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Aircraft Fuel Tank with an Electrical Bond Separate from a Fuel Tank Fastener

Abstract

A aircraft fuel tank includes an inner layer having an inner surface and an outer surface; an outer layer having an inner surface and an outer surface, the inner surface of the outer layer and the outer surface of the inner layer aligning at an interface; a fastener extending through the inner layer and the outer layer to hold the inner layer and the outer layer together; and an electrical bond separate from the fastener and conductively coupling the inner layer and the outer layer together; the electrical bond is to provide a pathway for an electrical current to travel separate from the fastener.

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Background/Summary

BACKGROUND

1. Field

[0001] Embodiments of the disclosure relate to aircraft fuel tanks, and in particular to an aircraft fuel tank having an electrical bond between two or more layers separate from a fuel tank fastener for diverting electrical current away from the fastener to reduce a risk associated with an electric discharge inside of the fuel tank.

2. Related Art

[0002] Aircraft fuel tanks are known in the art and commonly include one or more features to aid in managing an electrical current generated from a lightning strike. For example, U.S. Pat. No. 7,576,966 to Heeter et al. describes a fuel system specifically for aircraft having an electrical bond between a fuel access door and a fuel tank skin for lightning current diversion. U.S. Pat. No. 8,004,815 to Loche et al. describes a system for lightning protection for fuel systems for aircraft, wherein a conductive strip is utilized to divert and carry current. U.S. Pat. No. 7,898,785 to Winter et al. describes a system for lightning protection for a fuel system utilizing a conductive outer layer to direct and dissipate electrical current.

SUMMARY

[0003] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Other aspects and advantages of the invention will be apparent from the following detailed description of the embodiments and the accompanying drawing figures.

[0004] An embodiment of the present invention relates to an aircraft fuel tank, including an inner layer having an inner surface and an outer surface; an outer layer having an inner surface and an outer surface, the inner surface of the outer layer and the outer surface of the inner layer aligning at an interface; a fastener extending through the inner layer and the outer layer to hold the inner layer and the outer layer together; and an electrical bond separate from the fastener and conductively coupling the inner layer and the outer layer together; wherein the electrical bond is configured to provide a pathway for an electrical current to travel separate from the fastener.

[0005] Another embodiment of the present invention relates to a method of diverting current away from a fastener in an aircraft fuel tank, the method including selecting an inner layer, an outer layer, and a fastener for the aircraft fuel tank; connecting the inner layer and the outer layer with the fastener, the fastener extending from an outer surface of the outer layer to an inner surface of the inner layer; creating an electrical bond between the inner layer and the outer layer that is separate from the fastener such that the inner layer and the outer layer are conductively coupled. The electrical bond provides a pathway for the electrical current to travel that is separate from the fastener, thereby diverting at least a portion of the electrical current away from the fastener.

Description

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0006] Embodiments of the invention are described in detail below with reference to the attached drawing figures, wherein:

[0007] FIG. **1** depicts a side cross-sectional view of a conventional aircraft fuel tank at a location of one fastener.

[0008] FIG. **2** depicts a side cross-sectional view of an aircraft fuel tank having a spot face electrical bond at a location of one fastener in accordance with the present invention.

[0009] FIG. **3** depicts a top-down cross-sectional view of the spot face electrical bond surrounding a stem of the fastener.

[0010] FIG. **4** depicts another side cross-sectional view of the aircraft fuel tank having the spot face electrical bond of FIG. **2** with an electrical current traveling therethrough.

[0011] FIG. **5** is another side cross-sectional view of the aircraft fuel tank having the sport face electrical bond of FIG. **2** with a plurality of variables labeled.

[0012] FIG. **6** is a flowchart of a method of current diversion from the fastener utilizing the spot face electrical bond of FIG. **2**.

[0013] The drawing figures do not limit the invention to the specific embodiments disclosed and described herein. The drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the invention.

DETAILED DESCRIPTION

[0014] The following detailed description references the accompanying drawings that illustrate specific embodiments in which the invention can be practiced. The embodiments are intended to describe aspects of the invention in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments can be utilized and changes can be made without departing from the scope of the invention. The following detailed description is, therefore, not to be taken in a limiting sense. The scope of the invention is defined only by the appended claims, along with the full scope of the equivalents to which such claims are entitled.

[0015] In this description, references to “one embodiment,” “an embodiment,” or “embodiments” mean that the feature or features being referred to are included in at least one embodiment of the technology. Separate references to “one embodiment,” “an embodiment,” or “embodiments” in this description do not necessarily refer to the same embodiment and are also not mutually exclusive unless so stated and/or except as will be readily apparent to those skilled in the art from the description. For example, a feature, structure, act, etc. described in one embodiment may also be included in other embodiments, but is not necessarily included. Thus, the technology can include a variety of combinations and/or integrations of the embodiments described herein.

[0016] Aircraft conventionally utilize fuel tanks to transport and store fuel for powering components of the aircraft. Lightning currents in fuel tank fasteners can cause arcing and sparking at the fastener. Aircraft fuel tank systems are subject to compliance and regulatory testing, where lightning testing of fastener interfaces is a substantial portion of said testing. As discussed below, conventionally a metallic fastener secures materials together, leading to an exposed metal head, extending through the structure and into a fuel source, providing a direct, highly conductive path, for an electrical current to travel in the event of a lightning strike.

[0017] As shown in FIG. **1**, a simplified cross-sectional view depicts a conventional fuel tank **10** for an aircraft. The fuel tank **10** is a structure, having at least an outer layer **100** and an inner layer **102** secured together via a fastener **103**. Those skilled in the art will appreciate that the portion of the fuel tank **10** shown in FIG. **1** is a small section taken at one fastener **103**, and the entire fuel tank **10** would include a plurality of fasteners. As shown, an inner surface **104** of the outer layer **100** and an outer surface **106** of the inner layer **102** come together at an interface **108** such that the surfaces **104**, **106** are pressed together via the fastener **103**. In embodiments, these surfaces **104**, **106** may also include a layer of primer **110***a*, **110***b* to aid in protecting the fuel tank from corrosion.

[0018] Fastener(s) **103** are conventionally composed of a metal (e.g. screws or bolts) and extend from an outer surface **112** to an inner surface **116**, where the fastener **103** then engages with a fixing part **122**, again conventionally composed of metal. Accordingly, the fastener **103** is generally highly conductive and exposed both outside of the fuel tank **114** and inside of the fuel tank **118**.

[0019] The outer surface **112** of the outer layer **100** is also exposed to the elements outside of the fuel tank **114**, while the inner surface **116** of the inner layer **102** is exposed to fuel inside of the fuel tank **118**. Accordingly, the outer surface **112** may be exposed to lightning strikes, as well as conducted current from a lightning strike elsewhere on the aircraft, resulting in a lightning current **120** traveling through the fuel tank **10**. The lightning current **120** will generally condense and flow through the fastener **103** and then into the inside of the fuel tank **118**. Current flow into the fuel tank **118** may result in an electric discharge, which could result in ignition of the fuel. Accordingly, fuel tanks are tested to ensure safety standards are met with respect to a potential lightning threat.

[0020] To aid in reducing the risk of electric discharge within a fuel tank, the present invention provides for an electrical bond, such as a spot face electrical bond or a washer at least partially surrounding each fastener of the fuel tank, wherein the electrical bond will provide a current flow path away from the fastener to reduce the amount of current that travels through the fastener and into the fuel tank. In other words, a highly conductive flow path that is separate from the fasteners is provided to direct current from an outer layer to an inner layer, thereby reducing current flow directly into the fuel.

[0021] In FIG. **2**, a cross sectional view of a fuel tank **20** of the present invention is shown. Again, the section of the fuel tank **20** depicts a small area around one fastener **200**, however those skilled in the art will appreciate that the fuel tank **20** includes a plurality of fasteners. The fuel tank **20** is a structure with at least an outer layer **202** and an inner layer **204**, wherein an inner surface **206** of the outer layer **202** and an outer surface **208** of the inner layer **204** come together at an interface **210**. In embodiments, the layers **202**, **204** are metal. Some embodiments may include a layer of primer **212***a*, **212***b* at the interface **210** to aid in corrosion protection at the surfaces **206**, **208**. The materials that make up each of the outer layer **202** and the inner layer **204** may vary as would be understood by those skilled in the art, including metals, plastics, or any other suitable materials.

[0022] The fastener **200** extends through pre-established holes of both of the outer layer **202** and the inner layer **204**, extending from an outer surface **214** exposed to outside of the fuel tank **215** to an inner surface **216** inside of the fuel tank **217**. The fastener **200** can again vary as would be understood by those skilled in the art (e.g. bolts, screws, rivets). The fastener **200** will also generally extend from a top head **218** exposed along the outer surface **214** to a fastening element **220** exposed along the inner surface **216**. As discussed above, the fastener **200** and fastening element **220** are generally composed of a metal, therefore being highly conductive.

[0023] The fuel tank **20** of the present invention further comprises an electrical bond **222***a-b*, extending between the outer layer **202** and the inner layer **202**, such that a conductive path is formed away from the fastener **200**. The electrical bond **222***a-b* may vary in embodiments, for example, in some embodiments, the electrical bond **222***a-b* is a spot face electrical bond or a direct connection between a metallic outer layer **202** and a metallic inner layer **204**, such as an area with no primer or barrier between the two layers allows for a conductive path to be formed between the two layers. In other words, as the fastener **200** clamps the two layers together, the layers **202**, **204** come into direct contact at electrical bond **222***a-b* to form the electrical path that is separate from the fastener **200**. In other embodiments, a washer forms the electrical bond **222***a-b* by creating flow-path around the fastener **200**. In other words, a washer is selected from conductive material, which in embodiments is aluminum, such that an electrical current will at least partially flow through the bond **222***a-b* (i.e. the washer), as opposed to almost fully through the fastener **200**. This configuration aids in dispersing the current, as opposed to the current being concentrated as it flows through the fastener **200**. As shown, the electrical bond **222***a-b* is created adjacent to the fastener and extends at least partially around a stem **224** of the fastener **200**. This is best shown in FIG. **3** where the electrical bond **222** surrounds the stem **224** and extends out from the stem **224** a distance (d). The distance (d) being determined by those skilled in the art based on one or more factors associated with the fuel tank **20**. Those skilled in the art will appreciate that a larger fastener **200**, combined with thinner layers **202**, **204**, will generally not require a washer to create the electrical bond **222***a-b* as the layers **202**, **204** can be fully clamped together via the fastener **200**. Alternatively, in embodiments with a smaller fastener **200** and thicker layers **202**, **204**, a washer may be needed to create a connection between the layers **202**, **204**.

[0024] As shown in FIG. **4**, if the outer surface **214** is exposed to an electrical current **300**, or if electrical current **300** emanates from elsewhere in the aircraft, which may be from a lightning strike or generated in testing, an appreciable or substantial amount of the electrical current **302** is likely to travel through the electrical bond **222***b* to pass between the outer layer **202** and the inner layer **204**.

A lesser amount of the electrical current **304**, or in some cases no electrical current, will travel through the fastener **200** such that an electric discharge inside of the fuel tank **217** is unlikely to occur.

[0025] As shown in FIG. **5**, a plurality of variables is considered to determine an appropriate electrical bond **222***a-b* (e.g. the need for a washer or not) for a fuel tank **20**. First, a diameter of the fastener **200** hole or the diameter of the fastener stem **224** (Dh) is considered to have little to no impact on the relative conductivity of the electrical bond **222**. Accordingly, smaller fasteners may be utilized without increasing a risk of electric discharge inside of the fuel tank. The diameter of the spot face electrical bond **222***a-b* (Dsp) has a direct impact on the conductivity of the bond, as a larger diameter leads to more conductivity through the bond. The thickness of the primer **212***a-b* (Tp) also has an impact on the conductivity. Specifically, a greater thickness will lead to less pressure at the electrical bond **222**, and therefore reduce the conductivity through the bond **222**. The thickness of each of the outer layer **202** and inner layer **204** (Tol) (Til) impacts the conductivity, as thicker layers reduce flexing, thereby reducing pressure at the electrical bond **222** and further reducing conductivity. The force from fastener **200** clamping (Fcf) the two layers together also impacts the conductivity, as a higher clamping force will increase flexing of the layers **202**, **204**, further increasing conductivity at the bond **222**. Lastly, the conductivity of the fastener **200** impacts the effectiveness of the electrical bond **222**. The conductivity of the fastener **200** provides a parallel path, which can mask the relative conductivity of the electrical bond **222**. Accordingly, those skilled in the art will create a specific electrical bond **222** based on the above variables, as well as other variables associated with a particular fuel tank.

[0026] In FIG. **6**, a flowchart **60** depicts a method of diverting electrical current away from the fastener **200** as part of the fuel tank **20**. At step **600**, materials are selected to manufacture the fuel tank **20**, including the outer layer **202**, the inner layer **204**, the fastener **200**, and potential primers **212***a-b*. At step **602**, the fuel tank **20** is manufactured with the layers **202**, **204** secured together via the fastener **200** and the electrical bond **222** is created around the fastener **200**. As discussed above, the electrical bond **222** may vary to accommodate one or more variables associated with the fuel tank **20**. For example, the material and need for a fastener and diameter of the electrical bond **222** may be selected based on desired conductivity needed depending on a material of the fastener stem **224**, a thickness of the each of the layers **202**, **204**, a force from the fastener **200** clamping, and a thickness of the primer **212***a-b*.

[0027] At step **604**, the fuel tank **20** is exposed to lightning testing for certification and compliance with regulations. In other words, tests are conducted on the fuel tank **20**, including at least applying a predetermined amplitude of current to the outer layer **214**, wherein data is collected to determine the probability and potential for an ignition source. Such testing is extensive, and time consuming within the aircraft industry and merely simplified here.

[0028] At step **606**, during testing, the electrical bond **222** provides a path for the applied current to travel that is separate from the fastener **200**. Accordingly, the risk for a potential electric discharge at the inside end of the fastener **200** is reduced as the current is not condensed at the inside end of the fastener.

[0029] At step **608**, once the fuel tank **20** is fully tested, has past testing, and then installed within an aircraft, the fuel tank **20** may continuously be exposed to the elements, resulting in a possibility of a lightning strike or conducting current from a lightning strike elsewhere on the aircraft. Should the fuel tank **20** be exposed to electrical current, the electrical bond **222** will again divert the current at least partially away from the fastener **200** to continue to reduce the risk for an electrical discharge inside of the fuel tank **20**.

[0030] Although the invention has been described with reference to the embodiments illustrated in the attached drawing figures, it is noted that equivalents may be employed and substitutions made herein without departing from the scope of the invention as recited in the claims.

Claims

1. An aircraft fuel tank, comprising: an inner layer having an inner surface and an outer surface; an outer layer having an inner surface and an outer surface, the inner surface of the outer layer and the outer surface of the inner layer aligning at an interface; a fastener extending through the inner layer and the outer layer to hold the inner layer and the outer layer together; and an electrical bond separate from the fastener and conductively coupling the inner layer and the outer layer together, wherein the electrical bond is configured to provide a pathway for an appreciable amount of electrical current to travel separate from the fastener.
2. The aircraft fuel tank of claim 1, wherein the electrical bond is positioned adjacent to a stem of the fastener and extends outwardly from the stem.
3. The aircraft fuel tank of claim 2, wherein the electrical bond surrounds the stem of the fastener.
4. The aircraft fuel tank of claim 1, wherein the electrical bond extends through the interface between the inner layer and the outer layer.
5. The aircraft fuel tank of claim 1, wherein the electrical bond is a spot face electrical bond creating a direct connection between the inner layer and the outer layer.
6. The aircraft fuel tank of claim 1, wherein the electrical bond further comprises a washer positioned around a stem of the fastener to create the pathway between the outer layer and the inner layer.
7. The aircraft fuel tank of claim 1, further comprising a primer positioned along the outer surface of the inner layer and along the inner surface of the outer layer.
8. The aircraft fuel tank of claim 7, wherein the primer extends within the interface up to the electrical bond.
9. A method of diverting current away from a fastener in a aircraft fuel tank, the method comprising: selecting an inner layer, an outer layer, and a fastener for the aircraft fuel tank; connecting the inner layer and the outer layer with the fastener, the fastener extending from an outer surface of the outer layer to an inner surface of the inner layer; creating an electrical bond between the inner layer and the outer layer that is separate from the fastener such that the inner layer and the outer layer are conductively coupled; exposing the aircraft fuel tank to an electrical current; wherein the electrical bond provides a pathway for the electrical current to travel that is separate from the fastener, thereby diverting at least a portion of the electrical current away from the fastener.
10. The method of claim 9, wherein the electrical bond is positioned adjacent to a stem of the fastener and extends outwardly from the stem.
11. The method of claim 9, wherein creating the electrical bond further comprises surrounding the stem of the fastener with the electrical bond.
12. The method of claim 9, wherein the electrical bond extends through an interface between the inner surface of the outer layer and the outer surface of the inner layer.
13. The method of claim 9, wherein the electrical bond is a spot face electrical bond creating a direct connection between the inner layer and the outer layer.
14. The method of claim 9, wherein the electrical bond further comprises a washer positioned around a stem of the fastener to create the pathway between the outer layer and the inner layer.
15. The method of claim 9, further comprising adding a primer within the interface, the primer extending up to the electrical bond.
16. The method of claim 9, wherein at least a portion of the electrical current is a substantial amount of the electrical current.