insulating block of the secondary element, and a projecting member crossing the fluidtight barrier of the secondary element without reaching the fluidtight barrier of the primary element.

According to one embodiment, the adjacent metal sheets of the fluidtight barriers of the primary and secondary elements are lap-welded level with the connecting strips carried respectively by the thermal insulation barriers of the primary and secondary elements.

According to one embodiment, the projecting members are studs, the bases of which are attached to the continuous metal plate of the insulating block of the secondary element, an intermediate part being interposed between firstly a nut cooperating with the thread provided at the free extremity of the stud and secondly the overhanging parts of the plates of the insulating blocks of the thermal insulation barrier of the primary element. The bases of the studs are attached by welding and/or screwing to the continuous metal plate of the insulating block of the secondary element.

According to one embodiment, the sheets of the metal membranes, which form the fluidtight barrier, are rectangular and each have two folds formed along the axes of symmetry of the rectangle formed by the edges of same.

According to one embodiment, the two folds of a sheet and the fluidtight barrier of the primary element are secant at the center of the rectangular sheet.

According to one embodiment, one of the folds of a sheet is continuous and the other is interrupted in the central portion of same.

According to one embodiment, the sheets of a first type have a continuous fold along the major axis of same.

According to one embodiment, the sheets of a second type have a discontinuous fold along the major axis of same.

According to one embodiment, on one tank wall, the sheets of the first and second types are regularly alternated so that a sheet of one of the types is always adjacent to a sheet of the other type.

According to one embodiment, each insulating block of the thermal insulation barrier has two series of orthogonal slots, each of said series having slots arranged parallel to two opposing sides of the insulating block, and the sheets of the metal membrane each have two series of supplementary folds, each of said series of

supplementary folds having folds orthogonal to the folds in the other series, parallel to one of the two folds inserted in the gaps, and inserted into the slots of one of the series of slots formed in the insulating block.

5           According to another embodiment, the metal membrane has a second plurality of sheets, each of the sheets in the second plurality having a single fold parallel to two opposing sides of the insulating blocks, said fold being inserted into a gap formed between two insulating blocks.

10           According to another embodiment, each insulating block of the thermal insulation barrier has a slot parallel to two opposing sides of the insulating blocks and in which the metal membrane has a second plurality of sheets, each of the sheets in the second plurality having a fold inserted in a slot formed in an insulating block and a fold  
15           inserted in a gap formed between two insulating blocks.

          Such a tank may be part of an onshore storage facility, for example for storing LNG, or be installed on a coastal or deep-water floating structure, notably an LNG carrier ship, a floating storage and regasification unit (FSRU), a floating production, storage and  
20           offloading (FPSO) unit, inter alia.

          According to one embodiment, a ship used to transport a cold liquid product has a double hull and the aforementioned tank arranged in the double hull.

          According to one embodiment, the invention also provides a  
25           method for loading onto or offloading from such a ship, in which a cold liquid product is channeled through insulated pipes to or from an onshore or floating storage facility to or from the tank on the ship.

          According to one embodiment, the invention also provides a transfer system for a cold liquid product, the system including the  
30           aforementioned ship, insulated pipes arranged to connect the tank

installed in the hull of the ship to an onshore or floating storage facility and a pump for driving a flow of cold liquid product through the insulated pipes to or from the onshore or floating storage facility to or from the tank on the ship.

5           One idea at the heart of the invention is to provide a fluidtight and insulating multi-layer structure that is easy to build over extended surfaces. Certain aspects of the invention are based on the idea of building insulating blocks that have simple geometry and are cheap to manufacture. Certain aspects of the invention are based on the  
10       idea of providing a fluidtight membrane, in particular secondary membrane made of steel sheet with a low coefficient of expansion, for example Invar® or other, of limited thickness, in particular not exceeding 0.7 mm, thereby achieving limited stiffness which enables  
15       anchoring at the edges of the tank wall using relatively small anchoring means.

          The invention is further explained, along with additional objectives, details, characteristics and advantages thereof, in the detailed description below of several specific embodiments of the invention given solely as non-limiting examples, with reference to the  
20       drawings attached.

          In these drawings:

          - Figure 1 is a schematic perspective view of an assembly of different members forming a fluidtight and thermally insulated tank according to the invention: this general view includes the different  
25       parts removed to reveal the fluidtight and thermal insulation barriers of the secondary and primary elements of the tank wall;

          - Figure 2 is a schematic representation of a cross-section of a tank wall according to the invention, in which the primary fluidtight barrier has folds projecting from the side opposite the load-bearing  
30       wall;

- Figure 3 is a perspective view of an insulating block of the thermal insulation barrier of the secondary element of the wall of the tank in figure 1, said block having, in the central zone of same, attachment means for the insulating blocks of the thermal insulation barrier of the primary element of the wall of the tank;

- Figure 4 is a perspective view of an insulating block of the thermal insulation barrier of the primary element of the wall of the tank in figure 1;

- Figure 5 is a cut-away perspective view of the parts making up the fluidtight and thermal insulation barriers of the primary and secondary elements of a tank wall according to the invention including, in the fluidtight barrier of the primary element of same, folds projecting into the tank as shown in figure 2, said figure 5 showing in detail the construction of attachment means for the primary insulation barrier on a connecting strip of the secondary insulation barrier;

- Figure 6 is a view similar to figure 5, in which two parts of attachment means are shown individually in an exploded view;

- Figure 7 is a schematic cross-section of attachment means according to an embodiment other than the one in figures 5 and 6;

- Figure 8 is a top plan view of the attachment means in figure 7;

- Figure 9 shows an assembly drawing, in a tank wall, of the sheets making up a fluidtight barrier, the sheets being of a first and of a second type, so that the flexibility of the metal membrane of the fluidtight barrier is relatively uniform;

- Figure 10 shows an assembly drawing similar to the one in figure 9 for an alternative embodiment in which the folds of the metal sheet of the fluidtight barrier that are arranged in a first direction are substantially aligned from one sheet of the tank wall to an adjacent

sheet, while in the direction orthogonal to the first direction, the folds are interrupted to avoid the folds crossing;

- Figure 11 is a schematic perspective view of a polyhedral tank section formed in an LNG carrier ship using the fluidtight membrane shown in figure 10, which improves the flexibility of the fluidtight membrane for deformations of the axis of the ship during sea transport;

- Figure 12 is a schematic view of two other variants of metal sheets that can be used to form a fluidtight membrane;

- Figure 13 is a cut-away schematic view of an LNG carrier ship tank and of a loading/offloading terminal for this tank;

- Figures 14 to 16 are schematic views of two other variants of metal sheets that can be used to form a fluidtight membrane;

- Figure 17 is a schematic view of 17 embodiments of creased metal sheets that can be used to form a fluidtight membrane;

- Figures 18 to 23 are schematic views of different layouts of the creased metal sheets in figure 17, which can be repeated periodically to form fluidtight membranes;

- Figure 24 is a perspective view of an insulating block of the thermal insulation barrier of the secondary element, according to another embodiment;

- Figure 25 is a perspective view of the fluidtight and thermal insulation barriers of the secondary element according to the embodiment in figure 25, the fluidtight barrier being shown partially removed;

- Figure 26 is a cross-section of the fluidtight and thermal insulation barriers of the secondary element according to the embodiment in figures 24 and 25;

- Figure 27 is an assembly drawing, in a tank wall, of the sheets making up a secondary fluidtight barrier, according to another embodiment;

- Figure 28 is an assembly drawing, in a tank wall, of the sheets making up a secondary fluidtight barrier, according to another embodiment again.

In the different variants shown in the drawings, the components that perform the same function have been identified using the same reference signs, even if the implementation of same is not identical.

In the drawings, reference sign 1 refers, as a whole, to an insulating block of the thermal insulation barrier of the secondary element of a tank wall. This block has a length L and a width l, for example, respectively, 3 m and 1m; it has a right-angle parallelepiped shape and it is made of polyurethane foam between two plywood plates. One of the plates 2a overhangs the edge of the foam and is intended to bear against the load-bearing wall 3 with the interposition of resin beads 4 designed to make good the local defects in the load-bearing wall 3. The other plate 2b of the insulating block 1 includes, along the two axes of symmetry of same, a metal connecting strip 6, which is placed in a recess 7 and which is attached there using screws, rivets, staples or adhesive. In the crossing zone of the strips 5 and 6 there is a continuous metal plate, which bears, at the center of the crossing of the strips, a stud 8 projecting above the plate 2b. The plate 2a is held on the load-bearing wall 3 by bonding using resin beads 4, as well as using studs 9 welded onto the load-bearing wall 3. A gap 10 is formed between two adjacent blocks 1, for example caused by the presence of the overhanging parts of the plate 2a, or potentially using positioning blocks.

As shown in figure 1, starting with the uncovered secondary insulating block shown in the top left of the figure and moving in an

oblique direction downwards and to the right, the perspective shows a secondary insulating block 1 that is partially covered by a sheet 11 forming a part of the secondary fluidtight barrier of the tank wall. This metal sheet 11 has a substantially rectangular shape and includes, along each of the two axes of symmetry of this rectangle, a fold 12a, respectively 12b. The folds 12a and 12b form reliefs oriented towards the load-bearing wall 3 and they are seated in the gaps 10 in the secondary insulation barrier. The metal sheets 11 are made of Invar®, the coefficient of thermal expansion of which is typically between  $1.5 \times 10^{-6}$  and  $2 \times 10^{-6} \text{ K}^{-1}$ . They have a thickness of between approximately 0.7 mm and approximately 0.4 mm. Two adjacent sheets 11 are lap-welded together, as described in figures 5 and 6. The sheets 11 are held on the insulating blocks 1 using the strips 5 and 6 to which at least two edges of the sheets 11 are welded.

According to a preferred embodiment, the metal sheets 11 are made of a manganese-based alloy having a coefficient of thermal expansion substantially equal to  $7 \times 10^{-6} \text{ K}^{-1}$ . Such alloys are usually cheaper than alloys with a high nickel content, such as Invar®.

With reference to figure 1, moving obliquely to the right and downwards from the zone in which the metal sheets 11 of the fluidtight barrier of the secondary element of the tank wall, there is a zone in which the secondary fluidtight barrier is covered by an insulating block 13 of the thermal insulation barrier of the primary element of the tank wall. The insulating block 13 is shown in detail in figure 4. This block has an overall structure similar to the structure of the block 1, i.e. a sandwich formed by polyurethane foam between two plywood plates. The base plate 13a, which bears against a metal sheet 11, has overhanging parts 30 at the four corners. These insulating blocks 13 are attached using the overhanging parts 30 and the studs 8. On the upper face of the insulating block 13 there are two connecting strips

14a, 14b; these connecting strips are made of metal and arranged in the recesses formed in the insulating block 13 so as not to increase the thickness of this insulating block. The two strips 14a, 14b are arranged in parallel to the edges of the block 13 and they are attached in the  
 5 recesses of same, as described above for strips 5 and 6.

Finally, figure 1 shows, when moving from an element 13 obliquely downwards and to the right, the placement of a metal sheet 15 forming the fluidtight barrier of the primary element of the tank. This sheet 15 may be made of stainless steel with a thickness of  
 10 approximately 1.2 mm; it includes folds formed along the axes of symmetry of the rectangle that it forms, as already described for the metal sheets 11. These folds may be in relief on the side of the load-bearing wall 3, but they may also be in relief towards the inside of the tank; these folds are identified by 16a, 16b. In figure 2, as in figures 5  
 15 and 6, the folds 16a, 16b are oriented towards the inside of the tank.

Figures 5 and 6 show an embodiment in which the metal sheets 11 have a fold 12a arranged inside a gap 10 and shown using a dotted line. The adjacent sheets of the secondary fluidtight barrier are lap-welded, the weld zone being identified using reference sign 17.  
 20 The weld is formed on the connecting strip 6, which also bears the studs 18 welded to the base of same on the strip 6 and threaded at the upper extremity of same to cooperate with a locking bolt 19. This locking bolt is placed at the base of a bowl, the peripheral edge 20 of which rests in a recess 21 formed in the plywood plate 13b, which  
 25 delimits the primary insulation barrier 13 towards the inside of the tank. Upon the primary insulating block is placed a sheet 15 that has two lines of folds in relief towards the inside of the tank, the orthogonal folds meeting to form nodes; the sheets 15 are welded sealingly and form the primary fluidtight barrier of the tank.

The connecting strip 6 is continuous at the intersection with the connecting strip 5 such as to form a fluidtight zone 39 to which the corners of four sheets 11 can be welded about the stud 18. As such, there is no need to perforate a sheet 11 to enable the stud 18 to pass through towards the primary element of the tank wall. Throughout the remaining length of same, the connecting strips 5 and 6 are preferably formed of discontinuous juxtaposed segments in order to limit the stresses resulting from thermal contraction, in particular stresses in the welds with the sheets 11.

Figures 7 and 8 show a variant of the attachment means, which enable the insulating blocks 13 of the primary thermal insulation barrier to be pressed against the metal membrane 11 of the secondary fluidtight barrier. These attachment means include a stud 18, the base of which is rigidly attached to the plywood plate 2b of the secondary thermal insulating block 1. An elastic spacer 23 is placed between the nut 22 and the overhanging parts 30 of the plywood plates of the primary insulating blocks 13. This holds the insulating blocks 13 of the primary thermal insulation barrier of the tank on the secondary element of the tank without the stud 18 reaching the metal sheets 15 of the primary fluidtight barrier.

In the figures, in particular figure 2, stress-relieving slots 40 are shown through approximately half of the thickness of the insulating blocks from the cover plate. These stress-relieving slots effectively subdivide the cover plates 2b and 13b into separate portions. However, such stress-relieving slots are not always necessary, depending on the properties of the material used to make the insulating blocks and the thermal stresses applied to same. In one embodiment not shown, an insulating block 1 or 13 has no stress-relieving slots, and as such the cover plate 2b or 13b is continuous.

Figures 9 to 12 concern the arrangements relating to the folds made in the metal sheets of the secondary fluidtight barrier. These arrangements may also be used for the primary membrane.

Figure 9 shows the use of sheets having a continuous fold and a discontinuous fold orthogonal to the continuous fold. Two types of sheet 31 and 32 are arranged alternately. The edges of the sheets 31 and 32 are shown using broken lines. The folds are shown using unbroken lines. A membrane characterized by uniform flexibility in both directions is obtained.

Conversely, figure 10 proposes using only sheet type 32, in which all of the folds in one direction are continuous folds, and the folds in the other direction are discontinuous folds. Figure 11 shows that, for a tank designed to be fitted to a ship, the discontinuous folds are formed such that they are parallel to the axis of the ship and the continuous folds are formed such that they are perpendicular to said axis since, during transportation, the hull of the ship is deformed primarily by deformation of the axis of the ship in a vertical plane, due to pitching.

Figure 12 shows two other sheets 51 and 52 that can be used to form the fluidtight barrier at the partitions transverse to the axis of the ship, as shown in figure 11.

Figures 14 and 15 show creased sheets H and F that can be used instead of the sheets 51 and 52 in figure 11 to form the fluidtight barrier at the partitions transverse to the axis of the ship. This results in lines of corrugations that are continuous along the width of the tank, but not in the height of same.

Figure 16 shows a creased sheet E that can be used on its own or in combination with the preceding embodiments to form fluidtight barriers.

Figure 17 shows different creased sheets A to R, including the examples given above and other examples, that can be used on their own or in multiple combinations to form the fluidtight barriers.

The creased sheets A to R have in each instance simple folds or simple corrugations, which facilitates the assembly of same using fluidtight welds. They may be combined in multiple layouts enabling in each instance a certain elongation of the metal membrane in both directions of the plane. The preferred layouts are shown in figures 18 to 23.

In a variant not shown, two types of sheet are alternated similarly to figure 22 and 23, but in this case with sheets H and I from figure 17.

In one embodiment shown in figures 24, 25 and 26, the insulating block 1 of the thermal insulation barrier of the secondary element includes two series of orthogonal slots 53a, 53b. Each of the series of slots 53a, 53b is parallel to two opposing sides of the insulating block 1. In this case, each insulating block 1 has two slots 53a extending in the longitudinal direction of same and eight slots 53b extending transversely to the longitudinal direction of same. The slots 53a extend along the entire length of the insulating block 1 and the slots 53b extend along the entire width of same. Consequently, the connecting strips 5, 6 onto which the edges of the sheets 11 of the secondary fluidtight barrier are welded are in this case discontinuous.

Furthermore, as shown in figure 25, the metal sheets 11 of the secondary fluidtight barrier include two series of folds 12a, 12b, 12c, 12d. Each series has folds that are perpendicular to the folds in the other series. Furthermore, each series has one of the orthogonal folds 12a, 12b seated in the gaps 10 formed between the insulating blocks 1, and a plurality of supplementary folds 12c, 12d that are parallel to said fold 12a, 12b. The supplementary folds 12c, 12d are identical to

the folds 12a and 12b and form reliefs oriented towards the load-bearing wall 3. The supplementary folds are inserted into the slots 53a, 53b formed in the insulating blocks 1. Such an embodiment enables the flexibility of the secondary fluidtight barrier to be further increased.

5 In figure 27, the folds 12a, 12b of the sheets 11 of the metal membrane of the secondary element are shown using dotted lines. Furthermore, the position of an insulating block 1 of the secondary thermal insulation barrier 10 is shown, by means of transparency. The position of an insulating block 13 of the primary thermal insulation barrier attached to the insulating blocks 1 of the secondary thermal insulation barrier 10 is also shown. In this embodiment, the primary fluidtight barrier has more sheets 11 than insulating blocks 1. In this case, the primary fluidtight barrier has twice as many sheets 11 as insulating blocks 13. The length of the sheets 11 is therefore  
10 substantially equal to the length of the insulating blocks 1 and a width of same is substantially equal to half of the width of the insulating blocks. Consequently, a part of the sheets 11 is lap-welded to four adjacent insulating blocks 1. The other part of the sheets 11 is lap-welded to just two adjacent insulating blocks 1. To attach the sheets  
15 to the insulating blocks 1, they have three connecting strips 5a, 5b, 6. The connecting strip 5a is oriented transversely to the insulating block 1. The connecting strips 5a, 5b are arranged in the longitudinal direction of the insulating block 1.

The seats 11 lap-welded onto four adjacent insulating blocks 1  
25 each have orthogonal folds 12a, 12b inserted into the gaps 10 formed between the insulating blocks 1. Each of the sheets 11 lap-welded onto to adjacent insulating blocks 1 has only one fold 12b inserted between the two adjacent insulating blocks 1 between which it extends.

At the center of the crossings between the connecting strip 6  
30 and the connecting strips 5a, 5b, the insulating blocks 1 include a stud

18 projecting towards the inside of the tank and enabling attachment  
of the insulating blocks 13 of the primary thermal insulation barrier.

The embodiment shown in figure 28 is substantially similar to the  
embodiment in figure 27. However, in this embodiment, the sheets 11  
5 are identical and each have two orthogonal folds 12a, 12b.  
Consequently, the insulating blocks 1 include a median slot 53e  
extending in the longitudinal direction of same. The median slots 53e  
enable seating of the folds 12a extending in the longitudinal direction  
of the sheets 11 lap-welded to two adjacent insulating blocks 1.

10 Other variants of corrugated sheets and other combinations  
can be realized by changing the different features, in particular the  
spacing of the corrugations, the number of corrugations per sheet, the  
length of the discontinuous corrugations (number of steps), the form of  
the intersections between the corrugations, i.e. secant or non-secant  
15 intersection, the orientation of the continuous corrugations, i.e.  
longitudinal or transverse orientation, and the orientation of the sheets  
themselves, i.e. horizontal orientation or vertical orientation (90°  
rotation), and the combinations of such modifications.

The tanks described above may be used in different types of  
20 facilities such as onshore facilities or in a floating structure such as an  
LNG carrier ship or other.

With reference to figure 13, a cut-away view of an LNG carrier  
ship 70 shows a fluidtight insulated tank 71 having an overall prismatic  
shape mounted in the double hull 72 of the ship. The wall of the tank  
25 71 has a primary fluidtight barrier designed to be in contact with the  
LNG contained in the tank, a secondary fluidtight barrier arranged  
between the first fluidtight barrier and the double hull of the ship, and  
two thermally insulated barriers arranged respectively between the  
first fluidtight barrier and the second fluidtight barrier, and between  
30 the second fluidtight barrier and the double hull 72.

In a known manner, the loading/offloading pipes 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.

5           Figure 13 shows an example sea terminal comprising a loading/offloading point 75, an underwater duct 76 and an onshore facility 77. The loading/offloading point 75 is a fixed offshore installation comprising a movable arm 74 and a column 78 holding the movable arm 74. The movable arm 74 carries a bundle of insulated  
10           hoses 79 that can connect to the loading/offloading pipes 73. The orientable movable arm 74 can be adapted to all sizes of LNG carrier ships. A linking duct (not shown) extends inside the column 78. The loading/offloading point 75 makes loading and offloading of the LNG carrier ship 70 possible to or from the onshore facility 77. This facility has  
15           liquefied gas storage tanks 80 and linking ducts 81 connected via the underwater duct 76 to the loading/offloading point 75. The underwater duct 76 enables liquefied gas to be transferred between the loading/offloading point 75 and the onshore facility 77 over a large distance, for example 5 km, which makes it possible to keep the  
20           LNG carrier ship 70 a long way away from the coast during loading and offloading operations.

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 on the loading/offloading  
25           point 75 are used.

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  
30           invention.

Use of the verb "comprise" or "include", including when conjugated, does not exclude the presence of other elements or other steps in addition to those mentioned in a claim. Use of the indefinite article "a" or "one" for an element or a step does not  
5 exclude, unless otherwise specified, the presence of a plurality of such elements or steps.

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

## CLAIMS

1. An impermeable and thermally insulated tank built into a structure that includes a load-bearing wall, said tank having a tank wall attached to said load-bearing wall, the tank wall comprising:

a thermally insulated barrier held on the load-bearing wall and made up of cuboid thermally insulated blocks, juxtaposed in parallel rows separated from one another by gaps,

an impermeable barrier carried by the thermally insulated barrier, said impermeable barrier comprising a metal membrane formed of metal sheets welded together sealingly,

at least some of the insulated blocks of the thermally insulated barrier carrying, on the face of same opposite the load-bearing wall, at least two substantially orthogonal metal connecting strips, arranged parallel to the sides of the insulated block, the sheets of the metal membrane carried by said insulated block being welded to said strips, said connecting strips being rigidly connected to the insulated block bearing same, the adjacent metal sheets of the impermeable barrier being welded in an overlapping manner on top of the connecting strips carried respectively by the thermally insulated barrier;

a plurality of sheets of the metal membrane each having at least two orthogonal folds parallel to the sides of the thermally insulated blocks, said folds being inserted in the gaps formed between the insulating blocks.

2. The tank as claimed in claim 1, wherein the tank wall has a primary element and a secondary element arranged between the load-bearing wall and the primary element, both the primary element and the secondary element including a thermally insulated barrier made up of cuboid thermally insulated blocks, juxtaposed in parallel rows and both the primary and secondary elements including an impermeable barrier arranged on the thermally insulated barrier, the thermally insulated barrier of the secondary element being rigidly connected to the load-bearing wall, the thermally insulated barrier of the primary element being rigidly connected using attachment means connected to the thermally insulated barrier of the secondary element.

3. The tank as claimed in claim 2, wherein the impermeable barrier of the secondary element is formed by the metal membrane comprising a plurality of sheets each having at least two orthogonal folds parallel to the sides of the thermal insulated blocks, inserted in the gaps formed between the insulated blocks of the secondary element.

4. The tank as claimed in claim 3, wherein the sheets of the metal membrane of the secondary element are made of an iron alloy with nickel or manganese, having a coefficient of expansion not exceeding  $7 \times 10^{-6} \text{ K}^{-1}$ .
5. The tank as claimed in claim 2, wherein the impermeable barrier of the primary element is formed of metal sheets welded together sealingly, with folds oriented towards the inside of the tank.
6. The tank as claimed in claim 2, wherein the insulated block of the thermally insulated barrier has a base plate on which is arranged a foam layer, the base plate overhanging the foam.
7. The tank as claimed in claim 6, wherein the insulated block of the thermally insulated barrier of the secondary element is pressed against the load-bearing wall using fixtures welded to the load-bearing wall and cooperating with the overhanging zones of the base plate of the insulated block.
8. The tank as claimed in claim 2, wherein the insulated block of the thermally insulated barrier of the secondary element is held on the load-bearing wall by bonding.
9. The tank as claimed in claim 2, wherein each insulated block of the thermally insulated barrier of the secondary element carries the two connecting strips that are arranged along the two axes of symmetry of the rectangle defined by a large face of said insulated block.
10. The tank as claimed in claim 9, wherein the attachment means of the thermally insulated barrier of the primary element include a continuous metal plate arranged at the intersection of the two connecting strips at the center of the rectangle of each insulated block of the secondary element such as to form an impermeable zone to which the corners of the four sheets can be welded around said attachment means, and a projecting member crossing the impermeable barrier of the secondary element without reaching the impermeable barrier of the primary element.
11. The tank as claimed in claim 10, wherein the projecting members are studs, the bases of which are attached to the continuous metal plate placed at the intersection of the two

connecting strips of the insulated block of the secondary element, an intermediate part being interposed between firstly a nut cooperating with the thread provided at the free extremity of the stud and secondly the overhanging parts of the plates of the insulated blocks of the thermally insulated barrier of the primary element.

12. The tank as claimed in claim 2, wherein each insulated block of the thermally insulated barrier of the primary element has two connecting strips that are arranged in the vicinity of the edges of a large face of said insulated block.

13. The tank as claimed in claim 1, wherein the connecting strips of the insulated block are seated in recesses formed in the insulated block bearing same so as not to increase the thickness on the corresponding face of the insulated block.

14. The tank as claimed in claim 13, wherein the connecting strip of the insulated block is attached to the recess of same by screwing, riveting, stapling or bonding.

15. The tank as claimed in claim 1, wherein the metal sheets, which form the impermeable barrier, are rectangular and each have two folds formed along the axes of symmetry of the rectangle formed by the edges of the rectangular sheet.

16. The tank as claimed in claim 15, wherein the two folds of the sheet of the impermeable barrier intersect at the center of the rectangular sheet.

17. The tank as claimed in claim 15, wherein one of the folds of the sheet of the impermeable barrier is continuous and the other is interrupted in the central portion of same.

18. The tank as claimed in claim 17, wherein the impermeable barrier includes sheets of a first type that have a continuous fold along the major axis of same and sheets of a second type that have a continuous fold along the minor axis of same, the first and second types of sheet alternating regularly on a tank wall so that one sheet of one of the types is always surrounded by four sheets of the other type arranged along the four sides of same.

19. The tank as claimed in claim 1, wherein each insulated block of the thermally insulated barrier has two series of orthogonal slots, each of said series having slots arranged parallel to

two opposing sides of the insulated block, and in that the sheets of the metal membrane each have two series of supplementary folds, each of said series of supplementary folds having folds orthogonal to the folds in the other series, parallel to one of the two folds inserted in the gaps, and inserted into the slots of one of the series of slots formed in the insulated block.

20. The tank as claimed in claim 1, wherein the metal membrane has a second plurality of sheets, each of the sheets in the second plurality having a single fold parallel to two opposing sides of the insulated blocks, said fold being inserted into a gap formed between two insulated blocks.

21. The tank as claimed in claim 1, wherein each insulated block of the thermally insulated barrier has a slot parallel to two opposing sides of the insulated blocks and in which the metal membrane has a second plurality of sheets, each of the sheets in the second plurality having a fold inserted in a slot formed in an insulated block and a fold inserted in a gap formed between two insulated blocks.

22. A ship used to transport a liquid product, the ship having a double hull and a tank as claimed in claim 1 placed inside the double hull.

23. A method of using a ship as claimed in claim 22 for loading or offloading a liquid product, comprising the step of channeling a liquid product through insulated pipes to or from an onshore or floating storage facility to or from the tank on the ship.

24. A transfer system for a liquid product, the system including a ship as claimed in claim 22, insulated pipes arranged to connect the tank installed in the hull of the ship to an onshore or floating storage facility and a pump for driving a flow of liquid product through the insulated pipes to or from the onshore or floating storage facility to or from the tank on the ship.

25. The tank as claimed in claim 2, wherein the attachment means of the thermally insulated barrier of the primary element include a continuous metal plate arranged at the intersection of the two connecting strips to form an impermeable zone to which the corners of the four sheets can be welded around said attachment means, and a projecting member crossing the impermeable barrier of the secondary element without reaching the impermeable barrier of the primary element.

26. The tank as claimed in claim 1, wherein the plurality of sheets of the metal membrane each having at least two orthogonal folds inserted in the gaps formed between the insulating blocks are welded to the connecting strips.

27. The tank as claimed in claim 1, wherein the plurality of sheets of the metal membrane each having at least two orthogonal folds inserted in the gaps formed between the insulating blocks are juxtaposed and are welded together sealingly.

28. The tank as claimed in claim 1, wherein each insulating block of the thermally insulated barrier is covered by at least four sheets of the plurality of sheets of the metal membrane each having at least two orthogonal folds inserted in the gaps formed between the insulating blocks.

29. The tank as claimed in claim 1, wherein the two metal connecting strips that are carried by each insulating block of the thermally insulated barrier are arranged along the two axes of symmetry of a rectangle defined by a large face of said insulating block;  
wherein the plurality of sheets of the metal membrane each having at least two orthogonal folds inserted in the gaps formed between the insulating blocks are welded to the connecting strip and are rectangular, the orthogonal folds being formed along the axes of symmetry of the rectangle formed by the edges of the rectangular sheet.

30. An impermeable and thermally insulated tank built into a structure that includes a load-bearing wall, said tank having a tank wall attached to said load-bearing wall, the tank wall comprising:

a thermally insulated barrier held on the load-bearing wall and made up of cuboid thermally insulated blocks, juxtaposed in parallel rows separated from one another by gaps,

an impermeable barrier carried by the thermally insulated barrier, said impermeable barrier comprising a metal membrane formed of metal sheets welded together sealingly,

at least some of the insulating blocks of the thermally insulated barrier carrying, on the face of same opposite the load-bearing wall at least two substantially orthogonal metal connecting strips, arranged parallel to the sides of the insulating block, the sheets of the metal membrane carried by said insulating block being welded to said strips, said connecting strips being rigidly connected to the insulating block bearing same,

a plurality of sheets of the metal membrane each having at least two orthogonal folds parallel to the sides of the thermal insulating blocks, said folds being inserted in the gaps formed between the insulating blocks;

wherein each insulating block of the thermally insulated barrier has two series of orthogonal slots, each of said series having slots arranged parallel to two opposing sides of the insulating block, and in that the sheets of the metal membrane each have two series of supplementary folds, each of said series of supplementary folds having folds orthogonal to the folds in the other series, parallel to one of the two folds inserted in the gaps, and inserted into the slots of one of the series of slots formed in the insulating block.

31. An impermeable and thermally insulated tank built into a structure that includes a load-bearing wall, said tank having a tank wall attached to said load-bearing wall, the tank wall comprising:

a thermally insulated barrier held on the load-bearing wall and made up of cuboid insulating blocks, juxtaposed in parallel rows separated from one another by gaps,

an impermeable barrier carried by the thermally insulated barrier, said impermeable barrier comprising a metal membrane formed of metal sheets welded together sealingly,

at least some of the insulating blocks of the thermally insulated barrier carrying, on the face of same opposite the load-bearing wall at least two substantially orthogonal metal connecting strips, arranged parallel to the sides of the insulating block, the sheets of the metal membrane carried by said insulating block being welded to said strips, said connecting strips being rigidly connected to the insulating block bearing same,

a plurality of sheets of the metal membrane each having at least two orthogonal folds parallel to the sides of the thermal insulating blocks, said folds being inserted in the gaps formed between the insulating blocks ;

wherein each insulating block of the thermally insulated barrier has a slot parallel to two opposing sides of the insulating blocks and in which the metal membrane has a second plurality of sheets, each of the sheets in the second plurality having a fold inserted in a slot formed in an insulating block and a fold inserted in a gap formed between two insulating blocks.