DYNAMIC BY-PASS CONDUCTOR

Field of Invention

The present invention relates to a lightning protection apparatus for a floating roof tank.

Background

Floating roof tanks are commonly used to store large quantities of volatile liquids such as petroleum products. A floating roof tanks typically consists of an open top cylindrical shell equipped with a roof that floats on the surface of the stored liquid. The roof is designed to remain in contact with the liquid, and cover substantially its entire surface. This allows the roof to rise and fall with the liquid level in the tank. In principle, this eliminates tank breathing loss and greatly reduces the evaporative loss of the stored liquid. In some forms, the inner surface of the tank shell is covered by a seal.

However, floating roof tanks are susceptible to lightning strikes which may result in explosions or fires, causing substantial damage to facilities and loss of product, notwithstanding the significant environmental damage which may occur. In recent years lightning strikes have become more frequent, particularly in the tropics, and so pose an ever-greater risk to floating roof tank installations.

The impact of lightning strikes may be mitigated by using a lightning bypass conductor to electrically connect the floating roof to the shell of the tank, which is grounded. However, existing bypass conductors have some disadvantages. For example, hydrogen sulfide can occur naturally in crude oil or can be generated by refining processes, and thus may be found in a head space of a floating roof tank used to store petroleum products. This may cause corrosion of the conductor. In addition, stresses on the conductor due to wind may cause metal fatigue. Accordingly, frequent replacement of the conductor or tank components may be required.

Additionally, rudimentary protection measures such as shunts commonly suffer from sustained arcs, which are a major cause of rim fires. Furthermore, conventional bypass conductors create fire-risk situations whenever there is conductor slack. The conductor can coil randomly on itself, resulting a high-impedance situation on the tank roof.

It would be desirable to address or alleviate at least one of the above difficulties.

Summary

In a first aspect, the present invention provides a lightning protection apparatus for a liquid storage tank, the liquid storage tank having a shell and a floating roof, the lightning protection apparatus comprising:

a housing; and

a conductor spooled within the housing, the conductor being extendable from the housing and connectable to the floating roof of the tank to create a conductive path between the shell and the floating roof when the housing is mounted to the shell;

wherein the conductor comprises a solid metallic tape having an end that is connectable to the floating roof.

Advantageously, a solid metallic tape is not prone to fraying, and thus does not pose the same fire risk as conventional braided conductors. Further, a solid tape can avoid the possibility of “Joule heat” generation due to broken conductor strands in the event of lightning termination to the tank.

In another aspect, the present invention provides a lightning protection apparatus for a liquid storage tank, the liquid storage tank having a shell and a floating roof, the lightning protection apparatus comprising:

a housing; and

a conductor spooled within the housing, the conductor being extendable from the housing and connectable to the floating roof of the tank to create a conductive path between the shell and the floating roof when the housing is mounted to the shell;

wherein the conductor is under spring tension for automatic retraction into the housing when the conductor is disconnected from the floating roof; and

wherein the lightning protection apparatus further comprises a rotary dampener coupled to the conductor to control retraction speed of the conductor.

Advantageously, the rotary dampener provides a safety mechanism by acting to decelerate retraction of the conductor in the event that the conductor becomes disconnected from the tank roof.

In a third aspect, the present invention provides a lightning protection apparatus for a liquid storage tank, the liquid storage tank having a shell and a floating roof, the lightning protection apparatus comprising:

a housing; and

a conductor spooled within the housing, the conductor being extendable from the housing and connectable to the floating roof of the tank to create a conductive path between the shell and the floating roof when the housing is mounted to the shell;

wherein the housing is constructed from a polymer material.

Advantageously, the use of a polymer material to house the conductor enables the apparatus to be made much lighter than prior art devices that have metallic casings, allowing a single person to handle the device (instead of two), while retaining sufficient structural strength to protect the internal components of the device. Moreover, it also provides additional insulation which reduces the risk of electrical arcing.

Description of Figures

Embodiments of the invention will be described, by way of non-limiting example only, with reference to the accompanying drawings in which:

Figure 1 is a cutaway view of a floating roof tank with a lightning bypass conductor according to certain embodiments attached to the tank;

Figures 2a, 2b, and 2c show stages of mounting a lightning bypass conductor in a mounting bracket;

Figure 3a shows a protective cover for the lightning bypass conductor;

Figure 3b shows the protective cover mounted on the lightning bypass conductor;

Figure 4 is an isometric view of a lightning bypass conductor according to certain embodiments; and

Figure 5 is a front elevation view of the lightning bypass conductor.

Detailed Description

Figure 1 is a perspective view showing a lightning bypass conductor 100 in accordance with an embodiment of the present disclosure. As shown in Figure 1, the lightning bypass conductor 100 is attached inside a tank shell 104 of a floating roof tank 101. A long conductor 102 is drawn out from the lightning bypass conductor 100 and its tip is attached to the floating roof 105. This enables the tank shell 104 to be electrically connected to the floating roof 105 via the long conductor 102. The tank may also contain a foam dam (oil barrier) 103.

Conventionally, braided cables have been used as the primary conductor 102. This is because braided cables have good flexibility, and high effective surface area (and thus ability to effectively conduct lightning). However, the present inventors have realised that braided copper cables have a tendency to fray, particularly in the corrosive environments encountered in hydrocarbon storage. This increases the net resistance of the cable, poses a fire risk, and also renders such cables susceptible to breakage, thus rendering them ineffective. Fraying could be a problem due to corrosion (via hydrogen sulfide as mentioned above) or due to mechanical forces applied to the conductor 102, for example as the roof 105 moves.

Accordingly, embodiments provide a lightning protection apparatus 100 that comprises a conductor 102 in the form of a solid metallic tape. A solid metallic tape is not prone to fraying, and thus does not pose the same fire risk as conventional braided conductors. The

solid tape can avoid the possibility of “Joule heat” generation due to broken conductor strands in the event of lightning termination to the tank, which poses serious risks of explosion.

The solid metallic tape 102 may be constructed from a highly conductive heat resistant alloy with high durability. In some embodiments, the solid tape is a nickel-coated copper alloy solid tape.

Combining the properties of a copper alloy solid tape with a nickel coating significantly improves the corrosion resistance thus resulting in excellent conductivity, excellent corrosion resistance and high durability for longer life. For example, nickel-plating is particularly effective against corrosion by hydrogen sulfide in the tank headspace. In some embodiments, the nickel plating has a thickness of about 3 microns.

The solid metallic tape may have a width of about 40mm, and a thickness of about 0.8mm.

Referring now to Figures 2 to 5, certain aspects of the lightning bypass conductor 100 will be described in further detail.

As shown in Figures 2a, 2b, and 2c, the lightning bypass conductor 100 may include a holder 203 (Figure 2a) and a conductor housing 204. The housing 204 is adapted to be seated in the holder 203 such that the conductor 102 inside the housing 204 is in electrical contact with the holder 203. The holder 203 is attachable to a conductive mounting bracket 210 (Figure 2b), which is in turn mountable to the tank shell 104. Accordingly, a conductive path is established between the conductor 102 and the tank shell 104 when the mounting bracket 210 is attached to the tank shell 104.

The mounting bracket 210 has an elongate body 212 having a slot 214 formed at a first end, and a flanged mounting structure 216 extending from a second end opposite the first end. The mounting structure 216 is shaped to accommodate a rim of the tank 101 and may comprise two or more bolt holes to receive fasteners to attach the mounting bracket 210 to

the tank rim. The bracket 210 may be constructed from a metallic material such as stainless steel or galvanized steel.

The holder 203 has a body 206 defining a space to receive the housing 204 (Figure 2c), and may comprise one or more guides to ensure proper seating of the housing 204. The holder 203 may be directly mounted to the mounting bracket 210 for mounting to the tank 101.

The body 206 comprises a slot 205 to receive the conductor 102. To this end, when the holder 203 is attached to the mounting bracket 210, the slot 205 of body 206 is aligned with the slot 214 of bracket 210 so that the conductor 102 can be extended from the housing 204 along the aligned slots 205, 214.

In some embodiments, as shown in Figures 3a and 3b, the conductor housing 204 may be protected by a protective cover 220 having a body 222 to which one or more handles 230 are attached to facilitate attachment or removal of the cover 220. The cover 220 may be formed from stainless steel, for example, and provides protection against UV, impact load, and static charge on the polymer casing 204, as well as additional protection against ingress of moisture and dirt. To this end, the protective cover 220 may have a back plate 226 having a cutout portion 228 that cooperates with a plate 371 located at a rear of the conductor housing 204, as shown in Figure 3b. The back plate 226 may be formed from silicon rubber and/or silicon cork, for example. The plate 371 may be formed from stainless steel (for example) and nests within the cutout portion 228 of the cover 220 such that a moisture-resistant seal is formed.

The cover 220 has a flange 224 at a lower end thereof, the flange 224 having apertures to receive bolts to fasten the cover 220 to a circumferential portion of a base plate 208 that is attached to, or is integral with, a lower surface of the holder 203 (Figures 2a, 2c, 3b).

Holder 203 also has an angled front wall 306, as shown in Figures 4 and 5. The angled front wall 306 acts as a limiter for a swing guide 320 to avoid excessive vertical angle when the conductor 102 is spooled out from housing 204.

Further constructional details of the lightning bypass conductor 100 will now be described.

Inside the conductor housing 204, the conductor 102 is spooled about a coil spring. In particular, one end of the conductor 102 is connected to an end of the coil spring, such that extending the conductor 102 from the housing 204 increases the tension in the coil spring. Accordingly, if the conductor 102 is released, it will tend to automatically retract into the housing 204.

The coil spring may be supported on a shaft and attached to a rotary damper. The shaft is received in a bearing at each of its ends such that when assembled, the conductor spool 102 and coil spring form a rotating pulley assembly.
As the conductor 102 is extended from or retracted into the housing 204, the rotating pulley assembly rotates relative to support structure via the bearings to which the shaft is mounted.

In some embodiments, a rotary damper 340 may be used to function as a braking system to avoid retraction at excessive speed when the end 330 of the conductor 102 is freed from the tank roof joint. By the use of a rotary damper, it is ensured that the conductor 102 is always retracted at a measured rate (in the event of tape breakage or disconnected end straps). This also functions as a safety feature to slow down the retraction of the tape to avoid whiplash, which may injure persons nearby.

In some embodiments, the conductor 102 may exit the housing 204 via a swing guide 320 having a hydrophobic surface. The swing guide 320 is mounted at a front of the conductor housing 204 via a pin about which the swing guide 320 is adapted to rotate. The swing guide 320 may comprise a generally upright slotted member, with a pair of plates affixed to a lower surface of the upright slotted member. The first plate may be a tape guide of a stainless material, while the second plate may be a polymer material. Each of the first and second plates may have a respective slit formed therein. Each slit has a width such that the conductor

102 is able to slide relatively unimpeded along its length, but such that the tape guide 320 substantially impedes the ingress of foreign matter.

In particular, by providing a tape guide with the above slit mechanism for the swing guide 320, the tendency of moisture to be admitted to the housing 204 interior is minimised. In some embodiments, the surface of the swing guide 320 may be coated with a polymer, such as PTFE, to enable smooth sliding movement while minimising moisture ingress.

In some embodiments, the housing 204 may be constructed from a non-conductive, corrosion-resistant and lightweight polymer. One suitable polymer is acrylonitrile butadiene styrene (ABS), which is weather resistant and thus, suitable for outdoor use. Alternatively, a polycarbonate may be used. By the use of a polymer for construction of the housing 204, the lightning bypass conductor is made much lighter, allowing a single person to handle the device (instead of two), while retaining sufficient structural strength to protect the internal components of the device. Moreover, it also provides additional insulation which reduces the risk of electrical arcing. In some embodiments, the housing 204 may comprise an integrally-formed carry-handle 302 to facilitate transportation, as well as facilitating insertion of the housing 204 in the holder 203, and subsequent removal.

As mentioned above, the conductor 102 may comprise a solid metallic tape. As discussed, this type of structure is much more resistant to fraying than braided cables of the prior art. The conductor 102 may also comprise a conductive strap to which the metallic tape is connected via a pair of plates on opposite sides of the metallic tape, and which is used to connect the conductor 102 to the tank roof 105. To further improve the robustness of the conductor 102, a reinforcing structure may be provided at the end of the strap of the conductor 102 that attaches to the tank roof 105. In some embodiments, the reinforcing structure may comprise a pair of metallic plates attached to opposite surfaces of the end 330 of the conductor 102.

Embodiments

A description of some exemplary embodiments of the present disclosure is contained in one or more of the following numbered statements.

1. A lightning protection apparatus for a liquid storage tank, the liquid storage tank having a shell and a floating roof, the lightning protection apparatus comprising:

a housing; and

a conductor spooled within the housing, the conductor being extendable from the housing and connectable to the floating roof of the tank to create a conductive path between the shell and the floating roof when the housing is mounted to the shell;

wherein the conductor comprises a solid metallic tape having an end that is connectable to the floating roof.

2. The lightning protection apparatus of Statement 1, wherein the solid metallic tape is under spring tension for automatic retraction into the housing when the end of the solid metallic tape is disconnected from the floating roof.

3. The lightning protection apparatus of Statement 2, comprising a rotary dampener coupled to the conductor to control retraction speed of the solid metallic tape.

4. The lightning protection apparatus of any one of Statements 1 to 3, comprising a polymer-coated channel through which the solid metallic tape is extendable.

5. The lightning protection apparatus of any one of Statements 1 to 4, wherein the housing is constructed from a polycarbonate material.

6. The lightning protection apparatus of any one of Statements 1 to 4, wherein the housing is constructed from acrylonitrile butadiene styrene.

7. The lightning protection apparatus of any one of Statements 1 to 6, wherein the solid metallic tape is constructed from a heat resistant alloy.

8. The lightning protection apparatus of Statement 7, wherein the heat resistant alloy comprises copper.

9. The lightning protection apparatus of any one of Statements1 to 8, wherein the solid metallic tape comprises a nickel coating.

10. The lightning protection apparatus of any one of Statements 1 to 9, wherein the housing comprises a carry-handle.

11. The lightning protection apparatus of any one of Statements 1 to 10, comprising a mounting assembly for mounting the housing to a periphery of the tank shell.

12. The lightning protection apparatus of Statement 11, wherein the mounting assembly comprises a holder for securing the apparatus to the shell.

13. The lightning protection apparatus of Statement 11 or Statement 12, wherein the mounting assembly is attachable to a bracket that is configured for attachment to the shell.

14. A lightning protection apparatus for a liquid storage tank, the liquid storage tank having a shell and a floating roof, the lightning protection apparatus comprising:

a housing; and

a conductor spooled within the housing, the conductor being extendable from the housing and connectable to the floating roof of the tank to create a conductive path between the shell and the floating roof when the housing is mounted to the shell;

wherein the conductor is under spring tension for automatic retraction into the housing when the conductor is disconnected from the floating roof; and

wherein the lightning protection apparatus further comprises a rotary dampener coupled to the conductor to control retraction speed of the conductor.

15. A lightning protection apparatus according to Statement 14, wherein the conductor comprises a solid metallic tape, one end of which is connectable to the floating roof.

16. The lightning protection apparatus of Statement 14 or Statement 15, comprising a polymer-coated channel through which the conductor is extendable.

17. The lightning protection apparatus of any one of Statements 14 to 16, wherein the housing is constructed from a polycarbonate material.

18. The lightning protection apparatus of any one of Statements 14 to 16, wherein the housing is constructed from acrylonitrile butadiene styrene.

19. The lightning protection apparatus of any one of Statement 15 to 18, wherein the solid metallic tape is constructed from a heat resistant alloy.

20. The lightning protection apparatus of Statement 19, wherein the heat resistant alloy comprises copper.

21. The lightning protection apparatus of any one of Statements 15 to 20, wherein the solid metallic tape comprises a nickel coating.

22. The lightning protection apparatus of any one of Statements 14 to 21, wherein the housing comprises a carry-handle.

23. The lightning protection apparatus of any one of Statements 14 to 22, comprising a mounting assembly for mounting the housing to a periphery of the tank shell.

24. The lightning protection apparatus of Statement 23, wherein the mounting assembly comprises a holder for securing the apparatus to the shell.

25. The lightning protection apparatus of Statement 23 or Statement 24, wherein the mounting assembly is attachable to a bracket that is configured for attachment to the shell.

26. A lightning protection apparatus for a liquid storage tank, the liquid storage tank having a shell and a floating roof, the lightning protection apparatus comprising:

a housing; and

a conductor spooled within the housing, the conductor being extendable from the housing and connectable to the floating roof of the tank to create a conductive path between the shell and the floating roof when the housing is mounted to the shell;

wherein the housing is constructed from a polymer material.

27. The lightning protection apparatus of Statement 26, wherein the polymer material comprises acrylonitrile butadiene styrene or polycarbonate.

28. The lightning protection apparatus of Statement 26 or Statement 27, wherein the housing comprises a carry-handle.

29. The lightning protection apparatus of any one of Statements 25 to 28, wherein the conductor comprises a solid metallic tape having an end that is connectable to the floating roof.

30. The lightning protection apparatus of Statement 29, wherein the solid metallic tape is under spring tension for automatic retraction into the housing when the end of the solid metallic tape is disconnected from the floating roof.

31. The lightning protection apparatus of Statement 30, comprising a rotary dampener coupled to the conductor to control retraction speed of the solid metallic tape.

32. The lightning protection apparatus of any one of Statements 29 to 31, comprising a polymer-coated channel through which the solid metallic tape is extendable.

33. The lightning protection apparatus of any one of Statements 29 to 32, wherein the solid metallic tape is constructed from a heat resistant alloy.

34. The lightning protection apparatus of Statement 33, wherein the heat resistant alloy

comprises copper.

35. The lightning protection apparatus of any one of Statements 29 to 34, wherein the solid metallic tape comprises a nickel coating.

36. The lightning protection apparatus of any one of Statements 26 to 35, comprising a mounting assembly for mounting the housing to a periphery of the tank shell.

37. The lightning protection apparatus of Statement 36, wherein the mounting assembly comprises a holder for securing the apparatus to the shell.

38. The lightning protection apparatus of Statement 36 or Statement 37, wherein the mounting assembly is attachable to a bracket that is configured for attachment to the shell.

The embodiments have been described by way of example only and modifications are possible within the scope of the invention disclosed. The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgement or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.