A non-welded deck used to support insulation from the roof of a low temperature or cryogenic storage tank is disclosed. The deck may be comprised of a plurality of spaced apart bars with metal sheets covering the spaces between the bars. The edge of the metal sheets may be clamped to the bars to form the deck. The edges of adjacent metal sheets may overlap and be clamped together in such a way as to deform the sheets creating a metal-to-metal vapor and dust proof seal. The plurality of clamping bars and support bars may secure the metal sheets with sufficient strength to allow the entire deck to support loadings as a stressed membrane. The tank may be constructed with hardware that remains secure even after being subjected to repeated thermal cycling of over 200° Celsius (360° Fahrenheit).
SUSPENDED DECK FOR LIQUID NATURAL GAS TANK

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an insulation deck suspended from the roof of a low temperature tank, such as a liquid natural gas tank for example.

2. Description of the Related Art

Every year more and more natural gas reserves are discovered. Unfortunately, much of it is found far from the major consumer countries making economical transportation and distribution vital. Presently far more natural gas is removed from discovered natural gas reserves than is consumed globally. The excess amount of natural gas requires the rapid construction of storage facilities to hold the extracted natural gas. The size of the needed storage facilities and vessels can be decreased if the natural gas is stored cryogenically, which liquefies the natural gas. Liquefying natural gas decreases the volume of the natural gas by more than 600 percent. Thus, liquid natural gas ("LNG") requires less storage space than natural gas, but LNG must be stored at less than -163° Celsius (-261.4° Fahrenheit) in order to stay liquefied.

Such storage vessels must be constructed of a material that is able to remain ductile and not crack at cryogenic temperatures. Generally LNG tanks are constructed of an inner tank, which must be constructed of a metal that remains ductile at cryogenic temperatures such as 9% nickel steel, enclosed in an outer tank. The space between the inner tank and outer tank is filled with insulation of various forms to reduce the cost of maintaining the LNG at cryogenic temperatures. The outer tank is not subjected to the same cryogenic temperature and thus may be constructed of various materials such as pre-stressed concrete. These storage vessels may include an insulation deck suspended above the inner tank from the roof of the outer tank to aid in maintaining the inner vessel at the cryogenic temperature.

Like the inner storage vessel, the deck must be constructed of a material that remains ductile at -163° Celsius. Additionally, the insulation deck must be constructed of a material so that the deck may be able to support the loads of the insulation, insulation workmen, and inspection personnel. Various aluminum and stainless steel alloys are excellent construction materials to be used at cryogenic materials as they provide the necessary strength and remain ductile at cold temperatures. Further, aluminum alloys actually increase in strength at cryogenic temperatures. However, the use of these materials in the construction of the deck does have some disadvantages.

One method of constructing an insulation deck of aluminum or stainless steel alloys is by welding the deck together and then suspending the deck from the roof. Often the insulation deck is constructed by welding together various components of the deck at ground level and once complete using blowers and guide lines to float the outer roof into position with the deck attached. However, the time required to construct a welded deck can be lengthy as the deck must be welded together at the work site and welding can be a rather unpredictable process as aluminum is generally considered the most difficult alloy to weld. Stainless steel alloys are also difficult to weld in comparison to other carbon steel alloys. Thus, the construction of such a deck requires skilled welders, which increase the cost and time of construction. Since the deck must be completed and attached to the outer roof prior to the air lifting of the outer roof to the top of the tank, the deck assembly is often on the critical path of the project.

Welding together the insulation deck may also have an adverse affect on the strength of the insulation deck. Typically, aluminum comes in heat treatable and non-heat treatable alloys. Heat treatable aluminum alloys get their strength from a process called ageing. Aluminum alloys can also get their strength from the annealing process. However, significant decreases in tensile strength can occur when welding aluminum due to over aging or annealing of the aluminum. In order to compensate for the decrease in strength, often the thickness of the welded aluminum deck must be increased thus increasing the cost and weight of the deck. Further, the increased weight of the deck increases the number and size of the supports suspending the insulation deck from the roof of the outer tank.

Another method of constructing a suspended insulation deck is the bolting together components consisting of corrugated metal then suspending the corrugated metal deck from the roof. While a deck constructed of corrugated metal bolted together may be assembled together more rapidly than a welded deck, this type of insulation deck presents a limit as to the type of insulation that can be used. One type of insulation used in LNG tanks is perlite, which is an inexpensive, but a very effective insulation material. Perlite is a very fine powder and thus, will leak through the seams of the corrugated metal deck possibly causing contamination issues with the LNG held in the inner storage vessel. Other common insulation materials, such as fiberglass or rock wool, can also have fine particles of dust that can leak through the seams possibly causing contamination. Closing the seams with sealants or gasket materials increase the costs and such materials must be suitable for cryogenic temperatures and repeated differential thermal cycling.

Another problem with present decks that are screwed or bolted together is the thermal expansion and contractions of different materials used in the construction of the deck. Often the fasteners used in the construction of the insulation deck are comprised of a different material than the deck, and thus the fasteners and the deck contract and expand differently. The difference of expansion and contraction can loosen the fasteners of the deck due to the thermal cycling of the storage vessel. LNG tanks may be subjected to thermal cycling of at least 200° Celsius (360° Fahrenheit), the difference between typical summertime ambient temperatures and the cryogenic temperature needed to sustain the LNG in liquefied form. This thermal cycling may occur due to routine maintenance of the LNG tank.

In light of the foregoing, it would be desirable to provide an insulation deck and method of construction that does not require a skilled welder to construct. It would also be desirable for a deck that may be constructed in a minimal amount of time. Further, it would be desirable to provide a deck and method of construction that would have structural integrity during thermally cycling of at least 200° Celsius. Additionally, it would be desirable to construct a deck without welding on which a fine powdered insulation, such
as perlite, or other insulation materials which contain dust or fine fibers could be used without the chance of contaminating the stored LNG. It would also be desirable for the deck to be constructed such that the vapors from the LNG could not escape through the seams of the deck.

[0012] The present invention is directed to overcoming, or at least reducing the effects of, one or more of the issues set forth above.

SUMMARY OF THE INVENTION

[0013] The apparatus of one embodiment of the present disclosure is an insulation deck that is constructed by assembling metal components without welding and prevents the contamination of material, such as LNG, stored in a low temperature tank from the insulation supported by the insulation deck. As used herein, a low temperature tank is a tank in which temperatures within the tank reach cryogenic temperatures and the term low temperature tank may be utilized interchangeably with LNG tank, cryogenic tank, and the like, and each term (low temperature tank, LNG tank, cryogenic tank) is to be given its ordinary meaning.

[0014] The insulation deck is constructed such that metal-to-metal seals are created at the junction between the deck components creating an insulation deck without any cracks or seams for insulation to leak through contaminating the stored material. Additionally, the deck includes a sealing member that extends from the edges of the deck to the sides of the low temperature tank.

[0015] One embodiment of the present disclosure is an insulation deck for use in a low temperature tank comprising a plurality of beams, a plurality of support bars connected to the plurality of beams, a plurality of metal sheets wherein an external portion of each of the metal sheets rests on one of the support bars and covers openings between the support bars, a plurality of clamping bars that engage a top surface of at least one the metal sheets, and a plurality of fasteners that secure the clamping bars to the support bars. The plurality of clamping bars and support bars may secure the metal sheets with sufficient strength to allow the entire deck to support loadings as a stressed membrane. Additionally, one embodiment of the insulation deck may include a termination member extending around the edge of the insulation deck. The plurality of fasteners may be lock bolts. Alternatively, the plurality of fasteners may be mechanically locked in place. Insulation may be placed on the plurality of metal sheets. In one embodiment, the insulation may be a fine powder, such as perlite, or may contain significant dust components.

[0016] In one embodiment of the present disclosure, the insulation deck may be comprised of a plurality of beams that are aligned substantially parallel, a plurality of support bars connected to the plurality of beams that are aligned substantially parallel and substantially transverse to the beams, a plurality of metal sheets wherein an external portion of each of the metal sheets rests on one of the support bars and covers openings between the support bars, a plurality of clamping bars that engage a top surface of at least one the metal sheets, and a plurality of fasteners that secure the clamping bars to the support bars. The components of the insulation deck, namely the parallel beams, the support bars, the metal sheets, the clamping bars, and the fasteners may each be comprised of an aluminum alloy. However, the components could all be comprised of the same material, but not necessarily be aluminum alloy, so that the expansion and contraction rates of the deck components are uniform.

[0017] In one embodiment, the insulation deck may include means for suspending the insulation deck from the roof of a low temperature tank. The means for suspending the insulation deck may include metal bars, structural beams, metal cables, or stainless steel cables. The means for suspending the insulation deck may be connected to the plurality of beams. Alternatively, the means for suspending the insulation deck may be connected to plurality of fasteners. The insulation deck may be suspended from the roof of a low temperature tank using various structures, such as bars or cables, as would be appreciated by one of ordinary skill in the art having the benefit of this disclosure.

[0018] The metal sheets of the insulation deck may be substantially rectangular, but the size and shape of the sheets may be varied as would be appreciated by one of ordinary skill in the art having the benefit of this disclosure. The metal sheets may be at least partially deformed by the clamping bars when the clamping bars are secured to the support bars by the fasteners. Adjacent metal sheets may overlap at the edges and as such the deformation of the sheets caused by the clamping bars may create a metal-to-metal seal between the sheets. Likewise, the deformation of each sheet may create a metal-to-metal seal between the sheet and the clamping bar and/or between the sheet and the support bar.

[0019] In one embodiment at least one of the support bars may include a rib and at least one of the clamping bars may include a groove that mates with the rib. The rib on the support bar may deform a portion of the metal sheet into the groove when a fastener is tightened. Alternatively the support bar may include a groove while the clamping bar includes a mating rib and again a portion of a metal sheet may be deform into the groove by the mating rib when a fastener is tightened. In an alternative embodiment, at least one of the support bars may include a channel running along the support bar and at least one of the clamping bars may partially deform one of the metal sheets into the channel.

[0020] In one embodiment the plurality of support beams and plurality of clamping beams have interfitting convex and concave surfaces. Two adjacent metal sheets of the plurality of metal sheets may overlap such that a portion of the metal sheets rest between the convex and concave surfaces. The overlapping portion of the metal sheets may at least be partially deformed by the support beam and clamping beam when a fastener is tightened. The deformation of the overlapping portion may create a metal-to-metal seal.

[0021] One embodiment of the present disclosure is the method of constructing an insulation deck for use in a low temperature tank that comprises the steps of attaching a plurality of substantially parallel beams to the roof of the low temperature tank; attaching a plurality of substantially parallel support bars to the beams wherein the support bars extend transversely across the beam; placing a plurality of metal sheets across the openings between the support bars; placing a plurality of clamping bars on the metal sheets locating the clamping bars above the support bars; deforming at least a portion of the metal sheets by tightening a plurality of fasteners, wherein the fasteners secure together
the support bars, metal sheets, and clamping bars; attaching a sealing member that extends from the edge of the insulation deck to the sides of the low temperature tank; and installing insulation on top of the insulation deck.

[0022] The method may further include the step of overlapping the edges of the metal sheets. Additionally, the portion of the metal sheets that is deformed may be the overlapping edges. The insulation used in the method of constructing the insulation deck may be a fine powder or contain a significant amount of dust. In one embodiment of the method of constructing the insulation deck the parallel beams, the support bars, the metal sheets, the clamping bars, and the fasteners are all comprised of an aluminum alloy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. 1 shows a top view of one embodiment of an insulation deck for a low temperature tank of the present disclosure comprised of a network of metal sheets clamped together.

[0024] FIG. 2 shows a cross-section of the present embodiment of two metal sheets that overlap between a support bar and a clamping bar.

[0025] FIG. 3 shows the embodiment of FIG. 2 with a lock bolt inserted through opening of the clamping bar and opening of the support bar.

[0026] FIG. 4 shows the embodiment of FIG. 3 with the collar swaged onto the lock bolt and the pigtail broken off of the lock bolt.

[0027] FIG. 5 shows one embodiment of a perimeter plate that closes the gap between an insulation deck and an inner tank of a low temperature tank.

[0028] While the invention is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0029] Illustrative embodiments of the invention are described below as they might be employed in the use of the design for an insulation deck suspended from the roof of a LNG vessel or other fluid storage tank. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers’ specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0030] Further aspects and advantages of the various embodiments of the invention will become apparent from consideration of the following description and drawings.

[0031] As shown in FIG. 1, an insulation deck for a low temperature tank of the present disclosure may be comprised of a network of metal sheets clamped together. As shown in FIGS. 2-4, the insulation deck 1 may be constructed by clamping a metal sheet between a support bar 20 and a clamping bar 30. The assembly of the metal sheet 10, the support bar 20, and the clamping bar 30 may be secured together by a fastener 40. The support bar 20 may be connected to a beam 90 that is substantially perpendicular to the support bar 20. The insulation deck 1 may be suspended from the roof of the low temperature tank 2 by cables or bars connected to the beam 90.

[0032] As shown in FIG. 2, an embodiment of the present disclosure may be comprised of adjacent metal sheets that overlap between a support bar 20 and a clamping bar 30. The support bar 20 may contain a central opening through its top surface. The top surface of the support bar 20 may be concave in shape as shown in FIG. 2. The clamping bar 30 may contain a central opening through its bottom surface, which may be convex as shown in FIG. 2. Alternatively, the top surface of the support bar 20 and the bottom surface of the clamping bar may be flat and may additionally include a groove along its surface as would be appreciated by one of ordinary skill in the art having the benefit of this disclosure.

[0033] The support bar 20 includes a flange on the end opposite the top surface. As would be appreciated by one of ordinary skill in the art having the benefit of this disclosure, the shape of the flange 26 could be varied and the flange could be used to connect a beam to the support bar. For example, a fastener could be inserted through the flange into the beam to fasten the support bar to the beam. Likewise, clamping bar 30 may include a flange, of which the shape could be varied. The flange of the clamping bar could be used to secure the clamping bar to a beam or other structure.

[0034] As shown in FIG. 3, a fastener 40 may be inserted through opening in the support bar 20 and opening in the clamping bar 30. The fastener 40 may be a lock bolt that includes a collar and a pigtail, as shown in FIG. 3. The fastener 40 may be used to swedge the collar onto the serrated portion of the fastener. The tool 60 applies downward force on the collar causing the collar to deform onto the fastener locking it in place. The tool 60 may apply the necessary pressure through hydraulics, pneumatics, or other means as would be apparent to one of ordinary skill in the art having the benefit of this disclosure.

[0035] The force applied by the tool 60 to swedge the collar may break off the pigtail 70 of the fastener 40, as shown by FIG. 4. By swedge the collar 40 onto the fastener 40, the shank of the fastener 40 is put into tension. The tension of the fastener 40 and the collar 40 locks the support bar 20 and clamping bar 30 together and prevents the assembly from loosening due to thermal cycling of the tank in which it may be installed. Additionally, the swedge of the fastener 40 pulls the support bar and clamping bar 30
together causing the deformation of the overlapping metal sheets 10 clamping between the bars. The deformation of the metal sheets creates a metal-to-metal seal between the sheets. The convex surface of the clamping bar and the concave surface of the support bar cause the metal sheets to deform with substantially the same curvature as the surfaces. The mating convex and concave surfaces aid in forming a metal-to-metal seal between the overlapping metal sheets 10. The configuration and geometries of the surfaces of the both the support bar and clamping bar can be varied, such as including a groove in the surface, as would be apparent to one of ordinary skill in the art having the benefit of this disclosure.

[0036] The insulation deck 1 may be located above an inner tank of the low temperature tank 2 such that there is a gap between in the insulation deck and the inner tank. A perimeter plate 100, as shown in FIG. 5, may be used to connect the gap between the insulation deck 1 and the inner tank. The perimeter plate 100 may be comprised of polygonal beams 105 connected together with brackets 110. The polygonal beams 105, brackets 110, and fasteners 115 connecting the beams and brackets may all be comprised of the same material, such as an aluminum alloy for example, to allow for a uniform expansion and contraction rate as the perimeter plate may be subjected to thermal cycling. The perimeter plate can be constructed using a number of different designs and components as would be apparent to one of ordinary skill in the art having the benefit of this disclosure.

[0037] Although various embodiments have been shown and described, the invention is not so limited and will be understood to include all such modifications and variations as would be apparent to one skilled in the art.

What is claimed is:

1. A insulation deck for use in a low temperature tank, comprising:
   a plurality of beams;
   a plurality of support bars connected to the plurality of beams;
   a plurality of metal sheets, wherein an external portion of each of the plurality of metal sheets rests on one of the plurality of support bars and the plurality of metal sheets cover openings between the plurality of support bars;
   a plurality of clamping bars, wherein each of the plurality of clamping bars engages a top surface of at least one of the plurality of metal sheets; and
   a plurality of fasteners, wherein at least one of the plurality of fasteners secures at least one of the plurality of clamping bars to at least one of the plurality of support bars.

2. The insulation deck of claim 1, further comprising a termination member extending around the edge of the insulation deck.

3. The insulation deck of claim 1, wherein the plurality of fasteners are lock bolts.

4. The insulation deck of claim 1, wherein the plurality of fasteners are mechanically locked in place.

5. The insulation deck of claim 1, wherein the plurality of beams are aligned substantially parallel and wherein the plurality of support bars are aligned substantially parallel and substantially transverse to the plurality of beams.

6. The insulation deck of claim 5, wherein the plurality of substantially parallel beams, the plurality of substantially parallel support bars, the plurality of metal sheets, the plurality of clamping bars, and the plurality of fasteners are each comprised of an aluminum alloy.

7. The insulation deck of claim 6, further comprising means for suspending the insulation deck from the roof of the low temperature tank.

8. The insulation deck of claim 7, wherein the means for suspending the insulation deck is connected to the plurality of beams.

9. The insulation deck of claim 7, wherein the plurality of fasteners connect the means for suspending the insulation deck to the plurality of support bars or to the plurality of clamping bars.

10. The insulation deck of claim 7, wherein the means for suspending the insulation deck is metal bars or structural beams.

11. The insulation deck of claim 7, wherein the means for suspending the insulation deck is metal cables.

12. The insulation deck of claim 11, wherein the metal cables further comprise stainless steel cables.

13. The insulation deck of claim 6, wherein the insulation deck is suspended from the roof of the low temperature tank from the group consisting of metal bars, structural beams, or metal cables.

14. The insulation deck of claim 1, wherein at least one of the plurality of support bars has at least one rib and at least one of the plurality of clamping bars has at least one groove that mates with the at least one rib such that at least a portion of one of the plurality of metal sheets is pressed into the groove by the rib when at least one of the plurality of fasteners is tightened.

15. The insulation deck of claim 1, wherein at least one of the plurality of support bars has at least one groove and at least one of the plurality of clamping bars has at least one rib that mates with the at least one groove such that at least a portion of one of the plurality of metal sheets is pressed into the groove by the rib when at least one of the plurality of fasteners is tightened.

16. The insulation deck of claim 1, wherein the plurality of support beams and the plurality of clamping beams have interlocking convex and concave surfaces.

17. The insulation deck of claim 16, wherein at least two adjacent metal sheets of the plurality of metal sheets overlap such that a portion of the metal sheet rests between the concave and convex surfaces.

18. The insulation deck of claim 17, wherein at least one of the plurality of clamping bars and at least one of the plurality of support beams partially deforms a portion of the metal sheets when at least one of the plurality of fasteners is tightened.

19. The insulation deck of claim 18, wherein the deformation of the portion of the metal sheets creates a metal-to-metal seal.

20. The insulation deck of claim 1, wherein the plurality of beams, the plurality of support bars, the plurality of metal sheets, the plurality of clamping bars, and the plurality of fasteners are each comprised of the same material.

21. The insulation deck of claim 1, wherein at least one of the plurality of support bars further comprises a channel running along the support bar.
22. The insulation deck of claim 21, wherein at least one of the plurality of clamping bars at least partially deforms a portion of one of the plurality metal sheets into the channel running along the support bar.

23. The insulation deck of claim 1, wherein the plurality of fasteners are tightened such that the plurality of clamping bars and the plurality of support bars causes the plurality of metal sheets to be a stressed membrane.

24. The insulation deck of claim 23, further comprising insulation supported by the stressed membrane.

25. The insulation deck of claim 24, wherein the insulation is a powder.

26. The insulation deck of claim 1, further comprising insulation supported on the plurality of metal sheets.

27. The insulation deck of claim 26, wherein the insulation is a powder.

28. The insulation deck of claim 27, wherein the insulation is perlite.

29. The method of constructing an insulation deck for use in a low temperature tank, comprising:

attaching a plurality of substantially parallel beams to the roof of the low temperature tank;

attaching a plurality of substantially parallel support bars to the plurality of substantially parallel beams, wherein the plurality of support bars extend transverse to the plurality of beams;

placing a plurality of metal sheets across the openings between the plurality of support bars;

placing a plurality of clamping bars on the plurality of metal sheets, wherein the plurality of clamping bars are located above the plurality of support bars;

deforming at least a portion of the plurality of metal sheets by tightening a plurality of fasteners, wherein the plurality of fasteners secure together the plurality of support bars, the plurality of metal sheets, and the plurality of clamping bars;

attaching a sealing member that extends from the edge of the insulation deck to the sides of the low temperature tank; and

installing insulation on top of the insulation deck.

30. The method of claim 29, wherein each of the plurality of substantially parallel beams, the plurality of substantially parallel support bars, the plurality metal sheets, the plurality of clamping bars, and the plurality of fasteners are comprised of aluminum.

31. The method of claim 29, wherein the insulation is a powder.

32. The method of claim 31, wherein the insulation is perlite.

33. The method of claim 29, wherein the plurality of metal sheets are a stressed membrane.

34. The method of claim 29, further comprising the step of overlapping the edges of the plurality of metal sheets.

35. The method of claim 34, wherein the at least a portion of the plurality of metal sheets that is deformed is the overlapping edges of the plurality of metal sheets.

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