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Inventor(s)	HOLLAND; Stephen

SYSTEMS FOR REFUELING LIQUEFIED PETROLEUM (LP) GAS TANKS

Abstract

A liquefied petroleum (LP) gas refueling system includes a supply line connected to a storage tank, a delivery line connected to a fuel tank of a vehicle, and a compressor connected to the supply line and the delivery line. The compressor draws vapor LP gas from the storage tank through the supply line and discharges the vapor LP gas through the delivery line to the fuel tank of the vehicle. The LP gas refueling system includes a first outlet valve biased to a closed position to stop the discharge of the vapor LP gas to the delivery line. The first outlet valve actuates to an open position to transfer the vapor LP gas discharged from the compressor to the delivery line. The LP gas refueling system includes a controller to activate the compressor and actuate the first outlet valve.

Inventors: **HOLLAND; Stephen (Fletcher, NC)**

Applicant: **Blossman Services, Inc.** (Ocean Springs, MS)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present application is a continuation of U.S. application Ser. No. 18/505,817, filed Nov. 9, 2023, which is incorporated herein by reference in its entirety for all purposes.

BACKGROUND
Field
[0002] The disclosure relates to systems and methods for transferring liquefied petroleum (LP) gas, for example, from a storage tank to a fuel tank of a vehicle.
Background
[0003] LP gas is a by-product of natural gas processing and includes such fuels as propane and butane, and may also include amounts of propylene and butylene in various mixtures. As used herein, the terms “liquefied petroleum gas,” “LP gas,” and “LPG” are used interchangeably and are intended to refer to propane, butane, iso-butane, propylene, butylene, and methane, alone or in various mixtures, as well as to mixtures of other hydrocarbon gases that are stored in liquid form, under pressure, and are used as fuel for internal combustion engines.
[0004] LP gas is highly flammable and is commonly used for fueling cooking and heating appliances. LP gas is also increasingly being used to power personal and commercial vehicles. At normal atmospheric temperatures and pressures, LP gas is in a gas phase, but LP gas is in a liquid phase when stored under pressure, such as in a vehicle fuel tank. A partially filled vehicle fuel tank will typically contain some LP gas in a liquid phase as well as some LP gas in a gas phase.
[0005] Typically, a vehicle having an LP gas fuel system is refueled and operated similarly to other liquid fueled vehicles, such as those running on gasoline or diesel. During the refueling operation, a pump is typically used to move liquid LP gas from a storage tank to a vehicle fuel tank. Unlike gasoline and diesel refueling operations, LP gas-powered vehicles usually include a fuel system having a connector for receiving fuel from a refueling station and a vehicle fuel tank to store LP gas. Conventional LP gas refueling stations include a refueling pump for removing liquid LP gas from a storage tank, a pump station for controlling the refueling pump and monitoring the flow of liquid LP gas dispensed from the refueling pump, and a nozzle for dispensing fuel into the vehicle fuel tank of vehicle.
[0006] There are a number of ways that the pump station terminates a refueling operation. For example, a user can stop refueling at any point be releasing the lever on the nozzle, or the pump station can limit an amount of fuel based on the amount that was purchased. The pump station can also stop refueling upon activation of an overfill protection device (OPD) within the vehicle. An OPD prevents overfilling of the vehicle's fuel tank. Typically, OPD includes a float located near the fuel tank's fill inlet, where the float rises as liquid LP gas fills the fuel tank, and a plug that plugs the tank fill inlet when the float raises to a predetermined fuel level, typically 80% of the tank level. Conventional pump stations monitor the flow of liquid LP gas being dispensed to the vehicle such that when the flow of fuel stops (i.e., the rate of flow of the fuel is substantially zero gallons per minute due to the tank fill inlet being plugged by OPD), conventional pump stations turn off the refueling pump.
[0007] While convention LP gas refueling stations allow vehicles to be refueled relatively quickly, conventional LP gas refueling stations have limitations that discourage or hamper the more

widespread adoption of LP gas use in vehicles. For example, there are relatively few LP gas refueling stations in the United States, meaning that owners of LP gas fueled vehicles are forced to either drive extra distances for refueling or purchase refueling pumps for installation at the customer's home or business. Furthermore, transferring LP gas in a liquid state is difficult to meter effectively.

BRIEF SUMMARY

[0008] The present disclosure includes various embodiments of a liquefied petroleum (LP) gas refueling system.

[0009] In some embodiments, the LP gas refueling system includes a supply line connected to a storage tank storing LP gas. In some embodiments, the LP gas refueling system includes a delivery line connected to a fuel tank of the vehicle. In some embodiments, the LP gas refueling system includes a compressor connected to the supply line and the delivery line. In some embodiments, the compressor is configured to draw vapor LP gas from the storage tank through the supply line and discharge vapor LP gas through the delivery line to the fuel tank of the vehicle. In some embodiments, the LP gas refueling system includes a first outlet valve biased to a closed position to stop the discharge of vapor LP gas to the delivery line and configured to be actuated to an open position to transfer vapor LP gas discharged from the compressor to the delivery line. In some embodiments, the LP gas refueling system includes a first pressure switch biased to an open position and configured to be actuated to a closed position when pressure of vapor LP gas in the delivery line reaches a first pressure threshold. In some embodiments, the LP gas refueling system includes a controller operatively coupled to the compressor, the first outlet valve, and the first pressure switch. In some embodiments, the controller is configured to activate and deactivate the compressor. In some embodiments, the controller is configured to actuate the first outlet valve to the open position when activating the compressor such that vapor LP gas discharged from the compressor transfers to the delivery line. In some embodiments, the controller is configured to actuate the first outlet valve to the closed position when the first pressure switch is actuated to the closed position.

[0010] In some embodiments, the LP gas refueling system includes a discharge passage coupled to an outlet of the compressor and the first outlet valve; and

[0011] In some embodiments, the LP gas refueling system includes an outlet passage coupled to the first outlet valve and the delivery line, wherein the first pressure switch is coupled to the outlet passage.

[0012] In some embodiments, the LP gas refueling system includes a bypass passage coupled to the discharge passage and the outlet passage.

[0013] In some embodiments, the LP gas refueling system includes a second outlet valve coupled to the bypass passage and the outlet passage, the second outlet valve biased to a closed position to isolate the outlet passage from the bypass passage and configured to be actuated to an open position to transfer discharged vapor LP gas from the outlet passage to the bypass passage.

[0014] In some embodiments, the controller is operatively coupled to the second outlet valve, and the controller is configured to actuate the second outlet valve to the open position when the first pressure switch is actuated to the closed position.

[0015] In some embodiments, the LP gas refueling system includes a second pressure switch biased to an open position, the second pressure switch configured to be actuated to a closed position when pressure of vapor LP gas in the discharge line reaches a second pressure threshold that is greater than the first pressure threshold.

[0016] In some embodiments, the controller is configured to deactivate the compressor when the second pressure switch is actuated to the closed position.

[0017] In some embodiments, the LP gas refueling system includes a bypass valve coupled to the discharge passage and the bypass passage. In some embodiments, the bypass valve is biased to an open position to transfer vapor LP gas in the discharge passage to the bypass passage. In some embodiments, the bypass valve is configured to be actuated to a closed position to isolate the discharge passage from the bypass passage.

[0018] In some embodiments, the controller is configured to actuate the bypass valve to the closed position when activating the compressor to discharge vapor LP gas to the delivery line.

[0019] In some embodiments, the controller is configured to actuate the bypass valve to the open position after a predetermined period of time following deactivation of the compressor.

[0020] In some embodiments, the predetermined period of time ranges from 0.5 seconds to 10 seconds.

[0021] In some embodiments, the controller is configured to deactivate the compressor when the first pressure switch is actuated to the closed position.

[0022] In some embodiments, a liquefied petroleum (LP) gas refueling system includes a compressor configured to draw vapor LP gas through a supply line from a storage tank and discharge vapor LP gas through a delivery line to a fuel tank of the vehicle. In some embodiments, the LP gas refueling system includes a manifold unit. In some embodiments, the manifold unit includes an inlet manifold coupled to the supply line and an intake of the compressor. In some embodiments, the manifold unit includes a discharge passage coupled to the outlet of the compressor. In some embodiments, the manifold unit includes an outlet passage coupled to the discharge passage and the delivery line. In some embodiments, the manifold unit includes a bypass passage coupled to the inlet manifold and the outlet passage. In some embodiments, the manifold unit includes a bypass valve coupled to the discharge passage and the bypass passage. In some embodiments, the bypass valve is biased to an open position to transfer vapor LP gas in the discharge passage to the bypass passage. In some embodiments, the bypass valve is configured to be actuated to a closed position to isolate discharge passage from the bypass passage. In some embodiments, the LP gas refueling system includes a controller operatively coupled to the compressor and the bypass valve, the controller configured to activate and deactivate the compressor. In some embodiments, the controller is configured to actuate the bypass valve to the closed position when activating the compressor to discharge vapor LP gas to the delivery line and to actuate the bypass valve to the open position after a predetermined period of time following deactivation of the compressor.

[0023] In some embodiments, the manifold unit includes a first outlet valve coupled to the discharge passage and the outlet passage, a second outlet valve coupled to the outlet passage and the bypass passage. In some embodiments, the first and second outlet valves are each biased to a closed position to isolate outlet passage from the discharge passage and the bypass passage. In some embodiments, the first outlet valve is configured to be actuated to an open position to transfer vapor LP gas discharged from the compressor to the outlet passage. In some embodiments, the second outlet valve is configured to be actuated to an open position to transfer discharged vapor LP gas from the outlet passage to the bypass passage.

[0024] In some embodiments, the controller is operatively coupled to the first and second outlet valves. In some embodiments, the controller is configured to actuate the first outlet valve to the open position when activating the compressor to discharge vapor LP gas to the delivery line, while setting the second outlet valve in the closed position.

[0025] In some embodiments, the controller is configured to: actuate the first outlet valve to the closed position, actuate the second outlet valve to the open position, and deactivate the compressor, in response to the pressure of vapor LP gas in the outlet passage reaching a predetermined pressure threshold.

[0026] In some embodiments, the controller is configured to actuate the second outlet valve to the closed position during the predetermined period of time after deactivation of the compressor and before actuating the bypass valve to the open position.

[0027] In some embodiments, the LP gas refueling system includes a first pressure switch coupled to the outlet passage and operatively coupled to the controller. In some embodiments, the first

pressure switch is biased to an open position. In some embodiments, the first pressure switch is configured to be actuated to a closed position to output a signal to the controller when pressure of vapor LP gas in the delivery line reaches the first pressure threshold.
[0028] In some embodiments, the controller includes a first latch relay operatively coupled to the first outlet valve, a second latch relay operatively coupled to the bypass valve, and a third latch relay operatively coupled to the second outlet valve. In some embodiments, the controller includes a relay module configured to selectively actuate the first, second, and third relays according to a predetermined protocol.
[0029] The present disclosure includes various embodiments of a method for transferring vapor liquefied petroleum (LP) gas from a storage tank to a fuel tank of a vehicle.
[0030] In some embodiments, the method includes activating a compressor coupled to a manifold unit to draw vapor LP gas from the storage tank and discharge the vapor LP gas through a discharge passage and an outlet passage of the manifold unit to the fuel tank of the vehicle. In some embodiments, the method includes isolating the outlet passage from the discharge passage and deactivating the compressor in response to detecting a pressure in the outlet passage reaching a predetermined pressure threshold. In some embodiments, the method includes transferring vapor LP gas from the outlet passage to a bypass passage of the manifold unit to depressurize the outlet passage. In some embodiments, the method includes isolating the outlet passage from the bypass passage after a first period of time from initiating the transferring of vapor LP pas from the outlet passage to the bypass passage. In some embodiments, the method includes transferring vapor LP gas from the discharge passage to the bypass passage after a second period of time from initiating the transferring of vapor LP pas from the outlet passage to the bypass passage, wherein the second period of time is greater than the first period of time.
[0031] In some embodiments, the activating of the compressor includes closing a bypass valve coupled to the discharge passage and the bypass passage to raise pressure of the vapor LP gas discharged from the compressor. In some embodiments, the transferring of vapor LP gas from the discharge passage to the bypass passage includes opening the bypass valve.
[0032] In some embodiments, the activating of the compressor includes opening a first outlet valve coupled to the discharge passage and the outlet passage to transfer vapor LP gas discharged from the compressor to the outlet passage. In some embodiments, the isolating of the outlet passage from the discharge passage includes closing the first outlet valve.
[0033] In some embodiments, the transferring of vapor LP gas from the outlet passage to the bypass passage includes opening a second outlet valve coupled to the outlet passage and the bypass passage. In some embodiments, the isolating the outlet passage from the bypass passage includes closing the second outlet valve.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0034] The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate embodiments of the present disclosure and, together with the description, further serve to explain the principles of the disclosure and to enable a person skilled in the pertinent art to make and use the embodiments.
[0035] FIG. **1** illustrates a refueling system coupled to a storage tank and a fuel tank of a vehicle according to an embodiment of the present disclosure.
[0036] FIG. **2** illustrates a schematic of a refueling system according to an embodiment of the present disclosure.
[0037] FIG. **3** illustrates a circuit diagram of a controller for a refueling system according to an embodiment of the present disclosure.

[0038] FIG. **4** illustrates a flow chart of a method of transferring fuel from a storage tank to a fuel tank of a vehicle using a refueling system according to an embodiment of the present disclosure.

[0039] The present disclosure will be described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements. Additionally, the left most digit(s) of a reference number identifies the drawing in which the reference number first appears.

DETAILED DESCRIPTION

[0040] The following Detailed Description refers to accompanying drawings to illustrate embodiments consistent with the disclosure. References in the Detailed Description to “one embodiment,” “an embodiment,” “some embodiments,” “certain embodiments,” etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is within the knowledge of those skilled in the relevant art(s) to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0041] The following Detailed Description of the embodiments reveals the general nature of the disclosure so that others can, by applying knowledge of those skilled in the relevant art(s), readily modify and/or adapt for various applications such embodiments, without undue experimentation, without departing from the spirit and scope of the disclosure. Therefore, such adaptations and modifications are intended to be within the meaning and plurality of equivalents of the embodiments based upon the teaching and guidance presented herein. It is to be understood that the phraseology or terminology herein is for the purpose of description and is to be interpreted by those skilled in relevant art(s) in light of the teachings herein.

[0042] In the context of the present disclosure, the term “connected” can refer to a direct connection between two elements without any intervening components or an indirect interconnection with the presence of intervening components between the connected elements. For example, a fuel line can be connected to a source tank by coupling the fitting of the fuel line directly to the port of the source tank or coupling the fitting of the fuel line indirectly to the port via an intermediate component, such as a pressure regulator, whereby the direct and indirect interconnections both establish fluid communication between the source tank and the fuel line.

[0043] The refueling of LPG tanks used in motor vehicles has historically been liquid transfer only to provide quicker refueling rates (e.g., 10 gpm) that are comparable to traditionally gasoline refueling stations. But refueling vehicles via liquid transfer has drawbacks. First, liquid refueling stations must meet stricter regulations (e.g., National Fire Protection Association 30A) to transfer combustible liquid fuel at these rates. For example, these regulations require multiple safety measures designed to protect the refueling equipment and the users from harm caused by mishandling and vehicle collisions. Such regulations have made it unfeasible to create a traditional liquid LPG refueling “station” at one's private residence with curbs, bollards, signage etc. Notably, most residential LPG storage tanks are equipped with only a vapor withdrawal port which is connected to the home by way off first and second stage regulators, tubing and fittings to supply home appliances designed to work on low pressure vapor (heaters, stoves, clothes dryers, etc.). Refilling a vehicle at home using only LPG vapor both before and after the refueling system maintains a safer environment as with all other common household appliances using LPG.

[0044] Second, the temperature of liquid LPG fuel must be controlled precisely to accurately deliver true gallons of propane at various temperatures. Liquid LPG meters are cost-prohibitive for a small volume refueling system, whereas vapor metering devices are cost significantly less and can be added to the inlet port of a refueling unit when metering is needed for accounting (e.g., separating billing or calculating road taxes).

[0045] While transferring LP gas in vapor state is more effective for metering fluid flow, vapor LP gas tends to condense in the fuel lines, requiring stricter pressure regulations for the refueling system.

[0046] The present disclosure presents refueling systems and methods for transferring vapor LP gas from a storage tank to a recipient tank, such as a fuel tank of a vehicle, that overcomes the limitations of known systems and methods noted above. The disclosed refueling systems can include a compressor, a manifold unit, and a controller. The compressor is configured to draw vapor LP gas from a storage tank through a supply line and discharge vapor LP gas through a delivery line to the fuel tank of the vehicle. The manifold unit includes passages, valves, and pressure switches to regulate the flow of vapor LP gas received from the supply line to the delivery line in a manner that effectively controls LP gas drawn from the storage tank while minimizing condensation of vapor LP gas in the refueling system and reducing amperage draw of the compressor. The controller is configured to actuate the compressor and the valves according to a predetermined protocol that delivers vapor LP gas efficiently and reliably to the fuel tank of the vehicle.

[0047] FIG. **1** is a block diagram illustrating a LP gas refueling system **100**, according to an embodiment of the present disclosure. Refueling system **100** can be connected to a LP gas storage tank **10** and a fuel tank **30** of a vehicle **20**. Storage tank **10** can be any storage tank configured to store and permit transfer of LP gas, including both vapor and liquid LP gas. Vehicle **20** can be an automobile, bus, truck, freight carrier, off-road vehicle, aircraft, boat, or other type of vehicle configured to store and operate via LP gas. In some embodiments, refueling system **100** can transfer LP gas to a recipient tank not associated with a vehicle.

[0048] Refueling system **100** is configured to remove and transfer vapor LP gas from storage tank **10** to fuel tank **30** of vehicle **20**. Refueling system **100** can include a compressor **110** configured to pump vapor LP gas stored in storage tank **10** to fuel tank **30** through a plurality of distribution lines. Compressor **110** can discharge vapor LP gas at a volumetric flow rate (e.g., 5 cfm to 150 cfm) sufficient to transfer a desired volume of vapor LP fuel from storage tank **10** to fuel tank **30** within a reasonable amount of time. Compressor **110** can be configured to pump only vapor LP gas through refueling system **100**, without removing liquid LP gas from storage tank **10**, such that only vapor LP gas is transferred to fuel tank **30**. At fuel tank **30**, vapor LP gas condenses to liquid state to be stored in fuel tank **30**. In some embodiments, compressor **110** can be a R290-type compressor that can be powered by a standard 115/120 AC voltage supply. For example, compressor **110** can include any compressor designed for handling combustible mixtures.

[0049] Refueling system **100** can include a supply line **120** coupled to storage tank **10** to deliver vapor LP gas from storage tank **10** to compressor **110** of refueling system **100**. Supply line **120** can include conduits, tubes, pipes, and/or flexible hoses formed from a material that is substantially resistant to degradation by contact with an LP gas and having sufficient structural integrity to maximum allowable operating system pressures (e.g., 2 PSI-300 PSI). In some embodiments, supply line **120** can include a flexible hose or a rigid pipe formed from metals such as copper, brass, or steel, or some polymers such as polyethylene or nitrile, or combinations of these material. In some embodiments, supply line **120** can include a pipe line, such as a vapor LP gas supply line for a residential home, with a pressure regulator (e.g., a first stage pressure regulator) configured to deliver vapor LP gas to compressor **110** at a predetermined pressure, such as for example, a pressure in a range from 2 psig to 15 psig, such as 5 psig to 10 psig.

[0050] Refueling system **100** can include a delivery line **130** connected to fuel tank **30** of vehicle **20** to deliver vapor LP gas from compressor **110** at a high pressure, such as a pressure ranging from 5 psig to 300 psig. Delivery line **130** can include conduits, tubes, pipes, and/or flexible hoses formed from a material that is substantially resistant to degradation by contact with an LP gas and having sufficient structural integrity to maximum allowable operating system pressures (e.g., 2 psi-300 psi). In some embodiments, delivery line **130** can include a flexible hose formed from metals such as copper, brass, or steel, or some polymers such as polyethylene or nitrile, or combinations of these material. For example, delivery line **130** can be a synthetic rubber hose that provides sufficiently flexibility to facilitate the connection with fuel tank **30** of vehicle **20**.

[0051] Refueling system **100** can include a manifold unit **200** for connecting compressor **110** with supply line **120** and delivery line **130**. Manifold unit **200** can include a system of tubing or passages, valves, regulators, sensors, and/or controllers to regulate the flow of vapor LP gas received from supply line **120** to delivery line **130** in a manner that effectively controls LP gas drawn from storage tank **10** (e.g., withdrawing LP gas from storage tank **10** with minimal waste) while minimizing condensation of vapor LP gas in refueling system **100**. The passages and/or tubing of manifold unit **200** can be formed from a material that is substantially resistant to degradation by contact with LP gas and having sufficient structural integrity to maximum allowable operating system pressures (e.g., 2 psi-300 psi).

[0052] FIG. **2** illustrates a schematic of refueling system **100**, including manifold unit **200**, according to embodiments of the present disclosure. In some embodiments, manifold unit **200** can include a housing **210** containing the system of passages and valves of manifold unit **200**. Manifold unit **200** can include an inlet **220** coupled to supply line **120** to receive vapor LP gas drawn from storage tank **10**. In some embodiments, refueling system **100** can include a filter **140** located on supply line **120** proximate to inlet **220** of manifold unit **200** to supply filtered vapor LP gas (e.g., LP gas free or essentially free from debris) to compressor **110**. In some embodiments, supply line **120** can include a pressure regulator **122** to deliver vapor LP gas to inlet **220** at a predetermined pressure (e.g., 5 psig to 10 psig). Manifold unit **200** can include an outlet **230** coupled to delivery line **130** to deliver compressed, high-pressure vapor LP gas from compressor **110** to tank **30** of vehicle **20**. In the context of the present disclosure, high-pressure vapor LP gas can in a range from 5 psi to 300 psi.

[0053] In some embodiments, manifold unit **200** can include an inlet manifold **240** having a first port **242** located at or proximate to inlet **220**. Manifold unit **200** can include an intake passage **250** coupled to a second port **244** of inlet manifold **240** and to an intake **112** of compressor **110**. Manifold unit **200** can include a discharge passage **260** coupled to an outlet **114** of compressor **110** for discharging compressed vapor LP gas. Manifold unit **200** can include an outlet passage **270** coupled to discharge passage **260** and outlet **230** to deliver compressed vapor LP gas to outlet **230** and delivery line **130**. Manifold unit **200** can include a bypass passage **280** coupled to a third port **246** of inlet manifold **240** and outlet passage **270**. In some embodiments, bypass passage **280** is configured to direct vapor LP gas discharged from outlet **114** of compressor **110** back to inlet **220** or an accumulator coupled to inlet manifold **240** to depressurize discharge passage **260** and/or outlet passage **270**.

[0054] Manifold unit **200** can include any suitable number of valves to regulate the flow of vapor LP gas received at inlet **220** and to control the pressure of vapor LP gas discharged to outlet **230**.

[0055] In some embodiments, manifold unit **200** can include a pressure relief valve **290** coupled to bypass passage **280**. Pressure relief valve **290** can be biased to a closed position and configured to be actuated to an open position to release vapor LP gas from refueling system **100** in response to pressure reaching a predetermined threshold in bypass passage **280**. Manifold unit **200** can include a vent passage **292** connecting pressure relief valve **290** and bypass passage **280**.

[0056] In some embodiments, manifold unit **200** can include a bypass valve **262** coupled to discharge passage **260** and bypass passage **280** to control the pressure of vapor LP gas discharged from outlet **114** of compressor **110**. In some embodiments, bypass valve **262** can be a solenoid valve biased to an open position. At the open position, bypass valve **262** permits vapor LP gas to transfer from discharge passage **260** to bypass passage **280**, so that compressor **110** creates no rise in vapor pressure.

[0057] In some embodiments, manifold unit **200** can include a first outlet valve **272** coupled to discharge passage **260** and outlet passage **270** to selectively permit vapor LP gas discharged from compressor **110** to transfer to outlet **230**, ultimately to tank **30** of vehicle **20** via delivery line **130**.

In some embodiments, first outlet valve **272** can be a solenoid valve biased to a closed position. At the closed position, first outlet valve **272** isolates outlet passage **270** from discharge passage **260** such that vapor LP gas in discharge passage **260** is prevented from transferring to outlet **230** of manifold unit **200**.

[0058] In some embodiments, manifold unit **200** can include a second outlet valve **274** coupled to outlet passage **270** and bypass passage **280** to selectively direct vapor LP gas received in outlet passage **270** to bypass passage **280**, thereby depressurizing outlet passage **270** and delivery line **130**. In some embodiments, second outlet valve **274** can be a solenoid valve biased to a closed position. At the closed position, second outlet valve **274** isolates outlet passage **270** from bypass passage **280** such that vapor LP gas in outlet passage **270** is prevented from transferring to bypass passage **280**.

[0059] In some embodiments, manifold unit **200** can include a controller **300** and one or more sensors **310**, **320** to monitor operating pressure in manifold unit **200** so that vapor LP gas is selectively delivered to and isolated from outlet passage **270**.

[0060] The one or more sensors can include a first pressure switch **310** coupled to outlet passage **270**. In some embodiments, first pressure switch **310** is configured to monitor the pressure of vapor LP gas flowing in outlet passage **270**, which corresponds to the pressure of vapor LP gas at outlet **230**. In some embodiments, first pressure switch **310** is configured to signal controller **300** to deactivate compressor **110** and/or close first outlet valve **272** when pressure of vapor LP gas at outlet **230** of manifold unit **200** reaches a first pressure threshold. In the context of the present disclosure, activating the compressor **110** is energizing the motor of the compressor to drive vapor flow, and deactivating the compressor is de-energizing the motor of the compressor to cease movement of vapor flow. For example, first pressure switch **310** can be biased to an open position and configured to switch to a closed position (e.g., energizing contacts of the switch) with an electrical contact to generate an output signal when pressure in outlet passage **270** reaches the first pressure threshold. In some embodiments, the first pressure threshold ranges from 280 psi to 310 psi, such as, for example, from 290 psi to 300 psi. The first pressure threshold can correspond to a pressure rise caused by the actuation of an overfill protection device in fuel tank **30** of vehicle **20** such that first pressure switch **310** closes in response to the activation of the overfill protection device in fuel tank **30**, and thereby activate controller **300** to stop refueling of fuel tank **30** in vehicle **20**. For example, when the overfill protection device of fuel tank **30** closes and stops the flow of fuel into fuel tank **30**, compressor **110** continues elevate pressure in outlet passage **270** until first pressure switch **310** is actuated to the closed position.

[0061] The one or more sensors can include a second pressure switch **320** coupled to discharge passage **260**. In some embodiments, second pressure switch **320** is configured to monitor pressure of vapor LP gas in discharge passage **260** of manifold unit **200**, which corresponds to the pressure of vapor LP gas at outlet **114** of compressor **110**. In some embodiments, second pressure switch **320** is configured to signal controller **300** to deactivate compressor **110** and/or open bypass valve **262** when pressure of vapor LP gas in discharge passage **260** of manifold unit **200** reaches a second pressure threshold. For example, second pressure switch **320** can be biased to an open position and configured to switch to a closed position with an electrical contact to generate an output signal when pressure in discharge passage **260** reaches the second pressure threshold. In some embodiments, the second pressure threshold ranges from 295 psi to 315 psi, such as, for example, from 300 psi to 305 psi. The second pressure threshold can be greater than the first pressure threshold such that second pressure switch **320** when pressure of vapor LP gas in manifold unit **200** rises above an unsafe operating pressure. For example, second pressure switch **320** may be actuated if first outlet valve **272** failed to open or if first pressure switch **310** failed to be actuated.

[0062] FIG. **3** illustrates a schematic circuit diagram of controller **300**, according to an embodiment. Controller **300** can be operatively coupled (e.g., wired or wireless) to compressor **110** and valves **262**, **272**, **274**, and pressure switches **310**, **320** of manifold unit **200**. In some embodiments, controller **300** can include a relay module **330**; a plurality of latch relays **340**, **342**, **344**, **346**; a start switch **350**; a reset switch **360**; and a plurality of time delay modules **370**, **372**. In some embodiments, the plurality of latch relays **340**, **342**, **344**, **346** can be wired to valves **262**, **272**, **274**, pressure switches **310**, **320**, and compressor **110** to establish electrical communication with controller **300**. Relay module **330** can be configured to selectively activate each of latch relays **340**, **342**, **344**, **346** to trigger activation or deactivation of valves **262**, **272**, **274**, pressure switches **310**, **320**, and compressor **110** according to a predetermined protocol. Start switch **350** can be configured to activate relay module **330** to initiate a fuel flow process. Reset switch **360** can be configured to trigger relay module **330** to shut off all latch relays **340**, **342**, **344**, **346**, thereby stopping the fuel transfer process. The plurality of time delay modules **370**, **372** can be configured to delay relay module **330** from actuating one or more of latch relays **340**, **342**, **344**, **346** according to a predetermined protocol. In some embodiments, controller **300** can include an emergency stop switch to shut off power to all circuitry of controller **300**, thereby terminating operation of refueling system **100**.

[0063] In some embodiments, the plurality of latch relays **340**, **342**, **344**, **346** each include an electromechanical latch that can be actuated between: (i) an “on” position to distribute power to (i.e., energize) one or more of valves **262**, **272**, **274**, first and second pressure switches **310**, **320**, and compressor **110**; and (ii) an “off” position to cut power supplied to (i.e., de-energize) one or more of one or more of valves **262**, **272**, **274**; first and second pressure switches **310**, **320**; and compressor **110**. Each of the plurality latch relays **340**, **342**, **344**, **346** can be configured to remain in the “on” or “off” position until receiving an impulse power signal from relay module **330**. Each of the plurality of latch relays will default to the “off” position if their power supply is interrupted.

[0064] The plurality of latch relays can include a first latch relay **340** wired to first pressure switch **310**, second pressure switch **320**, compressor **110**, first outlet valve **272**, and reset switch **360**. When first latch relay **340** is set to the “on” position, power is supplied to first pressure switch **310**, second pressure switch **320**, compressor **110**, first outlet valve **272**, and reset switch **360**. In response, compressor **110** is activated to discharge vapor LP gas, and first outlet valve **272** switches from the closed position to the open position to allow discharged vapor LP gas to enter outlet **230** of manifold unit **200**, ultimately allowing compressor **110** to discharge vapor LP gas to fuel tank **30** of vehicle **20**. At the same time, first pressure switch **310** is energized to monitor pressure of vapor LP gas at outlet **230** of manifold unit **200**, and second pressure switch **320** is energized to monitor pressure of vapor LP gas in discharge passage **260**. When first latch relay **340** is set to the “off” position, power supply to first pressure switch **310**, compressor **110**, first outlet valve **272**, and reset switch **360** is disrupted. In response, compressor **110** shuts down, and first outlet valve **272** returns to the closed position, isolating discharge passage **260** from outlet passage **270**. At the same time, first and second pressure switches **310**, **320** are de-energized.

[0065] The plurality of latch relays can include a second latch relay **342** wired to bypass valve **262** and reset switch **360**. When second latch relay **342** is set to the “on” position, power is supplied to bypass valve **262** and reset switch **360**. In response, bypass valve **262** moves from its biased open position to the closed position, thereby allowing compressor **110** to discharge vapor LP gas at a high pressure. When second latch relay **342** is set to the “off” position, power to bypass valve **262** is disrupted. In response, bypass valve **262** returns to the open position, permitting vapor LP gas to flow to bypass passage **280**, thereby depressurizing discharge passage **260**.

[0066] The plurality of latch relays can include a third latch relay **344** wired to second outlet valve **274** and reset switch **360**. When third latch relay **344** is set to the “on” position, power is supplied to second outlet valve **274** and reset switch **360**. In response, second outlet valve **274** moves from its biased closed position to the open position, permitting discharged vapor LP gas to flow from outlet passage **270** to bypass passage **280**, thereby depressurizing outlet passage **270**. When third latch relay **344** is set to the “off” position, power to second outlet valve **274** is disrupted. In response, second outlet valve **274** returns to the closed position, thereby isolating the depressurized outlet passage **270** from bypass passage **280**.

[0067] The plurality of latch relays can include a fourth latch relay **346** wired to the plurality of time delay modules **370**, **372**. When fourth latch relay **346** is set to the “on” position, power is supplied simultaneously to the plurality of time delay modules **370**, **372**. In response, the plurality of time delay modules **370**, **372** generate output signals to relay module **330** after predetermined periods of time, to trigger relay module **330** to turn off the remaining latch relays **340**, **342**, **344** according to a predetermined protocol. When fourth latch relay **346** is set to the “off” position, power supply to the plurality of time delay modules **370**, **372** is disrupted. In response, the plurality of time delay modules **370**, **372** become de-energized after generating delayed output signals to relay module **330**.

[0068] In some embodiments, relay module **330** can include a plurality of switches (e.g., single-pole, single-throw relays and/or double pole, double throw relays) to selectively actuate the plurality of latch relays **340**, **342**, **344**, **346**. The switches of relay module **330** can be configured to generate power impulse signals to activate one or more of latch relays **340**, **342**, **344**, **346**. Relay module **330** can include a master switch wired to start switch **350** and a plurality of secondary switches each wired to the master switch and to one of latch relays **340**, **342**, **344**, **346**, reset switch **360**, and time delay modules **370**, **372**.

[0069] In some embodiments, the plurality of time delay modules **370**, **372** can each include an electromechanical timer relay triggered by an impulse signal generated by fourth latch relay **346** and configured to generate an output signal to relay module **330** after a set period of time from being triggered. The plurality of time delay modules can include a first time delay module **370** configured to generate a first output signal following a first period of time from being triggered by fourth latch relay **346**. The first period of time can range from 0.5 to 10 seconds. The first output signal generated by first time delay module **370** can actuate relay module **330** to turn off third latch relay **344** so that power is removed from second outlet valve **274**, thereby switching second outlet valve **274** from the open position to a closed position. The plurality of time delay modules can include a second time delay module **372** configured to generate a second output signal following a second period of time from being triggered by fourth latch relay **346**. The second period of time can range from 0.5 to 10 seconds. In some embodiments, the second period of time is longer than the first period of time.

[0070] In some embodiments, relay module **330** may be operatively coupled to a magnetic reed switch **132** associated with delivery line **130** such that removal of delivery line **130** from a stowed position to an operating position activates relay module **330**.

[0071] In some embodiments, controller **300** can include a processor (e.g., a microprocessor, a multi-core processor, a central processing unit) configured to receive input signals from first and second pressure switches **310** and **320** and generate actuation signals transmitted to compressor **110**, bypass valves **262**, and first and second outlet valves **272**, **274** to control the flow vapor LP gas through refueling system **100**. Controller **300** can include memory comprising computer storage media in the form of volatile memory, such as RAM, and/or nonvolatile memory, such as ROM. In some embodiments, the memory of controller **300** can be configured to store computer readable instructions, data structures, program modules, and other data, which are inputted to the processor for the execution of operations, as described herein. In some embodiments, controller **300** can include any type of circuitry components, such as a bus, for transmitting instructions stored in the memory to the processor.

[0072] In operation, controller **300** is configured to selectively activate and deactivate compressor **110**; valves **262**, **272**, **274**; and first and second pressure switches **310**, **320** according to a predetermined protocol that includes a plurality of operation modes. The plurality of operation modes can include, for example, a standby mode, a neutral (zero) mode, a first mode, a second mode, and a third mode.

[0073] In some embodiments, during the standby mode, delivery line **130** is isolated from discharge passage **260** of manifold unit **200** via closed first and second outlet valves **272** and **274**, and all circuits of controller **300** are shut down such that start and reset switches **350** and **360** are not configured to actuate relay module **330**. Bypass valve **262** is set in the open position such that discharge passage **260** of manifold unit **200** is depressurized. Refueling system **100** can transition from standby mode to neutral mode when delivery line **130** is removed from the stowed position to the operating position, which causes magnetic reed switch **132** to activate relay module **330**.

[0074] In some embodiments, during the neutral mode, delivery line **130** remains isolated from discharge passage **260** of manifold unit **200** via closed first and second outlet valves **272** and **274**, but relay module **330** is activated, thereby energizing start switch **350**. Bypass valve **262** remains set in the open position, keeping discharge passage **260** depressurized. Reset switch **360** remains de-energized during the neutral mode. When refueling system **100** is set in the neutral mode, a user may begin a LP gas refueling process by selecting start switch **350**, which transitions refueling system **100** to the first mode of operation.

[0075] In some embodiments, when transitioning to the first mode, relay module **330** is configured to actuate first latch relay **340** and second latch relay **342** to the “on” position, thereby: (i) activating compressor **110** to discharge vapor LP gas, (ii) closing bypass valve **262** to raise pressure of the discharged vapor LP gas, (iii) opening first outlet valve **272** to allow the high pressure vapor LP gas to enter delivery line **130**, (iv) energizing first pressure switch **310** to monitor pressure of vapor LP gas at outlet **230** of manifold unit **200**, and (v) energizing second pressure switch **320** to monitor pressure of vapor LP gas in discharge passage **260** of manifold unit **200**. During the first mode, vapor LP gas is drawn from storage tank **10** to compressor **110** via supply line **120** and then discharged from outlet **114** of compressor **110** through delivery line **130** to fuel tank **30** of vehicle **20**. In some embodiments, refueling system **100** can transition from the first mode to the second mode when pressure of vapor LP gas at outlet **230** of manifold unit reaches a predetermined pressure (e.g., 290 psig to 300 psig), thereby closing first pressure switch **310**. Closure of first pressure switch **310** generates an output signal to relay module **330** to initiate the second mode of operation. Because the first latch relay **340** is wired to reset switch **360**, a user can actuate reset switch **360** to transition refueling system **100** from first mode to neutral mode.

[0076] In some embodiments, when transitioning to the second mode, relay module **330** is configured to actuate first latch relay **340** to the “off” position, thereby: (i) deactivating compressor **110** to stop discharge of vapor LP gas, (ii) closing first outlet valve **272** to isolate discharge passage **260** from outlet passage **270** and delivery line **130**, and (iii) de-energizing first pressure switch **310**. Second latch relay **342** remains set in the “on” position during the second mode so that discharge passage **260** remains isolated from bypass passage **280**. Relay module **330** is further configured to actuate third latch relay **344** during the second mode to the “on” position, thereby opening second outlet valve **274** to direct vapor LP gas from outlet passage **270** to bypass passage **280**, ultimately depressurizing outlet passage **270** and delivery line **130**. Relay module **330** is further configured to actuate fourth latch relay **346** during the second mode to the “on” position, thereby activating first and second time delay modules **370** and **372**. In some embodiments, refueling system **100** can transition from the second mode to the third mode when first time delay module **370** generates an output signal to relay module **330** after the first period of time. That is, the duration of the second mode for refueling system **100** corresponds to the first period of time set by first time delay module **370**. Because second and third latch relay **342**, **344** are wired to reset switch **360**, a user can actuate reset switch **360** to transition refueling system **100** from second mode to neutral mode.

[0077] In some embodiments, when transitioning to third mode, relay module **330** is configured to actuate third latch relay **344** to the “off” position, thereby closing the second outlet valve **274** to isolate outlet passage **270** from bypass passage **280**. Consequently, outlet passage **270** of manifold unit **200** is isolated from supply line **120** and all passages (e.g., intake passage **250**, discharge passage **260**, and bypass passage **280**) located upstream. Second latch relay **342** remains set in the “on” position during the third mode so that discharge passage **260** remains isolated from bypass passage **280**. In some embodiments, refueling system **100** can transition from the third mode to the neutral mode when second time delay module **372** generates an output signal to relay module **330** after the second period of time. That is, the duration of the third mode for refueling system **100** corresponds to the difference between the first and second period of times set by first and second time delay modules **370** and **372**.

[0078] In some embodiments, when transitioning from third mode back to the neutral mode, relay module **330** is configured to actuate second latch relay **342** and fourth latch relay **346** to the "off" position, thereby: (i) opening bypass valve **262** to depressurize discharge passage **260** of manifold unit **200** and (ii) de-energizing first and second time delay modules **370** and **372**. Opening of bypass valve **262** relieves head pressure that was accumulated while compressor **110** was previously running, ultimately reducing amperage draw during the next compressor startup request.

[0079] FIG. **4** illustrates an example method **400** for transferring LP gas from storage tank **10** to fuel tank **30** of vehicle **20**.

[0080] In some embodiments, method **400** can include a step **410** of activating compressor **110** coupled to manifold unit **200** to draw vapor LP gas from storage tank **10** and discharge the vapor LP gas through discharge passage **260** and outlet passage **270** of manifold unit **200** to fuel tank **30** of vehicle **10**. Step **410** can include closing bypass valve **262** to raise pressure of the vapor LP gas discharged from compressor **110**. Step **410** can include opening first outlet valve **272** to transfer vapor LP gas discharged from compressor **110** to outlet passage **270**. In some embodiments, the activating of compressor **110**, the closing of bypass valve **262**, and the opening of first outlet valve **272** can occur simultaneously or all within a set period of time (e.g., 0.1 seconds to 2 seconds). Step **410** can include using relay module **330** of controller **300** to actuate first latch relay **340** to the "on" position to activate compressor **110** and energize first outlet valve **272** and first and second pressure switches **310** and **320**. Step **410** can include using relay module **330** of controller **300** to actuate second latch relay **342** to the "on" position to close bypass valve **262**.

[0081] In some embodiments, method **400** can include a step **420** of determining whether the pressure of vapor LP gas detected in outlet passage **270** (or at outlet **230**) has reached a predetermined pressure threshold. Step **420** can include using first pressure switch **310** to detect the pressure of vapor LP gas in outlet passage **270** or any sensor suitable for monitoring pressure in outlet passage **270** (or outlet **230**). In some embodiments, the predetermined pressure threshold corresponds to the pressure rating (the first pressure threshold) of first pressure switch **310**, which is in a range from 285 psi to 305 psi, such as, for example, from 290 psi to 300 psi.

[0082] In some embodiments, method **400** can include a step **430** of isolating outlet passage **270** from discharge passage **260** and deactivating compressor **110** in response to detecting the pressure in outlet passage **270** (or outlet **230**) reached the predetermined pressure threshold. Step **430** can include closing the first outlet valve **272** to isolate outlet passage **270** from discharge passage **260**. Step **430** can include using relay module **330** of controller **300** to actuate the first latch relay **340** to the "off" position to deactivate compressor **110** and de-energize first outlet valve **272** and first and second pressure switches **310** and **320**.

[0083] In some embodiments, method **400** can include a step **435** of maintaining the activation of compressor **110** to discharge vapor LP gas from storage tank **10** to fuel tank **30** of vehicle **20** in response to determining that the detected pressure of vapor LP gas in the outlet passage **270** (or at the outlet **230**) is below the predetermined pressure threshold. Step **435** can include keeping first outlet valve **272** in the open position.

[0084] In some embodiments, method **400** can include a step **440** of transferring vapor LP gas from outlet passage **270** to bypass passage **280** of manifold unit **200** to depressurize outlet passage **270**. Step **440** can include opening second outlet valve **272**. Step **440** can include using relay module **330** of controller **300** to actuate third latch relay **344** to the "on" position to energize second outlet valve **272**. Step **440** can include using relay module **330** of controller **300** to actuate fourth latch relay **346** to the "on" position to energize first time delay module **370** and second time delay

module **372**. In some embodiments, steps **430** and **440** can occur simultaneously or within set period of time (e.g., 0.1 seconds to 2 seconds).
[0085] In some embodiments, method **400** can include a step **450** of isolating outlet passage **270** from bypass passage **280** after a first period of time from the initiation of step **440**. Step **450** can include closing second outlet valve **272**. Step **450** can include using relay module **330** of controller **300** to actuate third latch relay **344** to the “off” position to de-energize second outlet valve **272**. Step **450** can include being initiated by first time delay module **370** outputting a signal to relay module **330** after the first period of time. In some embodiments, the first period of time ranges from 0.5 seconds to 10 seconds.
[0086] In some embodiments, method **400** can include a step **460** of transferring vapor LP gas from discharge passage **260** to bypass passage **280** after a second period of time from initiating step **440**. The second period of time is greater than the first period of time. In some embodiments, the second period of time ranges from 0.5 seconds to 10 seconds. Step **460** can include being initiated by second time delay module **372** outputting a signal to relay module **330** after the second period of time. Step **460** can include opening bypass valve **262**. Step **460** can include using relay module **330** of controller to actuate second latch relay **342** and fourth latch relay **346** to the “off” position to de-energize bypass valve **262** and first and second time delay modules **370** and **372**.
[0087] It is to be appreciated that the Detailed Description section, and not the Brief Summary and Abstract sections, is intended to be used to interpret the claims. The Brief Summary and Abstract sections may set forth one or more, but not all embodiments, and thus, is not intended to limit the disclosure and the appended claims in any way.
[0088] It will be apparent to those skilled in the relevant art(s) that various changes in form and detail can be made therein without departing from the spirit and scope of the disclosure. Thus, the disclosure should not be limited by any of the above-described embodiments, but should be defined only in accordance with the following claims and their equivalents.

Claims

1. A liquefied petroleum (LP) gas refueling system, comprising: a supply line connected to a storage tank storing LP gas; a delivery line connected to a fuel tank of a vehicle; a compressor connected to the supply line and the delivery line, the compressor configured to draw vapor LP gas from the storage tank through the supply line and discharge the vapor LP gas through the delivery line to the fuel tank of the vehicle; a first outlet valve biased to a closed position to stop the discharge of the vapor LP gas to the delivery line, wherein the first outlet valve is configured to be actuated to an open position to transfer the vapor LP gas discharged from the compressor to the delivery line; and a controller in electrical communication with the compressor and the first outlet valve, wherein the controller is configured to activate and deactivate the compressor, wherein the controller is configured to actuate the first outlet valve to the open position when activating the compressor such that the vapor LP gas discharged from the compressor transfers to the delivery line, and the controller is configured to actuate the first outlet valve to the closed position when a pressure of the vapor LP gas in the delivery line reaches a first pressure threshold.
2. The LP gas refueling system of claim 1, further comprising: a first pressure sensor in electrical communication with the controller, wherein the first pressure sensor is configured to monitor the pressure of the vapor LP gas in the delivery line and transmit a first actuation signal to the controller when the pressure of the vapor LP gas in the delivery line reaches the first pressure threshold.
3. The LP gas refueling system of claim 2, wherein the first pressure sensor comprises a first pressure switch biased to an open position and configured to be actuated to a closed position to transmit the first actuation signal to the controller when the pressure of the vapor LP gas in the delivery line reaches the first pressure threshold.

4. The LP gas refueling system of claim 2, further comprising: a discharge passage coupled to an outlet of the compressor and the first outlet valve; and an outlet passage coupled to the first outlet valve and the delivery line, wherein the first pressure sensor is coupled to the outlet passage.
5. The LP gas refueling system of claim 4, further comprising: a bypass passage coupled to the discharge passage and the outlet passage; and a second outlet valve coupled to the bypass passage and the outlet passage, the second outlet valve biased to a closed position to isolate the outlet passage from the bypass passage and configured to be actuated to an open position to transfer the discharged vapor LP gas from the outlet passage to the bypass passage.
6. The LP gas refueling system of claim 5, wherein the controller is in electrical communication with the second outlet valve, and the controller is configured to actuate the second outlet valve to the open position when the pressure of the vapor LP gas in the delivery line reaches the first pressure threshold.
7. The LP gas refueling system of claim 6, further comprising: a second pressure sensor configured to monitor a pressure of the vapor LP gas in the discharge passage and transmit a second actuation signal to the controller when the pressure of the vapor LP gas in the discharge passage reaches a second pressure threshold that is greater than the first pressure threshold.
8. The LP gas refueling system of claim 7, wherein the second pressure sensor comprises a second pressure switch biased to an open position, and the second pressure switch is configured to be actuated to a closed position to transmit the second actuation signal to the controller when the pressure of the vapor LP gas in the discharge passage reaches the second pressure threshold.
9. The LP gas refueling system of claim 7, wherein the controller is configured to deactivate the compressor when receiving the second actuation signal from the second pressure sensor.
10. The LP gas refueling system of claim 5, further comprising: a bypass valve coupled to the discharge passage and the bypass passage, the bypass valve biased to an open position to transfer the vapor LP gas in the discharge passage to the bypass passage, wherein the bypass valve is configured to be actuated to a closed position to isolate the discharge passage from the bypass passage.
11. The LP gas refueling system of claim 10, wherein the controller is configured to actuate the bypass valve to the closed position when activating the compressor to discharge the vapor LP gas to the delivery line.
12. The LP gas refueling system of claim 11, wherein the controller is configured to actuate the bypass valve to the open position after a predetermined period of time following deactivation of the compressor.
13. The LP gas refueling system of claim 12, wherein the predetermined period of time ranges from 0.5 seconds to 10 seconds.
14. The LP gas refueling system of claim 1, wherein the controller is configured to deactivate the compressor when the pressure of the vapor LP gas in the delivery line reaches the first pressure threshold.
15. The LP gas refueling system of claim 1, wherein the first pressure threshold is in a range from 280 psi to 310 psi.
16. The LP gas refueling system of claim 7, wherein the second pressure threshold is in a range from 295 psi to 315 psi.