USPTO PATENT FULL-TEXT AND IMAGE DATABASE

Home | Quick | Advanced | Pat Num | Help

Bottom

View Cart | Add to Cart

Images

United States Patent **8,430,263**
Jordan , et al. **April 30, 2013**

Universal support arrangement for semi-membrane tank walls

Abstract

Embodiments of the invention relate to support arrangements for semi-membrane tank walls and, more particularly, to a universal support assembly for tanks that experience thermal expansion and contraction. One embodiment of the invention may include a tank assembly having at least one tank wall, a support structure at least partially adjacent to the wall, and a link member coupling the tank to the support structure. The link member may be configured to accommodate relative movement between the tank and the support structure through rotation. The link member may be coupled to the tank wall by a ball and socket joint and coupled to the support structure with another ball and socket joint, allowing substantially unlimited in-plane movement of the tank wall relative to the support structure.

Inventors: **Jordan; David L.** (Pawcatuck, CT), **Michaud; William E.** (Groton, CT)

Applicant:

Name	City	State	Country	Type
Jordan; David L.	Pawcatuck	CT	US	
Michaud; William E.	Groton	CT	US	

Assignee: **General Dynamics *NASSCO*** (San Diego, CA)

Family ID: **39761608**
Appl. No.: **13/032,813**
Filed: **February 23, 2011**

Prior Publication Data

Document Identifier	Publication Date
US 20110132912 A1	Jun 9, 2011

Related U.S. Patent Documents

Application Number	Filing Date	Patent Number	Issue Date
11723039	Mar 16, 2007	7896188	

Current U.S. Class:	**220/560.05**; 114/74A; 114/74T; 137/376; 220/565; 220/581; 220/646
Current CPC Class:	F17C 3/022 (20130101); B65D 19/00 (20130101); B65D 25/00 (20130101); F17C 3/027 (20130101); Y10T 29/49826 (20150115); F17C 2201/0157 (20130101); F17C 2201/052 (20130101); F17C 2203/015 (20130101); F17C 2203/0304 (20130101); F17C 2203/0358 (20130101); F17C 2203/0604 (20130101); F17C 2203/0619 (20130101); F17C 2203/0629 (20130101); F17C 2203/0643 (20130101); F17C 2203/0646 (20130101); F17C 2209/228 (20130101); F17C 2209/232 (20130101); F17C 2221/033 (20130101); F17C 2223/0153 (20130101); F17C 2223/0161 (20130101); F17C 2223/033 (20130101); F17C 2270/0107 (20130101); F17C 2270/0113 (20130101); F17C 2270/0134 (20130101); Y10T 137/7039 (20150401)
Current International Class:	F17C 1/00 (20060101)
Field of Search:	;220/560,565,581,586,592,646,647,560.05 ;137/376 ;114/74T,74A

References Cited [Referenced By]

U.S. Patent Documents

2911125	November 1959	Dosker
3021027	February 1962	Claxton
3071094	January 1963	Leroux
3273740	September 1966	Herrenschmidt
3380611	April 1968	Brougham et al.
3423115	January 1969	Korecky
3425583	February 1969	Bridges
3509848	May 1970	Salmon
3547302	December 1970	Jackson et al.
3704903	December 1972	Ito
3759555	September 1973	Ito
3767150	October 1973	Tabata
3814361	June 1974	Gabron et al.
3841253	October 1974	Kircik et al.
3849009	November 1974	Bourdon
3856422	December 1974	Trefry
3858907	January 1975	Van Raden
3861021	January 1975	Yamamoto
3899988	August 1975	Menedez
3908574	September 1975	Miller et al.
3937353	February 1976	Becker et al.
3941272	March 1976	McLaughlin
3968764	July 1976	Kvamsdal et al.
3987925	October 1976	Sattelberg
4013030	March 1977	Stafford
4173936	November 1979	Secord et al.
4181235	January 1980	Baysinger

4207827	June 1980	Gondouin
4223797	September 1980	Skakunov
4225054	September 1980	Jean
4640328	February 1987	Arney
4672906	June 1987	Asai
5099779	March 1992	Kawaichi et al.
5263603	November 1993	McBride
5338383	August 1994	Polackowyj
5355819	October 1994	Hsia et al.
5363787	November 1994	Konopasek et al.
5531178	July 1996	Abe et al.
5595318	January 1997	Barno
5727492	March 1998	Cuneo et al.
5758456	June 1998	Case
6035795	March 2000	Dhellemmes et al.
6619502	September 2003	Walther et al.
6626319	September 2003	Miller et al.
6971537	December 2005	Enright, Jr.
7111750	September 2006	Gulati et al.
7469650	December 2008	Jordan et al.
7748336	July 2010	Jordan et al.
2003/0057214	March 2003	Miller et al.
2003/0066834	April 2003	Enright
2004/0188446	September 2004	Gulati et al.
2005/0139595	June 2005	Pepin-Lehalleur et al.
2009/0200318	August 2009	Handa

Foreign Patent Documents

53140617	Dec 1978	JP
2005093315	Oct 2005	WO

Other References

Transportation of Liquefied Natural Gas, Sep. 1977. cited by applicant .
Intellectual Property Office of the Philippines Bureau of Patents; Office Action for Patent Application No. 1/2009/501755 dated Dec. 3, 3012. cited by applicant .
Notification of Second Office Action; Chinese Patent Application No. 200880014712.1 dated Nov. 29, 2012. cited by applicant.

Primary Examiner: Yu; Mickey
Assistant Examiner: Rush; Kareen
Attorney, Agent or Firm: Ingrassia Fisher & Lorenz, P.C.

Parent Case Text

RELATED APPLICATIONS

This application is a Divisional of application Ser. No. 11/723,039, entitled "Universal Support Arrangement for Semi-Membrane Tank Walls," filed on Mar. 16, 2007, now U.S. Pat. No. 7,896,188.

Claims

What is claimed is:

1. A tank assembly comprising: a tank having at least one wall, the at least one wall having an external surface; a first support block coupled to the external surface of the at least one wall, the first support block having at least one first socket; a support structure at least partially adjacent to the external surface of the at least one wall; a second support block coupled to the support structure, the second support block having at least one second socket; a link member having a first end received by the at least one first socket, the first end being configured to rotationally move in the first socket relative to the at least one wall, the link member having a second end received by the at least one second socket, the second end being configured to rotationally move in the second socket relative to the support structure; a first plate coupled to the the first support block, the first plate having a first rectangular hole aligned with the first socket, the first end of the link member extending through the first rectangular hole into the at least one first socket, the first plate being configured to retain the first end of the link member within the first support block and to allow the link member to rotationally move in a first plane substantially aligned with a first length of the first rectangular hole; and a second plate coupled to the second support block, the second plate having a second rectangular hole, the second end of the link member extending through the second rectangular hole into the at least one second socket, the second plate being configured to retain the second end of the link member within the at least one second socket and to allow the link member to rotationally move in a second plane substantially aligned with a second length of the second rectangular hole.

2. The assembly of claim 1, wherein the at least one wall includes a substantially horizontal wall and the link member includes a first plurality of link members coupled to a respective first plurality of sockets arranged on at least a portion of the substantially horizontal wall of the tank, the first plurality of link members configured to couple the at least a portion of the substantially horizontal wall to the support structure.

3. The assembly of claim 2, wherein the at least one wall further includes a substantially vertical wall and the link member further includes a respective second plurality of link members arranged on at least a portion of the substantially vertical wall of the tank, the second plurality of link members configured to couple the at least a portion of the substantially vertical wall to the support structure.

4. The assembly of claim 1, further comprising at least one T-shaped stiffening member coupling the first end of the link member to the at least one wall.

5. The assembly of claim 1, wherein: the first plate is parallel to the at least one wall; and the first plate has a contoured surface around the first hole configured to match a shape and a size of the first end of the link member to retain the first end of the link member in the at least one first socket.

6. The assembly of claim 1, wherein the at least one first socket is rectangular shaped.

7. The assembly of claim 1, wherein at least one of the first end of the link member and the at least one first socket is rectangular shaped.

8. The assembly of claim 1, wherein the link member extends at an angle substantially normal to the at least one wall.

9. A support arrangement for a tank comprising: a tank having a first wall; a support structure at least partially adjacent to the first wall, the support structure having at least one first socket in at least one first support block; a

link member having a first end received by the at least one first socket and the first end being configured to rotationally move in at least one direction relative to the support structure, the link member having a second end coupled to the first wall and the second end being configured to rotationally move in at least one direction relative to the first wall; a first plate coupled to the support structure, the first plate having a first rectangular hole aligned with the at least one first socket, the first plate allowing rotation of the first end of the link member along a first plane substantially aligned with a first length of the first rectangular hole, the first plate configured to retain the first end of the link member extending through the first rectangular hole into the at least one first socket; and a second plate coupled to the first wall via at least one second support block, the second plate having a second hole, the second end of the link member extending through the second hole into the at least one second socket, the second plate configured to retain the second end within at least one second socket of the second support block.

10. The support arrangement of claim 8, further comprising: a first plurality of support members at least partially bordering the first wall of the tank; and a first plurality of link members configured to couple the first wall to the first plurality of support members and accommodate relative movement between at least a portion of the first wall and the first plurality of support members.

11. The support arrangement of claim 9, further comprising: a second plurality of link members configured to couple a second wall of the tank to a second plurality of support members, each of the second plurality of link members having: a third end rotationally coupled to the second wall; and a fourth end rotationally coupled to a respective one of the second plurality of support members; wherein the second wall is substantially vertical and at least one of the third end or the fourth end is configured to accommodate relative rotational movement of the second link member substantially only about a single axis.

12. The assembly of claim 10, wherein each of the second plurality of support members is coupled to a respective third plate configured to retain the third end coupled to second wall, the third plate defining a first substantially rectangular opening configured to allow the second link member to rotate in a first plane substantially aligned with the length of the first substantially rectangular opening.

13. The assembly of claim 11, wherein each of the second plurality of support members is coupled to a respective fourth plate configured to couple to the fourth support block and retain the fourth end of the second link member to the fourth support block, the fourth plate defining a second substantially rectangular opening configured to allow the second link member to rotate in a second plane substantially aligned with the length of the second substantially rectangular opening.

14. The support arrangement of claim 10, wherein: a first set of the second plurality of support members is arranged substantially along a horizontal centerline of the second wall and configured to allow relative motion of at least a portion the second wall in a substantially horizontal plane only.

15. The support arrangement of claim 13, wherein a second set of the second plurality of support members is arranged substantially along a vertical centerline of the second wall and configured to allow relative motion of at least a portion of the second wall in a substantially vertical plane only.

16. The support arrangement of claim 9, wherein: the first plate is parallel to the first wall; and the first plate has a contoured surface around the first hole configured to match a shape and a size of the first end of the first link member to retain the first end of the first link member in the at least one first socket.

17. The support arrangement of claim 9, wherein the first link member extends at an angle substantially normal to the first wall.

18. The support arrangement of claim 9, wherein the at least one first socket is rectangular shaped.

19. An assembly comprising: a tank having at least one wall; a first grid of stiffener members attached to the at least one wall; a plurality of first support blocks supported by respective stiffener members of the first grid, the

plurality of first support blocks having a plurality of first rectangular openings; a plurality of link members having a first end and a second end; a plurality of first plates having a plurality of first rectangular holes extending through the plurality of first plates, wherein the first plates are coupled to respective first support blocks and are configured to retain the first ends of the link members in respective first rectangular openings, the first ends of the link members extending through the first rectangular holes into the first rectangular openings of the first support blocks; a support structure external to the tank; a second grid of stiffener members attached to the support structure; a plurality of second support blocks supported by respective stiffener members of the second grid, the plurality of second support blocks having a plurality of second rectangular openings; and a plurality of second plates having a plurality of second rectangular holes extending through the plurality of second plates, wherein the second plates are coupled to respective second support blocks and are configured to retain the second ends of the link members in respective second rectangular openings, the second ends of the link members extending through the second rectangular holes into the second rectangular openings of the second support blocks; wherein the first ends of the link members are configured to rotationally move along a first plane substantially aligned with a first plurality of lengths of the first rectangular holes and the second ends of the link members are configured to rotationally move along a second plane substantially aligned with a second plurality of lengths of the second rectangular holes relative to the support structure.

20. A method of supporting a tank wall comprising: coupling a first support block to a tank wall with a link member, the first support block having a first support block opening configured to receive a first end of the link member; coupling a second support block to at least one of support members of a supporting structure, the second support block having a second support block opening configured to receive a second end of the link member; retaining the first end of the link member within the first support block opening with a first plate, the first plate having a first rectangular hole extending through the first plate, wherein the link member passes through the first rectangular hole to the first support block opening of the first support block; retaining the second end of the link member within the second support block opening with a second plate, the second plate having a second rectangular hole extending through the second plate, wherein the link member passes through the second rectangular hole to the second support block opening of the second support block; and accommodating movement of the tank wall relative to the supporting structure by allowing rotation of the first end of the link member within the first support block opening in at least one direction along a first plane substantially aligned with a first length of the first rectangular hole and by allowing rotation of the second end of the link member within the second support block opening in at least one direction along a second plane substantially aligned with a second length of the second rectangular hole.

21. The method of claim 20, wherein accommodating movement of the tank comprises accommodating thermal expansion and contraction of the tank wall.

22. The method of claim 20, wherein retaining the first end of the link member within the first support block opening with a first plate comprises matching a contoured surface around the first rectangular hole configured to a shape and size of the first end of the link member.

Description

FIELD OF THE INVENTION

Embodiments of the present invention relate to support arrangements for semi-membrane tank walls and, more particularly, to a universal support assembly for tanks that experience thermal expansion and contraction.

BACKGROUND OF THE INVENTION

U.S. Pat. No. 5,727,492 discloses an example of a semi-membrane tank capable of holding liquefied gases such as liquefied natural gas ("LNG"). Semi-membrane tanks for this purpose, however, lack sufficient wall strength and rigidity to be self-supporting and use a supporting structure to transfer load from the semi-membrane walls

to surrounding structure. The supporting structure typically includes a grid of beams connected to the semi-membrane walls and connected to an arrangement of support assemblies connecting the grid of beams to a surrounding structure. When a semi-membrane tank is installed in a ship or other containment structure, the structure of the ship may serve as the surrounding structure connecting to the support assemblies. Due to the low temperatures required to transport or store liquefied gases, insulating material or support blocks with low thermal conductivity are typically used to thermally isolate the semi-membrane tank from the surrounding structure.

The temperatures experienced by a semi-membrane tank fluctuate dramatically between ambient temperature and the very low temperatures of liquefied gases, such as -161 degrees Celsius for LNG. Depending on the coefficient of thermal expansion ("CTE") of the semi-membrane tank material, this temperature fluctuation results in thermal contractions when the semi-membrane tank cools. If the semi-membrane tank is rigidly attached to the surrounding structure, the thermal contractions and expansions during temperature fluctuations of the tank may induce unacceptable stresses on the surrounding structure. To alleviate this condition, the support assemblies connecting the semi-membrane tank and the surrounding structure may be configured to allow for relative movement between the semi-membrane tank and the surrounding structure.

U.S. Pat. No. 6,971,537 shows a support arrangement for a semi-membrane LNG tank having a support assembly allowing relative motion between the semi-membrane tank wall and the surrounding structure in two orthogonal directions. More particularly, the support assemblies include a complicated set of grooves and brackets that receive a connecting element in a linear sliding motion. The support arrangement provides for linear sliding motion in a groove in a first direction and linear sliding motion in a bracket in another direction. Although the horizontal center line of the LNG tank disclosed in the U.S. Pat. No. 6,971,537 may be supported in the vertical direction, the support assemblies disclosed allow the tank to expand and contract in the vertical and horizontal directions using the linear sliding configuration of the support assemblies.

The support assemblies of U.S. Pat. No. 6,971,537 are imbedded in the insulation covering the semi-membrane tank and requires a flexible boot to be installed around each support assembly. The flexible boot requires inspection and maintenance throughout the life of the semi-membrane tank, which can be costly because inspection typically requires the removal and replacement of tank insulation. Additionally, because the support assemblies only slide linearly along orthogonal directions, each row of support assemblies need to be installed along different radial paths from the center of the tank in order to achieve in-plane unrestricted movement. The configuration of support blocks on the semi-membrane tanks connecting to the support assemblies also complicates the manufacturing of and installation of the complex supporting assemblies. Because the support assemblies slide relative to the supporting blocks, an insulation gap around the support block is necessary to allow for free movement of the support assemblies during thermal expansion and contraction. This may function to increase heat loss to the liquefied gas containment system and increase the boil-off rate. Additionally since the support blocks are required to transfer the thermal and dynamic loads from the tank to the surrounding structure, they may become quite large complicating handling and installation and increasing installation/erection costs.

SUMMARY OF THE INVENTION

Embodiments of the invention include a tank assembly having at least one tank wall, a support structure at least partially adjacent to the wall, and a link member coupling the tank to the support structure. The link member may be configured to accommodate relative movement between at least a portion of the tank and the support structure. The link member may include a first end coupled to the wall and configured to rotationally move relative to the wall and a second end coupled to the support structure and configured to rotationally move relative to the support structure.

Another embodiment of the invention may include a support arrangement for a semi-membrane tank having a first plurality of support members at least partially adjacent to a semi-membrane tank having a first wall and a first plurality of support assemblies coupling the first wall to the first plurality of support members. Each of the first plurality of support assemblies may include a first link member having a first end rotationally coupled to the first wall and a second end rotationally coupled to the first plurality of support members. Each of the first

plurality of support assemblies may be configured to accommodate relative movement between at least a portion of the first wall and the first plurality of support members.

Another embodiment of the invention may include an assembly for storing liquified gas having a semi-membrane tank with a first wall, a plurality of support members at least partially adjacent to the first wall, and a first plurality of support assemblies configured to couple the first wall to the plurality of support members. Each of the first plurality of support assemblies may include a first link member having a first end rotationally coupled to the first wall and a second end rotationally coupled to at least one of the plurality of support members. Each of the first plurality of support assemblies may be configured to accommodate relative rotational movement between at least a portion of the first wall and the first plurality of support members.

Another embodiment of the invention may include a support assembly for a tank wall having a link member with a first end and a second end, a first ball and socket joint coupled to the first end of the link member and configured to couple to a semi-membrane tank wall, and a second ball and socket joint coupled to the second end of the link member and configured to couple to a semi-membrane support structure.

Embodiments of the invention may also include a method of supporting a tank wall by rotationally coupling a tank wall to a supporting structure and accommodating movement of the tank wall relative to the supporting structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates a semi-membrane tank and support arrangement in accordance with an embodiment of the invention;

FIGS. 2A, 2B, and 2C schematically illustrate a top view, side view, and end view, respectively, of an example of a support arrangement for one quarter of a semi-membrane tank in accordance with an embodiment of the invention;

FIG. 3A schematically illustrates an example of a semi-membrane tank and carriage structure in accordance with an embodiment of the invention;

FIG. 3B schematically illustrates an example of the semi-membrane tank and carriage structure shown in FIG. 3A installed in a permanent structure in accordance with an embodiment of the invention;

FIG. 4A schematically illustrates a cross section of a portion of the semi-membrane tank and surrounding structure in accordance with an embodiment of the invention;

FIG. 4B schematically illustrates an example of a universal support assembly in accordance with embodiments of the invention;

FIG. 5A schematically illustrates a top view of a portion of a semi-membrane tank in accordance with an embodiment of the invention;

FIG. 5B illustrates a cross-section of a stiffener in accordance with an embodiment of the invention;

FIG. 6 schematically illustrates a plan view of a portion of a wall of a semi-membrane tank in accordance with an embodiment of the invention;

FIG. 7 schematically illustrates a cross-section of a portion of the tank wall with insulation shown in FIG. 6 along line A-A;

FIG. 8 schematically illustrates a cross-section of a universal support assembly in accordance with an embodiment of the invention;

FIG. 9 schematically illustrates a perspective view of the universal support assembly shown in FIG. 8;

FIG. 10 schematically illustrates a plan view of the top of a supporting block in accordance with an embodiment of the invention;

FIG. 11 schematically illustrates a plane view of the top of a retainer plate in accordance with an embodiment of the invention;

FIG. 12 schematically illustrates a plane view of the top of another retainer plate in accordance with an embodiment of the invention;

FIG. 13 schematically illustrates a plane view of the top of another supporting block in accordance with an embodiment of the invention; and

FIG. 14 schematically illustrates a perspective view of a link member in accordance with an embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the invention relate to support assemblies and an arrangement of support assemblies for use with a semi-membrane tank wall capable of holding liquefied gases such as liquefied natural gas ("LNG"). The support arrangement may be configured to allow thermal expansion and contraction of a semi-membrane tank wall upon changes in temperature due to filling or emptying the tank. The support assemblies may be configured to provide a support arrangement for semi-membrane tank walls which permits relative motion of the tank walls with respect to the surrounding support structure while providing thermal insulation between the tank and the surrounding structure.

FIG. 1 schematically illustrates an example of a support arrangement 10 for a semi-membrane tank 20 in accordance with an embodiment of the invention. The semi-membrane tank 20 may include a top wall 21, four side walls 22, and a bottom wall 23 (not shown in FIG. 1). The tank 20 may also include a cylindrical vertical corner 24, upper and lower cylindrical horizontal corners 25, and spherical corner caps 26. The tank 20 may be fabricated out of various metals such as, for example, 9% Nickel steel or aluminum (Grade 5083), with the top, side, and bottom walls may be fabricated out of flat panels. The tank may also include a pipe tower 27 positioned either at the center or at the end of the top wall 21 and capable of facilitating the filling and emptying of the tank.

The top wall 21 may include stiffeners 30 arranged in a grid pattern. Likewise, the side walls 22 may include stiffeners 32 arranged in a grid pattern and stiffeners 34 arranged in a grid pattern as illustrated in FIG. 1. The stiffeners 30, 32, and 34 may be formed as "T" members as discussed in greater detail below. The stiffeners 30, 32, and 34 also provide an attachment structure for universal support assemblies 40 on the top wall 21, universal support assemblies 42 on one side wall 22, and universal support assemblies 44 on another side wall 22. The side walls 22 also include anchor support assemblies 46 positioned on each of the horizontal and vertical center lines of the side walls. Although not shown in FIG. 1, each of the side walls 22 include stiffeners and support assemblies.

As discussed in greater detail below, the universal support assemblies 40, 42, and 44 provide relative motion between a surrounding support structure and the tank 20. The support assemblies 46 may be configured as anchor supports that provide in-plane and normal support while allowing relative movement along the centerlines. For example, the support assemblies 46 arranged on the horizontal centerline shown in FIG. 1 may be configured to provide vertical support and support normal to the sidewall 22 while allowing relative movement along the horizontal centerline direction. The combined relative movement of the support assemblies 40, 42, 44, and 46 may be arranged to accommodate the thermal expansion and contraction of the tank 20. It should be understood that the number and arrangement of the stiffeners 30, 32, and 34 and the support

assemblies 40, 42, 44, and 46 shown in FIG. 1 may be changed and reconfigured according to the size and shape of the tank 20.

FIGS. 2A, 2B, and 2C schematically illustrate an example of one quarter of a semi-membrane tank 50 and a support arrangement for the quarter of the semi-membrane tank 50 in accordance with an embodiment of the invention. The tank 50 shown in FIGS. 2A, 2B, and 2C is an example of a larger semi-membrane tank than the semi-membrane tank 20 shown in FIG. 1. It should be understood that support arrangements in accordance with embodiments of the invention may be used with different sized and shaped semi-membrane tanks For instance, the semi-membrane tank shown in FIG. 1 is a 1/4 scale test tank with a capacity of 225 cubic meters. It should be understood that tank dimensions may be varied to obtain an unlimited range of storage capacities in order to fit within a ship, floating barge, or other such floating or land-based support structure. Additionally, the tank arrangement in FIG. 2 depicts an example of an embodiment of the invention applied to a semi-membrane tank having an internal volume of 40,000 m.sup.3 which approximates the capacity of current cargo tank sizes. While FIG. 2 depicts a regular prismatic shape, the semi-membrane tank may be alternatively shaped and sized to suit any ship, barge, or other support structure in order to maximize overall storage volume.

FIG. 2A schematically represents a top plan view of one quarter of the tank 50 and stiffeners 52. FIG. 2B schematically represents a side elevation view of half of one side wall of the tank 50 and the associated stiffeners 54. Likewise, FIG. 2C schematically represents an end elevation view of one half of one side of the of the tank 50 and the associated stiffeners 56.

In FIG. 2A, universal support assemblies 60 (shown representatively as a shaded circle) may be typically arranged at the intersections of the grid pattern for the stiffeners 52, which may be spaced according to the tank loading. Likewise, universal support assemblies 62, shown in FIG. 2B, may be arranged at the intersections of the grid pattern for the stiffeners 54. Finally, universal support assemblies 64, shown in FIG. 2C, may be arranged at the intersections of the grid pattern for the stiffeners 56.

The support assemblies 66 (shown representatively as a shaded square) shown in FIGS. 2B and 2C, may be arranged along the horizontal centerlines of the sidewalls of the tank 50. The support assemblies 68 may be arranged along the vertical centerlines of the sidewalls of the tank 50. The support assemblies 66 and 68 may provide support in-plane and normal to the side walls. For example, the support assemblies 66 arranged on the horizontal center line in FIG. 2B may be configured to provide support in the vertical direction and support in the direction normal to the side wall while allowing relative movement of the tank in the horizontal direction. Likewise, the support assemblies 68 arranged on the vertical center line in FIG. 2B may be configured as known to those of skill in the art to provide support in the horizontal direction and support the normal direction to the side wall while allowing relative movement of the tank in the vertical direction. The same arrangement may be applied to the support assemblies 66 and 68 shown in FIG. 2C. As discussed in greater detail below, the basic structure for the support assemblies may be configured for use with both the support assemblies 60, 62, and 64 and the support assemblies (or anchor blocks) 66 and 68.

As disclosed in U.S. patent application Ser. No. 11/353,222, filed on Feb. 14, 2006, which is hereby incorporated by reference in its entirely, the semi-membrane tank may be assembled with a support carriage, at least partially surrounding the semi-membrane tank and providing the structure to connect to the support assemblies attached to the top and sides of the semi-membrane tank. Once assembled, the semi-membrane tank and the support carriage may be moved or transported as a single pre-assembled unit. FIG. 3A schematically illustrates an assembled semi-membrane tank 70 surrounded by a surrounding support structure or carriage 100. As shown in FIG. 3A, the tank may have a pipe tower 76 positioned to one side of the semi-membrane tank 70. The tank 70 may also include a sidewall 72, a bottom wall 73, horizontal corner walls 75, and vertical corner walls 74. The semi-membrane tank 70 may be connected to the support structure 100 by an array of the support assemblies and the stiffeners (examples of which are shown in FIGS. 1 and 2). The support assemblies and stiffeners may not be seen in FIG. 3A due to the surround support structure 100. The surrounding support structure or carriage 100 may be constructed from I-beams, T-beams or other such structures. Once assembled, the semi-membrane tank 70 and the supporting structure 100 may be transported to a final installation in a ship, barge or other structure.

FIG. 3B schematically illustrates the assembled semi-membrane tank and supporting carriage 100 installed in walls 110 belonging to a ship, barge, or other permanent tank holding structure. The walls 110 may include transverse or longitudinal bulkheads surrounding at least partially surrounding the semi-membrane tank 70 and the support carriage 100. It should be understood that the structure 110 may include other structures capable of holding a semi-membrane tank for purposes of holding or transporting a liquefied gas. For example, the structure 110 may also include a floating barge or land-based structure configured to hold or transport liquefied gases, such as LNG.

FIG. 4A schematically illustrates a cross section of a portion of the structures shown in FIG. 3B, including a portion of the semi-membrane tank 70, three universal support assemblies 200, a portion of a surrounding support structure 100, and a portion of a supporting wall 110. The universal support assemblies 200 may represent, as an example, three of the universal support assemblies shown on the side walls in FIGS. 1, 2B, and 2C connecting the tank 20 to the surrounding support structure 100. FIG. 4A shows an array of stiffeners 120 arranged on and attached to the sidewall 72 of the tank 70. As shown in the figure, the universal support assemblies 200 connect the structure 100 to the stiffeners 120, effectively supporting the tank 70. Also shown in FIG. 4A, the tank 70 includes a series of insulation panels 130 installed along the bottom wall 73 and along the side wall 72 of the tank 70. It should be understood that insulation may be provided on every wall of the semi-membrane tank.

FIG. 4B schematically illustrates an example of one of the universal support assemblies shown in FIG. 4A in accordance with embodiments of the invention. Generally, each universal support assembly 200 may include a support block 205 attached to the stiffeners 120 of the tank 70 using fasteners 240. The assembly may include another support block 210 attached to the surrounding support structure 100 using fasteners 240. Each of the support blocks 205 and 210 may include a circular or partially spherical opening machined or formed into the block to receive a link member 230. The link member 230 may include spherical ball ends 231 and 232 configured to fit into the openings in the blocks 205 and 210. The ball end 231 may be held in the block 205 using a keeper or retainer plate 215. Likewise, the ball end 232 may be held in the block 210 using a keeper or retainer plate 220. In one embodiment of the invention, the space for the universal support assembly 200 between the support structure 100 and the tank stiffeners 120 may be about 400 mm. The installation of the universal support assemblies 200 and the support structure 100 may be shimmed.

As the tank experiences thermal expansion and contraction, the link member 230 and the ball ends 231 and 232 will rotate in the support blocks 205 and 210 allowing the tank wall to move relative to the surrounding support structure. When acting together, the universal support assemblies 200 in FIG. 4A will operate to allow substantially in-plane movement by expansion and contraction of a tank wall 22, thereby avoiding the build-up of unacceptable thermal stresses, while providing axial load carrying capability in the link members 230. Because of the ball and socket arrangement of the ball ends 231 and 232, the universal support assemblies 200 allow unrestricted in-plane movement (360 degree in-plane movement) of the tank wall 70. It should be understood that the in-plane movement of the tank wall 22 is accompanied by small movement of the tank wall 22 in the direction orthogonal to the tank wall due to the inherent rotational movement of the link members 230. As will be appreciated by those of skill in the art, the movement orthogonal to the tank wall will be much smaller than any in-plane movement.

In order to maintain the low temperatures of the liquefied gases contained in the tank 20, the supporting blocks 205 and 210 may have a low thermal conductivity in order to reduce heat loss, thereby ensuring that the specified boil-off rate for the containment system may be met. Laminated wood material, such as Lignostone produced by Roechling Haran in Gastonia, N.C., may be used as an insulating block. Other low thermal conductivity materials with good compressive strength, such as a many composite materials, may also be used for the support blocks 205 and 210. The link member 230 may be fabricated from commercially available stainless steel, such as 304L stainless steel, or other such metal. A stainless steel link member 230 may function as a thermal break due to its lower coefficient of thermal conductivity than the aluminum tank material. The fasteners 240 may be made from stainless steel, K-monel, or other suitable high strength fastener material depending upon final strength requirements.

FIG. 5A schematically illustrates a view of cylindrical vertical corners 74 of the tank 70 with portions of two sidewalls 72. As shown in the figure, the stiffeners 120 are attached to the exterior of the sidewalls 72. FIG. 5B illustrates the "T" shaped cross-section of the stiffeners 120 that form the grid patterns shown in FIGS. 1, 2A, 2B, and 2C. To illustrate the arrangement of the universal support assemblies around a vertical corner 74, the universal support assemblies attach to the stiffeners 120 at the intersections of the grid pattern. It should be understood that the universal support assemblies 200 may be arranged on alternative patterns or locations. Additionally, the locations and the patterns of the stiffeners 120 may be changed and altered.

FIG. 6 schematically illustrates a plan view of a portion of a wall of the semi-membrane tank 70 and an example of a portion of the insulation that may be applied to the tank 70 and the stiffeners 120. As shown, insulation panels 130 may be installed around the blocks 205 of the universal support assemblies 200, on and between the stiffeners 120. The insulation panels 130 may be configured to cover the walls of the tank 20 in order to reduce the boil-off rate to acceptable levels. The insulation panels 130 cover the entire length of the stiffeners 120 between the universal support assemblies 200. Although not shown in FIG. 6, insulation may be arranged to cover the entire tank 70.

FIG. 7 schematically illustrates a cross-section of the portion of the tank wall shown in FIG. 6 along line A-A. The insulation panels 130 are installed on the tank 70, including the placement of insulation panels between and on tope of the "T" shaped stiffeners 120. The insulation panels 130 cover the entire length of the stiffeners 120 between the universal support assemblies 200. As shown in FIGS. 6 and 7, no gap around the supporting blocks 205 is required on the tank walls because the blocks 205 and the ball ends 231 do not slide relative to the tank walls. Rather, the ball ends 231 rotate or pivot in a ball and socket configuration without restricting the placement of the insulation panels 130 or requiring a gap in the insulation. The insulation may be fabricated from either polyurethane or poly-isocyanurate foam panels, for example, and may be secured by shot studs to the tank walls.

FIG. 8 schematically illustrates an enlarged view of a cross-section of a universal support assembly 200 in accordance with one embodiment of the invention. Likewise, FIG. 9 schematically illustrates a perspective view of the same cross-section of the universal support assembly 200. The ball and socket configuration formed between the ball ends 231 and 232 and the sockets formed by the combination of the supporting blocks 231 and 232 and the retainer plates 215 and 220 provides for movement in any direction and is not limited to a sliding motion along a groove as previously taught in the prior art. As shown in FIGS. 8 and 9, the opening in the retainer plates 215 and 220 is undersized relative to the diameter of the ball ends 231 and 232. It should be understood that the undersized opening in the retainer plates 215 and 220 may be sized with sufficient clearance to allow the rotation of the link members, thereby accommodating unrestricted expansion and contraction of the tank 20. Because of the limitless range of motion between the link member and the blocks, it is not necessary to install the supporting blocks along radial lines of movement from the center of the tank. Such an arrangement reduces stresses induced in the tank structure and the surrounding supporting structure, reducing material fatigue and increasing usable tank life.

FIG. 10 schematically illustrates a plan view of the top of a supporting block 300, which represents the support blocks 205 or 210, for example, shown in the other figures. The block 300 includes through holes 310 for receiving the fasteners 240 and securing the retainer plate and the supporting blocks to their respective locations. Additionally, the block 300 includes an opening or hole 320. The block 300 and the hole 320 may be machined out of a block of material or formed as a unitary element. The hole 320 may formed a simple cylindrical shape internal to the block 300 or may have a partial contoured surface at the bottom of the hole to match the shape and surface of the ball ends on the link members 230.

FIG. 11 schematically illustrates a plan view of the top of a retainer plate 400, which may represent the retainer plates 215 or 220, for example, shown in the other figures. The retainer plate 400 may include through holes 410 for receiving the fasteners and securing the retainer plates and the supporting blocks to their respective locations. The retainer plate 400 also includes a hole or opening 420, which serves as a retaining mechanism for the ball ends on the link members 230. As shown in FIGS. 8 and 9, the underside of the retainer plates may include beveled edges or a contoured surface around the opening 420. The contoured surfaces around the underside of

the opening 420 may be configured to match the shape and size of the ball ends in order to facilitate smooth rotation of the ball end.

Although the size and shape of the ball ends 231 and 232, as well as the holes 320 and 420, may differ depending on the location for installation, the size and shape of the elements may be standardized over large portions of the assembled semi-membrane tank in order to reduce part count and complexity of the installation. Additionally, the universal support assemblies may be assembled by including a slot in the retainer plate 400 (shown in dotted lines) sufficient to allow the center section of the link member to slide into the opening 420. Once the link member 230 is positioned within the opening 420, the retainer plate may be secured to the support block, forming the ball and socket arrangement of the universal support assembly. Alternatively, the ball ends 231 and 232 on the link member 230 may be fabricated as separate pieces and assembled once the retainer plates have been placed onto the link members 230.

Additionally, it is contemplated that the ball and socket configuration discussed above may be easily modified for use as an anchored support assembly or an assembly configured to allow relative motion in only one direction, such as the support assemblies 46 in FIG. 1 and support assemblies 66 and 68 in FIG. 2. FIG. 12 schematically illustrates a plan view of the top of a retainer plate 500 for use in an anchor support assembly. It is contemplated that the retainer plates on a universal support assembly 200 may include the retainer plate 500 shown in FIG. 12 mounted on the support block 300 shown in FIG. 10. The retainer plate 500 may represent the retainer plates 215 or 220, for example, shown in the other figures to create a support assembly that allows relative motion in only one direction. Generally, the retainer plate 500 may include through holes 510 for receiving the fasteners and securing the retainer plates and the supporting blocks to their respective locations. However, the retainer plate 500 may include a rectangular opening 520, which serves as a retaining mechanism for the ball ends on the link members 230 and serves as a guide to the center section of the link member 230. By sizing the slot opening 520 such that the width (W) of the rectangular opening 520 is approximately the diameter or width of the center section of the link member 230, the rectangular opening 520 may be configured to allow movement in only one direction, in the direction of the length (L) of the rectangular opening 520. The size and shape of the rectangular opening 520 may be changed depending on the desired amount of possible movement. By placing the a retainer plate 500 on one or more of the plates 215 or 220 shown in FIG. 8 or 9, the support assembly 200 may be configured as a unidirectional support assembly as discussed with respect to support assemblies 46, 66, and 68 in FIGS. 1 and 2. It should be understood that the retainer plate 500 may be used with link members having spherical ends.

As an alternative, a support assembly may be configured to allow relative movement in only one direction by assembling a support assembly from a support block having a slotted opening and a link member having rounded flat ends configured to slide into the slotted opening. FIG. 13 schematically illustrates a plan view of the top of a support block 600 configured for use in a unidirectional support assembly. As with the support block 300, the support block 600 may include through holes 610 for receiving the fasteners and securing the retainer plates and the supporting blocks to their respective locations. FIG. 14 schematically illustrates a perspective view of an example of a link member 700 configured to be used with the support block 600 shown in FIG. 13. The rounded and flat ends 710 and 720 of the link member 700 may be inserted into the rectangular opening 620. Due to the rounded nature of the ends 710 and 720, the link member 700 may rotate in only one direction. It should be understood that the support block 600 and the link member 700 may be used with either the retainer plate 400 or the retainer plate 500. Although both ends of the link member 700 are configured to rotate only about a single axis, it should be understood that a support assembly may be configured with one end configured to support universal rotation (using retainer plate 400, for example) and the other end of the link member configured to rotate substantially about only one axis (using retainer plate 500, for example).

It should be understood that the support assemblies disclosed herein may be used with other tank arrangements and may be alternatively configured on the semi-membrane tank. Likewise, the size, number, and positioning of the support assemblies may be changed. It should also be understood that the semi-membrane tank and surrounding structures may be assembled using various methods. As discussed above, embodiments of the present invention may be employed on ships or floating structures or on other land-based structures capable of holding or transporting liquefied gases, such as LNG.

29.06.2020 United States Patent: 8430263

The embodiments described herein are examples of implementations of the invention. Modifications may be made to these examples without departing from the scope of the invention, which is defined by the claims, below.

* * * * *

Images
View Cart Add to Cart
Top
Home Quick Advanced Pat Num Help

patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&u=%2Fnetahtml%2FPTO%2Fsearch-adv.htm&r=1&p=1&f=G&l=50&d=PTXT&S1… 14/14