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(54) LOW HYDROCARBON EMISSION FUEL TANK WITH INTERNAL COMPONENTS

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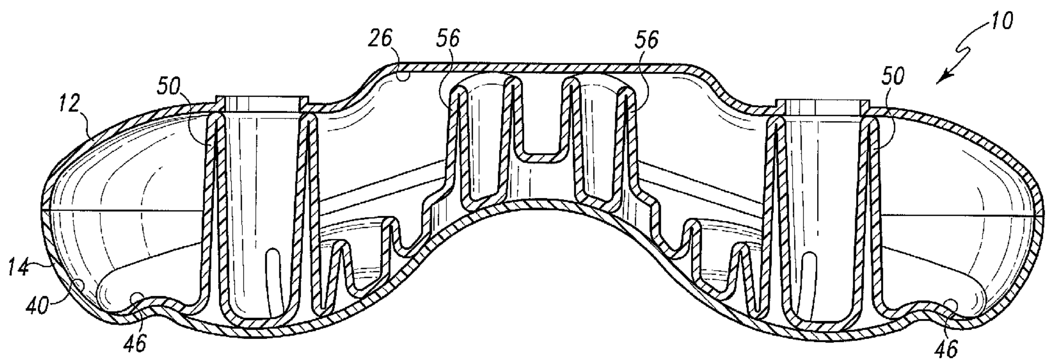
(57) **ABSTRACT**

A low permeation fuel tank formed with a first half and a second half includes a hydrocarbon barrier and a fuel system module. The hydrocarbon barrier reduces the emission of hydrocarbons from the fuel tank. Minimization of discontinuities in the hydrocarbon barrier is achieved by positioning the fuel system module within the fuel tank. The fuel system module includes a preformed sheet to provide flexible and rigid support to the fuel tank. In addition, the fuel system module may include fuel system components, structural enhancements of the fuel tank and/or functional features of the fuel tank to minimize production of holes or other discontinuities in the hydrocarbon barrier.



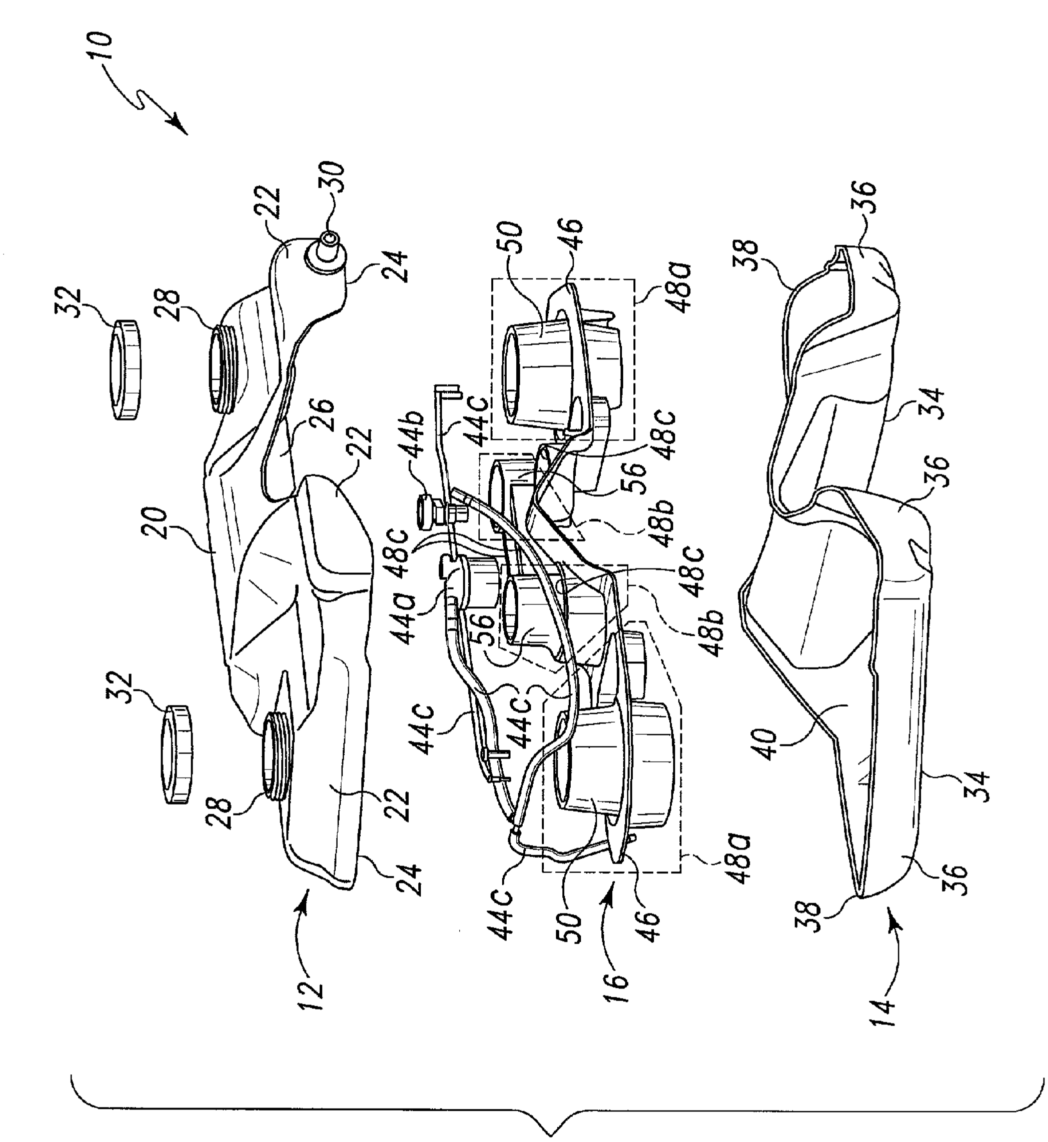

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Fig. 1

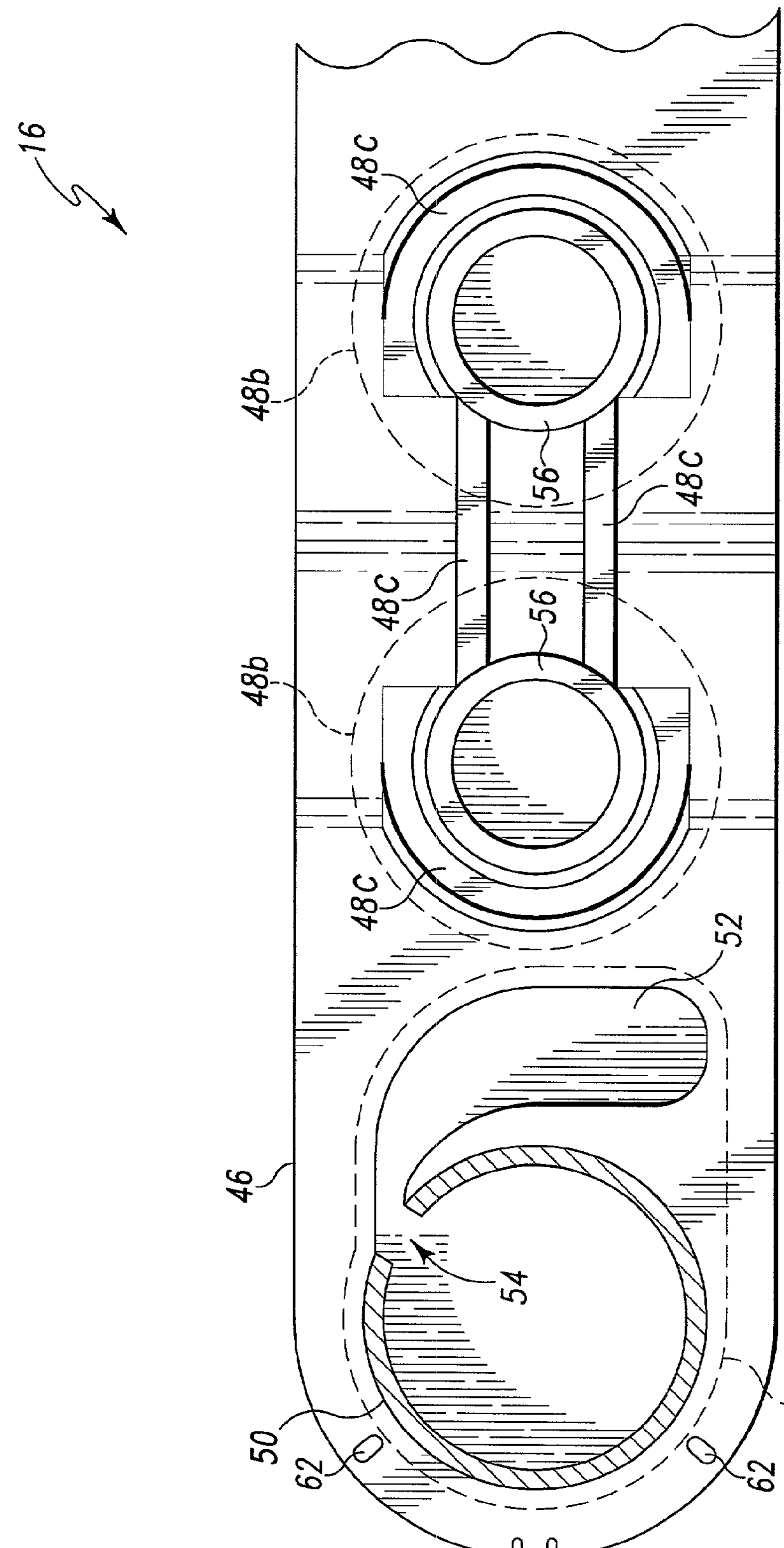

Fig. 2

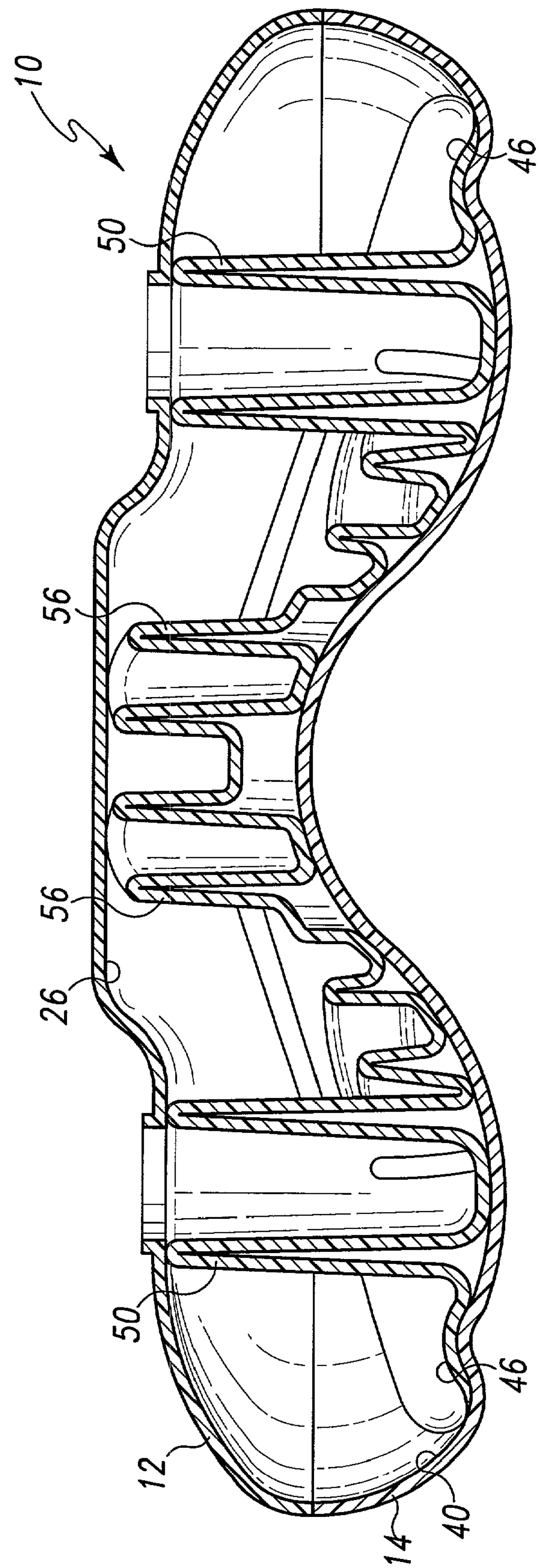

Fig. 3

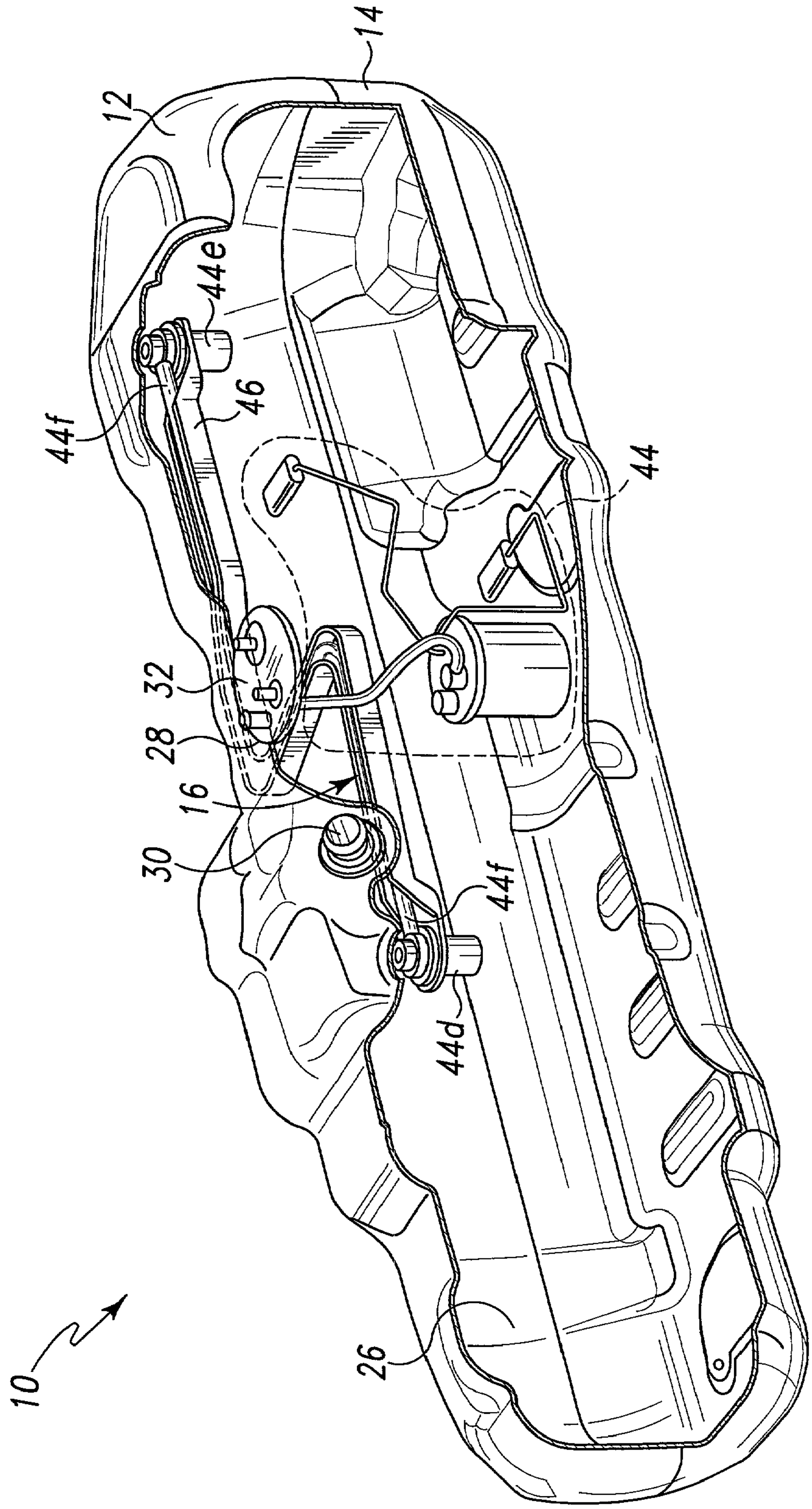

Fig. 4

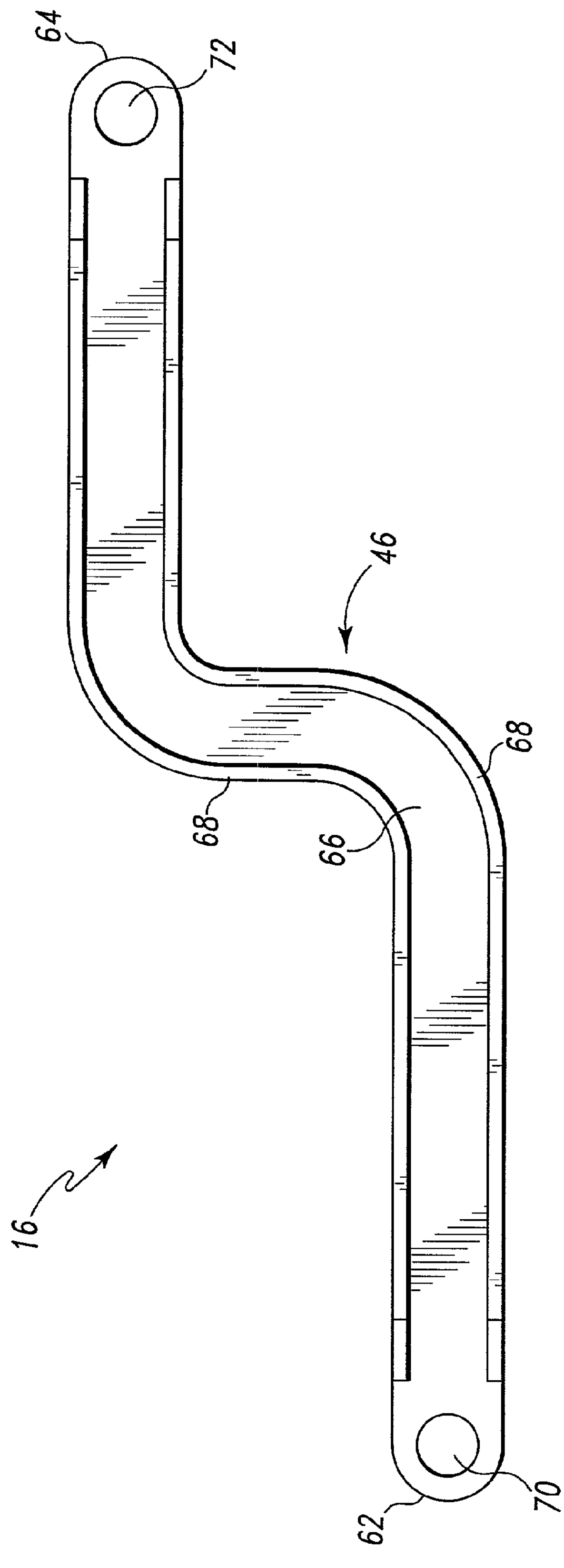

Fig. 5

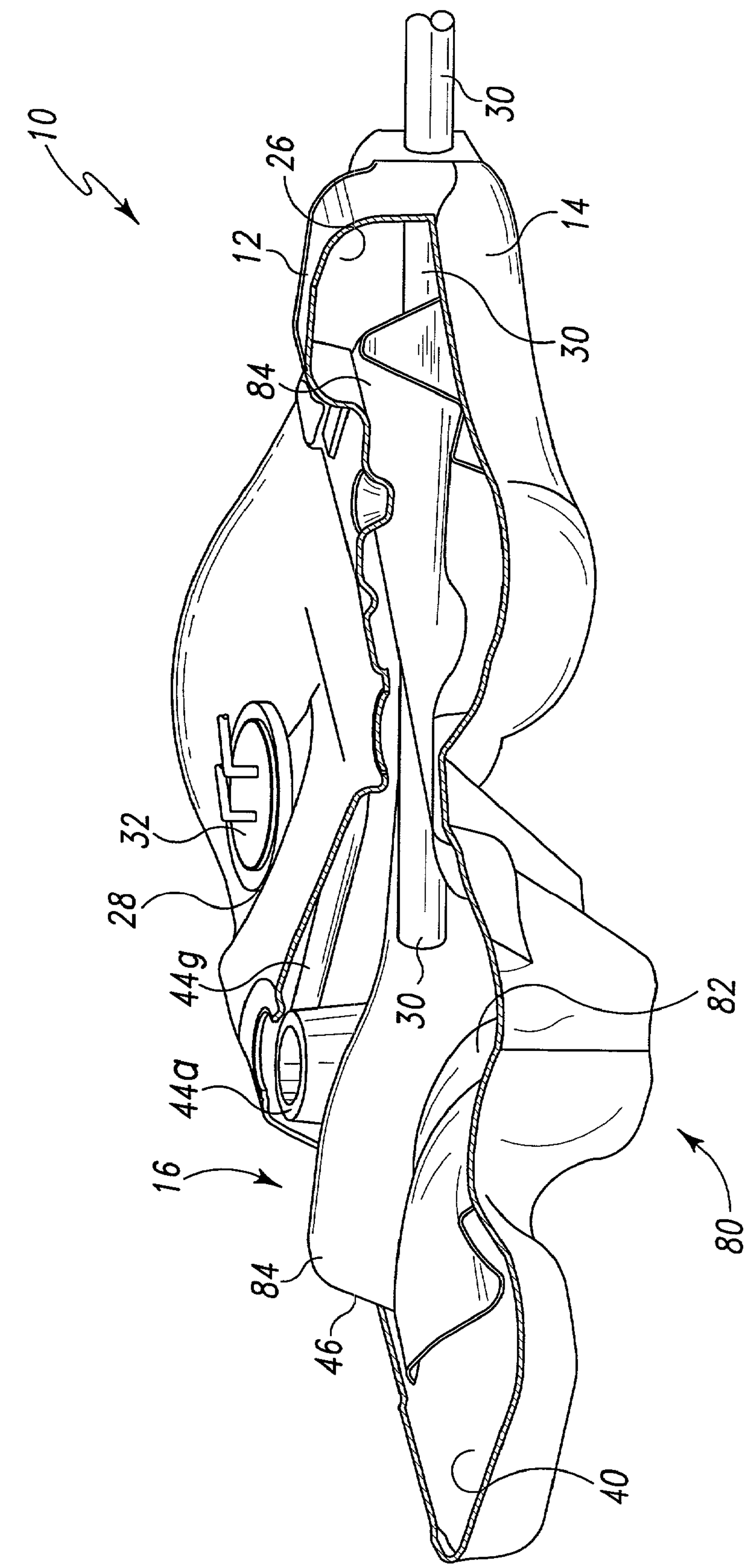

Fig. 6

LOW HYDROCARBON EMISSION FUEL TANK WITH INTERNAL COMPONENTS

[0001] This application claims the benefit under **35** U.S.C. §119(e) of Provisional U.S. patent application Ser. No. 60/224,487 filed on Aug. 11, 2000.

BACKGROUND

[0002] 1. Field of the Invention

[0003] This invention relates to fuel tanks, and more particularly to a low permeation fuel tank that includes internally mounted components.

[0004] 2. Description of the Related Art

[0005] Fuel tanks made of plastic or metal are well known for providing a reservoir of fuel for engines and other fuel consuming devices in land, water and air vehicles. A hydrocarbon barrier is typically included in fuel tanks to prevent passage of fuel and associated vapors therethrough. Additional components are usually added to the fuel tank to create a fuel system. The components may include valves, hoses, pumps, level sensors, structural supports, etc. Typically, some of these components are installed inside the fuel tank by cutting service holes in the tank. In addition, some of the components are installed outside the tank requiring additional holes, grooves and/or recesses.

[0006] Recent changes in government regulations have reduced the amount of allowable fuel vapor emissions from fuel tanks. One way to reduce allowable fuel vapor emissions is through minimization of breaches in the hydrocarbon barrier. Reduction in the number of holes in the fuel tank through internalization of fuel system components minimizes breaches. One way to internalize fuel system components is to insert the components during manufacture of the tank.

[0007] Some fuel tanks are manufactured with a structure inside the tank. The structure provides for internalized mounting of fuel system components. In addition, the structure includes rigid columns that are rigidly connected with opposite walls of the fuel tank to maintain the structure in position. The columns are located to generally define the perimeter of the structure. In addition to supporting the remaining structure, the columns also provide local structural support for the fuel tank. The remaining structure is created with rigid members. Some of the rigid members include compliant joints to allow the otherwise rigid structure to distort in response to external forces. Such a structure is described in U.S. Pat. No. 6,138,859 to Aulph et al.

[0008] One problem with prior art structures is the significant cost and complexity that is added to the tank to achieve structural support and the ability to distort in the presence of external forces. Manufacturing fuel tanks with prior art structures involves forming each of the individual members/columns, coupling the members and columns in a predetermined pattern and then coupling the resulting structure with a fuel tank. The quantity and placement of the members may vary significantly among different structures depending on the design of the fuel tank. In addition, coupling the columns with opposite walls of the fuel tank may be difficult to perform and/or verify. Aside from the significant design and manufacturing requirements to create and install the structure, accommodation of the structure may adversely affect the overall design and functionality of the fuel tank.

[0009] For example, the use of columns to support the structure may require placement of columns where no structural support of the fuel tank is needed. In addition, columns may provide stiffness that hinders desirable crushing and/or folding characteristics of the fuel tank during an impact, such as in a crash situation. Further, shearing and moment forces applied to only a portion of the tank, such as, for example, in a crash situation, may be transferred to another portion of the tank by the rigid nature of the columns causing additional damage. Finally, column placement required to support the structure may interfere with ribbing and other desirable features formed in the walls of the fuel tank.

BRIEF SUMMARY

[0010] The present invention is defined by the following claims, and nothing in this section should be taken as a limitation on those claims. By way of introduction, the embodiments herein described disclose a fuel tank system that includes a fuel system module. The fuel system module provides both rigid and flexible structural support using a fairly uncomplicated and economical design. The design is relatively easy to manufacture and install in the fuel tank system. The fuel system module may be formed to comply with the shape and structural features present in the fuel tank system. In addition, the fuel system module may be formed to selectively include formations that provide structural support and provisions for positioning fuel system components. Further, functional features of the fuel tank system and provisions for mounting the fuel system module within the fuel tank system may also be included.

[0011] The fuel tank system forms a container that includes a first half and a second half. The first and second halves are coupled by a weld joint to form a chamber. The fuel system module is positioned within the chamber prior to coupling the first and second halves to minimize holes and other discontinuities in a hydrocarbon barrier. The hydrocarbon barrier is formed by the first and second halves, and surrounds the fuel system module.

[0012] The fuel system module includes a pre-formed sheet. The pre-formed sheet is a continuous sheet formed in a predetermined shape. The preformed sheet may include formations to position at least one fuel system component thereon. In addition, the pre-formed sheet may be formed to include functional features of the fuel tank system, such as, for example, reservoirs and fuel channeling. The pre-formed sheet may also include formations to mount the fuel system module in one of the first half and the second half. Mounting of the fuel system module may involve coupling the fuel system module to an interior surface of either the first half or the second half of the container.

[0013] The fuel system module utilizes the pre-formed sheet to provide both rigid and flexible structural support when subject to forces external and/or internal to the fuel tank system. The pre-formed sheet includes formations that exhibit rigidity when subject to forces substantially perpendicular to the surface of the pre-formed sheet. In addition, the pre-formed sheet includes formations that exhibit flexibility when subject to forces substantially parallel with the surface of the pre-formed sheet. Accordingly, the fuel system module may be selectively formed to provide resistance to some forces and absorption of other forces occurring within the fuel tank system.

[0014] An interesting feature of the fuel system module is the absence of individually manufactured and assembled components and parts to achieve the functionality provided by the pre-formed sheet. The pre-formed sheet may also be formed contiguous with the contour of interior surfaces of the first and second halves. In addition, the pre-formed sheet consumes very little tank capacity while providing significant structural and operation functionality. Further, due to the inherent adaptability in the formation of the pre-formed sheet, accommodation of different shapes, structural support requirements and mounting requirements within the fuel system module are relatively simple.

[0015] Another interesting feature of the fuel system module is the flexible and rigid structural support that may be designed to enhance the manufacturing process. For example, structural rigidity may be included that allows an installation device, such as a robot arm to grasp, manipulate and insert the fuel system module into the fuel tank system without damage. In addition, damage to the hydrocarbon barrier when the fuel system module is pressed against the interior surface of the first or second halves with too much force may be avoided by providing selective flexibility.

[0016] Yet another interesting feature of the fuel system module is the ability to create a single module in which fuel system components may be pre-configured and tested prior to installation in the fuel tank system. As such, cooperative operation of multiple components may be confirmed before the fuel system module is sealed within the container.

[0017] Further aspects and advantages of the invention are discussed below in conjunction with the preferred embodiments.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0018] **FIG. 1** is a perspective exploded view of an embodiment of a fuel tank system illustrating an embodiment of a fuel system module.

[0019] **FIG. 2** is a top view of the fuel system module illustrated in **FIG. 1**.

[0020] **FIG. 3** is a cross-section side view of another embodiment of the fuel tank system illustrating another embodiment of the fuel system module.

[0021] **FIG. 4** is a perspective view of another embodiment of the fuel tank system with a portion cutaway to illustrate another embodiment of the fuel system module.

[0022] **FIG. 5** is a top view of the fuel system module illustrated in **FIG. 4**.

[0023] **FIG. 6** is a perspective view of another embodiment of the fuel tank system with a portion cutaway to illustrate another embodiment of the fuel system module.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] Embodiments of a fuel system module for use in a fuel tank system are disclosed. The fuel system module comprises at least one pre-formed sheet that is shaped for insertion as a layer between the two halves of a fuel tank during the manufacturing process. Fuel system components and functional features of the fuel system may be included as part of the fuel system module. The fuel system module is formed to provide structural rigidity for supporting the fuel system components and functional features while also providing flexibility to alleviate undesirable stresses that may develop. In addition, the fuel system module may be pre-formed in any shape compatible with the structural features and/or contours of the fuel tank. Support of the fuel system module within one of the two halves of the fuel tank is provided by formations in the pre-formed sheet. The pre-formed sheet also maximizes fuel capacity to within the fuel tank and provides desirable crushing and folding characteristic during an impact.

[0025] **FIG. 1** illustrates an exploded perspective view of a fuel tank system **10**. The fuel tank system **10** forms a container that includes a first half **12**, a second half **14** and a fuel system module **16**. In the illustrated embodiment, the fuel tank system **10** is formed as a saddle type fuel tank. In other embodiments, the fuel tank system **10** may be formed in any other shape forming a fuel tank.

[0026] The first half **12** forms the top half and the second half **14** forms the bottom half of the fuel tank in the illustrated embodiment. In other embodiments, the first and second halves may be left and right side halves, front and backside halves or any other formation of two halves forming a fuel tank. In still other embodiments, the two halves **12**, **14** may each be formed of a number of panels connectively coupled to form the two halves **12**, **14**. In yet other embodiments, the first and second halves **12**, **14** may not be two "halves" of the container. For example, the second half **12** may form the bottom and sides of the container and the second half **14** may form a top cover.

[0027] The first and second halves **12**, **14** may be formed of, for example, thermoplastic materials, thermoset materials, metal materials, polymers containing both thermoplastic and thermoset materials and/or any other materials capable of forming a container that includes a hydrocarbon barrier. Exemplary thermoset materials include epoxy, phenolic resin ("bakelite"), carbon fiber/epoxy and other thermoset type materials. Metal materials may be, for example, stainless steel or any other metals that do not corrode, form gels, or in any other way structurally degrade or degrade the quality of fuel stored therein. Thermoplastic materials may be single, or multi-layer, resin based thermoplastic materials.

[0028] In one embodiment, the thermoplastic materials are in the form of thermoplastic sheets with six layers. The first layer is an outer layer that includes high-density polyethylene (HDPE) and carbon black. The second layer is an inner layer positioned adjacent to the first layer and includes reground thermoplastic sheet material. A third layer positioned adjacent the second layer is also an inner layer and includes adhesive polymer. Positioned adjacent the third layer is a fourth layer that includes ethylene vinyl alcohol (EVOH). The EVOH layer of this embodiment provides a hydrocarbon barrier for reduction of the emission of hydrocarbons permeating through the thermoplastic sheet. A fifth layer is positioned adjacent the fourth layer and includes adhesive polymer. The sixth layer forms the other outer layer adjacent to the fifth layer and includes HDPE. In other embodiments, different compositions, arrangements and quantities of layers may be used to form the thermoplastic sheet.

[0029] The first and second halves **12, 14** may be formed by stamping, casting, molding or any other technique for forming the desired contour, structural and functional features. The formation technique utilized is dependent to some extent on the materials from which the first and second halves **12, 14** are formed. For example, metal materials are typically stamped, thermoset materials are typically cured in a mold, and thermoplastic materials may be blow molded or thermoformed using molds.

[0030] In one embodiment, where thermoplastic sheets are used, the first and second halves **12, 14** may be formed by twinsheet thermoforming. An exemplary twinsheet thermoforming technique is disclosed in a co-pending patent application entitled "HIGH VOLUME PRODUCTION OF LOW PERMEATION PLASTIC FUEL TANKS USING PARALLEL OFFSET TWINSHEET PRESSURE FORMING" Ser. No. ______ filed the same day as the present application, which is herein incorporated by reference in its entirety. In general, twinsheet thermoforming allows the first and second halves **12, 14** to be formed separately from molten thermoplastic sheets. The thermoplastic sheets are formed into the first and second halves **12, 14** and brought together under controlled conditions to be hermetically sealed to form the container.

[0031] In the illustrated embodiment, the first half **12** includes a contoured top surface **20** that laterally extends to a contoured side surface **22**. The side surface **22** surrounds and extends various predetermined distances generally perpendicular to the top surface **20** to an edge **24**. The edge **24** generally forms a lip or a flange compatible with the second half **14**. The top surface **20** and the side surface **22** form a generally concaved shape with a first interior surface **26**.

[0032] The first half **12** of this embodiment also includes at least one access port **28** and a fill neck **30**. The access port **28** is a formation within the contoured top surface **20**. The access port **28** includes provisions for creating an aperture to access the interior of the first and second halves **12, 14** following sealing. In addition, the access port **28** may also be formed to couple a cap **32** to the first half **12** by, for example, snap fit, threaded connection, snap lock or some other coupling mechanism. In other embodiments, the access port **28** and cap **32** is not included. The fill neck **30** is formed in the side surface **22** to provide an entrance into the container for fluids, such as, for example, fuel. In other embodiments, the fill neck **30** may be formed in the top surface **20** or the second half **14**.

[0033] The second half **14** similarly includes a contoured top surface **34** laterally extending to a contoured side surface **36**. The side surface **36** extends a predetermined distance generally perpendicular to the top surface **34** to an edge **38**. The edge **38** is formed to create a seal with the edge **24** of the first half **12** when the first and second halves **12, 14** are brought together. The top surface **34** and the side surface **36** generally form another concaved shape with a second interior surface **40**. When the first and second halves **12, 14** are brought together the edges **24, 38** are sealed by formation of a weld joint. The weld joint, or pinchoff, is positioned to surround the periphery of the first and second halves **12, 14** and form a hermetic seal.

[0034] Once sealed, the first and second interior surfaces **26, 40** define a chamber in which fluids, such as, for example fuel may be stored. Each of the first and second halves **12, 14** also include a continuous hydrocarbon barrier surrounding the chamber to deter migration of fluid out of the chamber. In one embodiment, the first and second halves **12, 14** form a low permeation plastic fuel tank.

[0035] The fuel system module **16** is positioned within the chamber defined by the first and second halves **12, 14**. The fuel system module **16** provides a single module encompassing whatever functionality is selected for inclusion within the fuel tank system **10**. Accordingly, the selected functionality may be relatively quickly and easily installed during manufacture of the fuel tank system **10**.

[0036] In addition, the fuel system module **16** may comprise functionality requiring cooperative operation of a number of different components. By building the functionality as part of the fuel system module **16**, cooperative operation of the components may be verified. Verification may be performed prior to installation of the fuel system module **16**. Further, a low hydrocarbon emission fuel tank may be created since the fuel system module **16** is completely enclosed within the hydrocarbon barrier provided by the first and second halves **12, 14**.

[0037] The embodiment of the fuel system module **16** illustrated in **FIG. 1** includes at least one fuel system component **44** and a pre-formed sheet **46**. The fuel system component **44** may be a valve, a hose, an electric conductor, a pump, a filter, a sensor or any other fuel system related mechanism and/or feature. In the illustrated embodiment, a plurality of fuel system components **44** are depicted. Namely, **FIG. 1** includes a fuel level vent valve (FLW) **44***a*, a rollover valve **44***b*, and a plurality of hoses **44***c* for transporting fuel and vapors. In other embodiments, additional or fewer fuel system components **44** may be included. The fuel system components **44** are positioned contiguous with the pre-formed sheet **46**.

[0038] The pre-formed sheet **46** may be any sheet fashioned in a predetermined shape forming a continuous layer between the first and second halves **12, 14**. As used herein, the term "sheet" refers to materials with opposing surfaces in which the thickness of the materials between the opposing surfaces are thin in comparison to the length and/or the width of the opposing surfaces. The pre-formed sheet **46** may be relatively flat or may include contours, ridges, ribs, flanges, fins, folds, cavities, grooves, notches, troughs, passageways, holes or any other formations formable within a sheet. The pre-formed sheet **46** may be formed from polymers such as for example, thermoplastic material, thermoset material or a combination of both. In addition the pre-formed sheet **46** may be formed of metal or any other semi-rigid material capable of being fashioned into a sheet with a predetermined functional shape.

[0039] In the presently preferred embodiments, the pre-formed sheet **46** provides both a rigid structure and a flexible structure as a function of the shape of the pre-formed sheet **46**. A sheet is inherently relatively stiff when subject to forces acting in directions substantially perpendicular to the opposing surfaces, and relatively flexible when subject to forces acting in directions substantially parallel to the opposing surfaces.

[0040] As used herein, "substantially parallel" refers to forces with a larger shear stress component and a smaller normal stress component acting on the opposing surfaces of the sheet. Similarly, "substantially perpendicular" refers to those forces with a larger normal stress component and a smaller shear stress component acting on the opposing surfaces of the sheet. In addition, references herein to "surfaces" of the pre-formed sheet **46** refer to the orientation of the plane generally occupied by the extending pre-formed sheet **46** and not the individual formations thereon.

[**0041**] By strategically shaping formations within the pre-formed sheet **46**, rigidity when exposed to some forces, and flexibility when exposed to other forces may be achieved. The formations may also be designed and shaped with pre-determined failure levels to provide predictable crushing and folding characteristics when subject to excessive and/or undesirable forces. Forces the pre-formed sheet **46** may be subject to include external forces imparted on the fuel tank system **10** as well as internally created forces. Exemplary external forces include vibration, impact forces and vacuum/pressure created in the fuel tank system **10**. On the other hand, exemplary internal forces include shrinkage and swelling between structures, transient thermal imbalances due to uneven heating and cooling and dynamic loading caused by lateral movement of the fuel system components **44** or fuel within the fuel tank system **10**.

[**0042**] For example, the pre-formed sheet **46** may include formations that allow the application of pressure to urge the fuel system module **16** into contact with the first interior surface **26** or the second interior surface **40**. Rigidity designed into the pre-formed sheet **46** allows manipulation by, for example, a robot arm without creating undesirable and potentially damaging deformation and/or stress of the fuel system module **16**. Design of the preformed sheet **46** may also include flexibility to alleviate any excessive pressure that may otherwise cause damaging stress to the hydrocarbon barrier when the fuel system module **16** is urged into contact. Accordingly, the fuel system module **16** absorbs undesirable stresses while at the same time providing rigid resistance to other stresses to maintain the integrity and functionality of the fuel tank system **10**.

[**0043**] In one embodiment, the pre-formed sheet **46** is formed from thermoplastic material. The thermoplastic material may be formed by blow molding, thermosetting, and/or any other technique for forming thermoplastic. In one embodiment, the thermoplastic material is a single continuous thermoplastic sheet. In other embodiments, the thermoplastic material may include at least two separately formed thermoplastic sheets that are welded, or otherwise coupled together to form a continuous sheet.

[**0044**] The pre-formed sheet **46** may also include at least one functional feature **48** formed within the pre-formed sheet **46**. Exemplary functional features **48** include a liquid reservoir, a liquid channel, a baffle, provisions for fuel system components **44**, provisions for coupling the pre-formed sheet **46** to one of the first and second halves **12**, **14**, a structural support and/or any other functional features pertaining to fuel systems and fuel system operation. The pre-formed sheet **46** may also include apertures. The apertures may be located to allow the flow of fuel and air through the pre-formed sheet **46**, as well as avoiding undesirable pooling of fuel and creation of air pockets.

[**0045**] In addition, the functional features **48** within the pre-formed sheet **46** may include formations to provide stiffness as well as flexibility when subject to internal and external forces. For example, through selective formation of the functional features **48**, forces applied substantially perpendicular to surfaces of the pre-formed sheet **46** may be presented with stiffness. Similarly, forces applied substantially parallel with surfaces of the pre-formed sheet **46** may be presented with flexibility. In addition, functional features **48** may be formed to allow the pre-formed sheet **46** to selectively react with flexibility and/or stiffness to non-parallel and/or non-perpendicular shearing forces, as well as moment loading, within the fuel tank system **10**.

[**0046**] In the illustrated embodiment, the functional features **48** include a first feature **48***a*, a second feature **48***b* and a third feature **48***c*. The first feature **48***a* includes a number of functional characteristics. One characteristic is structural and is provided by a cylindrical, hollow, generally barrel shaped first housing **50** formed in the preformed sheet **46**. In other embodiments, the formation forming the first housing **50** may be generally shaped as, for example, square, rectangular, spherical, conical, elliptical or any other shape.

[**0047**] The first housing **50** may longitudinally extend to be perpendicular and adjacent to both the first interior surface **26** and the second interior surface **40** when the first and second halves **12**, **14** are brought together. The nature of the formation of the first housing **50** allows the pre-formed sheet **46** to provide rigid support when the first and second halves **12**, **14** are subject to compressive forces. Exemplary compressive forces include forces induced by vacuum, bending and warping that may cause the first and second halves **12**, **14** to move closer together. It should be noted that the first housing **50** does not provide a fixed rigid connection between the first and second surfaces **26**, **40**. In addition, the first housing **50** may be formed to be adjacent only the first or the second halves **12**, **14** and provide no rigid support.

[**0048**] Another characteristic provided by the first housing **50** is support for fuel system components **44** inserted into the hollow within the first housing **50**. The support may be formed to be rigid and/or flexible. For example, the pre-formed sheet **46** may flex to allow the fuel system component **44** to move substantially parallel to surfaces of the pre-formed sheet **46** while remaining rigid against movement perpendicular to surfaces of the pre-formed sheet **46**.

[**0049**] In the illustrated embodiment, a fuel system component **44**, such as, for example, a fuel pump may be positioned within the first housing **50**. Installation of the fuel system component **44** may be performed by removing the cap **32** and lowering the fuel system component **44** through the access port **28**. Alternatively, the fuel system component **44** may be installed before the first and second halves **12**, **14** are sealed together. The fuel system component **44** may be held within the first housing **50** by friction fit, screw connection, snap-fit, welding, gluing or any other mechanism for coupling the fuel system component **44** to the first housing **50**.

[**0050**] **FIG. 2** illustrates a top view of a portion of the fuel system module **16** with the fuel system components **44** removed and portions of the pre-formed sheet **46** cross-sectioned. Another characteristic provided by the illustrated embodiment of the first feature **48***a* is a reservoir formed by the hollow within the first housing **50** that includes a swirl pot **52**. The swirl pot **52** is formed in the pre-formed sheet **46** to provide a channel for flow of liquid through an aperture **54** in the first housing **50**. The swirl pot **52** operates in a well-known manner to retain fuel within the first housing **50**.

[**0051**] Referring now to **FIGS. 1 and 2**, the second feature **48***b* of this embodiment similarly includes a cylindrical, hollow, generally barrel shaped second housing **56** formed in the pre-formed sheet **46**. The second housing **56** similarly includes provision to accept at least one fuel system component **44** such as for example, the FLW **44***a* and/or the roll over valve **44***b*. In addition, the second housing **56** may provide rigidity and/or flexibility within the pre-formed sheet **46** similar to the first housing **50**. In other embodiments, the formation of the second feature **48***b* may be generally shaped as, for example, square, rectangular, spherical, conical, elliptical or any other shape.

[**0052**] In another embodiment, the first and second housings **50, 56** may be used as temporary positioning devices for the fuel system components **44**. During manufacture, a fuel system component **44** may be temporarily positioned in one of the first or second housings **50** or **56**. The fuel system component **44** is maintained in a predetermined position and coupled to the first or second interior surfaces **26** or **40**. In other embodiments, the fuel system components **44** may be temporarily positioned by other formations within the pre-formed sheet **46**.

[**0053**] Coupling occurs when the first and second halves **12, 14** are brought together and the fuel system component **44** is pressed against the first or second interior surfaces **26** or **40** by the first or second housings **50** or **56**. In one embodiment, the first and second housings **50, 56** may be formed in the pre-formed sheet **46** to provide sufficient flexibility and rigidity (compressive resistance) to promote proper coupling of the fuel system component **44**. Sufficient flexibility may, for example, prevent the fuel system component **44** from being embedded to an undesirable depth in the first or second interior surfaces **26** or **40**.

[**0054**] The third feature **48***c* of the illustrated embodiment comprises a plurality of ribs, or channels selectively formed in the pre-formed sheet **46** for enhancement of the structural integrity of the fuel system module **16**. The ribs may be selectively formed to enhance flexibility as well as rigidity. Other features may also be formed in the preformed sheet **16**, such as, for example, apertures to provide a baffling function for slosh abatement and noise control as well as improved durability. Other exemplary formations such as, shelves, grooves, notches or folds provided to maintain the position of the hoses **44***c* or any other functional features **48** may be formed in the pre-formed sheet **46**. In addition, the pre-formed sheet **46** as a whole may serve as a condensing surface and an anti-turbulence system to reduce fuel-air mixing and resultant fuel vapor generation.

[**0055**] The fuel system module **16** may be positioned in either the first half **12** or the second half **14** during the manufacturing process. In one embodiment, the fuel system module **16** is fixedly coupled to either the first interior surface **26** or the second interior surface **40**. In this embodiment, the pre-formed sheet **46** may include formations to provide rigid and/or flexible coupling. The formations for coupling may cooperatively operate with other formations in the pre-formed sheet **46** similarly providing rigidity and or flexibility. Exemplary formations for coupling may include areas of the pre-formed sheet **46** formed to be contiguous with the first interior surface **26** or the second interior surface **40**.

[**0056**] The formations may be fixedly coupled with the contiguous first or second interior surface **26** or **40** by, for example, welding, gluing or any other coupling mechanism that does not compromise the hydrocarbon barrier. In another embodiment, some form of adapter mechanism may be formed from the pre-formed sheet **46** or provided as a separate device to facilitate coupling. An exemplary adapter mechanism is disclosed in a co-pending patent application entitled "ADAPTER FOR WELDING OBJECTS TO PLASTIC" Ser. No. ______ filed the same day as the present application, which is herein incorporated by reference in its entirety.

[**0057**] Due to the formations, stresses otherwise created between the first or second halves **12** or **14** and the fuel system module **16** are absorbed. For example, pressurization of the fuel tank system **10** may cause the first and second halves **12, 14** to move apart. When this occurs, tensile stresses that would otherwise develop between the first or second halves **12** or **14** and the fuel system module **16** are absorbed by the flexibility of the formations.

[**0058**] In another embodiment, the fuel system module **16** is not fixedly coupled to either the first half **12** or the second half **14**. Instead, geometric interferences between the contours of the first half **12**, the second half **14** and formations in the pre-formed sheet **46** hold the fuel system module **16** in position. In this embodiment, the fuel system module **16** is mounted in, and supported by, one of the first half **12** and the second half **14**.

[**0059**] **FIG. 3** is a cross-sectioned side view of another embodiment of the fuel tank system **10** depicted in an assembled state (e.g. following sealing of the first and second halves **12,14**). In the illustrated embodiment, the pre-formed sheet **46** is positioned in the second half **14** and is held in place by geometric interferences. The pre-formed sheet **46** includes formations conforming to the contour of the second interior surface **40** such that the first and second housings **50, 56** are contiguous with the second interior surface **40**.

[**0060**] In addition, the first and second housings **50, 56** of this embodiment are formed to extend through the cavity and selectively contact the first interior surface **26**. Accordingly, the formations maintain the position of the fuel system module **16** by engagement of the pre-formed sheet **46** with the first and second interior surfaces **26, 40**. The absence of mechanical connections to the first and second halves **12, 14**, allows the fuel system module **16** to remain flexible and rigid. Movable and flexible to absorb built up stresses, while providing stiffness for forces, such as, for example, compressive forces acting on the first and second halves **12, 14**. In another embodiment, the geometric interferences and coupling mechanisms of the previously discussed embodiments may be used in combination.

[**0061**] Referring again to **FIG. 2**, in yet another embodiment, the fuel system module **16** may include at least one weld tab **60** formed to provide a coupling mechanism with the first or second interior surfaces **26** or **40 (FIG. 1)**. The weld tabs **60** are formed from the pre-formed sheet **46** to provide flexibility and rigidity. In this embodiment, the weld tabs **60** may be oriented and positioned so as to provide flexible support as well as rigid support. In addition, the location of other formations in the pre-formed sheet **46** in the vicinity of the weld tabs **60** may further determine the support characteristics. In one embodiment, the weld tabs **60** may be welded, glued or otherwise fixedly coupled with the first or second interior surfaces **26** or **40**. In another embodiment, sleeves formed in the first or second interior surfaces **26** or **40** may be formed to slidably accept the weld tabs **60**.

[**0062**] As further illustrated in **FIG. 2**, in still other embodiments, the preformed sheet **46** includes slots **62**. The slots **62** may be formed to slidably engage fingers extending from the first or second interior surfaces **26** or **40**. The design and position of the slots **62** within the pre-formed sheet **46** provides a predetermined range of motion of the fuel system module **16**.

[**0063**] **FIG. 4** is a perspective view of another embodiment of the fuel tank system **10** with portions cutaway to illustrate an embodiment of the fuel system module **16** included therein. The fuel tank system **10** also includes a first half **12**, a second half **14**, an access port **28**, a fill neck **30**, a cap **32** and a plurality of fuel system components **44** similar to the previously described embodiments. In addition, the fuel system module **16** includes the pre-formed sheet **46** and at least one fuel system component **44**.

[**0064**] In the illustrated embodiment, the fuel system module **16** is coupled to the first interior surface **26** of the first half **12**. As in the previous embodiments, the pre-formed sheet **46** is a predetermined shape providing a continuous layer between the first half **12** and the second half **14**. In addition, the pre-formed sheet **46** is formed to provide rigid, yet flexible, structural support for the fuel system components **44**.

[**0065**] The fuel system components **44** positioned on the pre-formed sheet **46** are a first rollover valve **44***d*, a second rollover valve **44***e* and an interconnecting hose **44***f*. The first and second rollover valves **44***d* and **44***e* are positioned away from each other in a predetermined position by the pre-formed sheet **46**. In this embodiment, the remaining fuel system components **44** are installed away from the fuel system module **16**. In other embodiments, however, the pre-formed sheet **44** may be enlarged to accommodate positioning of additional fuel system components **44** and additional functionality on the fuel system module **16**.

[**0066**] **FIG. 5** is a top view of the fuel system module **16** illustrated in **FIG. 4** that has been removed from the fuel tank system **10**. In addition, the fuel system components **44***d*, **44***e* and **44***f* have been removed. The pre-formed sheet **46** is shaped in a longitudinally extending channel with a first end **62** and a second end **64**. The channel includes a base **66** with walls **68** extending perpendicularly from the base **62**. Near the first end **62** is a first aperture **70** formed to accommodate the first rollover valve **44***d*, and a second aperture **72** formed near the second end **64** to accommodate the second rollover valve **44***e*. The first and second apertures **70**, **72** represent a screw connection, a snap fit connection, a friction fit connection or any other form of mechanical connection with the first and second rollover valves **44***d*, **44***e*. In other embodiments, the first and second rollover valves **44***d*, **44***e* may be coupled with the pre-formed sheet **46** by welding, gluing or any other mechanism that provides coupling.

[**0067**] The base **66** in cooperative operation with the walls **68** provides routing and support for the interconnecting hose **44***f* as best illustrated in **FIG. 4**. In TO other embodiments, routing for additional fuel system components **44** may also be provided. Referring now to **FIGS. 4 and 5**, the base **66** and the walls **68** provide rigidity of the pre-formed sheet **46** to maintain the first and second roll over valves **44***d*, **44***e* adjacent to the first interior surface **26**. The base **66** and the walls **68** also provide flexibility in allowing the first and second ends **62**, **64** to move closer together and further away. The first and second ends **62**, **64** may move as a result of compressive and tensile forces acting substantially parallel to surfaces of the fuel system module **16**.

[**0068**] The fuel system module **16** may be fixedly coupled to the interior surface **26** of the first half **12**. Although not illustrated, as in previously discussed embodiments, the preformed sheet **46** may include formations such as, weld tabs **60**, slots **62**, arid/or areas of the pre-formed sheet **46** that may be coupled with the interior surface **26**. Stresses that would otherwise occur during differential shrinkage and swelling of the interior surface **26** with respect to the pre-formed sheet **46** may be absorbed by the flexibility of the pre-formed sheet **46**.

[**0069**] **FIG. 6** is a perspective view of another embodiment of the fuel tank system **10** with a portion cut away to illustrate another embodiment of the fuel system module **16**. Similar to the previously described embodiments, the fuel tank system **10** of this embodiment also includes a first half **12**, a second half **14**, an access port **28**, a fill neck **30** and a cap **32**. In addition, the fuel system module **16** includes the pre-formed sheet **46** and fuel system components **44** that include the FLW **44***a* and a vapor removal hose **44***g*.

[**0070**] In the illustrated embodiment, the fill neck **30** is a conduit extending a predetermined distance into the chamber formed by the first and second halves **12**, **14**. In addition, a reservoir **80** is formed in the interior surface **40** of the second half **14**. The fuel system module **16** includes formations to allow mounting within the second half **14** by one of the previously discussed techniques.

[**0071**] In this embodiment, the pre-formed sheet **46** is functionally formed to support and route the fill neck **30** as illustrated. Further, the pre-formed sheet **46** includes formations to provide a channel **82** to direct liquid flowing from the fill neck **30** to the reservoir **80**. The formations within the pre-formed sheet **46** supporting the fill neck **30** and forming the channel **82** provide rigidity to maintain the flow of liquid into the reservoir **80**. In addition, flexibility is also included to absorb the stresses caused by high velocity liquid flowing out of the fill neck **30**.

[**0072**] The pre-formed sheet **46** is also functionally formed to rigidly maintain the position of the FLW **44***a*, provide routing for the vapor removal hose **44***g* and provide rigid structural support between the first half **12** and the second half **14**. The structural support is provided by a series of ridges **84** that are formed to extend from the second interior surface **40** to contact the first interior surface **26** of the first half **12**.

[**0073**] Referring now to FIGS. **1-6**, the previously discussed embodiments of the fuel tank system **10** utilize the fuel system module **16** to provide a flexible, yet rigid, low permeation fuel tank with internalized fuel system components. Low permeation is achieved by inserting the fuel system module **16** within the fuel tank system **10** during manufacturing without compromising the hydrocarbon barrier. Flexibile as well as rigid support for the fuel system components **44** and the fuel tank system **10** is provided by the pre-formed sheet **46** included in the fuel system module **16**.

[**0074**] The pre-formed sheet **46** is a continuous layer formed in a predetermined shape to provide functionality as well as address stresses developed in the fuel tank system **10**. Formations included in the pre-formed sheet **46** provide for positioning of fuel system components **44** as well as the ability to provide suitable compressive resistance to promote proper internal welding of fuel system components **44** to the first and second interior surfaces **26**, **40**. In addition, formations may act as stiffners to resist tank collapse under vacuum and/or undesireable bending or warping. Futher, the formations may be shaped to channel fuel, provide a reservoir for fuel, act as a baffle for slosh abatement and provide routing for the fuel system components **44**.

[**0075**] Due to the thin wall properties of the pre-formed sheet **46**, fuel capacity within the fuel tank system **10** is maximized. In addition, inherent adaptibility in designing the formations in the pre-formed sheet **46** allows the adaptation of the fuel system module **16** to the contours of almost any fuel tank design. Finally, selection of the technique and locations for fixedly positioning the fuel system module **16** within the fuel tank system **10** provides efficient and economical manufacturing while maximizing functionality and structural support.

[**0076**] While the invention has been described above by reference to various embodiments, it will be understood that many changes and modifications can be made without departing from the scope of the invention. It is therefore intended that the foregoing detailed description be understood as an illustration of the presently preferred embodiments of the invention, and not as a definition of the invention. It is only the following claims, including all equivalents that are intended to define the scope of this invention.

What is claimed is:

1. A container comprising:

a first half of the container;

a second half of the container coupled with the first half to define a chamber; and

a pre-formed sheet coupled with one of the first half and the second half, the pre-formed sheet positioned within the chamber to provide flexible and rigid structural support to the container.

2. The container of claim 1, wherein the pre-formed sheet is operable to exhibit rigidity to forces imparted substantially perpendicular to the preformed sheet.

3. The container of claim 1, wherein the pre-formed sheet is operable to exhibit flexibility to forces imparted substantially parallel to the preformed sheet.

4. The container of claim 1, wherein the preformed sheet comprises a fluid reservoir.

5. The container of claim 1, wherein the pre-formed sheet is operable to channel fluid within the chamber to a reservoir.

6. The container of claim 1, wherein each of the first half and the second half are formed from thermoplastic sheets.

7. The container of claim 1, wherein the first half and the second half operably cooperate to form a barrier surrounding the chamber, the barrier operable to limit migration of fluid from the chamber.

8. The container of claim 1, wherein the container comprises a low permeation plastic fuel tank.

9. A low permeation fuel tank comprising:

a fuel system module comprising a continuous pre-formed sheet; and

a first half and a second half of the low permeation fuel tank positioned to surround the fuel system module, the fuel system module formed to the contours of at least one of the first half and the second half.

10. The low permeation fuel tank of claim 9, wherein the fuel system module is operable to resist movement of the first half toward the second half.

11. The low permeation fuel tank of claim 9, wherein the fuel system module is operable to flexibly move in response to expansion of one of the first half and the second half.

12. The low permeation fuel tank of claim 9, wherein the continuous preformed sheet comprises a formation with provisions to couple with one of the first half and the second half.

13. The low permeation fuel tank of claim 12, wherein the formation comprises at least one of a weld tab, a slot and an area of the continuous preformed sheet contiguous with one of the first half and the second half.

14. The low permeation fuel tank of claim 9, wherein the fuel system module comprises thermoplastic.

15. The low permeation fuel tank of claim 9, wherein the first half and the second half comprise multiple layer thermoplastic sheets.

16. The low permeation fuel tank of claim 9, wherein the fuel system module comprises a fuel system component.

17. The low permeation fuel tank of claim 16, wherein the fuel system module is operable to temporarily maintain the fuel system component in position to weld to one of the first half and the second half.

18. The low permeation fuel tank of claim 9, wherein the fuel system module is operable to channel fuel to a fuel reservoir within the low permeation fuel tank.

19. A low hydrocarbon emission fuel tank comprising:

a first thermoplastic sheet and a second thermoplastic sheet each comprising a plurality of layers;

a weld joint operable to couple the first thermoplastic sheet and the second thermoplastic sheet to form the fuel tank, the first and second thermoplastic sheets operable to provide a hydrocarbon barrier; and

a fuel system module positionable within the fuel tank prior to application of the weld joint to minimize discontinuities in the hydrocarbon barrier, the fuel system module comprising a pre-formed sheet and a fuel system component.

20. The low hydrocarbon emission fuel tank of claim 19, wherein the preformed sheet comprises a continuous sheet in a predetermined functional shape the pre-formed sheet forming a layer between the first thermoplastic sheet and the second thermoplastic sheet.

21. The low hydrocarbon emission fuel tank of claim 19, wherein the fuel system module is coupled to the first thermoplastic sheet.

22. The low hydrocarbon emission fuel tank of claim 19, wherein the fuel system module is coupled to the second thermoplastic sheet.

23. The low hydrocarbon emission fuel tank of claim 19, wherein the fuel system module is held in position by geometric interference between formations in the preformed sheet and contours of the first thermoplastic sheet and the second thermoplastic sheet.

24. The low hydrocarbon emission fuel tank of claim 19, wherein the fuel system module is formed to position one of at least two fuel system components away from another of the at least two fuel system components.

25. The low hydrocarbon emission fuel tank of claim 19, wherein the fuel system module comprises a first end and a second end, one of at least two fuel system components positioned near the first end and another of the at least two fuel system components positioned near the second end.

26. The low hydrocarbon emission fuel tank of claim 19, wherein the preformed sheet comprises formations, the formations with provisions to couple the fuel system module with one of the first thermoplastic sheet and the second thermoplastic sheet.

27. The low hydrocarbon emission fuel tank of claim 26, wherein the formations are operable to allow flexible movement of the fuel system module in response to forces acting substantially parallel to surfaces of the preformed sheet.

28. The low hydrocarbon emission fuel tank of claim 26, wherein the formations are operable to resist movement of the fuel system module in response to forces acting substantially perpendicular to surfaces of the preformed sheet.

29. A fuel system module for installation in a low hydrocarbon emission fuel tank, the fuel system module comprising:

a pre-formed sheet;

the pre-formed sheet with provisions to support a fuel system component in a predetermined position; and

the pre-formed sheet formed to fit within the low hydrocarbon emission fuel tank with provisions to couple with an interior surface of the low hydrocarbon emission fuel tank.

30. The fuel system module of claim 29, wherein the pre-formed sheet is operable to flexibly absorb forces applied substantially parallel to surfaces of the pre-formed sheet and rigidly withstand forces applied substantially perpendicular to surfaces of the pre-formed sheet.

31. The fuel system module of claim 29, wherein the pre-formed sheet is contiguous with the contours of the interior surface.

32. The fuel system module of claim 29, wherein the pre-formed sheet comprises thermoplastic.

33. The fuel system module of claim 29, wherein the pre-formed sheet comprises functional features of the low hydrocarbon emission fuel tank.

34. The fuel system module of claim 29, wherein the pre-formed sheet is operable as a structural support.

35. A method of internalizing fuel system components, the method comprising:

forming a first half of a fuel tank;

forming a second half of the fuel tank;

mounting a fuel system module in one of the first half and the second half of the fuel tank, the fuel system module comprising a pre-formed sheet and a fuel system component; and

joining the first half and the second half to surround the fuel system module and form the fuel tank, wherein the fuel system module forms a continuous layer between the first half and the second half.

36. The method of claim 35, further comprising coupling the fuel system module to an interior surface of one of the first half and the second half.

37. The method of claim 35, further comprising positioning the fuel system module within a concave shape formed in one of the first half and the second half.

38. The method of claim 35, further comprising preserving a hydrocarbon barrier provided by the first half and the second half during mounting of the fuel system module.

39. The method of claim 35, further comprising applying pressure to the fuel system module to couple the fuel system module to one of the first half and the second half.

40. The method of claim 35, further comprising forming the fuel system module in a predetermined shape contiguous with the contours of at least one of the first half and the second half.

41. A method of creating a fuel system module for internalizing fuel system components, the method comprising:

forming a sheet in a predetermined shape;

creating provisions on the sheet to fixedly couple the sheet to an internal surface of a fuel tank; and

positioning a fuel system component on the sheet.

42. The method of claim 41, further comprising routing the fuel system component with the sheet.

43. The method of claim 41, wherein forming the sheet comprises forming a fuel reservoir as part of the sheet.

44. The method of claim 41, further comprising testing to verify cooperative operation of the fuel system component and the sheet.

45. The method of claim 41, wherein the sheet comprises thermoplastic and configuring the sheet comprises molding the sheet to the predetermined shape.

46. The method of claim 41, wherein forming the sheet comprises shaping formations in the sheet to provide rigidity to forces applied substantially perpendicular to a surface of the sheet and flexibility to forces applied substantially parallel to a surface of the sheet.

47. The method of claim 41, further comprising installing the sheet in a fuel tank.

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