

CLAIMS

1. A sealed and thermally insulating tank for storing a fluid, integrated in a support structure (6), in which a tank wall comprises, in a thickness direction:
 - a secondary thermally insulating barrier (1) and a primary thermally insulating barrier
 - 5 (3) made up of juxtaposed insulating modules (5, 7, 17, 18, 26, 30, 36), an insulating module (5, 7, 17, 18, 26, 30, 36) comprising a cover panel (10), a bottom panel (9) and an insulating lining (8) interposed between the bottom panel (9) and the cover panel (10),
 - a primary sealed membrane (4) resting on the primary thermally insulating barrier (3),
 - 10 and
 - a secondary sealed membrane (2) resting on the secondary thermally insulating barrier (1),
 - the tank wall comprising, in a length direction:
 - a first area (11) in which the insulating modules (5, 7) include spacers extending
 - 15 in the thickness direction of the tank wall between the cover panel (10) and the bottom panel (9) of said insulating modules (5, 7), said spacers being distributed over the surface of the cover panel (10) and of the bottom panel (9) in such a way that the bottom panel (9) and the cover panel (10) of said insulating modules (5, 7) are kept at a distance from one another by said spacers,
 - 20 - a second area (12) in which the insulating lining (8) of the insulating modules (5, 7) comprises a structural insulating foam interposed between the cover panel (10) and the bottom panel (9) on the surface of the cover panel (10) and of the bottom panel (9) in such a way that the cover panel (10) of said insulating modules (5, 7) is kept at a distance from the bottom panel (9) mainly by said structural insulating
 - 25 foam,
 - a transition area (14) interposed between the first area (11) and the second area (12), in which the insulating modules (5, 7, 18, 26, 30, 36) are formed in such a way that the tank wall in said transition area (14) has at least one parameter, chosen from the coefficient of thermal contraction and the modulus of elasticity in
 - 30 the thickness direction of the tank wall, the value of which lies between the value of said at least one parameter of the first area (11) of the tank wall in the thickness

direction of the tank wall and the value of said at least one parameter of the second area (12) of the tank wall in the thickness direction of the tank wall.

2. The sealed and thermally insulating tank as claimed in claim 1, in which the first area (11) is arranged over all or part of a periphery of the wall.

5 3. The sealed and thermally insulating tank as claimed in claim 1, in which the first area (11) is a corner area of the tank, a gas dome, a liquid dome or an area for attaching a support stand for a pump.

 4. The sealed and thermally insulating tank as claimed in one of claims 1 to 3, in which the insulating modules (5, 7, 18, 26, 30, 36) of the transition area (14)
10 comprise:

- a first insulating module (5, 26, 30) arranged in the secondary thermally insulating barrier (1), the first insulating module (5, 26, 30) having a first value of said at least one parameter in the thickness direction of the tank wall, and
- 15 - a second insulating module (7, 18, 26, 36) arranged in the primary thermally insulating barrier, the second insulating module (7, 18, 26, 36) having a second value of said at least one parameter in the thickness direction of the tank wall, the first insulating module (5, 26, 30) and the second insulating module (7, 18, 26, 36) being superposed
20 in the direction of the thickness of the tank wall.

5. The sealed and thermally insulating tank as claimed in claim 4, in which

- one out of the first insulating module (5, 30) and the second insulating module (7, 36) comprises spacers extending in a thickness direction of
25 the tank wall between the cover panel (10) and the bottom panel (9) of said insulating module, said spacers being distributed over the surface of the bottom panel (9) and of the cover panel (10) in such a way that the bottom panel (9) and the cover panel (10) of said insulating module are kept at a distance from one another by said spacers, and

- the other out of the first insulating module (5, 26) and the second insulating module (7, 18, 26) comprises a structural insulating foam interposed between the cover panel (10) and the bottom panel (9) on the surface of the cover panel (10) and of the bottom panel (9) in such a way that the cover panel (10) of said other insulating module is kept at a distance from the bottom panel (9) of said other insulating module by said structural insulating foam.

6. The sealed and thermally insulating tank as claimed in claim 5, in which the value of said at least one parameter of the other out of the first insulating module (5, 26) and the second insulating module (7, 18, 26) is lower than the value of said at least one parameter of the one out of the first insulating module (5, 30) and the second insulating module (7, 36).

7. The sealed and thermally insulating tank as claimed in one of claims 4 to 6, in which the first area (11) corresponds to a corner area of the tank comprising a connection ring, and the transition area (14) is directly adjacent to the connection ring, the second insulating module (7, 18, 26) comprises a structural insulating foam interposed between the cover panel (10) and the bottom panel (9) on the surface of the cover panel (10) and of the bottom panel (9) in such a way that the cover panel (10) of said other insulating module is kept at a distance from the bottom panel (9) of said other insulating module by said structural insulating foam.

8. The sealed and thermally insulating tank as claimed in claim 7, in which the first insulating module comprises spacers extending in a thickness direction of the tank wall between the cover panel (10) and the bottom panel (9) of said insulating module, said spacers being distributed over the surface of the bottom panel (9) and of the cover panel (10) in such a way that the bottom panel (9) and the cover panel (10) of said insulating module are kept at a distance from one another by said spacers.

9. The sealed and thermally insulating tank as claimed in claim 7 or claim 8, in which the insulating modules (5, 7, 18, 26, 30, 36) of the transition area (14) comprise:

- a third insulating module (26) arranged in the secondary thermally insulating barrier

(1), the third insulating module being closer to the second area (12) than the first insulating module (5, 26, 30) and having a third value of said at least one parameter in the thickness direction of the tank wall,
 - a fourth insulating module (7, 18, 26, 36) arranged in the primary thermally insulating
 5 barrier (3), the fourth insulating module (7, 18, 26, 36) being closer to the second area (12) than the second insulating module (7, 18, 26, 36) and having a fourth value of said at least one parameter in the thickness direction of the tank wall,
 and in which the third value of said at least one parameter of the third insulating module (26) is between the first value of said at least one parameter of the first
 10 insulating module (5, 26, 30) and the second value of said at least one parameter of the second insulating module (7, 18, 26, 36).

10. The sealed and thermally insulating tank as claimed in claim 9, in which the third insulating module (26) is a mixed module comprising an intermediate panel (20) arranged between the bottom panel and the cover panel, the insulating
 15 lining comprising a lower lining arranged between the intermediate panel and the bottom panel and an upper lining arranged between the intermediate panel and the cover panel, the mixed module having a coefficient of thermal expansion which is between the coefficient of thermal expansion of an insulating module of the first area (11) and the coefficient of thermal expansion of an insulating module of the second
 20 area (12).

11. The sealed and thermally insulating tank as claimed in claim 9 or claim 10, in which the fourth insulating module (7, 18, 26, 36) is identical to the second insulating module (7, 18, 26, 36), such that the fourth value of said at least one parameter is equal to the second value of said at least one parameter.

25 12. The sealed and thermally insulating tank as claimed in one of claims 4 to 6, in which the insulating modules (5, 7, 18, 26, 30, 36) of the transition area (14) comprise a third insulating module (26) arranged in the secondary thermally insulating barrier (1), the third insulating module being closer to the second area (12) than the first insulating module (5, 26, 30) and having a third value of said at least one
 30 parameter in the thickness direction of the tank wall, and in which the second insulating module (7, 18, 26) extends over the entire length of the transition area in the primary thermally insulating barrier (3), the third value of said at least one

parameter of the third insulating module (26) being between the first value of the first insulating module (5, 26, 30) of said at least one parameter and the second value of said at least one parameter of the second insulating module (7, 18, 26, 36).

13. The sealed and thermally insulating tank as claimed in claim 5, in which said other out of the first insulating module and the second insulating module (18) extends jointly in the transition area (14) and in the second area (12) of the tank wall.

14. The sealed and thermally insulating tank as claimed in one of claims 1 to 13, in which the transition area (14) has a coefficient of thermal contraction in the thickness direction of the tank wall increasing in the length direction of the tank wall from the first area (11) toward the second area (12) of the tank wall.

15. The sealed and thermally insulating tank as claimed in one of claims 1 to 14, in which the transition area (14) has a modulus of elasticity in the thickness direction of the tank wall decreasing in the length direction of the tank wall from the first area (11) toward the second area (12) of the tank wall.

16. The sealed and thermally insulating tank as claimed in claim 14, in which the coefficient of thermal contraction in the thickness direction of the tank wall in the transition area (14) increases continuously and gradually from the first area (11) toward the second area (12).

17. The sealed and thermally insulating tank as claimed in one of claims 1 to 16, in which an insulating module (7, 26) of the transition area (14) comprises a structural insulating foam (27, 41, 42) interposed between the cover panel (10) and the bottom panel (9) on the surface of the cover panel (10) and of the bottom panel (9) of said insulating module (7, 26) in such a way that the cover panel (10) of said insulating module (7, 26) is kept at a distance from the bottom panel (9) of said insulating module by said structural insulating foam, (27, 41, 42), said structural insulating foam (27, 41) having a coefficient of thermal contraction in the thickness direction of the tank wall which is lower than the coefficient of thermal contraction in said thickness direction of the structural insulating foam of the second area (12).

18. The sealed and thermally insulating tank as claimed in claim 17, in which the structural insulating foam (41, 42) of said insulating module (7) of the

transition area comprises a first portion (41) of structural insulating foam and a second portion (42) of structural insulating foam, the first portion (41) of structural insulating foam being closer to the first area (11) than the second portion (42) of structural foam, the first portion (41) of structural insulating foam having a coefficient of thermal contraction in the thickness direction of the tank which is lower than the coefficient of thermal contraction of the second portion (42) of structural insulating foam in said thickness direction.

19. The sealed and thermally insulating tank as claimed in one of claims 1 to 16, in which an insulating module (7, 26) of the transition area (14) comprises a structural insulating foam (27, 41, 42) interposed between the cover panel (10) and the bottom panel (9) on the surface of the cover panel (10) and of the bottom panel (9) of said insulating module (7, 26) in such a way that the cover panel (10) of said insulating module (7, 26) is kept at a distance from the bottom panel (9) of said insulating module by said structural insulating foam (27, 41, 42), said structural insulating foam (27, 41) having a modulus of elasticity in the thickness direction of the tank wall which is higher than the modulus of elasticity in said thickness direction of the structural insulating foam of the second area (12).

20. The sealed and thermally insulating tank as claimed in claim 19, in which the structural insulating foam (41, 42) of said insulating module (7) of the transition area comprises a first portion (41) of structural insulating foam and a second portion (42) of structural insulating foam, the first portion (41) of structural insulating foam being closer to the first area (11) than the second portion (42) of structural foam, the first portion (41) of structural insulating foam having a modulus of elasticity in the thickness direction of the tank which is higher than the modulus of elasticity of the second portion (42) of structural insulating foam in said thickness direction.

21. The sealed and thermally insulating tank as claimed in claim 18 or 20, in which the structural insulating foam (41, 42) of said module (7) of the transition area is a fiber-reinforced polyurethane foam, the first portion (41) of structural insulating foam having the fibers oriented in a thickness direction of the tank wall and the second portion (42) of structural insulating foam having the fibers oriented perpendicular to the thickness direction of the tank wall.

22. The sealed and thermally insulating tank as claimed in claim 18 or 20, in which the thickness of the first portion (41) gradually decreases from the first area (11) toward the second area (12) and the thickness of the second portion gradually increases from the first area (11) toward the second area (12).

5 23. The sealed and thermally insulating tank as claimed in one of claims 1 to 20, in which the insulating modules of the transition area comprise a mixed module (30, 36) comprising an intermediate panel (34, 39) arranged between the bottom panel (9) and the cover panel (10), the insulating lining (8) comprising a lower lining arranged between the intermediate panel (34, 39) and the bottom panel (9) and
10 an upper lining arranged between the intermediate panel (34, 39) and the cover panel (10),

the mixed module (30, 36) comprising support spacers extending in a thickness direction of the tank wall between the intermediate panel (34, 39) and one out of the bottom panel (9) and the cover panel (10), said spacers being distributed over the
15 surface of the intermediate panel (34, 39) and of said one out of the bottom panel (9) and the cover panel (10) in such a way that the intermediate panel (34, 39) and said one out of the bottom panel (9) and the cover panel (10) are kept at a distance from one another by said support spacers,

the insulating lining arranged between the intermediate panel (34, 39) and the other
20 out of the bottom panel (9) and the cover panel (10) comprising a structural insulating foam distributed over the surface of the intermediate panel (34, 39) and of said other out of the bottom panel (9) and the cover panel (10) in such a way that the intermediate panel (34, 39) and said other out of the bottom panel (9) and the cover panel (10) are kept at a distance by said structural insulating foam.

25 24. The sealed and thermally insulating tank as claimed in claim 23, in the intermediate panel (39) extends in a plane which is inclined relative to the bottom panel (9) and to the cover panel (10).

25. The sealed and thermally insulating tank as claimed in claim 23 or claim 24, in which the intermediate panel (39) is at a distance from an edge of the
30 mixed module (36) located close to one out of the first area (11) and the second area (12).

26. The sealed and thermally insulating tank as claimed in one of claims 1 to 25, in which the primary and secondary sealed membranes are made up essentially of metal strips extending in the length direction and having raised longitudinal edges, the raised edges of two adjacent metal strips being welded in pairs so as to form expansion bellows allowing deformation of the sealed membrane in a direction perpendicular to the length direction, in which the corner of the tank comprises a primary anchoring wing (23) and a secondary anchoring wing, a first end of said anchoring wings (23) being anchored to the support structure (6) and a second end of said anchoring wings (23) being leaktightly welded to the corresponding sealing membrane.

27. The sealed and thermally insulating tank as claimed in claim 26, in which the primary sealing membrane comprises corrugations extending perpendicular to the raised edges and arranged in line with the first area (11).

28. The sealed and thermally insulating tank as claimed in one of claims 1 to 25, in which the secondary sealed membrane (2) is made up essentially of metal strips extending in the length direction and having raised longitudinal edges, the raised edges of two adjacent metal strips being welded in pairs so as to form expansion bellows allowing deformation of the sealed membrane in a direction perpendicular to the length direction, in which the corner of the tank comprises a secondary anchoring wing (23), a first end of said anchoring wing (23) being anchored to the support structure (6) and a second end of said anchoring wing (23) being leaktightly welded to the secondary sealing membrane, and in which the primary sealed membrane (4) comprises corrugated metal plates.

29. A carrier (70) for the transport of a cold liquid product, the carrier comprising a double hull (72) and a tank (71) as claimed in one of claims 1 to 28, arranged in the double hull.

30. A transfer system for a cold liquid product, the system comprising a carrier (70) as claimed in claim 29, insulated pipelines (73, 79, 76, 81) arranged so as to connect the tank (71) installed in the hull of the carrier to a floating or onshore storage facility (77), and a pump for pumping a flow of cold liquid product through the insulated pipelines from or to the floating or onshore storage facility, to or from the tank of the carrier.

31. A method for loading or unloading a carrier (70) as claimed in claim 29, in which a cold liquid product is conveyed through insulated pipelines (73, 79, 76, 81) from or to a floating or onshore storage facility (77), to or from the tank (71) of the carrier.