A fuel tank cap for use with a fuel storage tank includes: a vapor storage receptacle; a purge path in fluid communication with the vapor storage receptacle; and a liquid discriminating membrane configured to be disposed at least in part between the vapor storage receptacle and fuel in the fuel storage tank. A fuel storage system includes: a fuel storage tank; a fill inlet connected to the fuel storage tank; and a fuel tank cap. The fuel tank cap includes: a vapor storage receptacle; a purge path in fluid communication with the vapor storage receptacle; and a liquid discriminating membrane configured to be disposed at least in part between the vapor storage receptacle and fuel in the fuel tank.
FUEL CAP WITH EMISSIONS PROTECTION

TECHNICAL FIELD

[0001] The present invention generally relates to a fuel tank cap for use with a fuel storage tank, including a fuel tank cap with an integrated vapor storage receptacle and liquid discriminating membrane to protect the integrated vapor storage receptacle from liquid fuel.

BACKGROUND

[0002] Small engine equipment powered by internal combustion engines generally include a fuel tank. It is commonly necessary to vent a fuel tank to relieve pressure build-up which may occur when the fuel tank cap is in place and to permit the escape of air during normal filling operations when the fuel tank cap is removed. An evaporative control system is generally used for such venting operations. A typical evaporative control system vents fuel vapor to a vapor storage container, such as a carbon canister. The evaporative control system is generally configured to prevent fuel vapors and/or raw fuel from the tank from flooding the vapor storage container during normal engine operation and/or during filling. Current environmental control laws and regulations may require an evaporative control system for fuel tanks found even in small engine applications or portable fuel containers. The compact size of such engines may create challenges.

SUMMARY

[0003] A fuel tank cap for use with a fuel storage tank includes: a vapor storage receptacle; a purge path in fluid communication with the vapor storage receptacle; and a liquid discriminating membrane configured to be disposed at least in part between the vapor storage receptacle and liquid fuel in the fuel storage tank.

[0004] A fuel storage system includes: a fuel storage tank; a fill inlet connected to the fuel storage tank; and a fuel tank cap. The fuel tank cap includes: a vapor storage receptacle; a purge path in fluid communication with the vapor storage receptacle; and a liquid discriminating membrane configured to be disposed at least in part between the vapor storage receptacle and liquid fuel in the fuel storage tank.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

[0006] FIG. 1A is a side elevation view of a fuel storage system according to an embodiment of the invention.

[0007] FIG. 1B is a side elevation view of a fuel storage system of the type shown in FIG. 1A illustrated in a substantially filled condition.

[0008] FIG. 2 is a bottom view of an embodiment of a fuel tank cap with an integrated canister.

[0009] FIG. 3 is a cross-sectional view of a fuel storage system according to an embodiment of the invention and shown taken along line 3-3 of FIG. 2.

[0010] FIG. 4 is a cross-sectional view of a fuel storage system according to another embodiment of the invention.

DETAILED DESCRIPTION

[0011] Reference will now be made in detail to embodiments of the present invention, examples of which are described herein and illustrated in the accompanying drawings. While the invention will be described in conjunction with embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as embodied by the appended claims.

[0012] FIGS. 1A and 1B generally show a fuel storage system 10. The fuel storage system 10 may include a fuel storage tank 12 operatively connected to an engine (not shown). Fuel storage tank 12 may contain fuel (e.g., with an indicated level L). Fuel storage tank 12 may be connected to a fill inlet (e.g., filler tube) 14. Fill inlet 14 may extend to an inlet opening 16, such as, for example, a conventionally-threaded fuel inlet opening, which may open to the atmosphere and may be adapted to connect to and/or receive a fuel tank cap 18. In accordance with an embodiment of the invention, the fuel tank cap 18 may be particularly useful for small engine applications and/or portable fuel containers in embodiments of the invention.

[0013] Fuel tank cap 18 may be configured to be disengaged and removed from inlet opening 16, such as during a refueling process, without causing an unacceptable level of interference between fuel tank cap 18 and inlet opening 16. Fuel tank cap 18 may be comprised of plastic (e.g., fuel-resistant plastic) in accordance with an embodiment of the invention. Although plastic is mentioned in detail, fuel tank cap 18 may comprise various other materials in other embodiments of the invention. Referring now to FIGS. 2-4, fuel tank cap 18 may include an outer surface 18a and an inner surface 18b and may further include a partially threaded surface 18c. The partially threaded surface 18c may extend from the interior surface 18b of the fuel tank cap 18 in an embodiment of the invention. The partially threaded surface 18c of fuel tank cap 18 can be configured to engage fuel inlet opening 16, which can result in effectively securing fuel tank cap 18 to filler tube 14. A seal 20 may be provided between fill inlet (e.g., filler tube) 14 and fuel tank cap 18, effectively sealing fill inlet (e.g., filler tube) 14 and fuel tank 12 from the atmosphere. Some embodiments of the invention may not use a seal 20, but may still be configured to result in effective sealing of fill inlet (e.g., filler tube) 14 and fuel tank 12 from the atmosphere. In some embodiments, the threaded engagement of fuel tank cap 18 and filler tube 14 may allow atmospheric air to pass between the fuel tank cap 18 and filler tube 14. In such a configuration, the internal pressure in fuel storage tank 12 and fill inlet (e.g., filler tube) 14 is generally greater than the atmospheric pressure. The outer surface 18a, inner surface 18b, and/or partially threaded surface 18c may define a cavity 22.

[0014] Fuel tank cap 18 may include a vapor storage receptacle 24. The vapor storage receptacle 24 may be coupled with the fuel tank cap 18 in an embodiment of the invention. In an embodiment, the vapor storage receptacle 24 may be coupled with the inner surface 18b of the fuel tank cap 18. The vapor storage receptacle 24 may be located within cavity 22 of fuel tank cap 18. When fuel tank cap 18 is in an installed position (i.e., engaging inlet opening 16 of fill inlet 14), the vapor storage receptacle 24 may be located in fuel tank cap 18 so as to face fuel storage tank 12 and/or extend in a downward direction toward fuel storage tank 12. Vapor storage receptacle 24 may be coupled with fuel tank cap 18 by any method and/or in any manner that is known and/or conventional in the
art. For example and without limitation, the vapor storage receptacle 24 may be snap-fit into an aperture located on the fuel tank cap 18 (e.g., a portion 26 of vapor storage receptacle 24 may be snap-fit into an aperture 28 located on fuel tank cap 18) such as generally illustrated in FIG. 3. Alternatively and without limitation, vapor storage receptacle 24 may be coupled to the fuel tank cap 18 by forming the vapor storage receptacle 24 and fuel tank cap as an integral unit, by threaded engagement (e.g., both inner surface 18b and the vapor storage receptacle 24 may have corresponding threaded surfaces that may be screwed together), by welding (e.g., ultrasonic welding, spin welding, electro-mechanical welding, or the like), and/or by a friction fit forming between the vapor storage receptacle 24 and the partially threaded surface 18c of the fuel tank cap 18. For example and without limitation, referring now to FIG. 4, the vapor storage receptacle 24 may be substantially friction fit within the cavity 22 formed by the fuel tank cap 18. In some embodiments, fuel tank cap 18 and vapor storage receptacle 24 may be coupled in such a manner as to allow fuel tank cap 18 to rotate independently of vapor storage receptacle 24.

[0015] The vapor storage receptacle 24 may be configured to function as a storage receptacle for fuel vapors and/or to absorb hydrocarbons which escape from the fuel storage tank 12, which would otherwise be vented to the atmosphere. Hydrocarbons may then be able to be combusted back to the engine, for example, in an embodiment of the invention. The fuel tank cap 18 may be configured to thereby reduce emissions in accordance with an embodiment of the invention. The vapor storage receptacle 24 may include an outer shell or canister 30. Canister 30 may comprise plastic (e.g., fuel-resistant plastic) in accordance with an embodiment of the invention. Canister 30 may be generally cylindrical in shape and may have a diameter that is smaller than the diameter of the inlet opening 16. However, the canister 30 may comprise any of various materials, shapes, and dimensions in other embodiments of the invention. Canister 30 may be packed tightly with an absorbent granulated carbonaceous material, such as but not limited to, carbon pellets, charcoal, or the like, as is known in the art. The vapor storage receptacle 24 may thus comprise a carbon bed. The absorbent granulated carbonaceous material may be packed using screens or filters 32. Screens or filters 32 may prevent the absorbent granulated carbonaceous material from escaping from the vapor storage receptacle 24. Screens 32 may generally comprise a frame with a net or mesh, and filters 32 may generally comprise a sponge. Screens or filters 32 may be generally configured to allow air flow while retaining the carbonaceous material and/or or carbon bed of the vapor storage receptacle 24 in place. Screens or filters 32 are generally not configured for liquid discriminating functions in accordance with some embodiments of the invention. Further, in some embodiments, a spring loaded volume compensator plate may be used to continually push upon the screens or filters 32 to keep the absorbent granulated carbonaceous material in place. Referring now to the embodiment generally illustrated in FIG. 4, the vapor storage receptacle 24 may comprise a carbon bed of a different structure than that generally illustrated in FIG. 3. For example, the carbon bed may not necessarily include an outer shell or canister 30, but may include any means known in the art to maintain the shape and structure of the carbon bed.

[0016] The vapor storage receptacle 24 may be an actively purged system or a passively purged system in various embodiments of the invention. In accordance with an actively purged system, ambient air may be drawn through the canister 30 by a vacuum created by the intake system (e.g., intake manifold of engine). In accordance with a passively purged system, ambient may be drawn through the canister 30 by a vacuum created by normal diurnal temperature variations in the temperature of the fuel tank 12. Canister 30 may therefore include a purge path 34 in an embodiment of the invention. Purge path 34 may comprise a purge line in accordance with an embodiment of the invention and as generally illustrated in FIG. 3. One or more apertures may be disposed in fuel tank cap 18 and/or canister 30 that are in fluid communication with purge path 34 (e.g., purge line) to direct vapors to purge path 34 (e.g., purge line). Purge path 34 (e.g., purge line) may be operatively connected to a component of an engine, such as the intake manifold of the engine in an actively purged system, for example. Referring again to FIG. 3, screens and/or filters 32 may be disposed between the vapor storage receptacle 24 and the purge path 34 (e.g., purge line) in an embodiment of the invention. The screen and/or filter 32 may be configured to change the hydrocarbon percentage of the fuel vapor prior to it being purged via purge path 34 (e.g., purge line). Screens and/or filters 32 are disposed between the vapor storage receptacle 24 and the atmosphere to allow air flow. Fuel tank cap 18 may be loose and/or tethered in various embodiments of the invention. A tethered system may, among other things, prevent fuel tank cap 18 from being misplaced or lost. In an actively purged system (e.g., as generally illustrated in FIG. 3), the purge path 34 (e.g., purge line) may also serve as the tether for fuel tank cap 18.

[0017] In a passively purged system (e.g., as generally illustrated in FIG. 4), the purge path 34 may comprise a port and/or opening, for example. Still referring to FIG. 4, a filter 35 may be disposed between the vapor storage receptacle 24 and the purge path 34 (e.g., purge port and/or opening) in an embodiment of the invention. The filter 35 may be configured to change the hydrocarbon percentage of the fuel vapor prior to it being purged via purge path 34 (e.g., purge port and/or opening). The filter 35 may comprise a synthetic foam in accordance with an embodiment of the invention. Although the filter 35 is described as a synthetic foam in an embodiment of the invention, the filter 35 may comprise any number of other materials in other embodiments of the invention. While the purge path 34 (e.g., purge line) of the actively purged system is generally illustrated as extending from the fuel tank cap 18 toward the fuel storage tank 12 (e.g., in a downward direction), and the purge path 34 (e.g., purge port) of the passively purged system is generally illustrated as extending from the fuel tank cap 18 away from the fuel storage tank 12 (e.g., in an upward direction), the purge path 34 may be disposed at any location on the fuel tank cap 18 and may extend in any of various directions in various embodiments of the invention.

[0018] The fuel tank cap 18 may further include a membrane 36. Membrane 36 may be a vapor permeable membrane and may be configured to allow fuel vapor to pass at a predictable rate. Membrane 36 may comprise a liquid discriminating membrane and may be configured to protect the vapor storage receptacle 24 (e.g., absorbent granulated carbonaceous material of canister 30) from liquid fuel. Membrane 36 may thus be resistive to passage of liquid fuel. Membrane 36 may comprise a microporous oleophobic membrane in accordance with an embodiment of the invention. Membrane 36 may be surface treated to improve repellency in accor-
dance with an embodiment of the invention. Although membrane 36 may be a microporous oleophobic membrane and/or may be surface-treated to improve repellency with embodiments of the invention, the membrane 36 may comprise any number of materials or surface treatments or may be untreated in other embodiments of the invention. Membrane 36 may be formed with a porous non-woven substrate, thereby forming a composite of a microporous membrane layer and a support layer (e.g., the non-woven substrate) in an embodiment of the invention. The support layer may be configured to enhance the mechanical properties of the membrane 36. Although membrane 36 may be formed with a non-woven substrate in an embodiment of the invention, the membrane may not be supported in accordance with other embodiments of the invention. Membrane 36 may be configured to be disposed at least in part between the vapor storage receptacle 24 and liquid fuel in the fuel storage tank 12. Mechanical means found in conventional fuel tank caps, such as liquid discriminator valves, vapor vent valves, rollover valves, or the like, involving moving parts (e.g., which may affect reliability) and are generally complex. The liquid discriminating membrane 36 configured to protect the vapor storage receptacle 24 from liquid fuel may not require moving parts and may be of a less complex design. Membrane 36 is configured to allow the passage of air and/or fuel vapor to vapor storage receptacle 24 (e.g., without being generally configured to filter the fuel vapor and/or substantially change (e.g., lower and/or increase) the hydrocarbon concentration of the fuel vapor). Membrane 36 may also be configured to block the passage of liquid fuel from entering the vapor storage receptacle 24. For example, during operation of the engine and/or the portable fuel tank container, fuel may slosh about in fuel storage tank 12 and otherwise come into contact with vapor storage receptacle 24. In other instances, fuel storage tank 12 may be accidentally or intentionally turned upside down.

Membrane 36 may be operatively engaged with vapor storage receptacle 24. Membrane 36 may be disposed between the fuel in fuel tank 12 and the vapor storage receptacle 24. Membrane 36 may be configured for connection with vapor storage receptacle 24 such that the flow and/or passage of air and/or liquid cannot bypass membrane 36 (i.e., fuel vapor must pass through membrane 36 to get to the vapor storage receptacle 24). The membrane 36 may thus be configured to fluidly seal the vapor storage receptacle 24. Membrane 36 may be on the liquid side of the vapor storage receptacle 24. In an embodiment of the invention, membrane 36 may extend substantially across the cross-section of the fuel tank cap 18 in order to keep liquid fuel from coming into contact with the vapor storage receptacle 24. Membrane 36 may be directly connected to the canister 30 in any manner, including without limitation, welding, insert molding, heat sealing, and/or adhesives, for example. FIG. 3 generally shows a configuration where a membrane 36 is connected to the canister 30. FIG. 4 generally shows a configuration where a membrane 36 is connected to a support 38. Support 38 may be disposed between the vapor storage receptacle 24 and a portion of the fuel tank cap 18 that may face and/or extend downward toward the fuel tank 12 when in an installed position. The support 38 may extend completely across the cavity 22 defined by the inner surface 185 or any other portion of the fuel tank cap 18. The carbon canister and/or support 38 may include at least one or more apertures 40 in various embodiments of the invention. The particular material used for the membrane and the surface area of the membrane may be varied in accordance with different embodiments of the invention.

In accordance with some embodiments of the invention, the fuel tank cap 18 may further include a protective member 42 that may be configured to shield membrane 36 from fuel that may be stored in fuel storage tank 12 when fuel tank cap 18 is in an installed position. Protective member 42 may include an aperture 44 that may be centrally located in protective member 42 in accordance with an embodiment of the invention. Although a protective member 42 is generally illustrated in the embodiment of FIG. 4, other embodiments of the invention may not have such a member disposed near the membrane 36. For example, FIG. 3 does not include a protective member that would be disposed between the membrane 36 and the fuel storage tank 12 when the fuel tank cap 18 is in an installed position.

Referring now to FIG. 3, in some embodiments, the vapor storage receptacle 24 may include an air inlet or air aperture 46. Air inlet or air aperture 46 may be in fluid communication with an aperture 48 on fuel tank cap 18. Air inlet or air aperture 46 may allow canister 30 to be open to the atmosphere, thereby allowing atmospheric air to enter canister 30 and, among other things, refresh the adsorbent granulated carbonaceous material. Vapor storage receptacle 24, including canister 30 for example, may include additional apertures to allow fuel vapors stored in the vapor storage receptacle to escape in accordance with all embodiments of the invention. The vapor storage receptacle 24 and/or the fuel tank cap 18 may not include additional apertures (e.g., other than purge path 34) in accordance with some embodiments, including the embodiment as generally illustrated in FIG. 4.

In accordance with an embodiment of the invention, the fuel tank cap 18 may be configured to control vapor flow via a variable orifice. For example and without limitation, the fuel tank cap 18 may include an orifice plate 50. The orifice plate 50 may comprise a relatively thin plate with a central hole, for example. The orifice plate 50 may be placed in the purge path 34 (e.g., purge line) in accordance with an embodiment of the invention and as generally illustrated in FIG. 3. In accordance with other embodiments of the invention, the orifice plate 50 may be placed at an end of the purge path 34, at either opposing end of the vapor storage receptacle 24, and/or at any other location in the fuel tank cap 18. The orifice plate 50 may generally be configured to regulate the rate of fluid flow by changing the velocity and pressure as the fluid reaches the orifice plate 50 with the central hole that forces the fluid to converge to go through the central hole. The fluid may then expand and the velocity and pressure may change again after a certain point called the vena contracta point located downstream of the orifice plate 50.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and variations and modifications are possible in light of the above teaching. The embodiments were chosen and described in order to explain the principles of the invention and its practical application, to thereby enable others skilled in the art to utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. The invention has been described in great detail in the foregoing specification, and it is believed
that various alterations and modifications of the invention will become apparent to those skilled in the art from a reading and understanding of the specification. It is intended that all such alterations and modifications are included in the invention, insofar as they come within the scope of the appended claims. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents.

What is claimed:
1. A fuel tank cap for use with a fuel storage tank, comprising:
   a vapor storage receptacle;
   a purge path in fluid communication with the vapor storage receptacle; and
   a liquid discriminating membrane disposed at least in part between the vapor storage receptacle and liquid fuel in the fuel storage tank.
2. The fuel tank cap of claim 1, wherein the fuel tank cap defines a cavity, and the vapor storage receptacle is disposed in the cavity.
3. The fuel tank cap of claim 1, wherein the vapor storage receptacle is connected to the fuel tank cap.
4. The fuel tank cap of claim 1, wherein the vapor storage receptacle comprises a canister.
5. The fuel tank cap of claim 1, wherein the vapor storage receptacle comprises an absorbent granulated carbonaceous material.
6. The fuel tank cap of claim 1, wherein the vapor storage receptacle comprises a carbon bed.
7. The fuel tank cap of claim 1, wherein the purge path comprises a purge line configured for active purge.
8. The fuel tank cap of claim 1, wherein the purge path is configured for passive purge.
9. The fuel tank cap of claim 1, further comprising a filter disposed between the vapor storage receptacle and the purge line.
10. The fuel tank cap of claim 1, wherein the purge path corresponds with a tether for the fuel tank cap.
11. The fuel tank cap of claim 1, wherein the membrane is configured to impede liquid from contacting the vapor storage receptacle.
12. The fuel tank cap of claim 1, wherein the membrane is vapor permeable.
13. The fuel tank cap of claim 1, wherein the membrane is configured so that the vapor storage receptacle is fluidly sealed from the fuel storage tank.
14. The fuel tank cap of claim 1, wherein the membrane is directly connected to the vapor storage receptacle.
15. The fuel tank cap of claim 1, further comprising a support, wherein the membrane is configured for connection to the support.
16. The fuel tank cap of claim 1, wherein the vapor storage receptacle comprises an aperture in fluid communication with atmospheric air.
17. The fuel tank cap of claim 1, further comprising an orifice plate disposed in the purge path.
18. A fuel storage system, comprising:
   a fuel storage tank;
   a fill inlet connected to the fuel storage tank; and
   a fuel tank cap having:
   a vapor storage receptacle;
   a purge line in fluid communication with the vapor storage receptacle; and
   a liquid discriminating membrane disposed at least in part between the vapor storage receptacle and fuel in the fuel storage tank.
19. A fuel tank cap for use with a fuel storage tank, comprising:
   a carbon bed;
   a purge path in fluid communication with the carbon bed;
   a filter disposed between the carbon bed and the purge line;
   and
   a vapor permeable and liquid discriminating membrane disposed between the carbon bed and fuel in the fuel storage tank to fluidly seal the carbon bed from the fuel storage tank, wherein the membrane discriminates between liquid fuel and fuel vapor and impedes liquid from contacting the carbon bed.

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