

Description

Title of the invention: Vessel comprising a superstructure and a tank for the storage of liquefied gas to the rear of the superstructure

5 **Technical field**

[1] The invention relates to the field of vessels comprising a superstructure and a sealed and thermally insulating tank for the storage of a liquefied combustible gas at low temperature situated to the rear of the superstructure. The tank is intended to receive liquefied combustible gas serving as fuel for the propulsion of the vessel.

10 [2] In one embodiment, the liquefied combustible gas is liquefied natural gas (LNG), namely a mixture with high methane content stored at a temperature of approximately -162° C at atmospheric pressure. Other liquefied combustible gases can also be envisaged, notably ethane, propane, butane, liquefied petroleum gas (LPG), ethylene, ammonia or methanol.

15 **Prior art**

[3] Already proposed, in the documents CN110789663 B, KR 10-2015-0082929 A or CN 108502102 A, are vessels in which a sealed and thermally insulating tank for the storage of LNG is situated to the rear of the superstructure of the vessel. This makes it possible to propel the vessel primarily, even entirely, using LNG, instead of diesel oil usually used
20 in the maritime sector, which offers certain advantages, notably by limiting certain atmospheric pollutant waste; and doing so without positioning the tank at a location which otherwise would have been used for the transportation of the cargo or of the payload of the vessel.

[4] However, the movements of the vessel at sea, for example under the effect of the
25 climatic conditions such as the state of the sea or of the wind, cause an agitation of the liquid in the tank. The agitation of the liquid, generally designated by the term « sloshing », generates strains on the walls of the tank which can compromise the integrity of the tank. Now, the integrity of the tank is particularly important in the context of a tank of LNG because of the flammable or explosive nature of the liquid transported
30 and the risk of a cold point on the steel hull of the vessel.

[5] Also, in the context of a vessel as proposed by the above-mentioned documents, the risk of damage to the tank due to the sloshing is increased because of two distinct factors.

[6] Firstly, since the LNG contained in the tank is gradually consumed during the voyage of the vessel, the tank is neither entirely full nor entirely empty for a significant part of the voyage. Now it is known that the risk of damage due to the sloshing is greater with a tank which is neither entirely full nor entirely empty, since, in an empty tank, the residual liquid contained in the tank has a limited weight and generates only weak strains on the walls of the tanks, while in a full tank, the residual space not occupied by the liquid in the tank is limited, which commensurately limits the freedom of movement of the liquid in the tank and therefore the force of the impacts on the tank walls.

[7] Secondly, the disposition of the tank to the rear of the superstructure, which itself is situated to the rear of the vessel, leads the tank to be situated very far from the metacentre of the vessel, which exacerbates the movements of the liquid in the tank and therefore the corresponding risk of damage to the tank due to the sloshing.

Summary of the invention

[8] Certain aspects of the invention start from the observation that if it is desirable to dispose the tank to the rear of the superstructure, it is important to ensure that this positioning of the tank does not increase the risk of damage to the tank due to the sloshing.

[9] One idea on which the invention is based thus consists in proposing a vessel of the above-mentioned type in which the tank is able to withstand the damage due to the sloshing despite its positioning to the rear of the superstructure.

[10] The invention thus proposes a vessel comprising:

- a hull extending in a longitudinal direction of the vessel, the hull comprising a bottom and a top deck spaced apart from the bottom in a vertical direction of the vessel;
 - a superstructure situated in a rear last quarter of the vessel in the longitudinal direction and extending above the top deck in the vertical direction;
 - a sealed and thermally insulating tank for the storage of a liquefied combustible gas, the tank being situated to the rear of the superstructure in the longitudinal direction, the tank comprising tank walls including: a bottom wall; a ceiling wall spaced apart from the bottom wall; two longitudinal walls; two chamfered top walls each linking the ceiling wall to a longitudinal wall; and two chamfered bottom walls each linking the bottom wall to a longitudinal wall,
- the two longitudinal walls being parallel and spaced apart from one another in a transverse direction of the vessel, the transverse direction being at right angles to the longitudinal direction and to the vertical direction of the vessel, and the bottom wall having a median line extending parallel to the longitudinal direction of the vessel, one of the chamfered bottom walls meeting the bottom wall at a bottom edge, and

meeting the adjacent longitudinal wall at an intermediate edge,
 wherein a distance B, parallel to the transverse direction, between the median line of the
 bottom wall and the intermediate edge, and a distance C1, parallel to the transverse
 direction, between the bottom edge and the intermediate edge, bear out the inequality
 5 $C1 \geq 0.45 \cdot B$.

[11] It is specified that the expressions “rear last quarter” and “to the rear of the
 superstructure” are understood with respect to the normal forward direction of the vessel
 in the longitudinal direction. Likewise, the expression “forward of” is understood with
 respect to this forward direction of the vessel.

10 [12] It has been found by the applicant that, with such a dimensioning of the tank, there is
 a tendency to limit the risk of damage to the tank due to the sloshing. The tank is thus
 able to withstand the damage due to the sloshing despite its positioning to the rear of the
 superstructure.

15 [13] According to embodiments, such a vessel can have one or more of the following
 features.

[14] According to one embodiment, the distance B and the distance C1 bear out the
 inequality $0.50 \cdot B \geq C1 \geq 0.45 \cdot B$. Such a dimensioning tends to facilitate the installation of
 a scaffolding in the tank during the construction of the tank.

20 [15] According to another embodiment, the distance B and the distance C1 bear out the
 inequality $C1 \geq 0.60 \cdot B$. It has been found by the applicant that, with such a dimensioning
 of the tank, the risk of damage to the tank due to the sloshing is very appreciably limited.
 The tank is thus even more able to withstand the damage due to the sloshing despite its
 positioning to the rear of the superstructure.

25 [16] Furthermore, the chamfered bottom wall of the tank being relatively large compared
 to the bottom wall, a relatively large free space can be freed up in the hull under the
 chamfered bottom wall, which can accommodate other equipment of the vessel.

[17] According to one embodiment, the two chamfered bottom walls are symmetrical with
 respect to a plane of symmetry extending parallel to the vertical direction and including
 the median line of the bottom wall.

30 [18] According to one embodiment, the tank is symmetrical with respect to a plane of
 symmetry extending parallel to the vertical direction and including the median line of the
 bottom wall.

[19] According to one embodiment, the plane of symmetry coincides with a median plane
 of the hull, the median plane extending parallel to the longitudinal direction of the vessel.

[20] Thus, the tank is not only symmetrical with respect to the plane of symmetry, but also centered with respect to the hull of the vessel, which tends to limit the sloshing.

[21] According to one embodiment, the ceiling wall of the tank has a surface area greater than the surface area of the bottom wall of the tank.

5 [22] According to one embodiment, the chamfered bottom wall meets the bottom wall at the bottom edge so as to form an angle equal to 45° with the bottom wall.

[23] This way, it is possible to produce the tank walls, or at the very least the bottom wall and the chamfered bottom wall, according to constructions that are known for membrane tanks which allow the production of angles at 45° . Furthermore, the angle equal to 45°
10 makes it possible to free up a large free space in the hull under the chamfered bottom wall. However, other values can be envisaged for the angle.

[24] According to one embodiment, one of the chamfered top walls meets the ceiling wall at a top edge so as to form an angle equal to 45° with the ceiling wall, and meets the adjacent longitudinal wall at a second intermediate edge.

15 [25] According to one embodiment, a distance H, parallel to the vertical direction of the vessel, between the bottom edge and the top edge, and a distance C3, parallel to the vertical direction of the vessel, between the second intermediate edge and the top edge, bear out the inequality $C3 \geq 0.17 \cdot H$.

[26] According to one embodiment, the distance C1 is strictly greater than the distance
20 C3. According to another embodiment, the distance C1 is equal to the distance C3.

[27] According to one embodiment, the tank walls further include two transverse walls that are parallel and spaced apart in the longitudinal direction of the vessel.

[28] According to one embodiment, each of the tank walls comprises a multilayer structure comprising, from the outside to the inside of the tank, a secondary thermally
25 insulating barrier, a secondary sealing membrane situated against the secondary thermally insulating barrier, a primary thermally insulating barrier situated against the secondary sealing membrane and a primary sealing membrane situated against the primary thermally insulating barrier and intended to be in contact with the liquefied gas.

[29] According to one embodiment, the vessel further comprises a plurality of
30 intermediate decks situated between the bottom and the top deck of the hull and including a first intermediate deck, and the tank extends, in the vertical direction, from the first intermediate deck to above the top deck.

[30] This way, it is possible to vary the filling capacity of the tank, simply by modifying the height of the part of the tank which extends above the top deck, without appreciably modifying the rest of the configuration of the vessel. This makes it possible to adapt the liquefied combustible gas carrying capacity of the vessel according to the needs of the vessel.

[31] According to one embodiment, the intermediate decks further include a second intermediate deck situated above the first intermediate deck in the vertical direction, and the intermediate edge is situated, in the vertical direction, between the second intermediate deck and the top deck.

10 [32] According to one embodiment, the vessel further comprises a plurality of cofferdam walls surrounding the tank, and each of the tank walls is fixed to a facing cofferdam wall.

[33] The cofferdam walls constitute a structural assembly fixed to the hull of the vessel and which entirely surrounds the tank, which ensures a satisfactory structural anchoring of the tank on the hull, protects the tank from the external elements despite its positioning partly above the top deck, and protects the hull against any contact with the liquefied combustible gas in the event of an accidental leak from the tank.

15 [34] According to one embodiment, the cofferdam walls include: two longitudinal cofferdam walls, each of the two longitudinal walls of the tank being fixed to a longitudinal cofferdam wall; and two chamfered cofferdam walls, each of the two chamfered bottom walls of the tank being fixed to a chamfered cofferdam wall, and one of the chamfered cofferdam walls meeting a longitudinal cofferdam wall at an intermediate cofferdam edge; and the intermediate edge is above the intermediate cofferdam edge in the vertical direction of the vessel.

20 [35] According to one embodiment, the cofferdam walls further include two transverse cofferdam walls, each of the two transverse walls of the tank being fixed to a transverse cofferdam wall.

[36] According to one embodiment, the tank comprises a pump configured to vent liquefied combustible gas from an internal volume of the tank.

25 [37] According to one embodiment, the bottom wall comprises a sump, and the pump comprises a pump head disposed in the sump.

[38] Such a configuration makes it possible to appreciably reduce the volume of liquefied combustible gas which cannot be pumped by the pump.

30 [39] According to one embodiment, the vessel further comprises a gas vent mast comprising a mast body and a mast head, a first end of the mast body being fixed to the

vessel to the rear of the superstructure in the longitudinal direction of the vessel and above the ceiling wall of the tank in the vertical direction of the vessel, the mast head being disposed at a second end of the mast body and comprising an opening allowing the combustible gas contained in the tank to be vented, and the mast body being inclined such that the second end is farther away from the superstructure, in the longitudinal direction of the vessel, than the first end.

[40] Such a configuration makes it possible to ensure that the opening allowing the combustible gas contained in the tank to be vented is situated as far as possible away from the superstructure. This contributes to protecting the crew of the vessel in the event of overpressure and/or of serious damage to the tank.

[41] According to one embodiment, the vessel further comprises at least one liquefied combustible gas intake installation configured to convey liquefied combustible gas to the tank, the liquefied combustible gas intake installation being situated on the top deck forward of the superstructure in the longitudinal direction of the vessel, and preferably situated in a lateral region of the top deck in the transverse direction of the vessel.

[42] According to one embodiment, the ceiling wall of the tank is topped by a tank connection space comprising a dome structure through which a liquefied combustible gas loading duct passes through the ceiling wall of the tank.

[43] According to one embodiment, the vessel further comprises a propulsion system, the tank being intended to supply the combustible gas to the propulsion system.

[44] The vessel can thus be propelled primarily by burning the liquefied combustible gas contained in the tank, which limits certain atmospheric pollutant waste associated with the combustion of marine diesel oil; and does so without positioning the tank at a location which otherwise would have been used for the transportation of the cargo or of the payload of the vessel.

[45] According to one embodiment, the vessel further comprises at least one gas management system disposed above the ceiling wall of the tank and configured to supply liquefied combustible gas contained in the tank to the propulsion system.

[46] According to one embodiment, the propulsion system comprises a main engine and at least one auxiliary engine, the main engine being situated in the hull forward of the tank in the longitudinal direction of the vessel, the auxiliary engine being situated in the hull more laterally than the main engine in the transverse direction of the vessel.

[47] According to one embodiment, the main engine is disposed in a main machine room provided on the first intermediate deck and the second intermediate deck in the

extension of the plane of symmetry of the tank, and the auxiliary engine is disposed in an auxiliary machine room provided on the second intermediate deck more laterally than the main machine room in the transverse direction of the vessel.

[48] According to one embodiment, the propulsion system comprises a combustible gas vent duct linked both to the main engine and to the auxiliary engine and passing through the second intermediate deck between the tank and the superstructure in the longitudinal direction of the vessel.

[49] This limits the total length of piping needed to vent the combustion gases coming from the main engine and from the auxiliary engine.

[50] According to one embodiment, the combustion gas vent duct emerges in a funnel disposed between the tank and the superstructure in the longitudinal direction of the vessel.

[51] According to one embodiment, the liquefied combustible gas is liquefied natural gas. According to another embodiment, the liquefied combustible gas is a liquefied combustible gas taken from the group formed by ethane, propane, butane, liquefied petroleum gas (LPG), ethylene, ammonia and methanol; in particular taken from the group formed by ethane, propane, butane, liquefied petroleum gas (LPG), and ethylene.

[52] According to one embodiment, the vessel comprises, forward of the superstructure in the longitudinal direction of the vessel, at least one hold for transporting a loose solid product.

[53] According to one embodiment, the vessel comprises a loading opening passing through the top deck and configured to allow a loose solid product to be loaded in the hold.

[54] According to one embodiment, the vessel comprises, forward of the superstructure in the longitudinal direction of the vessel, a plurality of holds spaced apart in the longitudinal direction of the vessel, the plurality of holds comprising a hold closest to the superstructure.

[55] According to one embodiment, the liquefied combustible gas intake installation is situated on the top deck forward of the superstructure and to the rear of the loading opening of the hold closest to the superstructure, in the longitudinal direction of the vessel.

[56] This way, the liquefied combustible gas intake installation is situated relatively close to the superstructure and to the rear of all the hold loading openings, which respectively makes it possible to limit the length of the pipelines conveying the liquefied combustible

gas to the tank, and limit the risk of dropping of a load on the liquefied combustible gas intake installation.

[57] According to one embodiment, the invention also provides a transfer system for a liquefied combustible gas, the system comprising an above-mentioned vessel, insulated pipelines arranged so as to link the tank of the vessel to a floating or onshore storage installation and a pump for driving a flow of liquefied combustible gas through the insulated pipelines from the floating or onshore storage installation to the tank of the vessel.

[58] According to one embodiment, the invention also provides a method for loading an above-mentioned vessel, wherein a liquefied combustible gas is conveyed through insulated pipelines from a floating or onshore storage installation to the tank of the vessel.

Brief description of the figures

[59] The invention will be better understood, and other aims, details, features and advantages thereof will become more clearly apparent from the following description of several particular embodiments of the invention, given in a purely illustrative and nonlimiting manner, with reference to the attached drawings.

[60] [Fig. 1] Figure 1 is a cross-sectional view of the rear part of a vessel comprising a sealed and thermally insulating tank for the storage of a liquefied combustible gas, the tank being situated to the rear of the superstructure of the vessel in the longitudinal direction of the vessel.

[61] [Fig. 2] Figure 2 is a cross-sectional view of the vessel of figure 1 according to the line II-II.

[62] [Fig. 3] Figure 3 is a cross-sectional view of the vessel of figure 1 according to the line III-III.

[63] [Fig. 4] Figure 4 is a cross-sectional schematic view of a half of the tank of the vessel of figure 1, serving to illustrate relevant quantities for the dimensioning of the tank.

[64] [Fig. 5] Figure 5 is a cross-sectional view of the vessel of figure 1 along the plane V.

[65] [Fig. 6] Figure 6 is a cross-sectional view of the vessel of figure 1 along the plane VI.

[66] [Fig. 7] Figure 7 is a cross-sectional view of the vessel of figure 1 along the plane VII.

[67] [Fig. 8] Figure 8 is a schematic representation of a vessel comprising a sealed and thermally insulating tank for the storage of a liquefied combustible gas, the tank being

situated to the rear of the superstructure of the vessel, and a terminal for loading this tank.

Description of the embodiments

[68] There now follows a description, with reference to figures 1 to 8, of a vessel 1 comprising a sealed and thermally insulating tank for the storage of a liquefied combustible gas, the tank being situated to the rear of the superstructure of the vessel 1.

[69] Figure 1 is a cross-sectional view of the rear part of the vessel 1. The vessel 1 is, here, a bulk carrier, that is to say a vessel designed for the transportation of loose solid products. Thus, as is known per se, the vessel 1 comprises, forward of its superstructure 6 in a longitudinal direction $X'-X$ of the vessel 1, one or more holds 9 for transporting a loose solid product. The holds 9 are spaced apart in the longitudinal direction $X'-X$ of the vessel 1 as is known per se. It is specified that just one of these holds 9, namely the hold 9 closest to the superstructure 6, is represented schematically in figure 1. As is known per se, each hold 9 is accessible from a loading opening 99 passing through the top deck 5 and allowing the loose solid product to be introduced into the hold 9.

[70] It is however specified that the following description is applicable to types of vessel other than bulk carriers, provided that these vessels include a superstructure 6.

[71] As has just been mentioned, the vessel 1 comprises a superstructure 6, the construction of which is known as such and which is situated in a rear last quarter of the vessel 1 in the longitudinal direction $X'-X$ of the vessel 1. It is specified that the expressions "rear last quarter" and "to the rear of the superstructure 6" are understood with respect to the normal forward direction F of the vessel 1 in the longitudinal direction $X'-X$. Likewise, the expression "forward of" is understood with respect to this forward direction F of the vessel 1.

[72] As is known per se, the hull 3 of the vessel 1 comprises a bottom 4, possibly double-walled, and a top deck 5 spaced apart from the bottom 4 in a vertical direction $Y'-Y$ of the vessel 1, the superstructure 6 extending above the top deck 5 in the vertical direction $Y'-Y$. Still as is known per se, the superstructure 6 is a structure which shelters various decks 6D for the crew of the vessel, and comprises, at its top, a bridge 6P accommodating various equipment for enabling the crew of the vessel 1 to pilot the vessel 1.

[73] The vessel 1 comprises a sealed and thermally insulating tank 2, hereinafter designated "the tank 2" for convenience. The tank 2 is designed to allow the storage of a liquefied combustible gas. In one embodiment, the liquefied combustible gas is liquefied

natural gas (LNG). Other liquefied combustible gases can also be envisaged, notably ethane, propane, butane, liquefied petroleum gas (LPG), ethylene, ammonia or methanol. The liquefied combustible gas contained in the tank 2 is intended to supply a propulsion system 80 which will be described in more detail later.

5 [74] There now follows a more detailed description of the construction of the tank 2 and its positioning in the vessel 1.

[75] Generally, as is represented in figure 1, figure 6, and figure 7, the tank 2 is situated to the rear of the superstructure 6 in the longitudinal direction X'-X.

10 [76] Returning to figure 1, the vessel 1 further comprises a first intermediate deck 11, a second intermediate deck 12 and a third intermediate deck 13. The intermediate decks 11, 12 and 13 extend between the bottom 4 and the top deck 5 and are spaced apart in the vertical direction Y'-Y.

[77] Referring to figure 1, figure 2 and figure 3, the tank 2 extends, in the vertical direction Y'-Y, from the second intermediate deck 12 to above the top deck 5.

15 [78] Figure 2 and figure 3 are, respectively, cross-sectional views of the vessel 1 along the planes II-II and III-III of figure 1, and thus show the tank 2 in cross-section in a transverse direction Z'-Z of the vessel 1. It is specified that the transverse direction Z'-Z is at right angles to the longitudinal direction X'-X and to the vertical direction Y'-Y.

20 [79] As can be seen in figure 2 and figure 3, the tank 2 comprises tank walls including: a bottom wall 22; a ceiling wall 23; two longitudinal walls 24; two chamfered bottom walls 25; and two chamfered top walls 26. The above-mentioned tank walls, together with two transverse walls (not represented) extending parallel to the transverse direction Z'-Z, delimit an internal volume 21 of the tank 2 in which the liquefied combustible gas is received.

25 [80] Each of the above-mentioned tank walls comprises a multilayer structure comprising, from the outside to the inside of the tank, a secondary thermally insulating barrier, a secondary sealing membrane situated against the secondary thermally insulating barrier, a primary thermally insulating barrier situated against the secondary sealing membrane and a primary sealing membrane situated against the primary thermally insulating barrier
30 and intended to be in contact with the liquefied combustible gas. By way of example, such membrane tanks are notably described in the documents WO 2019/239048 A1, WO 2014/057221 A1, FR 2 691 520 A1 and FR 2 877 638 A1. Membrane tanks can notably be correspond to the products GTT Next1®, Mark V®, Mark III® and NO96® developed by the applicant.

[81] As can be seen in figure 3, the ceiling wall 23 of the tank 2 is topped by a "Tank Connection Space" (TCS) 50. The tank connection space 50 notably comprises a dome structure 29 through which a loading duct (not represented) passes through the ceiling wall 23 in order to fill the tank 2 with liquefied combustible gas. This tank connection space 50 is a secured space in which the ducts passing through the ceiling wall 23 are coupled to the other equipment of the vessel 1.

[82] It can also be seen in figure 3 that one or more "Fuel Gas Handling Systems" (FGHS) 51 are disposed above the ceiling wall 23 of the tank 2. The fuel gas handling systems 51, as is known per se, are configured to supply liquefied combustible gas contained in the tank 2 to the propulsion system 80, by means of a set of ducts and valves not represented in the drawings.

[83] Still referring to figure 3, the tank connection space 50 is topped by a "gas vent mast" 60 which will be described in more detail later.

[84] As is known per se and not represented in the drawings, the internal volume 21 of the tank 2 is provided with at least one pump configured to drive the liquefied combustible gas from the internal volume 21 of the tank to the propulsion system 80, via the dome structure 29. The pump is for example supported by a tripod mast that is known per se and disposed in the internal volume 21 of the tank.

[85] In one embodiment, the bottom wall 22 of the tank 2 comprises a sump 65, and the pump comprises a pump head which is disposed in this sump 65. Such a configuration is advantageous because it makes it possible to appreciably reduce the volume of liquefied combustible gas which cannot be pumped by the pump. As a variant, as represented in figure 3, the tank 2 can comprise several pumps, and several distinct sumps 65 can be provided on the bottom wall 22 to each receive a pump head of a corresponding pump.

[86] The above-mentioned tank walls are surrounded by a set of cofferdam walls generally designated by the reference 40, and more particularly visible in figures 2 and 3. Each of the tank walls is fixed to a facing cofferdam wall of the set of cofferdam walls 40.

[87] In more concrete terms, the set of cofferdam walls 40 includes:

- a bottom cofferdam wall 42, to which the bottom wall 22 of the tank 2 is fixed;
- a top cofferdam wall 43, to which the ceiling wall 23 of the tank is fixed;
- two longitudinal cofferdam walls 44, each of the longitudinal walls 24 of the tank 2 being fixed to a longitudinal cofferdam wall 44;
- two chamfered cofferdam walls 45, each of the chamfered bottom walls 25 of the tank 2 being fixed to a chamfered cofferdam wall 45; and
- two transverse cofferdam walls (not represented) extending parallel to the transverse

direction Z'-Z, each of the transverse walls (not represented) of the tank 2 being fixed to a transverse cofferdam wall.

[88] As represented in figures 2 and 3, each of the chamfered cofferdam walls 45 meets the adjacent longitudinal cofferdam wall 44 at an intermediate cofferdam edge 49.

5 [89] It is well understood that the set of cofferdam walls 40 constitutes a structural assembly fixed to the hull 3 of the vessel 1 and which entirely surrounds the tank 2, which ensures a satisfactory structural anchoring of the tank 2 on the hull 3, protects the tank 2 from the external elements despite its positioning partly above the top deck 5, and protects the hull 3 against any contact with the liquefied combustible gas in the case of
10 an accidental leak from the tank 2.

[90] The positioning of the tank 2 to the rear of the superstructure 6 in the longitudinal direction X'-X, which itself is situated to the rear of the vessel 1, causes the tank 2 to be situated very far from the metacentre (not represented) of the vessel 1. This exacerbates the movements of the liquefied combustible gas contained in the tank 2 and therefore the
15 corresponding risk of damage to the tank 2 due to the sloshing. Described hereinbelow, by referring more particularly to figure 4, are features of the tank 2 which allow the tank 2 to withstand the damage due to the sloshing despite its positioning to the rear of the superstructure in the longitudinal direction X'-X.

[91] It is possible to define a median line 31 of the bottom wall 22 which extends parallel
20 to the longitudinal direction X'-X of the vessel 1. The term "median" is understood to mean that the median line 31 divides the bottom wall 22 into two half-walls which have equal surface areas. In the example represented, the median line 31 corresponds to a central height axis of the tank 2. The plane 31P at right angles to the bottom wall 22 and including the median line 31 thus divides the internal volume 21 of the tank 2 into two
25 portions which have equal volumes.

[92] The central height axis of the tank 2 can possibly pass through the dome structure 29 as represented in figure 2 and figure 3.

[93] Referring to figure 2, to figure 3 and to figure 4, a chamfered bottom wall 25 meets the bottom wall 22 at a bottom edge 32 so as to form an angle δ (see figure 4) equal to
30 45°. Furthermore, this chamfered bottom wall 25 meets the adjacent longitudinal wall 24 at an intermediate edge 33.

[94] Referring to figure 2 and to figure 3, the intermediate edge 33 can be situated, in the vertical direction Y'-Y, between the intermediate deck 13 and the top deck 5, and/or the

intermediate edge 33 can be situated, in the vertical direction Y'-Y, above the intermediate cofferdam edge 49.

[95] Referring to figure 4, the following are defined:

- a distance B, parallel to the transverse direction Z'-Z, between the median line 31 and the intermediate edge 33;
- a distance C1, parallel to the transverse direction Z'-Z, between the bottom edge 32 and the intermediate edge 33; and
- a distance C2, parallel to the vertical direction Y'-Y, between the bottom edge 32 and the intermediate edge 33.

[96] It is understood that the distances C1, C2 and B together define the relative dimensions of the chamfered bottom wall 25 and of the bottom wall 22 of the tank 2. It is also understood that, since the chamfered bottom wall 25 meets the bottom wall 22 at a bottom edge 32 so as to form an angle δ equal to 45° , then $C1 = C2$.

[97] Furthermore, the distances C1 and B are chosen such that the following inequality is borne out: $C1 \geq 0.60 \cdot B$.

[98] When the tank 2 is dimensioned in the manner which has just been described, the chamfered bottom wall 25 is relatively large with respect to the bottom wall 22 and is inclined at 45° with respect to the bottom wall 22. It has been observed by the applicant that this makes it possible to very appreciably limit the risk of damage to the tank 2 due to the sloshing, notably by limiting the risk of the liquefied combustible gas contained in the tank 2 breaking to the chamfered top wall 26, and more generally by allowing the chamfered bottom wall 25 to absorb most of the impacts of the liquefied combustible gas.

[99] As a variant, the distances C1 and B are chosen such that the following inequality is borne out: $C1 \geq 0.45 \cdot B$, for example such that $0.50 \cdot B \geq C1 \geq 0.45 \cdot B$. Such a dimensioning tends to limit the risk of damage to the tank 2 due to the sloshing, although to a lesser degree than when $C1 \geq 0.60 \cdot B$. Furthermore, such a dimensioning tends to ensure that the bottom wall 22 has a surface area that is sufficient for the installation of a scaffolding in the tank 2 during the construction of the tank 2, and therefore tends to facilitate the installation of such a scaffolding.

[100] As represented in the drawings, the tank 2, or at the very least the chamfered bottom walls 25, can be symmetrical with respect to the plane 31P.

[101] It is specified that the plane 31P can coincide with a median plane (not referenced) of the hull 3, this median plane extending parallel to the longitudinal direction X'-X of the

vessel 1. Thus, the tank 2 is not only symmetrical with respect to the plane 31P, but also centered with respect to the hull 3 of the vessel 1, which tends to limit the sloshing.

[102] It is further specified that the angle δ formed by the chamfered bottom wall 25 and the bottom wall 22 at the bottom edge 32 can have a value different from 45° . For example, this value can be equal to approximately 135° or any other value that is feasible in the context of a membrane tank.

[103] Referring once again to figure 2, to figure 3 and to figure 4, a chamfered top wall 26 meets the ceiling wall 23 at a top edge 35 so as to form an angle ζ (see figure 4) equal to 45° . Furthermore, this chamfered top wall 26 meets the adjacent longitudinal wall 24 at an intermediate edge 34.

[104] Referring once again to figure 4, the following are defined:

- a distance H, parallel to the vertical direction Y'-Y, between the bottom edge 32 and the top edge 35;
- a distance C3, parallel to the vertical direction Y'-Y, between the intermediate edge 34 and the top edge 35; and
- a distance C4, parallel to the transverse direction Z'-Z, between the intermediate edge 34 and the top edge 35.

[105] It is understood that the distances C3, C4 and H together define the relative dimensions of the chamfered top wall 26 and of the ceiling wall 23 of the tank 2. It is further understood that, since the chamfered top wall 26 meets the ceiling wall 23 at a top edge 35 so as to form an angle ζ equal to 45° , then $C3 = C4$.

[106] Furthermore, the distances C3 and H are chosen such that the following inequality is borne out: $C3 \geq 0.17 \cdot H$.

[107] Furthermore, in some embodiments, the distance C1 is strictly greater than the distance C3, and/or the ceiling wall 23 of the tank 2 has a surface area which is greater than the surface area of the bottom wall 22 of the tank 2.

[108] In other embodiments, the distance C1 is equal to the distance C3, even $C1 = C2 = C3 = C4$.

[109] The positioning of the tank 2 which has been described above with reference to the drawings is only an example. Various other positionings of the tank 2 are possible, as long as the tank 2 is situated to the rear of the superstructure 6 in the longitudinal direction X'-X.

[110] As mentioned previously, the tank connection space 50 is topped by a "gas vent mast" 60. As is known per se and as described for example in the document WO

2019/097131 A1, the mast 60 comprises a mast body 60C, and a mast head (not represented) disposed at an end 62 of the mast body 60C and comprising an opening 63 allowing the combustible gas contained in the tank 2 to be vented.

[111] Still as is known per se, the gas vent mast 60 is provided to allow the combustible gas contained in the tank 2 to be vented in the case of overpressure and/or of serious damage to the tank 2, and to do so in order to avoid a catastrophic rupture and/or an explosion of the tank 2.

[112] The end 61 of the mast body 60C which is opposite the end 62 is fixed to the vessel 1 above the ceiling wall 23 of the tank 2 and to the rear of the superstructure 6. For example, as represented in figures 1 and 3, the end 61 is fixed above the tank connection space 50.

[113] Referring to figure 1, provision is made for the mast body 60C to be inclined such that the end 62 is farther away from the superstructure 6, in the longitudinal direction X'-X, than the end 61. This way, the opening 63 allowing the combustible gas contained in the tank 2 to be vented is situated as far as possible away from the superstructure 6 and therefore from the decks 6D and the bridge 6P. This contributes to protecting the crew of the vessel 1 in the case of overpressure and/or serious damage to the tank 2.

Furthermore, it is understood that if the overpressure and/or the serious damage to the tank 2 occurs when the vessel 1 is advancing in the forward direction F, the relative wind due to the inertia of the vessel 1 will tend to push back the combustible gas even further from the superstructure 6, which contributes more to protecting the crew.

[114] As has been mentioned previously, the liquefied combustible gas contained in the tank 2 is intended to supply a propulsion system 80. There now follows a description of the propulsion system 80 and its positioning in the vessel 1, by referring more particularly to figure 1 and to figure 5.

[115] The propulsion system 80 comprises a main engine 81. The main engine 81 drives a propeller 7 via a corresponding drive shaft 7A (see figure 1). The main engine 81 can be of any known type, provided that it is able to consume liquefied combustible gas coming from the tank 2. In some variants not represented, several main engines 81 can be provided.

[116] The propulsion system 80 further comprises three auxiliary engines 82 (see figure 5). The auxiliary engines 82 are for example electric generators used to power various electrical equipment of the vessel 1 and/or turbo-electric propulsion engines of the vessel 1. The auxiliary engines 82 can be of any known type, provided that they are able to

consume liquefied combustible gas coming from the tank 2. As a variant, a different number of auxiliary engines 82 can be provided.

[117] Referring to figure 5, the main engine 81 is disposed in the hull 3 forward of the tank 2 in the longitudinal direction X'-X. For example, a central axis of the main engine 81 can be aligned with the plane 31P of the tank 2 described above. Also, the auxiliary engines 82 are disposed in the hull 3 more laterally than the main engine 81 in the transverse direction Z'-Z. For example, the main engine 81 can be disposed in a main machine room 121 provided on the intermediate decks 11 and 12 in the extension of the plane 31P of the tank 2, while the auxiliary engines 82 are disposed in an auxiliary machine room 122 provided on the intermediate deck 12 more laterally than the main machine room 121 in the transverse direction Z'-Z.

[118] The disposition of the main engine 81 and of the auxiliary engines 82 which has just been described can provide for the venting of the combustion gases leaving the main engine 81 and the auxiliary engines 82 to be done through a single combustion gas vent duct 88 (see figure 1), which limits the total length of piping necessary to the venting of the combustion gases. Referring to figure 1, the duct 88 passes through the intermediate deck 13 between the tank 2 and the superstructure 6 in the longitudinal direction X'-X. Referring to figure 1, figure 5 and figure 6, the duct 88 emerges in a funnel 8 which is disposed between the tank 2 and the superstructure 6 in the longitudinal direction X'-X.

[119] Referring once again to figure 5, a tank 89 intended to contain "Marine Diesel Oil" can be provided laterally with respect to the main machine room 121 and on the side opposite the auxiliary machine room 122 in the transverse direction Z'-Z.

[120] Referring to figure 1 and to figure 7, for the intake of the liquefied combustible gas into the tank 2, the vessel 1 is provided with at least one liquefied combustible gas intake installation (also called "bunker station") 90, that is known as such. In the example represented, two installations 90 are provided, one on each side of the vessel 1 in the transverse direction Z'-Z, more specifically in a lateral region of the top deck 5 in the transverse direction Z'-Z.

[121] The installations 90 are situated on the top deck 5 forward of the superstructure 6 in the longitudinal direction X'-X. More specifically, in the example represented, the installations 90 are situated on the top deck 5 forward of the superstructure 6 and to the rear of the opening 99 closest to the superstructure 6 in the longitudinal direction X'-X. It is understood that, in this way, the length of the pipelines 99C conveying the liquefied combustible gas to the tank 2 is limited; and the risk of dropping of a load on the installations 90 is limited.

[122] Referring to figure 8, a vessel 1 has been represented of the type described previously comprising a sealed and thermally insulating tank 2 mounted in the hull 3 of the vessel 1 behind the superstructure 6 of the vessel 1. As is known per se, vessel loading pipelines can be coupled, by means of appropriate connectors, to a maritime or port terminal to transfer a cargo of LNG to the tank 2.

[123] Figure 8 represents an example of a maritime terminal comprising a loading and offloading station 75, a submarine duct 76 and an onshore installation 77. The loading and offloading station 75 is a fixed offshore installation comprising a movable arm 74 and a tower 78 which supports the movable arm 74. The movable arm 74 bears a bundle of insulated flexible pipes 79 that can be connected to the loading pipeline of the vessel. The orientable movable arm 74 adapts to all vessel templates. A link duct that is not represented extends inside the tower 78. The loading station 75 allows the vessel 1 to be loaded with LNG fuel from or to the onshore installation 77. The latter comprises liquefied gas storage tanks 80 and link ducts 81 linked by the submarine duct 76 to the loading station 75. The submarine duct 76 allows liquefied gas to be transferred between the loading station 75 and the onshore installation 77 over a great distance, for example 5 km, which makes it possible to keep the vessel 1 at a great distance from the coast during the loading operations.

[124] To generate the pressure necessary for the transfer of the liquefied gas, pumps embedded in the vessel 1 and/or pumps with which the onshore installation 77 is equipped and/or pumps with which the loading station 75 is equipped are implemented.

[125] Although the invention has been described in association with a number of particular embodiments, it is obvious that it is in no way limited thereto and that it includes all the technical equivalents of the means described and the combinations thereof if the latter fall within the context of the invention.

[126] The use of the verb “comprise” or “include” and its conjugate forms does not preclude the presence of elements or steps other than those stated in a claim.

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

Claims

[Claim 1] A vessel (1) comprising:

- a hull (3) extending in a longitudinal direction (X'-X) of the vessel (1), the hull (3) comprising a bottom (4) and a top deck (5) spaced apart from the bottom (4) in a vertical direction (Y'-Y) of the vessel (1);
- a superstructure (6) situated in a rear last quarter of the vessel (1) in the longitudinal direction (X'-X) and extending above the top deck (5) in the vertical direction (Y'-Y);
- a sealed and thermally insulating tank (2) for the storage of a liquefied combustible gas, the tank (2) being situated to the rear of the superstructure (6) in the longitudinal direction (X'-X),
the tank comprising tank walls including: a bottom wall (22); a ceiling wall (23) spaced apart from the bottom wall (22); two longitudinal walls (24); two chamfered top walls (26) each linking the ceiling wall (23) to a longitudinal wall (24); and two chamfered bottom walls (25) each linking the bottom wall (22) to a longitudinal wall (24),
the two longitudinal walls (24) being parallel and spaced apart from one another in a transverse direction (Z'-Z) of the vessel (1), the transverse direction (Z'-Z) being at right angles to the longitudinal direction (X'-X) and to the vertical direction (Y'-Y) of the vessel (1), and the bottom wall (22) having a median line (31) extending parallel to the longitudinal direction (X'-X) of the vessel (1),
one of the chamfered bottom walls (25) meeting the bottom wall (22) at a bottom edge (32), and meeting the adjacent longitudinal wall (24) at an intermediate edge (33),
wherein a distance B, parallel to the transverse direction (Z'-Z), between the median line (31) of the bottom wall (22) and the intermediate edge (33), and a distance C1, parallel to the transverse direction (Z'-Z), between the bottom edge (32) and the intermediate edge (33), bear out the inequality $C1 \geq 0.45 \cdot B$.

[Claim 2] The vessel (1) as claimed in claim 1, wherein the distance B and the distance C1 bear out the inequality $C1 \geq 0.60 \cdot B$.

[Claim 3] The vessel (1) as claimed in either one of claims 1 and 2, wherein the tank (2) is symmetrical with respect to a plane of symmetry (31P) extending parallel to the vertical direction (Y'-Y) and including the median line (31) of the bottom wall (22).

[Claim 4] The vessel (1) as claimed in any one of claims 1 to 3, wherein each of the tank walls comprises a multilayer structure comprising, from the outside to the inside

of the tank, a secondary thermally insulating barrier, a secondary sealing membrane situated against the secondary thermally insulating barrier, a primary thermally insulating barrier situated against the secondary sealing membrane and a primary sealing membrane situated against the primary thermally insulating barrier and intended to be in contact with the liquefied gas, and wherein the chamfered bottom wall (25) meets the bottom wall at the bottom edge (32) so as to form an angle (δ) equal to 45° with the bottom wall (22).

[Claim 5] The vessel (1) as claimed in any one of claims 1 to 4, further comprising a plurality of intermediate decks situated between the bottom (4) and the top deck (5) of the hull (3) and including a first intermediate deck (12), and wherein the tank (2) extends, in the vertical direction ($Y'-Y$), from the first intermediate deck (12) to above the top deck (5).

[Claim 6] The vessel (1) as claimed in claim 5, wherein the intermediate decks further include a second intermediate deck (13) situated above the first intermediate deck (12) in the vertical direction ($Y'-Y$), and wherein the intermediate edge (33) is situated, in the vertical direction, between the second intermediate deck (13) and the top deck (5).

[Claim 7] The vessel (1) as claimed in any one of claims 1 to 6, further comprising a plurality of cofferdam walls (40) surrounding the tank (2), and wherein each of the tank walls is fixed to a facing cofferdam wall.

[Claim 8] The vessel (1) as claimed in claim 7, wherein the cofferdam walls include: two longitudinal cofferdam walls (44), each of the two longitudinal walls (24) of the tank (2) being fixed to a longitudinal cofferdam wall (44); and two chamfered cofferdam walls (45), each of the two chamfered bottom walls (25) of the tank (2) being fixed to a chamfered cofferdam wall (45), and one of the chamfered cofferdam walls (45) meeting a longitudinal cofferdam wall (44) at an intermediate cofferdam edge (49); and wherein the intermediate edge (33) is above the intermediate cofferdam edge (49) in the vertical direction ($Y'-Y$) of the vessel (1).

[Claim 9] The vessel (1) as claimed in any one of claims 1 to 8, wherein the bottom wall (22) comprises a sump (65), the tank (2) comprises a pump configured to vent liquefied combustible gas from an internal volume (21) of the tank (2), and the pump comprises a pump head disposed in the sump (65).

[Claim 10] The vessel (1) as claimed in any one of claims 1 to 9, further comprising a gas vent mast (60) comprising a mast body (60C) and a mast head, a first end (61) of the mast body (60C) being fixed to the vessel (1) to the rear of the superstructure (6)

in the longitudinal direction (X'-X) of the vessel (1) and above the ceiling wall (23) of the tank in the vertical direction (Y'-Y) of the vessel (1), the mast head being disposed at a second end (62) of the mast body (60C) and comprising an opening (63) allowing the combustible gas contained in the tank (2) to be vented, and the mast body (60C) being inclined such that the second end (62) is farther away from the superstructure (6), in the longitudinal direction (X'-X) of the vessel (1), than the first end (61).

[Claim 11] The vessel (1) as claimed in any one of claims 1 to 10, further comprising at least one liquefied combustible gas intake installation (90) configured to convey liquefied combustible gas to the tank (2), the liquefied combustible gas intake installation (90) being situated on the top deck (5) forward of the superstructure (6) in the longitudinal direction (X'-X) of the vessel (1), and preferably situated in a lateral region of the top deck (5) in the transverse direction (Z'-Z) of the vessel (1).

[Claim 12] The vessel (1) as claimed in any one of claims 1 to 11, further comprising a propulsion system (80), the tank (2) being intended to supply combustible gas to the propulsion system (80).

[Claim 13] The vessel (1) as claimed in claim 12, wherein the propulsion system (80) comprises a main engine (81) and at least one auxiliary engine (82), the main engine (81) being situated in the hull (3) forward of the tank (2) in the longitudinal direction (X'-X) of the vessel (1), the auxiliary engine (82) being situated in the hull (3) more laterally than the main engine (81) in the transverse direction (Z'-Z) of the vessel (1).

[Claim 14] The vessel (1) as claimed in claim 13 taken in combination with claim 6, wherein the propulsion system (80) comprises a combustion gas vent duct (88) linked both to the main engine (81) and to the auxiliary engine (82) and passing through the second intermediate deck (13) between the tank (2) and the superstructure (6) in the longitudinal direction (X'-X) of the vessel (1).

[Claim 15] The vessel (1) as claimed in claim 14, wherein the combustion gas vent duct (88) emerges in a funnel (8) disposed between the tank (2) and the superstructure (6) in the longitudinal direction (X'-X) of the vessel (1).

[Claim 16] The vessel (1) as claimed in any one of claims 1 to 15, wherein the liquefied combustible gas is liquefied natural gas.

[Claim 17] The vessel (1) as claimed in any one of claims 1 to 16, wherein the vessel (1) comprises, forward of the superstructure (6) in the longitudinal direction (X'-X) of the vessel (1), at least one hold (9) for transporting a loose solid product.

5 [Claim 18] A transfer system for a liquefied combustible gas, the system comprising a vessel (1) as claimed in one of claims 1 to 17, insulated pipelines (73, 79, 76, 81) arranged so as to link the tank (2) of the vessel (1) to a floating or onshore storage installation (77) and a pump for driving a flow of liquefied combustible gas through the insulated pipelines from the floating or onshore storage installation to the tank (2) of the vessel (1).

[Claim 19] A method for loading a vessel (1) as claimed in one of claims 1 to 17, wherein a liquefied combustible gas is conveyed through insulated pipelines (73, 79, 76, 81) from a floating or onshore storage installation (77) to the tank (2) of the vessel (1).