

EXHIBIT 1005



US005718265A

United States Patent [19]

Elsdon et al.

[11] **Patent Number:** 5,718,265[45] **Date of Patent:** Feb. 17, 1998[54] **CAP AND SHIELD ASSEMBLY**[75] **Inventors:** Stanley Robert Elsdon, Islington;
Arthur S. Cornford, Mississauga, both
of Canada[73] **Assignee:** Emco Wheaton Fleet Fueling, Corp.,
Oakville, Canada[21] **Appl. No.:** 393,674[22] **Filed:** Feb. 24, 1995[51] **Int. Cl.⁶** F16L 55/10[52] **U.S. Cl.** 138/89; 285/45; 285/901;
292/DIG. 4; 49/507[58] **Field of Search** 285/901, 325,
285/45; 292/DIG. 4; 138/94.5; 49/171,
208, 385, 507[56] **References Cited****U.S. PATENT DOCUMENTS**

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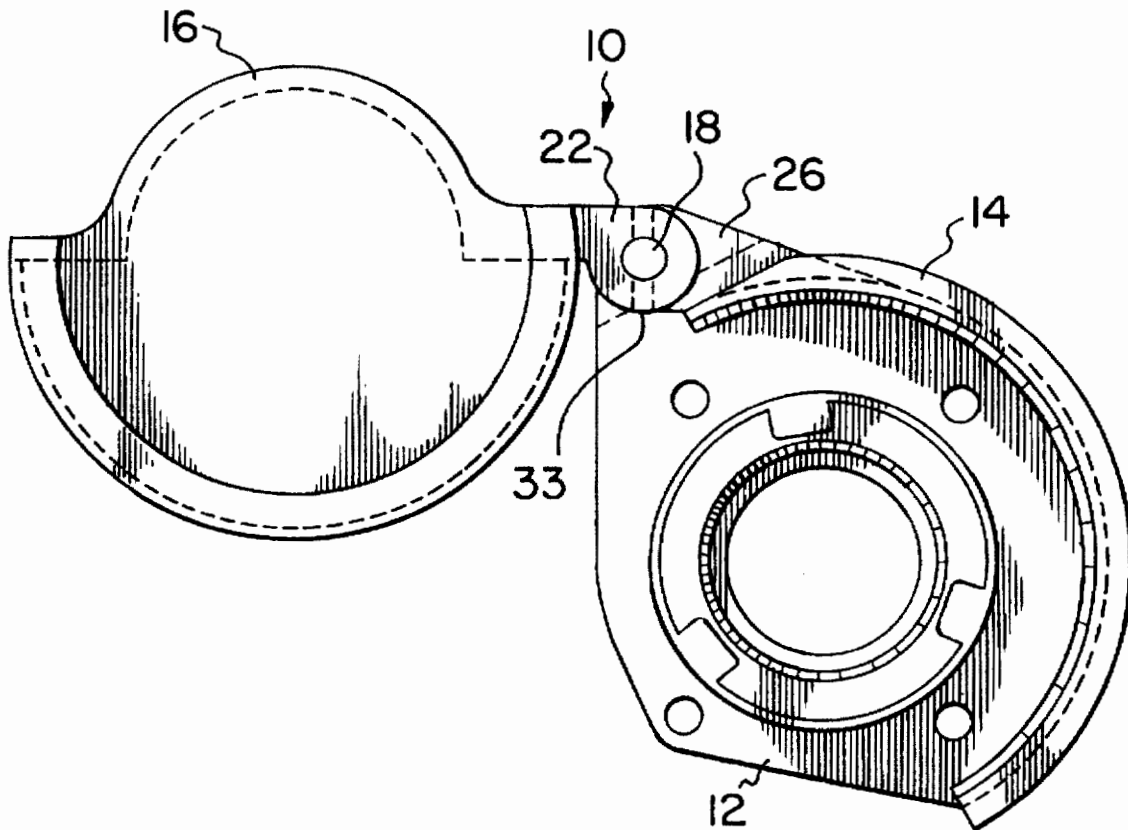
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Primary Examiner—Dave W. Arola**Attorney, Agent, or Firm**—Evenson, McKeown, Edwards &
Lenahan P.L.L.C.

[57]

ABSTRACT

A cap and shield assembly for a fluid conduit coupler has a shield and a cap hingedly connected to the shield with a shaft having a cross-pin extending therethrough. A cam bushing in the bore of the shield has a cam surface which coacts with the cross-pin to provide a positive closed position for the cap relative to the shield. Preferably, the cam bushing also provides a positive open position. The cap and shield assembly is particularly advantageous for couplers having a dry-break interface because the cap is readily moved between open and closed positions and operators will be more inclined to use the cap after fluid transfer. Shrouds on the cap and the shield coact to protect the coupler interface when the cap is in the closed position thereby protecting the dry-break interface from contamination by road and environmental debris. This is particularly advantageous compared to the dust cap of the prior art which tends not to be used for its intended purpose of protecting the fluid conduit coupler.

25 Claims, 6 Drawing Sheets

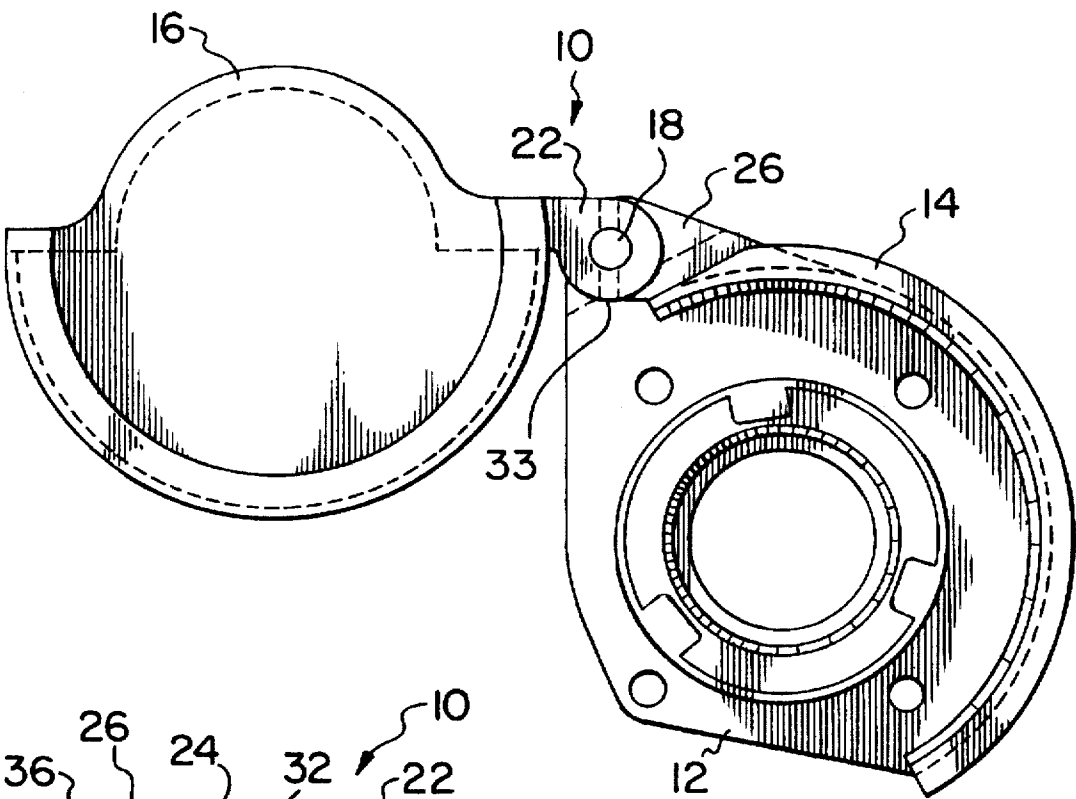


FIG. 1

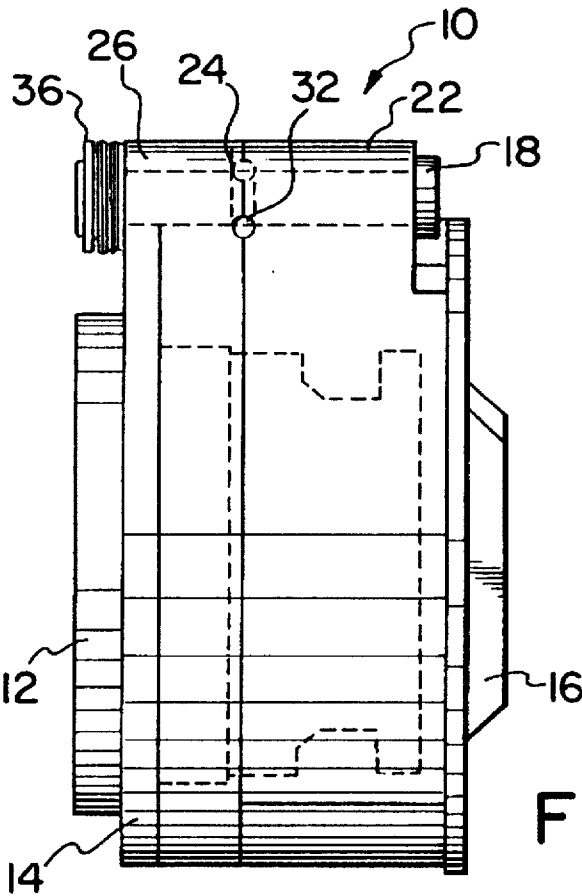


FIG. 2

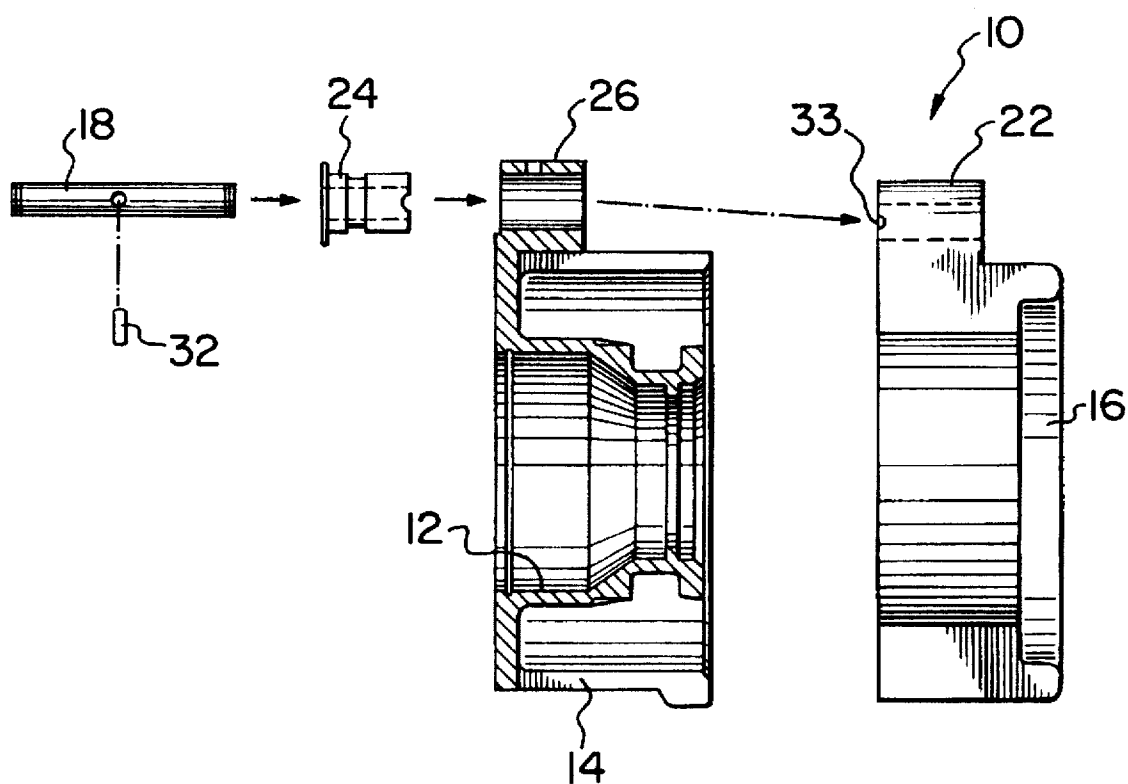


FIG. 3

FIG. 5

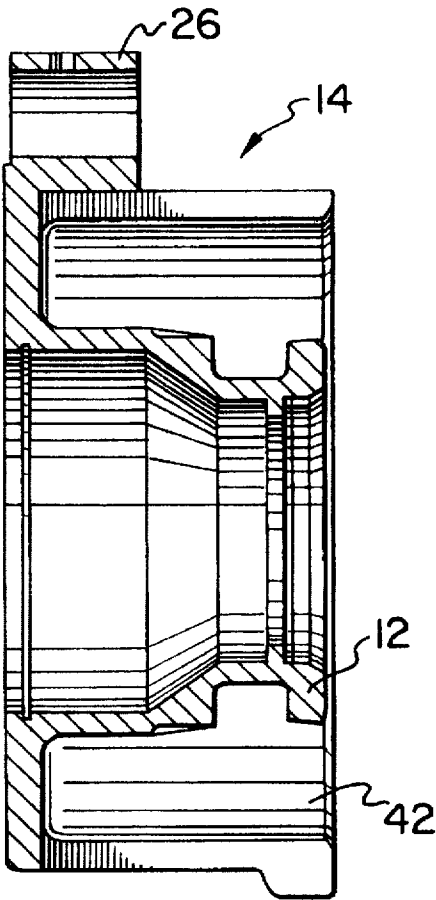
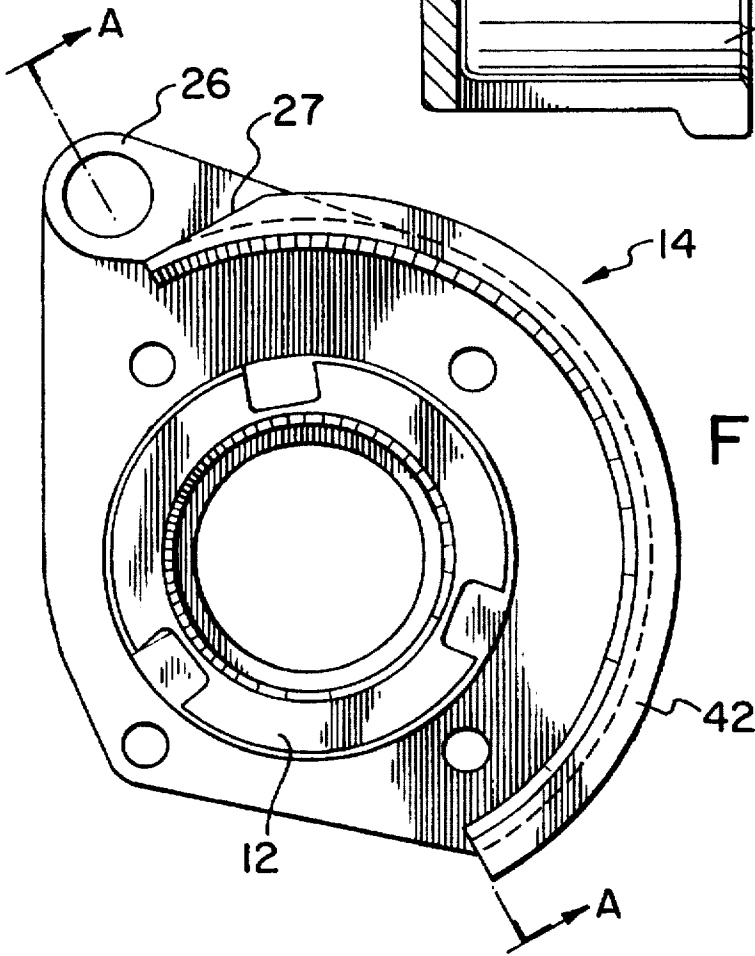


FIG. 4



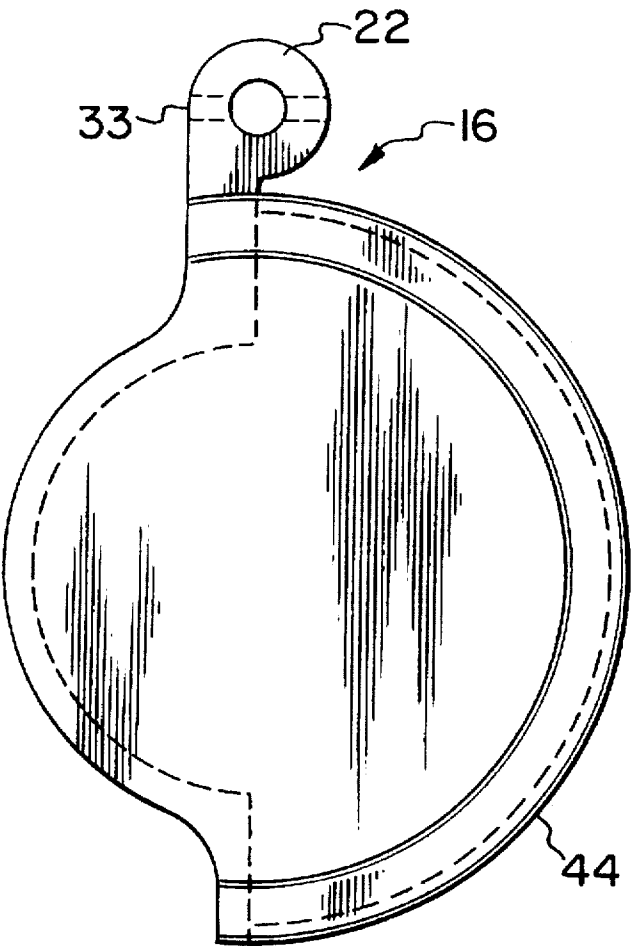
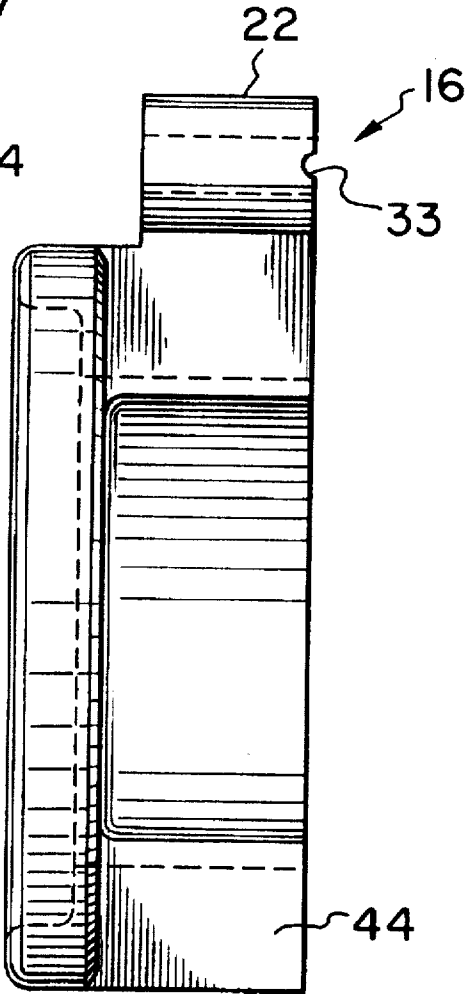


FIG. 6

FIG. 7



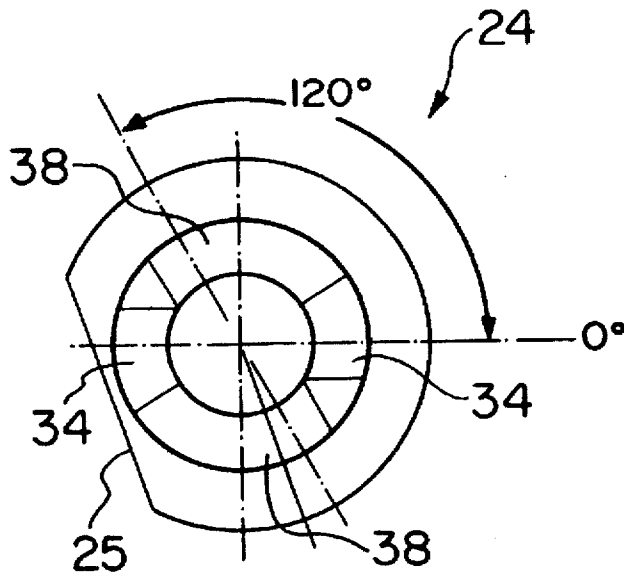


FIG. 8B

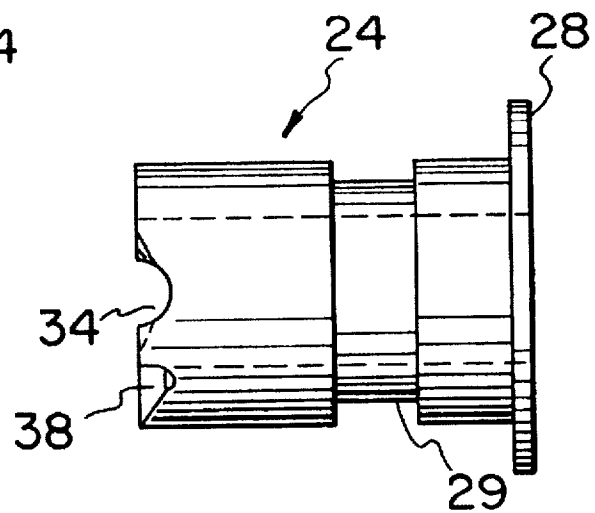


FIG. 8A

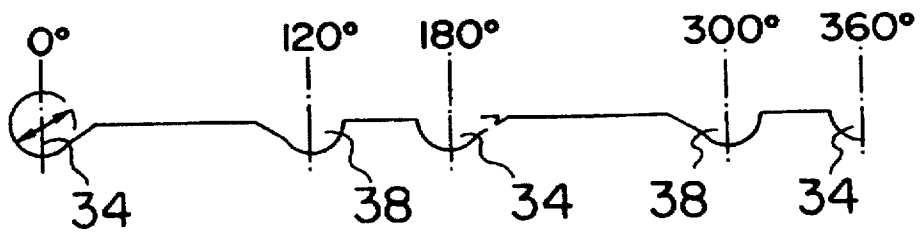
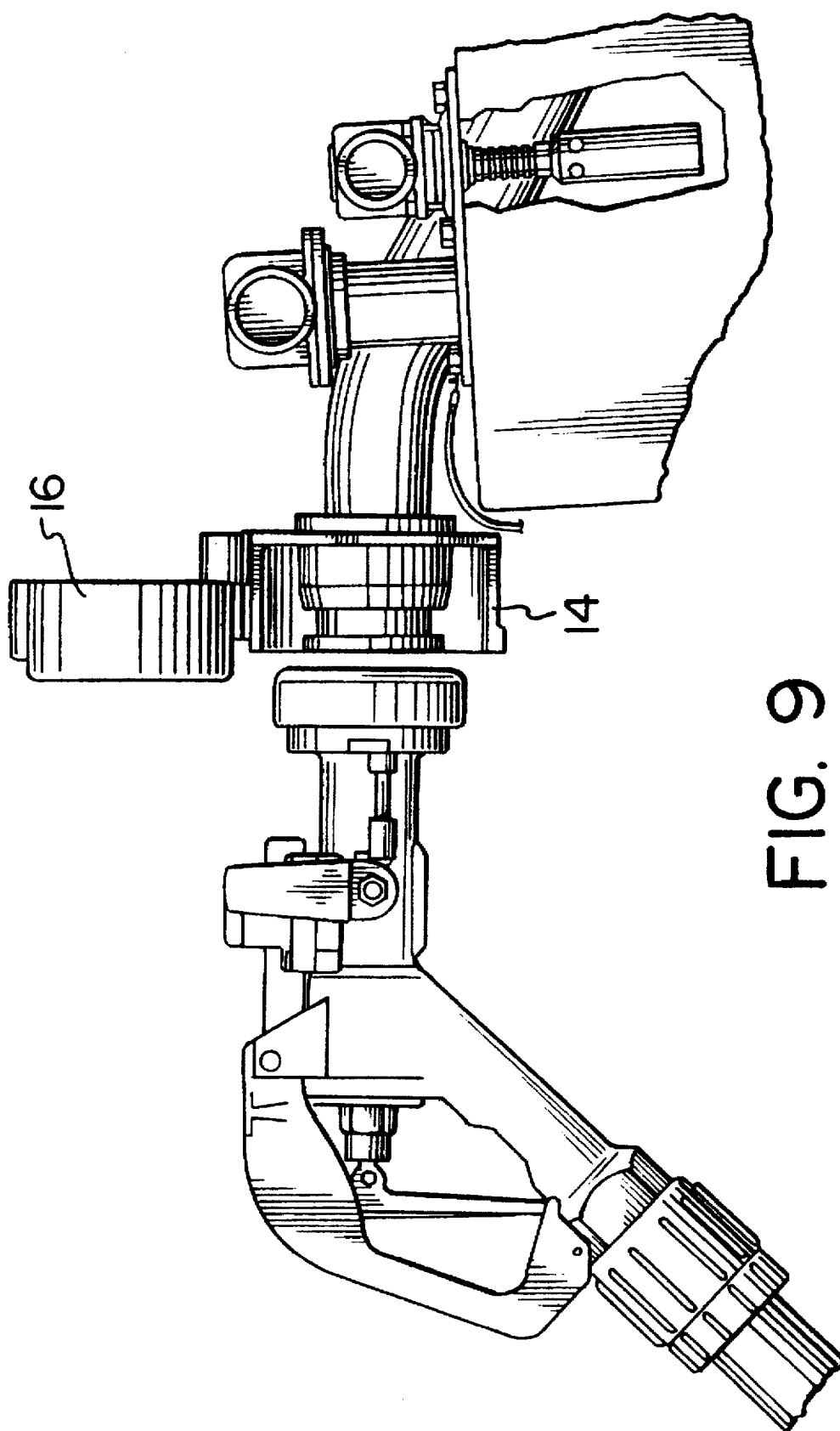


FIG. 8C



CAP AND SHIELD ASSEMBLY

FIELD OF THE INVENTION

The present invention relates to the field of fluid transfer systems and in particular to a cap and shield assembly for a fluid conduit coupler, and more particularly for a coupler having a dry-break interface.

BACKGROUND OF THE INVENTION

Certain fluid conduits and particularly those for transferring flammable or other hazardous fluids, such as fuel, pose potential safety and environmental hazards in the event of leakage from the fluid conduit. For example, in the refuelling of fleet vehicles, such as buses and trucks, it is desirable to deliver fuel at a high flow rate to reduce the time required for refuelling. However, there is a potential safety and environmental hazard if fuel spills from the fuel tank, for example by overflowing, or if fuel escapes from the fuel nozzle when it is not inserted into the fuel tank. There is also a danger that fuel may foam or splash out of the tank during refuelling, especially at high flow rates.

Accordingly, it is recognized that couplers between fluid conduit sections should be capable of coupling and uncoupling while preventing fluid leakage. Such couplers are frequently referred to as "dry-break couplers" and are provided with valves which must be closed before the couplers can be disconnected and which cannot be operated until the couplers are connected. In this way, dry-break couplers inhibit leakage of fluid, for example fuel, from a nozzle and/or a fluid reservoir.

U.S. Pat. No. 5,078,170 (Jan. 7, 1992, Emco Wheaton, Inc.) relates to a coupler for a fluid conduit. The coupler is a dry-break coupler and is specifically constructed so as to be locked in coupled relation when liquid and other fluids flow therethrough. A valve in the coupler must be closed to prevent leakage before uncoupling can be effected. The dry-break mechanism is described in detail in U.S. Pat. No. 5,078,170, the disclosure of which is incorporated herein by reference.

An example of a suitable positive nozzle connector is the POSI/LOCK-105® (Emco Wheaton, Toronto, Canada) automatic fuelling system. The POSI/LOCK-105® system has a nozzle with a bumper ring a popper valve and an interlock plate. In operation, the nozzle is connected to the coupler such that an interface in the coupler engages the interlock plate in the nozzle. The poppet valve of the nozzle is then actuated and a corresponding poppet valve in the dry-break coupler is thus opened. The fuel lever can then be operated and fuel can be transferred to the fuel tank. To disengage the nozzle, the popper lever is released and the dry-break seals in the nozzle and the coupler provide a spill-free disconnection.

It will be appreciated by those skilled in the art that the connection between couplers of the dry-break coupler system is dependent on a good connection between the interface plates of the couplers. It is therefore important that the interface in the coupler be kept free of debris. To this end, the prior art coupler has been provided with a dust cap which is attached by a chain to the coupler assembly, as shown in U.S. Pat. No. 5,078,170. It is not necessary that the dust cap provide a fluid-tight seal since the dry-break interface in the coupler already serves this function. Unfortunately, in the experience of the present applicant, operators find the dust cap inconvenient to use and the dust caps therefore tend not to be used. The applicant has also found that since the dry-break seal provides a liquid-tight seal, operators are not

concerned about fuel leaking from the tank or nozzle and tend not to be concerned with replacing the dust cap over the coupler after refuelling. Furthermore, the chain is prone to breakage so that the dust cap may be lost in transit. In either case, the coupler interface is exposed and is not protected from debris, especially when the vehicle is in transit.

It is an object of the present invention to provide a cap and shield assembly to protect a fluid conduit coupler from debris.

It is another object of the present invention to provide a cap and shield assembly for retrofit to an existing fluid conduit coupler.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided a cap and shield assembly for a fluid conduit coupler, comprising a shield and a cap hingedly connected to the shield. The shield and the cap are arranged such that when the cap is in a closed position, the fluid conduit coupler is protectively disposed therebetween, and when the cap is rotated from a closed position to an open position, the coupler is exposed. The cap and shield assembly also comprise cam means for positively retaining the cap in the closed position and for moving the cap vertically away from the coupler and the shield when the cap is rotated from the positively closed position to the open position.

According to another aspect of the present invention, there is provided a kit for retrofit to a coupler for a fluid conduit, comprising a shield and a cap adapted to be hingedly connected to the shield. The retrofit fluid conduit coupler is protectively disposed between the shield and the cap when the cap is in a closed position and is exposed when the cap is rotated from a closed position to an open position. The kit also comprises cam means adapted for positively retaining the cap in the closed position and for moving the cap vertically away from the coupler and the shield when the cap is rotated from the positive closed position to the open position.

BRIEF DESCRIPTION OF THE DRAWINGS

In drawings which illustrate embodiments of the present invention,

FIG. 1 is a top plan view of one embodiment of a cap and shield assembly of the present invention wherein the cap and shield assembly is shown with a cap in the open position;

FIG. 2 is a side elevational view of the cap and shield assembly of FIG. 1 with the cap in the positive closed position;

FIG. 3 is an exploded view of the cap and shield assembly of FIG. 1;

FIG. 4 is a top plan view of a unitary structure of the coupler and shield of FIG. 1;

FIG. 5 is a cross-sectional view of the unitary structure of FIG. 4 along the A—A;

FIG. 6 is a top plan view of the cap of FIG. 1;

FIG. 7 is a side elevational view of the cap of FIG. 6;

FIG. 8A is a side elevational view of a cam bushing according to the present invention;

FIG. 8B is a bottom plan view of the cam bushing of FIG. 8A;

FIG. 8C is a cam profile of the cam bushing of FIG. 8A; and

FIG. 9 is an illustration of an existing coupler adapted with the cap and shield assembly of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, a cap and shield assembly 10 for a fluid conduit coupler 12 has a shield 14 and a cap 16. The cap 16 is hingedly connected to the shield 14 so that the cap 16 can be moved between a positive closed position as shown in FIG. 2 and an open position as shown in FIG. 1. In accordance with the present invention, the cap 16 is readily movable from the closed position to the open position and back again so that operators will be inclined to use the cap 16 for its intended purpose of protecting the fluid conduit coupler 12. In the case of a dry-break coupler, the shield 14 and the cap 16 coact to protect the coupler interface (not shown) from debris.

As shown more clearly in FIG. 3, the cap 16 and the shield 14 are held in position relative to each other with a shaft 18 which extends through a bore in a boss 22 of the cap 16 and a cam bushing 24 which is disposed in a bore in a boss 26 of the shield 14.

The cam bushing 24 is illustrated in more detail in FIGS. 8A and 8B. One end of the cam bushing 24 has a flange 28 to abut against the shield 14. Preferably, the flange 28 has a flat region 25 to abut against a corresponding flat portion 27 (shown more clearly in FIG. 4) on the shield 14 to rotationally position the cam bushing 24 relative to the shield 14. The other end of the cam bushing 24 has a contoured cam surface. The cam profile of the cam bushing 24 of FIGS. 8A and 8B is illustrated more clearly in FIG. 8C. Preferably, the cam bushing 24 is held in position vertically relative to the shield 14 with a retaining screw (not shown) which extends through a radial bore in the boss 26 into an undercut 29. The shaft 18 is provided with a radial bore to receive a cross-pin 32 (shown more clearly in FIG. 3) which, when the cap 16 is in the closed position, is seated in the cam grooves 34. The facing end surface of the boss 22 of the cap 16 has a retaining groove 33 to engage the cross-pin 32. The shaft 18 is held in position at each end by a retaining device, such as a circlip, and is provided at least at one end with biasing means, such as one or more conical disc spring washers 36 (see FIG. 2) or a coil spring (not shown).

In the embodiment shown in the drawings, the cam bushing 24 is disposed in a bore in the boss 26 of the shield 14. However, it will be appreciated by those skilled in the art that the cam bushing 24 may also be disposed in a bore in the boss 22 of the cap 16.

Furthermore, it will be appreciated by those skilled in the art that the cam action could also be achieved by providing a cam surface on an end surface or in an intermediate groove of either the boss 22 of the cap 16 or the boss 26 of the shield 14. The advantage of using the present arrangement is that the pin 32 and bushing 24 can be made of hard material to reduce wear and to facilitate manufacture by machining, while the cap 16 and shield 14 may be made of less expensive softer materials.

With reference again to FIG. 8C, when the cap 16 is in the closed position (see FIG. 2), the cross-pin 32 is seated in opposing cam grooves 34. When the cap 16 is rotated away from the closed position, the cross-pin 32 follows the contour of the slope of the cam grooves 34 to a flat surface of the cam profile, moving the cap 16 vertically away from the coupler 12 and the shield 14. It will be understood by those skilled in the art that reference to vertical movement is relative to a horizontal plane defined by the base of the shield 14 and does not necessarily refer to the orientation of the cap and shield assembly 10.

Upon further rotation of the cap 16, the cross-pin 32 travels along the flat surface of the cam profile and is urged

into opposing cam grooves 38 by the spring washer 36. When the cross-pin 32 is seated in the cam grooves 38, the cap 16 is in a positive open position. Thus, in accordance with the present invention, the cam bushing 24 provides positive open and closed positions for the cap 16 by retaining the cross-pin 32 into the cam grooves 38 and the cam grooves 34, respectively.

In the embodiment shown in FIGS. 8A, 8B and 8C, the cam grooves 34, 38 are separated by an angle of 120° to provide a corresponding 120° angle opening of the cap 16 relative to the shield 14. The size of the angle is not important; however, a 120° angle has been found to provide sufficient room for an operator to manually engage the bumper ring of a nozzle, such as the POSI/LOCK-105®, described hereinbefore. The positive open position of the cap 16, relative to the positive closed position, is preferably at an angle in the range of from about 90° to 180° and more preferably in the range of from about 110° to 130°.

In the embodiment depicted in the drawings, the cam follower is a cross-pin 32 extending through the shaft 18. However, it will be appreciated by those skilled in the art that other cam follower arrangements are possible without departing from the scope of the present invention. For example, a cam pin may extend outwardly from the shaft on only one side thereof. In this case, only one cam groove would be required to lock the cap 16 in the positive closed position.

It will also be appreciated by those skilled in the art that the cam profile may also be changed without departing from the scope of the present invention. For example, there could be only two grooves separated by an angle of 180°. In this case, one end of the cross-pin 32 rests in a first of the two grooves in the positive closed position and sits in the second of the two grooves in the positive open position.

While it is preferable to have both positive open and closed positions for the cap 16, it is not necessary for the open position to be positive. In this case, the operator holds the cap 16 open during the coupling and uncoupling steps and the cap 16 rests against the coupled fluid conduits during fluid transfer. The biasing spring washer and the cam surface urge the cap 16 into a positive closed position once decoupled.

Referring now to FIGS. 4 and 5, the shield 14 has a shroud 42 which extends around a portion of the shield 14. The coupler 12 is of a known construction, for example as described in U.S. Pat. No. 5,078,170. The cap and shield assembly of the present invention is particularly suited for protecting a coupler which is provided with a dry-break seal and valve (not depicted in the drawings). In FIGS. 4 and 5, the coupler 12 and the shield 14 are formed as a unitary structure adapted for subsequent attachment to a fluid conduit flange (not shown).

However, it will be appreciated by those skilled in the art that the coupler 12 can be fastened to a separate shield 14 for subsequent attachment to a filler neck flange. It will therefore be appreciated by those skilled in the art that the cap and shield assembly 10 of the present invention could be supplied as a complete unit for new installations or as a kit for retrofit to an installed coupler, as illustrated in FIG. 9.

Referring now to FIGS. 6 and 7, the cap 16 is provided with a shroud 44 which extends around a portion of the cap 16. When the cap 16 is in the closed position, the shroud 42 of the shield 14 and the shroud 44 of the cap 16 coact to protect the coupler 12 and in particular the coupler interface (not shown) from contamination by road/environmental debris.

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While it is not necessary to provide a fluid-tight seal between the cap 16 and the shield 14 or the cap 16 and the coupler 12, it may be advantageous to provide such a seal to further protect the coupler interface from the environment. Such a seal may be effected, for example, with a gasket.

It may also be desirable to have the capability to lock the cap into position relative to the shield to protect the coupler and/or the fluid conduit or reservoir from tampering. This can be readily effected in the cap and shield assembly of the present invention in a conventional manner.

The cap and shield assembly is particularly suitable for mounting on the fuel tanks of fleet vehicles, such as buses and trucks, off-road vehicles, construction equipment, locomotive and marine vehicles. The cap and shield assembly may also be used to protect the interface of a fuel nozzle.

It will be apparent from reading this description of preferred embodiments that many modifications or alterations may be made without departing from the spirit and scope of the invention as defined in the following claims, which are meant also to encompass all equivalent forms of the invention as would be apparent to a person skilled in the art.

We claim:

1. A cap and shield assembly for a fluid conduit coupler, comprising:

a shield and a cap hingedly connected to the shield, the shield and the cap being arranged such that when the cap is in a closed position, the fluid conduit coupler is protectively disposed therebetween, and when the cap is rotated from a closed position to an open position, the coupler is exposed; and

cam means for positively retaining the cap in the open and closed positions and for moving the cap vertically away from the coupler and the shield when the cap is rotated from the positive closed position to the open position.

2. A cap and shield assembly according to claim 1, wherein the coupler and the shield are formed as a unitary structure.

3. A cap and shield assembly according to claim 1, wherein the cam means has a cam profile which also provides a positive open position for the cap relative to the shield.

4. A cap and shield assembly according to claim 3, wherein the positive open position of the cap is at an angle in the range of from about 90° to 180° relative to the positive closed position.

5. A cap and shield assembly according to claim 3, wherein the positive open position of the cap is at an angle in the range of from about 110° to 130° relative to the positive closed position.

6. A cap and shield assembly according to claim 3, wherein the positive open position of the cap is at an angle of about 120° relative to the positive closed position.

7. A cap and shield assembly according to claim 1, wherein the cam means is a cam bushing which coacts with a cam follower on a hinge shaft.

8. A cap and shield assembly according to claim 7, wherein the cam bushing is disposed in the shield.

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9. A cap and shield assembly according to claim 7, wherein the cam bushing is disposed in the cap.

10. A cap and shield assembly according to claim 7, wherein the cam follower is a cross-pin which extends through the hinge shaft.

11. A cap and shield assembly according to claim 1, wherein the cap and the shield are provided with shrouds which coact in the closed position to protect the coupler.

12. A cap and shield assembly according to claim 1, further comprising means for providing a seal between the coupler and the cap.

13. A cap and shield assembly according to claim 1, further comprising means for providing a seal between the shield and the cap.

14. A kit for retrofit to a coupler for a fluid conduit, comprising:

a shield and means for mounting the shield around the coupler;

a cap hingedly connected to the shield, so as to arrange the shield and cap such that when the cap is in a closed position, the fluid conduit coupler is protectively disposed therebetween, and when the cap is rotated from a closed position to an open position, the coupler is exposed; and

cam means for positively retaining the cap in the closed position and for moving the cap vertically away from the coupler and the shield when the cap is rotated from the positive closed position to the open position.

15. A kit according to claim 14, wherein the cam means has a cam profile which provides a positive open position for the cap relative to the shield.

16. A kit according to claim 15, wherein the positive open position of the cap is at an angle in the range of from about 90° to 180° relative to the positive closed position.

17. A kit according to claim 15, wherein the positive open position of the cap is at an angle in the range of from about 110° to 130° relative to the positive closed position.

18. A kit according to claim 15, wherein the positive open position of the cap is at an angle of about 120° relative to the positive closed position.

19. A kit according to claim 14, wherein the cam means is a cam bushing for coacting with a cam follower on a hinge shaft.

20. A kit according to claim 19, wherein the cam bushing is disposed in the shield.

21. A kit according to claim 19, wherein the cam bushing is disposed in the cap.

22. A kit according to claim 19, wherein the cam follower is a cross-pin extending through the hinge shaft.

23. A kit according to claim 14, wherein the cap and the shield are provided with shrouds which coact in the closed position to protect the coupler.

24. A kit according to claim 14, further comprising means for providing a seal between the coupler and the cap.

25. A kit according to claim 14, further comprising means for providing a seal between the shield and the cap.

* * * * *

EXHIBIT 1006

[54] DUAL FUEL SYSTEM

[75] Inventor: John E. Hallberg, Peachtree City, Ga.

[73] Assignee: PetroSystems International, Inc., Nashville, Tenn.

[21] Appl. No.: 239,005

[22] Filed: Feb. 27, 1981

[51] Int. Cl.³ F02B 43/00; F02M 21/04

[52] U.S. Cl. 123/527; 123/577; 48/180 C; 261/16; 261/44 C

[58] Field of Search 123/525, 527, 577; 48/180 C, 180 R, 184; 261/16, 41, 44 C

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Primary Examiner—Charles J. Myhre

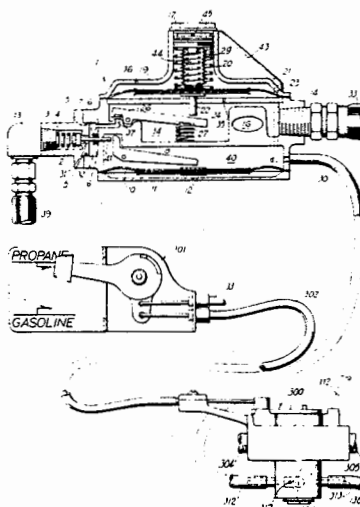
Assistant Examiner—E. Rollins Cross

Attorney, Agent, or Firm—L. Lawton Rogers, III

[57] ABSTRACT

A dual fuel system for use with internal combustion engines comprising a manually actuated dual fluid valve which alternatively supplies gasoline to the engine's carburetor or engine intake manifold vacuum to a single-stage liquified gas to gaseous fuel converter having a liquified fuel inlet valve actuated in response to intake manifold vacuum by a diaphragm of substantially the same diameter as a second diaphragm which actuates a valve to a converter gaseous expansion chamber where desired gaseous pressure is maintained and is automatically reduced during cruise conditions by compression of a bellows which acts on the second diaphragm in response to reduced engine intake manifold pressure during such cruise conditions, and a pressurized gaseous fuel and air mixer having a plunger structure responsive to venturi vacuum which meters air flow and actuates a valve needle to meter fuel flow. One alternative preferred embodiment of the mixer employs a relatively large piston which travels a relatively short distance within a cylinder and meters flow of air between the lower surface of the piston and a coaxial annular surface defining a passage into which air flows between such surface and the piston together with fuel, which fuel flows into the fuel and air passage through the piston and through a fuel transfer tube that acts as a piston guide. A second alternative preferred embodiment of the mixer utilizes a smaller diameter piston which travels a relatively long distance and a substantially oval plunger which projects into a substantially rectangular air passage to meter air flow.

25 Claims, 14 Drawing Figures



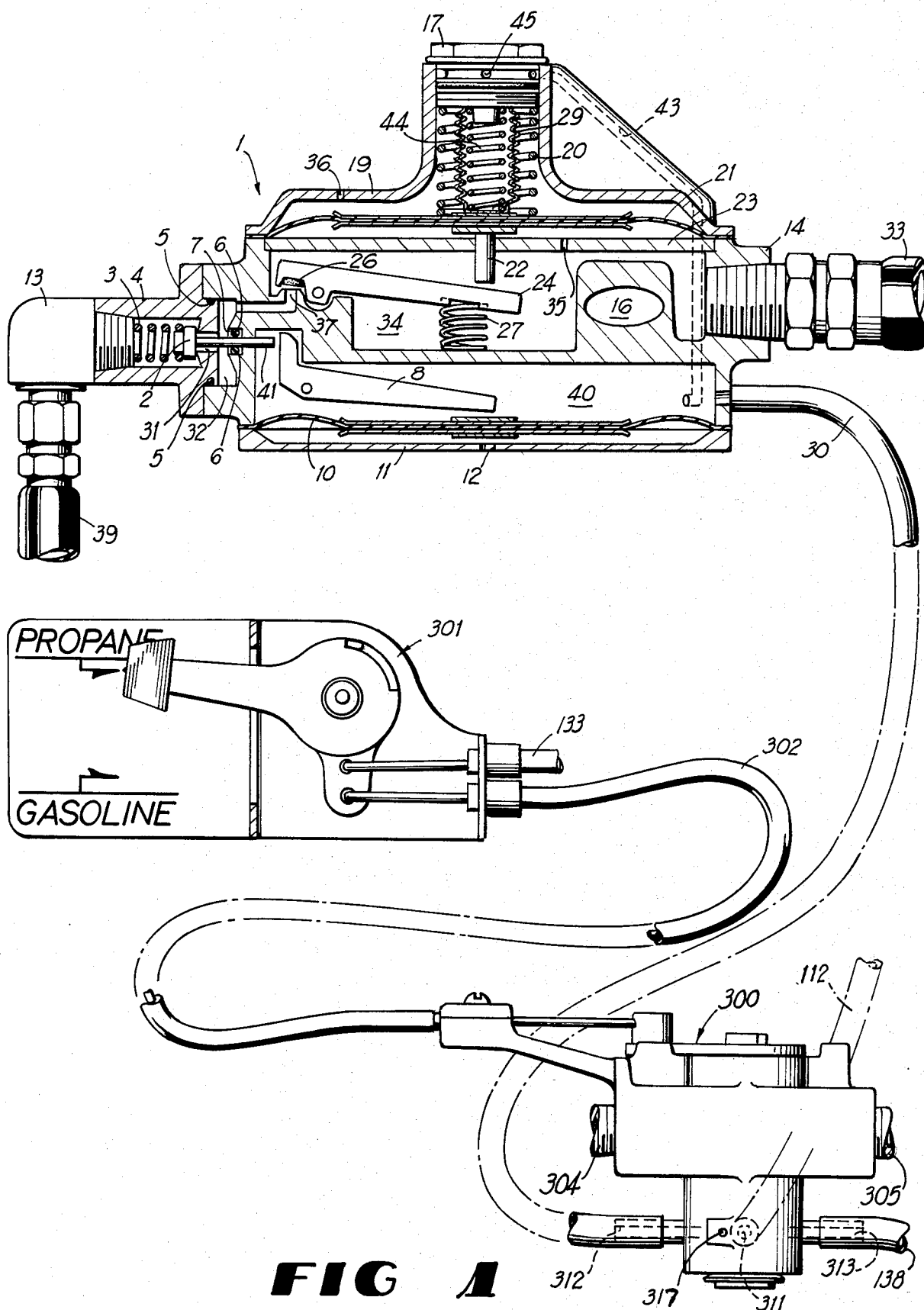


FIG 1

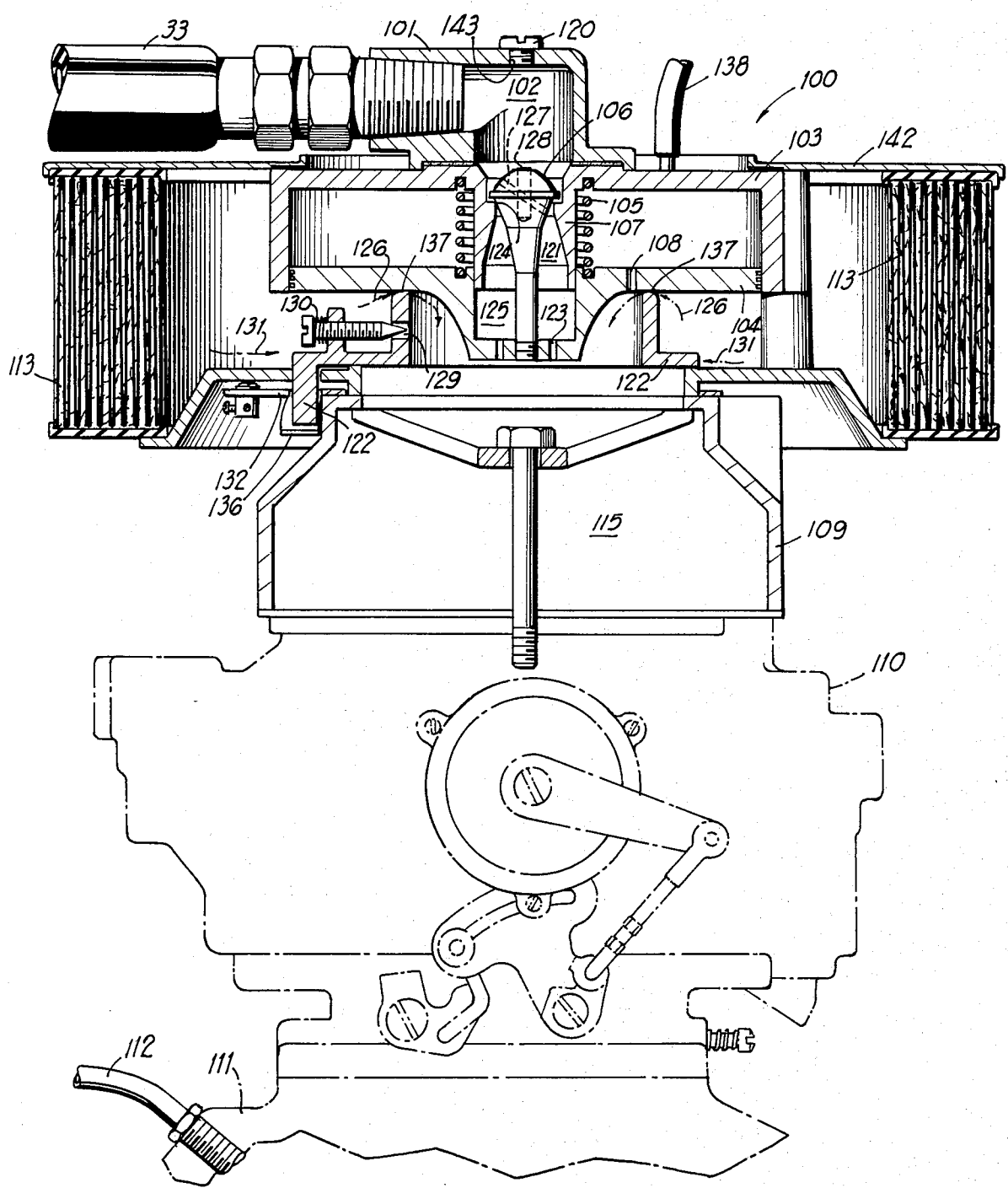
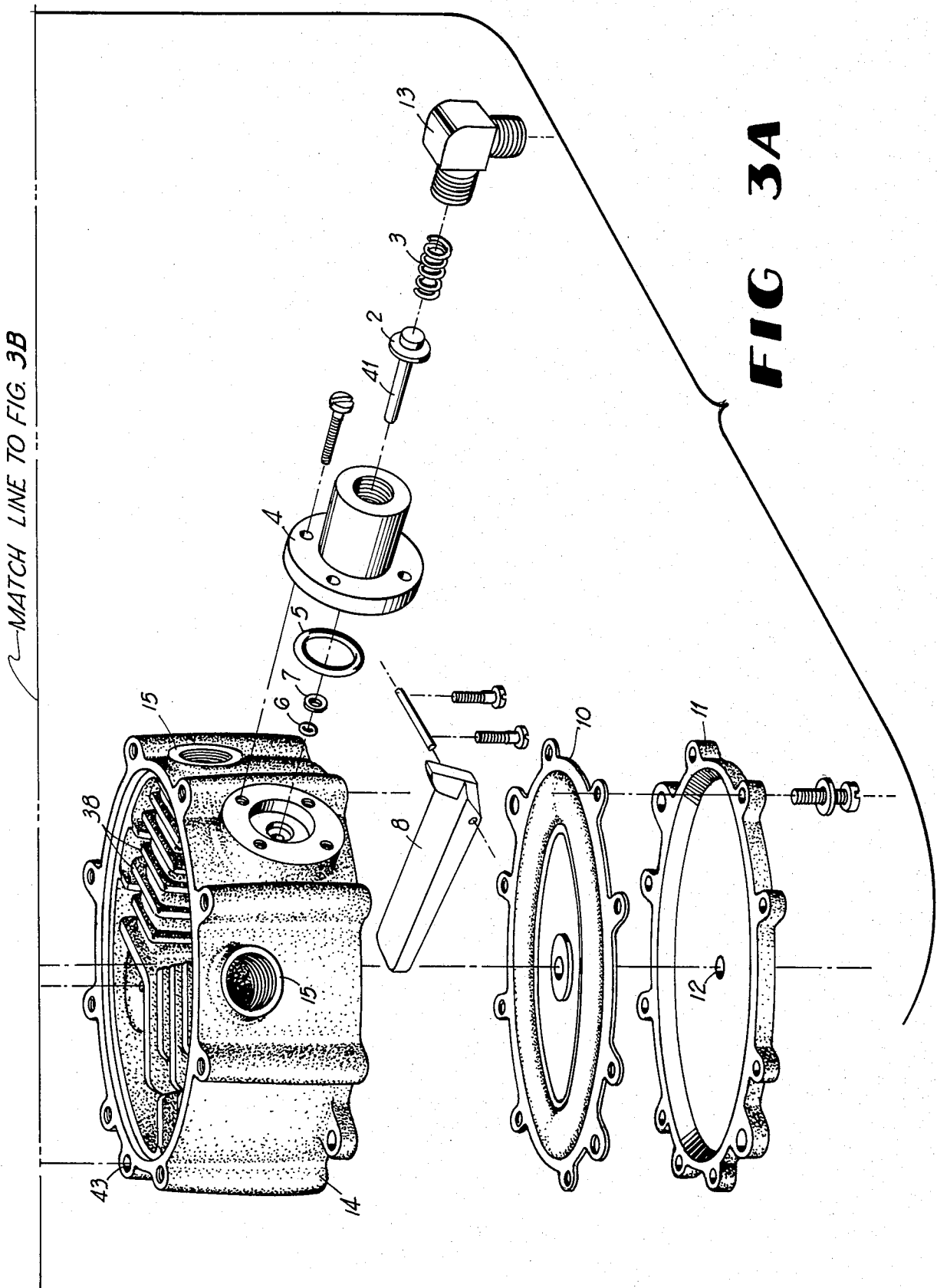


FIG 2



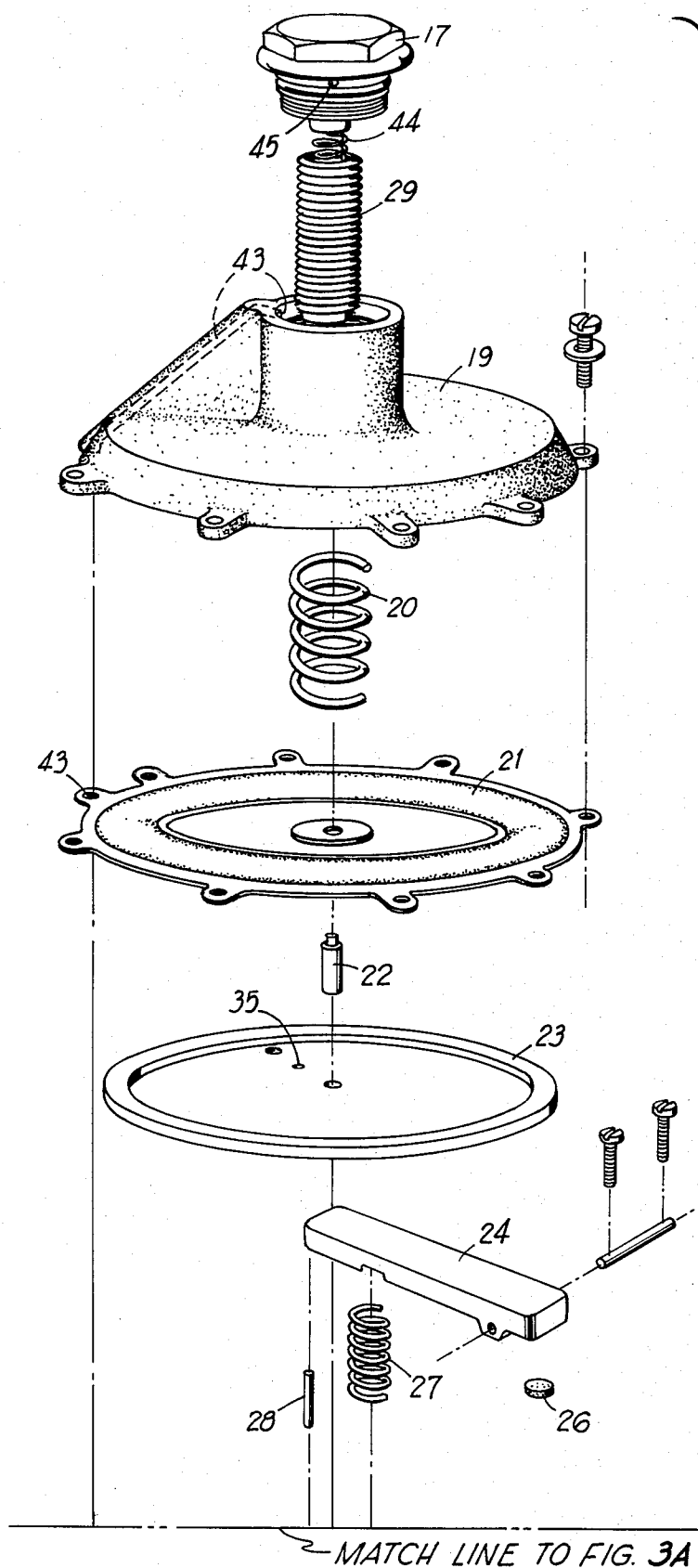


FIG 3B

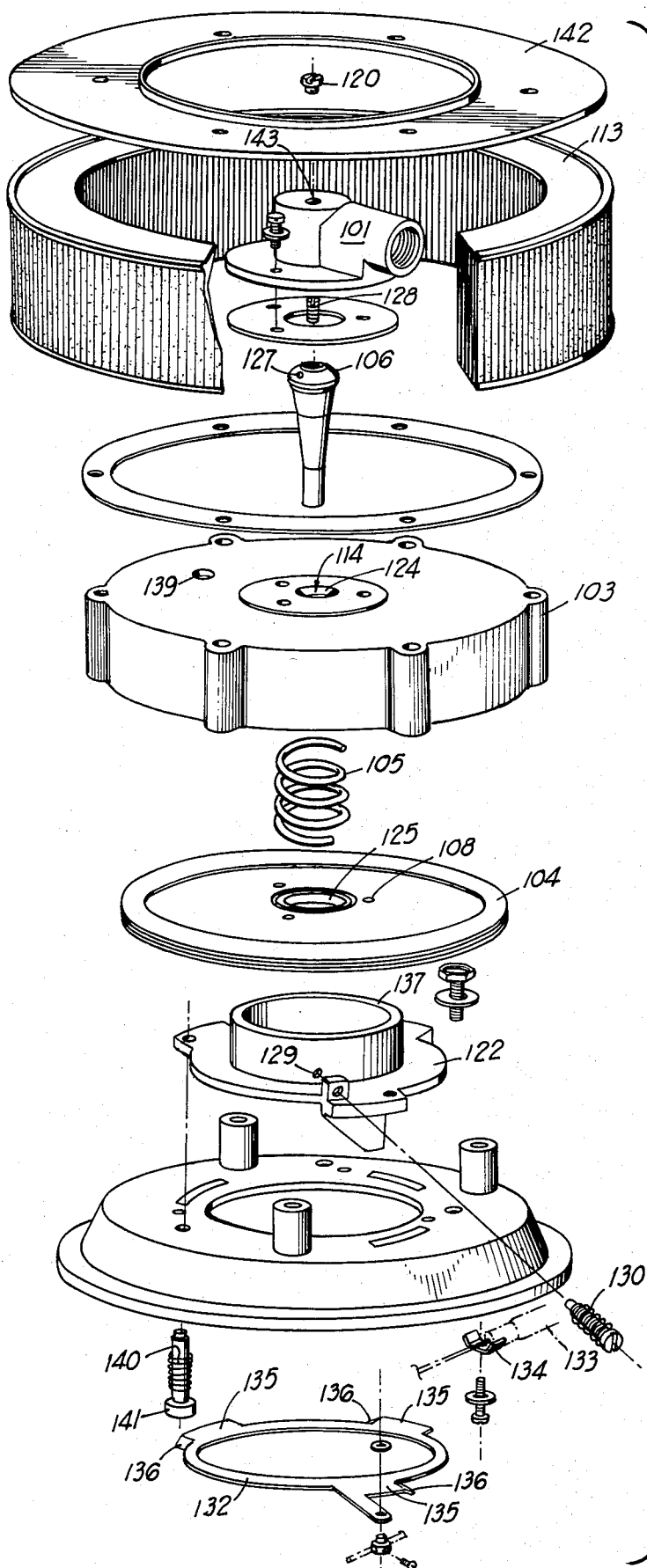


FIG 4

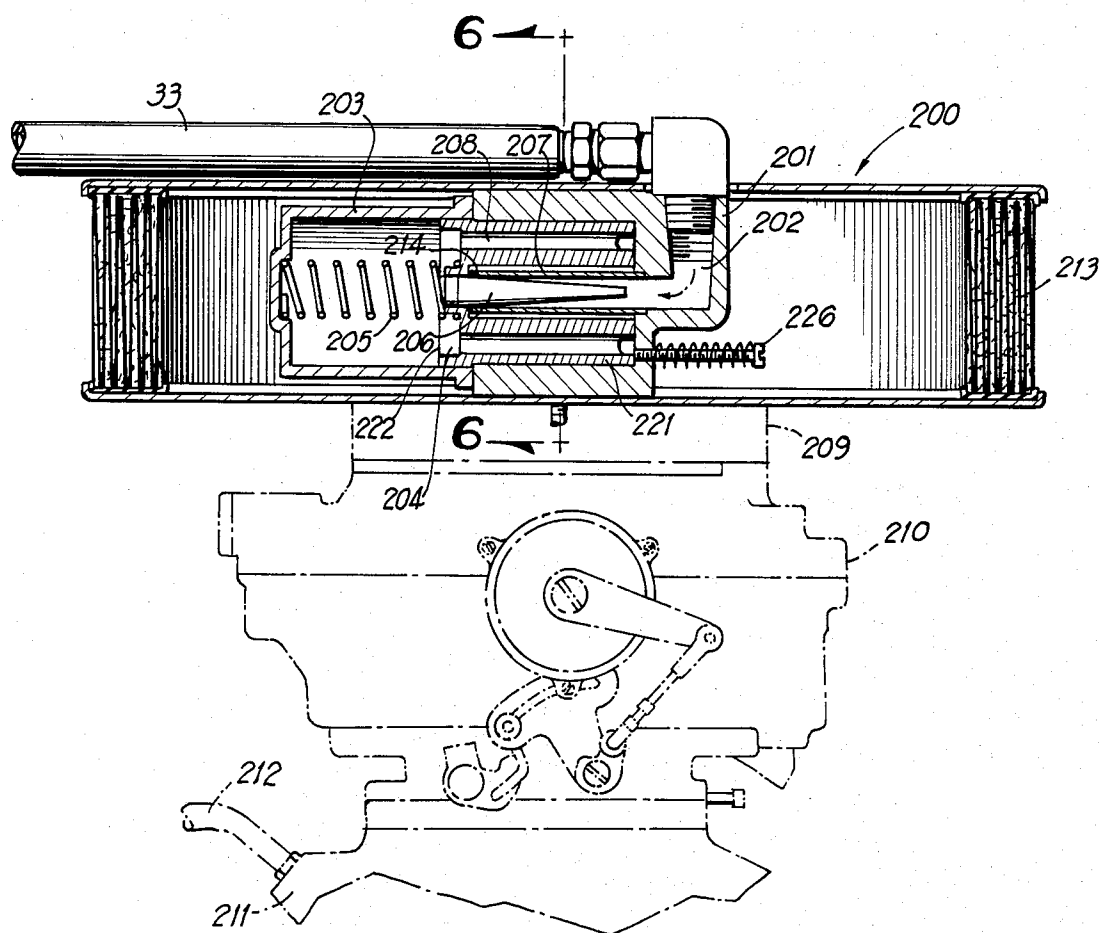


FIG 5

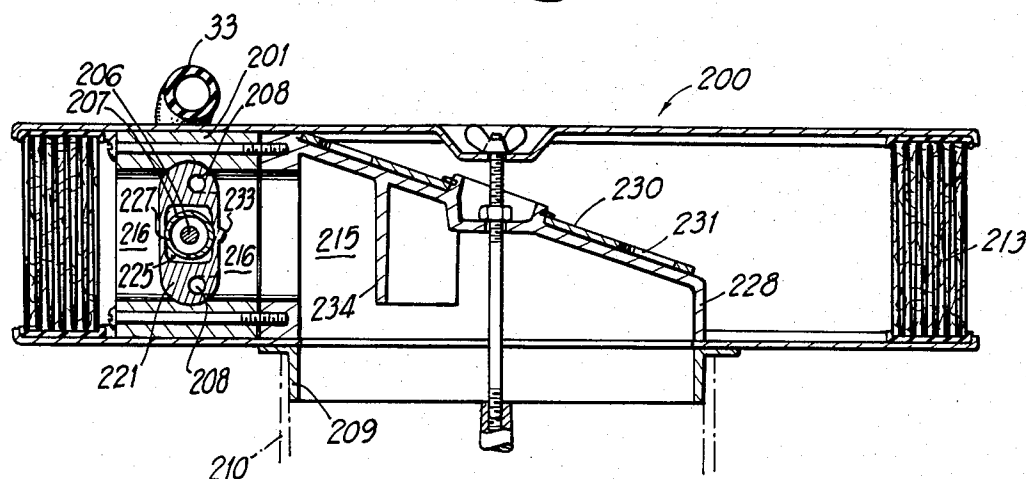


FIG 6

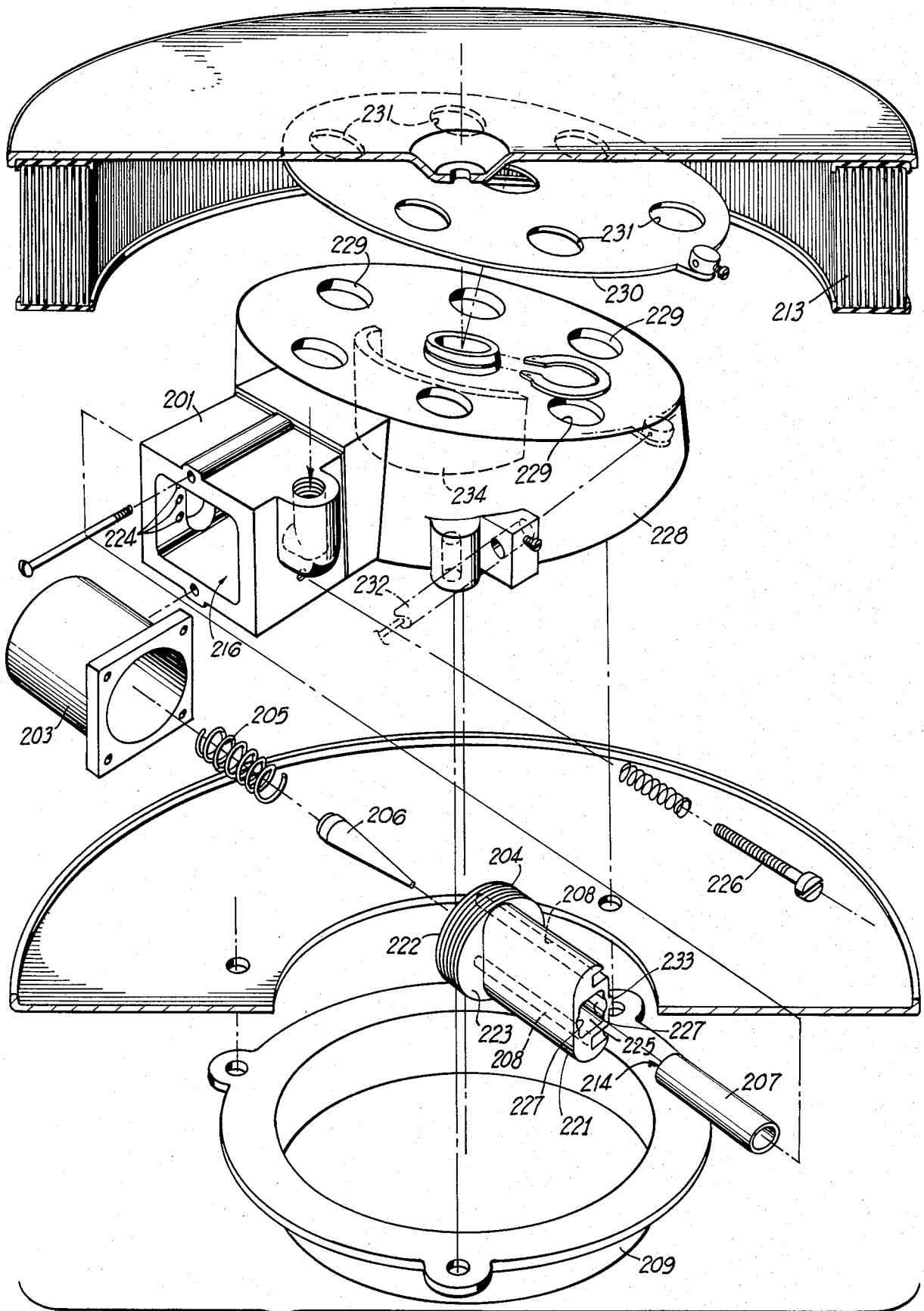


FIG 7

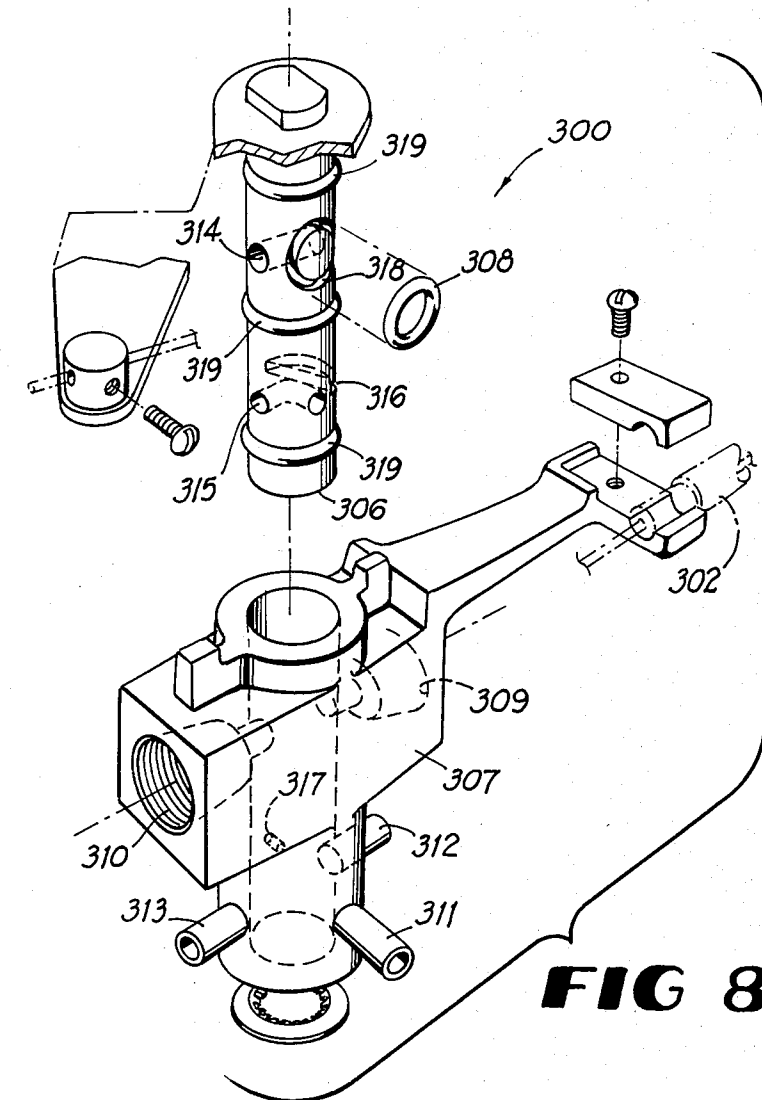


FIG 8

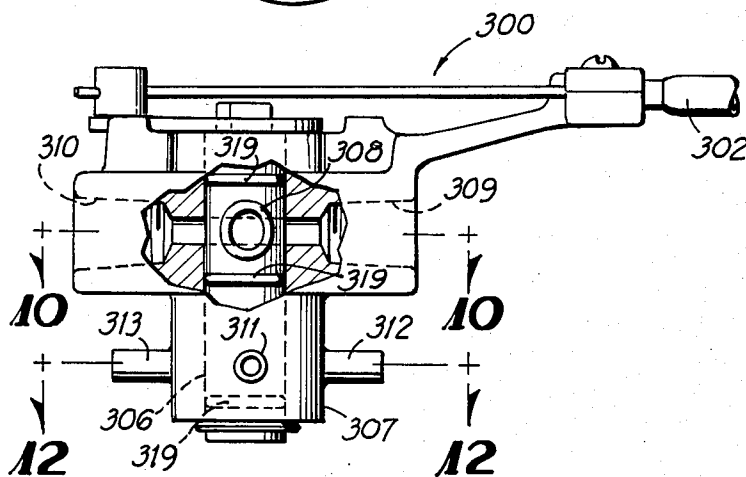


FIG 9

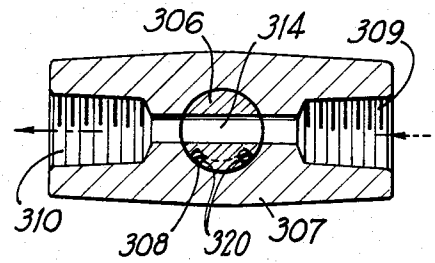


FIG 10

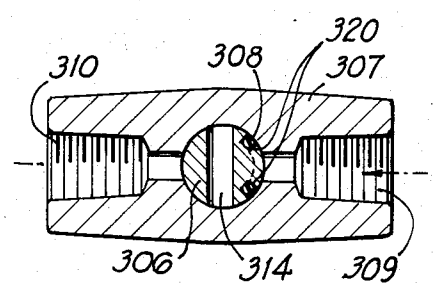


FIG 11

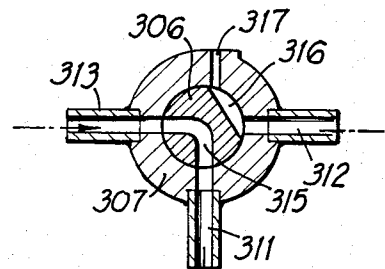


FIG 12

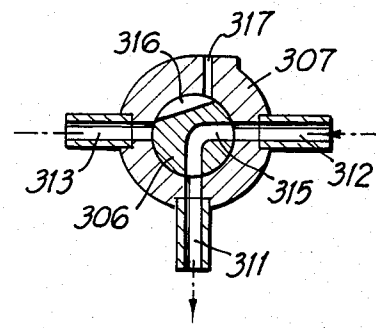


FIG 13

DUAL FUEL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a system for use with a conventional internal combustion engine, such as an automobile engine, to permit alternative utilization of a liquified gas fuel such as liquified petroleum gas, natural gas, hydrogen or propane and a liquid fuel such as gasoline, alternatively selectable by a manually operated control.

2. Description of the Prior Art

Dual fuel systems having manually actuated selection means are well known in the prior art. Illustrative of early dual fuel systems are the following U.S. Pat. Nos.

Number	Issued	Inventor
1,931,698	October 24, 1933	Holzapfel
1,970,425	August 14, 1934	Grabbe

Such systems for use with a liquid fuel and a liquified gas fuel typically consist of three principal elements: (a) a means for selecting the fuel to be utilized, (b) a liquified-to-gaseous fuel converter or vaporizer and (c) a gaseous fuel and air mixer or carburetor. Each of these principal elements will be addressed seriatim.

a. Fuel Selection Means

Most conventional modern propane carburetion equipment utilizes electrically operated solenoid valves for alternative selection of fuels. One valve is normally in the liquid propane line running from the propane storage tank of the vehicle adjacent to the inlet to the propane converter or vaporizer, and another is in the gasoline line supplying the carburetor. Such solenoid valves are typically activated by a single pole double throw switch mounted where it may be conveniently operated by the driver to permit alternative selection of propane or gasoline. Such electrically operated solenoid valves are typically the weakest link in conventional dual fuel carburetion systems. They frequently do not work well in the environment of the engine, and it is difficult to locate a reliable voltage source in the vehicle's electrical system which is the right voltage, is available during engine starting and does not affect the ignition system.

At least one prior art dual fuel system utilizes a vacuum operated solenoid valve in the propane portion of the system but retains an electrically operated solenoid valve in the gasoline portion of the system.

b. Converters

Liquified petroleum gas, propane and the other "gaseous" fuels with which the present invention is intended to be used are normally held for use in a reservoir or tank under sufficient pressure and at a temperature such that the fuels are in a liquid state. Thus, such fuels are referred to as "liquified gas" fuels. Conversion of such liquified fuel to a gaseous state at a pressure and temperature usable by conventional internal combustion engines must be accomplished in a converter structure which is accordingly denominated a "liquified gas to gaseous fuel converter" or a "liquified-to-gaseous fuel converter."

Most conventional liquified gas to gaseous fuel converters are of the two stage variety comprising a relatively small diameter first stage, or primary, diaphragm

within a chamber warmed by hot engine coolant liquid, which primary diaphragm controls a normally open inlet valve, and a large diameter second diaphragm which controls a normally closed valve.

U.S. Pat. No. 3,528,787, for "Fuel Carburation Apparatus," assigned to the same assignee as the instant application, disclosed a liquified-to-gaseous fuel converter structure comprising a single diaphragm responsive to engine venturi vacuum which actuates an inlet valve. The present invention improves upon the converter element of that patent and conventional converter structures.

c. Mixers

Early propane mixers consisted simply of a tube affixed in the existing gasoline carburetor at a point where the venturi narrows. These so called "spud ins" were acceptable during a period when gasoline and propane were very inexpensive. Subsequent development was directed toward design of a separate propane venturi, and designs for a separate venturi and separate idling system were developed. However, as one skilled in the art will appreciate, a venturi is not very effective as a metering device when air flow is low and slow. Furthermore, a venturi typically has a narrow control range such that it is difficult to design a venturi which will satisfy both low speed and high speed conditions. Accordingly, an ideal system would incorporate a separately engineered venturi for each speed of air flow.

Several mixer designs have been directed to a variable venturi which used a tapered plug device in the opening of the carburetor, with the plug moving up and down in response to variations in air flow. Inherent limitations in such "variable venturi" or "air valve" carburetors are present due to the weight of the plug and short distance of travel. Typically all engine operation conditions must be accommodated within approximately five-eighths of an inch (15.9 millimeters) of plug travel. Additionally, such designs exhibit hysteresis problems and relatively poor fuel economy characteristics. Thus, such problems weigh against the utilization of the variable venturi.

The mixer structures disclosed in U.S. Pat. No. 3,528,787 and utilized in similar "SU" type carburetors employ a plunger structure comprising a round piston acted on by venturi vacuum and atmospheric pressure and a smaller round piston or plunger which variably obstructs air flow through an air passage and from which extends a needle positionable in a fuel orifice on the side of the air passage opposite the plunger structure. Such projection of the needle from the plunger results in a relative large mixer structure.

Another prior art mixer utilizes a relatively large diaphragm to regulate air flow and to move a valve needle to cooperate with an orifice in a mixer structure somewhat similar to one embodiment of the mixer of the present invention.

It is therefore an object of the present invention to overcome the problems associated with prior art dual fuel systems.

It is yet another object of the present invention to provide a dual fuel system adaptable for use with original equipment or for addition to existing equipment, which system fills a need for alternatively selectable fuel provision means.

It is a further object of the present invention to provide a dual fuel system having a mixer which can ac-

commodate relatively large variations in the manufacturing tolerances of its parts.

It is a further object of the present invention to provide a dual fuel system which assists in compliance with strict emission control standards for internal combustion engines by providing for utilization of inherently clean burning propane in conventional vehicles.

It is a further object of the present invention to provide a dual fuel system having a gaseous fuel mixer and to provide a mixer having positive fuel control while minimizing hysteresis.

It is a further object of the present invention to provide a dual fuel system having a liquified gas to gaseous fuel converter in which the converter has a valving structure on which undue pressure is not exerted by the valve actuator when the valve is in the closed position.

It is a further object of the present invention to provide a dual fuel system having a liquified gas to gaseous fuel converter with the converter adapted to operate at very low manifold vacuum pressures such as those experienced during engine starting in cold climates.

It is a further object of the present invention to provide a dual fuel system having a liquified gas to gaseous fuel converter which automatically self adjusts to provide an "economy" fuel mixture during cruise conditions.

It is a further object of the present invention to provide a dual fuel system having a liquified gas to gaseous fuel converter which has an inlet valve which positively locks off incoming fuel even if the inlet valve actuator diaphragm breaks.

It is a further object of the present invention to provide, in a dual fuel system, a positive acting means for selecting fuel which functions without the use of electricity.

It is a further object of the present invention to provide a dual fuel system having a gaseous fuel and air mixer which is easily adaptable to use with a variety of fuels, including liquified petroleum gas, propane, natural gas and hydrogen as well as other gases usable for combustion in internal combustion engines.

It is a further object of the present invention to provide a dual fuel system utilizing a mixer which is sufficiently compact to occupy substantially only the space within the air cleaner element on conventional engines.

SUMMARY OF THE INVENTION

The present invention achieves these and other objectives in a system which may be used with conventional internal combustion engines, such as automobile engines, to permit alternative utilization of a liquified gas fuel, such as liquified petroleum gas, propane, natural gas, hydrogen or other gases usable for combustion in internal combustion engines, and a liquid fuel, such as gasoline, alternatively selectable by a manually operated control. While other fuels may advantageously be utilized with the instant invention, for the purposes of the following description, it will be assumed that the fuels to be utilized are propane and gasoline unless otherwise indicated.

The system comprises generally: (a) a fuel selection means generally including a fluid dual valve which may be controlled by a remote control mounted, for instance, on the dashboard of an automobile, (b) a converter for converting the pressurized, liquified fuel, such as propane, to a gaseous state at desired pressures and temperatures and (c) a mixer for combining the pressurized gaseous fuel with air and delivery to the

conventional gasoline carburetor. Alternative embodiments of the mixer are disclosed. Operation of the dual fuel system is as follows.

Positioning of the fuel selection control in the "gasoline" mode results in opening the vacuum line connected to the converter to the atmosphere and a consequent absence of pressure differential between the two sides of the converter liquid inlet diaphragm and positive lock-off of the converter liquid inlet valve. With the control in such position, a valve in the gasoline line between the gasoline pump and conventional gasoline carburetor is "on," and the conventional carburetor functions in the normal fashion with air passing through the air filter and mixer and into the carburetor. Additionally, there may be optional provision in the "gasoline" mode for opening of the air passage within the mixer or an air bypass around the mixer to facilitate passage of air into the conventional carburetor.

When the "propane" mode is selected, the gasoline valve portion of the fuel selection means is "off," thereby preventing supply of gasoline to the carburetor, and the connection of a vacuum line between the intake manifold of the engine and the converter is completed. When the engine is started, engine intake manifold vacuum reduces the pressure on one side of the converter liquid inlet valve diaphragm, resulting in movement of the diaphragm against a liquid inlet valve lever as a result of atmospheric pressure on the opposite side of the inlet valve diaphragm. Movement of the inlet valve lever urges the liquid inlet valve open, thereby permitting liquid propane to enter a fuel passage in the converter. Propane is admitted through a second valve in the converter structure into a gaseous fuel chamber where it expands to a gas with the resulting gas pressure normally being regulated to 11 inches w.c. Such regulation is achieved by a second, or main, diaphragm which is spring biased on one side to actuate the gas valve and is urged by increased pressure within the chamber on the other side of the second diaphragm to allow the gas valve to close.

In the preferred embodiment, the liquified fuel inlet valve diaphragm is substantially the same size as the second, or main, diaphragm. Utilization of such a large inlet valve diaphragm results in very quick starting capability because relatively little drop in intake manifold pressure is required to activate the inlet valve. Such a small drop in manifold pressure at starting is common with the low engine starting speeds normally experienced during cold weather conditions.

Elevation of the temperature of the propane to encourage vaporization is achieved in a portion of the gaseous fuel chamber where fins are warmed by heat from engine coolant piped through the body of the converter. Such vaporization of the propane and elevation of its temperature is achieved primarily during cruise and medium speed operation of the engine. At higher speed operation, propane is elevated in temperature less, which is desirable since it is beneficial for an engine to run with cooler propane at higher speeds because the volumetric efficiency of the engine is thereby improved. Accordingly, the engine will run slightly richer at the wide open throttle position.

Conversely, during cruise conditions, engine coolant elevates the temperature of the propane, thereby increasing its volume and resulting in a leaner fuel mixture. Additionally, a duct from the engine manifold pressure chamber of the converter communicates with a bellows and bellows spring structure which is located

inside the second diaphragm spring such that the second diaphragm is biased by the bellows and bellows spring structure toward the gaseous fuel chamber. During cruise conditions, the engine intake manifold vacuum, which is between 7 inches h.g. and 20 inches h.g., causes the bellows to contract, thereby decreasing pressure on the second diaphragm, which in turn reduces the pressure in the gaseous fuel chamber from approximately 11 inches w.c. to approximately 8 inches w.c. This further reduces fuel flow during cruise conditions, thereby insuring a lean fuel mixture which is desirable for fuel economy during cruise conditions.

The mixer of the instant invention, which is shown and described in alternative embodiments, utilizes a plunger structure and tapered member or needle to meter fuel and air flow in response to engine demand. The plunger structure in the first embodiment is a relatively large round piston which provides a larger effective surface area than a diaphragm of the same diameter, thereby resulting in more effective fuel and air control because the ratio of piston surface areas subjected to pressure differentials is greater than the same ratio on similar diaphragm type mixers. In the second embodiment, the plunger structure is a smaller round piston with a projecting portion having a cross section which is substantially oval (e.g., of elongated cross section having two parallel sides and half-circular ends). In both embodiments the piston is actuated by atmospheric pressure and engine vacuum. Engine vacuum is communicated to the side of the piston away from the air passage while atmospheric pressure is maintained on the opposite side of the piston. Attached to the plunger structure is a needle which extends into an orifice thereby forming a needle valve fuel meter. Engine vacuum actuates the piston, which opens the needle valve and supplies a fuel and air mixture to the engine (through the conventional carburetor), thereby tending to increase pressure within the mixer, which results in stable piston positions and uniform fuel flow at various engine speeds.

In the first embodiment of the mixer of the present invention air flow is regulated by the distance between one face of a large round piston and an annular surface coaxial with the piston. Since the area of the "cross section" of the air passage in this embodiment is effectively the product of the diameter of the annular surface multiplied by the distance of the piston from that surface, a relatively large volume of air is admitted for a given increment of piston travel, and total piston travel can be relatively short, permitting design of a compact mixer. In the second embodiment of the present invention control of air flow is achieved, in part, by using an oval plunger which affords a greater ratio of air control surface area to surface area of the piston covered by the plunger than the ratio achieved in round plunger mixers. Thus the ratio of the area of the cross section of the air passage to piston diameter is relatively large, permitting a compact mixer.

In the second embodiment of the mixer of the present invention, unlike the structure disclosed in U.S. Pat. No. 3,528,787 and similar "SU" type carburetors, the valve needle is mounted entirely within a cavity in the plunger which controls air flow, and the needle projects into an orifice located at the end of a gaseous fuel passage formed by a fuel transfer tube also entirely within the plunger cavity (when the plunger fully occludes the air passage). Such structure provides a compact mixer while utilizing a very long needle to allow accurate

control of fuel flow, and the fuel transfer tube may be utilized as a guide for the plunger/piston structure, obviating the need for such a separate guide within the cylinder in which the piston travels or elsewhere. Such relatively long piston travel also substantially lessens any effect of hysteresis because the effect of any hysteresis which may be experienced is negligible by comparison to the total piston and needle travel.

The needle may also be mounted partially within a cavity in the piston in the second embodiment of the mixer of the present invention, and a fuel transfer tube acts as a piston guide, but there are certain structural differences between the two mixer preferred embodiments which will become apparent by reference to the drawings and detailed description which follows.

The foregoing and other objects and advantages of the present invention, as well as the details of an illustrative embodiment and alternatives thereto will be more fully understood from the following description of the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational partial cross-section of the converter assembly with schematized fluid dual valve and valve control means.

FIG. 2 is a side elevational cross section of a first embodiment of the mixer assembly shown mounted on a conventional carburetor.

FIG. 3A is an exploded perspective view of the body and lower portions of the converter assembly.

FIG. 3B is an exploded perspective view of the top and upper portions of the converter assembly with a portion of a duct 43 shown in dotted lines.

FIG. 4 is an exploded perspective view of the first embodiment of the mixer assembly.

FIG. 5 is a side elevational partial cross-section of the second embodiment of the mixer assembly shown mounted on a conventional carburetor.

FIG. 6 is an elevational cross-section taken along the lines 6—6 in FIG. 5 of the second embodiment of the mixer assembly.

FIG. 7 is an exploded perspective view of the second embodiment of the mixer assembly.

FIG. 8 is an exploded perspective view of the fluid dual valve assembly.

FIG. 9 is a side elevational view of the valve assembly shown in FIG. 8 with a portion of the valve body cut away to show a portion of the internal construction of the fluid dual valve.

FIG. 10 is a cross sectional view taken along lines 10—10 of FIG. 9 when the dual fluid valve is in a first, "gasoline on," position.

FIG. 11 is a cross sectional view similar to FIG. 10 with the valve spool rotated 90 degrees to a second, "propane on," position.

FIG. 12 is a cross sectional view taken along lines 12—12 of FIG. 9 when the dual fluid valve is in the first, "gasoline on," position.

FIG. 13 is a cross sectional view similar to FIG. 12 with the valve spool rotated 90 degrees to the second, "propane on," position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The converter and fuel selection means of the invention are shown in FIG. 1 and two alternative embodiments of the mixer portion of the invention are shown in partial section in FIG. 2 and in FIGS. 5 and 6. An ex-

ploded view of the converter assembly is shown in FIGS. 3A and 3B, an exploded view of the fluid dual valve is shown in FIG. 8 and exploded views of the alternative embodiments of the mixer portion of the invention are shown in FIGS. 4 and 7. In the figures, 1 is the liquified-to-gaseous fuel converter structure, 300 is the fluid dual valve structure and 100 and 200 are alternative embodiments of the mixer structure.

Operation of converter structure 1 and fluid dual valve structure 300 is the same, except as specifically indicated hereinafter, with mixer embodiment 100 and mixer embodiment 200, which are shown mounted on conventional carburetors 110 and 210 in FIGS. 2 and 5, respectively. Carburetors 110 and 210 are shown in FIGS. 2 and 5 mounted on engine intake manifolds 111 and 211, to which are connected intake manifold vacuum lines 112 and 212, respectively. Accordingly, mixer 100, carburetor 110, engine intake manifold 111, and intake manifold vacuum line 112 alone will hereafter be referred to in description of converter structure 1 and fluid dual valve structure 300, but it should be understood that such description is equally applicable to operation of converter structure 1 and fluid dual valve structure 300 with mixer 200, carburetor 210, engine intake manifold 211 and intake manifold vacuum line 212, respectively, unless otherwise specifically indicated.

Referring to FIGS. 1, 8 and 9, the fuel to be utilized is selected by positioning fluid dual valve control 301 in one of two positions, either "gasoline" or "propane." Positioning of control 301 in the "gasoline" mode acts through control cable 302 to rotate spool 306 within valve body 307 such that converter vacuum line 30 shown in FIG. 1 communicating with first vacuum outlet port 312 is open to the atmosphere through notch 316 in spool 306 communicating, as shown in FIG. 12, between first vacuum outlet port 312 and vent 317. The vent 317 communicates with the atmosphere when valve control 301 is in the "gasoline" mode. Simultaneously, gasoline from gasoline supply line 304 is supplied to the carburetor 110 through engine gasoline line 305, which lines communicate through tunnel 314 (see FIG. 10) connecting liquid inlet opening 309 and liquid outlet opening 310 in fluid dual valve 300. In this mode, the carburetor functions normally.

Liquid inlet diaphragm 10 in converter 1 is peripherally clamped between converter body 14 and converter base plate 11 such that the top side of diaphragm 10 is exposed to the pressure condition within converter vacuum line 30, which is atmospheric pressure during "gasoline" mode operation. The bottom side of liquid inlet diaphragm 10 is subjected to external atmospheric pressure at all times via converter base plate bleed 12.

Plunger-type liquified fuel inlet valve 2 is spring biased, as by liquid inlet spring 3, such that when pressure on opposite sides of liquid inlet diaphragm 10 is equal, liquid inlet lever 8 is not lifted, and the inlet valve 2 is closed.

Leakage of pressurized propane from supply 39 through inlet valve fitting 13 and into converter 1 is prevented by liquid inlet body O-ring 5 which creates a seal between liquid inlet body 4 and converter body 14. Sealing around liquified fuel inlet valve shaft 41 is provided by liquid inlet valve O-ring 6 which is held in place by liquid inlet valve O-ring retainer 7. Liquified fuel inlet valve 2 and the related structures of the present invention thus provide a "lock-off" of liquified gaseous fuel supplied to the converter 1 because the valve 2 will remain closed even if the integrity of converter

vacuum line 30 is broken or liquid inlet diaphragm 10 is ruptured.

When the "propane" mode of control 301 is selected, spool 306 is rotated within valve body 307 by control cable 302 such that O-ring 308 on the face of spool 306 forms a seal between spool 306 and valve body 307 around liquid inlet opening 309, as shown in FIG. 11, thereby prohibiting flow of gasoline to conventional carburetor 110 and preventing leakage of gasoline from gasoline supply line 304. Referring to FIG. 8, O-ring 308 is seated in a slot 318 milled into the face of spool 306. The walls of slot 318 are substantially parallel to the radius of the spool 306 at each incremental segment of the slot. Thus, as may be observed in FIGS. 10 and 11, opposing segments of the inner slot wall 320 proximate the greatest arc of the spool 306 oppose each other at an acute angle, as do the elements of the letter "V," and thereby capture the O-ring 308 and hold it in place in slot 318. Seal rings 319, which may be O-type rings, seated in circumferential slots (not shown) in spool 306, provide seals to the atmosphere and provide bearing surfaces which separate spool 306 from valve body 307.

Simultaneously, during "propane" mode operation, duct 315 within spool 306 is aligned to communicate with vacuum inlet port 311 and first vacuum outlet port 312, as is shown in FIG. 13, thereby connecting converter vacuum line 30 (shown in FIG. 1) through outlet port 312 and inlet port 311 to intake manifold line 112, which connects to engine intake manifold 111 shown in FIG. 2.

When the engine (not shown) is started, intake manifold starting vacuum, communicated to engine intake manifold pressure chamber 40 in converter 1 shown in FIG. 1 through lines 112 and 30 and fluid dual valve 300, creates a reduced pressure on the upper side of the liquid inlet diaphragm 10. Atmospheric pressure on the opposite (lower) side of diaphragm 10 urge diaphragm 10 upward against liquid inlet lever 8, the opposite end of which drives inlet valve shaft 41 against bias spring 3 and opens liquid inlet valve 2. Thus, liquified gaseous fuel flows through inlet valve orifice 31 into liquified fuel passage 32.

Pressure constantly exerted on the top side of main diaphragm 21 by a yieldable means, such as main diaphragm spring 20 and bellows 29 (more fully explained below) urges main diaphragm 21 against valve actuator stem 22, which in turn actuates fuel lever 24. Once actuated, fuel level 24 lifts fuel outlet cover 26, typically sponge, from fuel outlet 37, thereby permitting flow of fuel into gaseous fuel chamber 34. As pressure within gaseous fuel chamber 34 reaches that desired, the bias of spring 20 and bellows 29 is overcome and main diaphragm 21 moves upward, permitting fuel level 24 to seat fuel outlet cover 26 on outlet 37, thereby stopping flow of fuel into gaseous fuel chamber 34.

As the mixer 100 admits pressurized gaseous fuel to the engine, as will be more fully explained below, through gaseous fuel line 33 when the engine is being started or is running, the pressure within gaseous fuel chamber 34 of converter 1 is reduced. Such reduction of pressure is communicated to the lower side of main diaphragm 21 through opening 35 in guide plate 23. Consequently, main diaphragm 21 is urged downward by atmospheric pressure communicated to its top side through orifice 36 in converter top 19 and by the force exerted by main diaphragm spring 20 and optional bellows 29. Such downward movement again moves stem 22 against fuel lever 24, thereby lifting fuel outlet cover

26 from fuel outlet 37 and permitting additional flow of gaseous fuel into gaseous fuel chamber 34 to maintain the desired pressure. Stem 22, which acts as a valve actuator, is guided by guide plate 23 and contacts but is not connected to fuel lever 24 so that no force in addition to that exerted by fuel lever spring 27 is exerted on fuel lever 24 and fuel outlet cover 26 when main diaphragm 21 moves upward beyond the point at which fuel outlet cover 26 is fully seated. This prevents undesirable pressure on and compression of fuel outlet cover 26. Rotation of guide plate 23 within body 14 is prevented by guide plate pin 28 as shown in FIG. 3B.

The pressure of gaseous fuel within gaseous fuel chamber 34 is normally regulated to a pressure of approximately 11 inches w.c., achieved by selection of main diaphragm spring 20 and bellows 29 and bellows spring 44 to provide the desired pressure.

Fuel flowing into gaseous fuel chamber 34 is warmed by heat from a hot liquid, such as engine coolant, communicated to the fuel through fins 38 visible in FIG. 3A surrounding hot liquid coolant passage 16, through which engine coolant is circulated via hot liquid inlets 15, also shown in FIG. 3A. Such elevation of the temperature of the fuel is achieved primarily during cruise and medium speed operation of the engine. At higher engine speed operation, gaseous fuel passes through the converter so quickly that the temperature thereof is not significantly affected, which is desirable because it is beneficial for an engine to run with cooler gaseous fuel at higher speeds because secondary cooling by the fuel improves the volumetric efficiency of the engine. The engine thus runs slightly richer at wide open throttle since more fuel is contained in a given volume of fuel at lower gaseous fuel temperatures. Conversely, during cruise conditions, a lesser quantity of fuel is contained in a given volume of gaseous fuel as a result of elevation of the gaseous fuel temperature within converter 1, and a relatively leaner fuel mixture results.

Additionally, a duct 43 (shown in FIGS. 1 and 3B) communicating with engine manifold chamber 40, where engine manifold pressure is maintained, also communicates through passages 45 in converter cap 17 with a bellows 29, which is located inside the main diaphragm spring 20 and is biased against main diaphragm 21 by a means for yieldably forcing the bellows 29, such as bellows spring 44 inside of bellows 29. Thus, during cruise conditions, when the engine intake manifold pressure is between 7 inches h.g. and 20 inches h.g., bellows 29 contracts responsive to reduced intake manifold pressure, thereby decreasing the pressure on main diaphragm 21 and thus reducing the pressure level maintained in gaseous fuel chamber 34 from the normal level of approximately 11 inches w.c. Main diaphragm spring 20, bellows spring 44 and bellows 29 are selected to cooperate such that the pressure will be reduced in gaseous fuel chamber 34 during cruise conditions to approximately 8 inches w.c. This pressure reduction further reduces fuel flow to the mixer 100 during cruise conditions, thereby automatically providing for a lean fuel mixture (lower fuel-to-air mixture ratio) desirable for fuel economy during cruise conditions.

FIGS. 2 and 4 show section and exploded views, respectively, of a first alternative preferred embodiment of the mixer of the present invention, indicated by numeral 100 on FIG. 2. Mixer 100 includes, generally, (a) body structure including fuel inlet elbow 101, which forms a pressurized gaseous fuel passage 102, and cylinder 103 and (b) a plunger structure comprising piston

104 which moves within cylinder 103. Attached to piston 104 is needle 106 which cooperates with an orifice 114 above pressurized gaseous fuel passage 102 to form a needle valve-type structure which controls passage of pressurized gaseous fuel through valve passage 121 and into mixing chamber 115. Needle 106 may be removably attached to piston 104 by threading, press fitting or other conventional mounting means to permit interchangeable use of needles having different tapers appropriate for use with different gaseous fuels. Generally, a steeper needle taper is required for use with a fuel having a relatively smaller energy content and therefore requiring a higher fuel-to-air ratio for proper combustion.

Operation of mixer 100 may be understood by reference to FIGS. 2 and 4. At starting in the "propane" mode, engine starting venturi vacuum is communicated to mixing chamber 115 through conventional carburetor 110 and carburetor adapter 109. Such reduction of pressure within mixing chamber 115 is also communicated to the upper side of piston 104 via piston orifices 108. The lower side of piston 104 disposed radially outward of annular surface 137 on piston lifter 122 is subjected to outside atmospheric pressure communicated through air filter 113, which is held in place by air filter top plate 142. Such atmospheric pressure acting on the lower side of piston 104 urges the piston upward, overcoming the resistance of a yieldable bias means, such as spring 105, which urges piston 104 downward. Upward movement of piston 104, which is guided by sliding contact between the outside surface of fuel transfer tube 107 and the inner surface of piston cavity 125, lifts needle 106 from the annulus of contact 124 between the needle 106 and fuel transfer tube 107 at orifice 114, thereby permitting gaseous fuel within pressurized gaseous fuel passage 102 to flow through orifice 114 and valve passage 121 into piston cavity 125 and thence into mixing chamber 115 through fuel ports 123 (visible only in FIG. 2) in piston 104. Additionally, atmospheric air flows through the air filter 113 and as indicated by arrows 126 into mixing chamber 115 through the air passage which opens between piston 104 and piston lifter 122 when piston 104 moves upward, and such air continues to flow toward the engine through mixing chamber 115. Thus, gaseous fuel and atmospheric air mix within mixing chamber 115 and as both are drawn into conventional carburetor 110 through carburetor adapter 109.

The above-described flow of pressurized gaseous fuel and atmospheric air into mixing chamber 115 increases the pressure in the air passage within carburetor adapter 109, which increase in pressure is communicated to the top side of piston 104 via piston orifices 108. Resulting equalization of pressure on both sides of piston 104 permits spring 105 to urge piston 104 downward, thereby reducing the flow of gaseous fuel and atmospheric air into mixing chamber 115, which, in turn, results in a decrease in pressure in mixing chamber 115 as a consequence of venturi vacuum and repeat of the above-described sequence, which tends toward an equilibrium condition at each engine speed.

Provision is also made for separately controlled supply of atmospheric air and pressurized gaseous fuel to mixing chamber 115 at engine idle speeds while piston 104 remains in its downmost position. Gaseous fuel may pass through idle inlet tunnel 127 in needle 106, which inlet is variably partially obstructed by an adjustable valve means such as idle fuel adjustment screw 128. Idle

adjustment screw 128 is adjusted by insertion of a screwdriver through the access 143 in inlet elbow 101 created by removal of plug 120. Idle inlet tunnel 127 is positioned through the needle 106 surface above and below the annulus of contact 124 around orifice 114 to communicate with the needle 106 surface above and below the annulus of contact 124 so that fuel may pass from pressurized gaseous fuel passage 102 through idle inlet tunnel 127 and into valve passage 121. Air is admitted to mixing chamber 115 through idle air orifice 129 in piston lifter 122, and such air is metered by an adjustable valve means, such as by idle air adjustment screw 130. Such separate provision for supply at engine idle speeds permits improved control of air and fuel during idle without materially affecting fuel and air supply at higher engine speeds.

During "gasoline" mode operation of the dual fuel system, venturi vacuum communicated to the top side of piston 104 causes the piston 104 to be raised as described above, resulting in flow of air between the bottom side of piston 104 and annular surface 137 of piston lifter 122 as indicated by arrows 126 and into then functioning conventional carburetor 110 through mixing chamber 115.

More fuel efficient operation may be achieved by providing optional means for mechanically lifting piston 104 to permit flow of air as indicated by arrows 131 under piston lifter 122 when the "gasoline" mode is selected and mixer 100 is not functioning. Such lifting may be accomplished by addition of lifter actuator 132. In use, lifter actuator 132 is slightly rotated about its vertical axis by an actuation means, such as control cable 133 connected to control cable connector 134 and operated by a control means, which may conveniently be fluid dual valve control 301, shown in FIG. 1, which also actuates fluid dual valve 300. Such rotation results in sliding movement of lifter actuator arms 135 against camming surfaces 136 on piston lifter 122, thereby urging piston lifter 122 upward against the resistance of springs 140 surrounding pins 141 (one set of which pins and springs is shown in FIG. 4), thus permitting flow of air under piston lifter 122 and into conventional carburetor 110. Upon reverse rotation of lifter actuator 132 in response to movement of control 301, piston lifter 122 is pulled down to its normal, seated position by springs 140. Rotation of lifter actuator 132 in the desired direction with coupling to control 301 as shown in FIG. 1 requires that cable 133 pass through a bell crank (not shown) or other means to reverse cable movement or, alternatively, cable 133 may be coupled to lifter actuator 132 to rotate it in the opposite direction from that achieved by connection as shown in FIG. 4.

Alternatively, a second optional means for providing free air flow to the conventional carburetor 110 during "gasoline" operation of the dual fuel system may be achieved by providing communication between the top side of piston 104 and a vacuum source during "gasoline" operation, which thereby reduces the pressure on the top side of piston 104, resulting in movement of piston 104 upward responsive to atmospheric pressure on its lower side, thus permitting free flow of air between piston 104 and annular surface 137 on piston lifter 104. Provision for such communication is shown in FIGS. 1 and 2 by mixer vacuum line 138 which communicates with the top side of piston 104 through cylinder fitting 139, visible in FIG. 4, and connects to second vacuum outlet port 313 in fluid dual valve body 307. When fluid dual valve control 301 is positioned in the

"gasoline" mode, duct 315 in spool 306 communicates between vacuum inlet port 311 and second vacuum outlet port 313, as is shown in FIG. 13, thereby resulting in communication of engine intake manifold vacuum to the top side of piston 104 through mixer vacuum line 138.

FIGS. 5 and 6 show section views and FIG. 7 shows an exploded view of an alternative embodiment of the mixer assembly of the present invention, indicated by numeral 200. In this embodiment, mixer 200 includes, generally, (a) body structure comprising mixer body 201 and fuel transfer tube 207, which together form a pressurized gaseous fuel passage 202, and cylinder 203 and (b) a plunger structure comprising a piston 204, which moves within cylinder 203, and piston actuator 221 of substantially oval cross section. Mixer body 201 also forms an air passage 216 shown in FIGS. 6 and 7 into which piston actuator 221 projects with the greater oval axis of the cross section of piston actuator 221 oriented transverse to air passage 216 for movement therein to variably restrict air flow. Movement of the plunger structure (comprising piston actuator 221 and piston 204) is guided by sliding contact between a portion of the outside surface of fuel transfer tube 207 and arcuate sliding surfaces 227 in piston actuator cavity 225. Attached to piston 204 is a needle 206, which moves within orifice 214 of pressurized gaseous fuel passage 202 to form a needle valve-type structure which controls passage of the pressurized gaseous fuel into mixing chamber 215. Needle 206 may be removably mounted in the plunger structure by employing threading, press fitting or other conventional mounting means to permit interchangeable use of needles having different tapers appropriate for use with different gaseous fuels as described above in connection with mixer 100.

Operation of second embodiment of mixer 200, which is similar to operation of first embodiment of mixer 100, may be understood by reference to FIGS. 5, 6 and 7.

At starting in "propane" mode operation, engine starting venturi vacuum is communicated to mixing chamber 215 and the downstream side of air passage 216 through a conventional carburetor 210 and carburetor adaptor 209. Such venturi vacuum is also communicated to the back side 222 of piston 204 through piston orifices 208. The front side 223 of piston 204 is substantially subjected to outside atmospheric pressure communicated through air filter 213 and into cylinder 203 through mixer body 201 holes 224 (visible in FIG. 7). Such atmospheric pressure acting on the front side 223 of piston 204 urges piston 204 against the resistance of a yieldable bias means such as spring 205, and the reduced pressure on the back side 222 of piston 204 induced by venturi vacuum. Such movement of piston 204 moves piston actuator 221 and needle 206. Movement of needle 206 away from orifice 214 at the end of fuel transfer tube 207 permits gaseous propane within pressurized gaseous fuel passage 202 to flow into piston actuator cavity 225 and thence into air passage 216 in mixer body 201 and into mixing chamber 215. Venturi vacuum also draws atmospheric air through air filter 213 and air passage 216 past piston actuator 221 and into mixing chamber 215. Thus, gaseous fuel and atmospheric air mix within mixing chamber 215 as both are drawn into conventional carburetor 210 through carburetor adaptor 209. Baffle 234 attached to housing 228 serves to break up air and fuel flow and induce turbulence so that such flow will not stratify and limit flow into the engine.

The above-described flow of pressurized gaseous fuel and atmospheric air into mixer body 201 increases the gaseous pressure within the mixer body, which increase in pressure is communicated to the back side 222 of piston 204 through piston actuator 221 orifices 208. 5 Resulting equalization in pressure on both sides of piston 204 permits spring 205 to urge piston 204 and the structures attached thereto toward mixer body 201, thereby reducing the flow of gaseous propane between orifice 214 and needle 206 into piston actuator cavity 10 225 and thence into mixer body 201, and movement of piston actuator 221 projecting into mixer body 201 reduces the flow of atmospheric air through mixer body 201. Such reduction in air and fuel flow, in turn, results in a decrease in pressure on the downstream side of air 15 passage 216 as a consequence of venturi vacuum and repeat of the above-described sequence, which tends toward an equilibrium condition at each engine speed.

Provision is made for controlled supply of atmospheric air and pressurized gaseous fuel to the engine by 20 second mixer embodiment 200 at engine idle speeds by providing a means for adjustably inhibiting projection of piston actuator 221 into mixer body 201 such as screw 226 which passes through mixer body 201 and contacts the end of piston actuator 221, thereby limiting 25 travel of piston actuator 221 and piston 204 and needle 206 rigidly connected thereto. Such limitation of travel provides a minimum passage for atmospheric air through air passage 216 and maintains a passage for gaseous propane between orifice 214 and needle 206. 30

During "gasoline" mode operation of the dual fuel system, as with first mixer embodiment 100, venturi vacuum communicated to the back side 222 of piston 204 against spring 205 as described above results in withdrawal of piston actuator 221 from air passage 216, 35 thereby permitting flow of air through air passage 216. More fuel efficient operation may be achieved by provision of an optional air valve providing a passage for air bypassing air passage 216. Such an optional air valve, best shown in FIG. 7, is provided in mixer 200 by openings 229 in housing 228 which align with air valve plate 40 openings 231 in air valve plate 230 which is rotated by a control cable 232, which may conveniently be actuated by control 301 by coupling to control 301 in place of cable 133 shown in FIG. 1. 45

Inadvertent incorrect orientation of the plunger structure of second mixer embodiment 200 to mixer body 201 during assembly or reassembly after servicing may be prevented by providing piston actuator 221 with an irregular cross sectional shape, as for instance, by the 50 provision of ridge 233 so that piston actuator 221 will be received in mixer body 201 only in the correct orientation.

Although the present invention is described and illustrated above with detailed reference to the preferred 55 embodiments, the invention is not intended to be limited to the details of such embodiments but includes numerous modifications and changes thereto while still falling within the intent and spirit hereof.

I claim:

1. A dual fuel system for an internal combustion engine comprising:

- (a) a fluid dual valve actuated by a manual control to permit flow of liquid fuel to the engine's carburetor when the control is in a first position and to prevent 60 such flow when the control is in a second position;
- (b) a liquified gas to gaseous fuel converter actuated by a decrease in engine manifold pressure commu-

nicated from the engine to the converter through the fluid dual valve when the control is in the second position; and

- (c) a mixer which mixes gaseous fuel supplied by the converter with air and supplies the mixture to the engine when the control is in the second position and which permits flow of air to the engine's carburetor when the control is in the first position.

2. A dual fuel system for an internal combustion engine comprising:

- (a) a converter body forming a liquified fuel passage and a gaseous fuel chamber;
- (b) a liquid fuel inlet valve yieldably biased toward a closed position and a first actuator responsive to a drop in engine manifold pressure to actuate the liquid fuel inlet valve for permitting fuel to flow into the liquified fuel passage;
- (c) a gaseous fuel inlet valve between the liquified fuel passage and the gaseous fuel chamber which valve is yieldably biased toward a closed position and a second actuator responsive to a pressure drop in the gaseous fuel chamber to actuate the gaseous fuel valve for permitting fuel flow into the gaseous fuel chamber;
- (d) a mixer body forming an air passage and a pressurized gaseous fuel passage communicating with the gaseous fuel chamber and having an orifice communicating with the air passage;
- (e) a plunger proximate the air passage for movement to variably restrict air flow through the air passage;
- (f) a means for yieldably biasing the plunger in one direction of movement, the plunger having a surface communicating with the air passage at the downstream side of the plunger to receive application of vacuum tending to move the plunger in the opposite direction against resistance imposed by the yieldable bias means;
- (g) a needle positionable within the orifice, one of the orifice and needle being movable relative to the other by the plunger to control the flow of gaseous fuel through the orifice;
- (h) a valve body having a liquid inlet opening, a vacuum outlet opening, a vacuum inlet port, a vacuum outlet port communicating with the first actuator, and a vent; and
- (i) a spool rotatable within the valve body in response to a control, said spool having a tunnel communicating between the liquid inlet opening and the liquid outlet opening when the control is in a first position, a duct communicating between the vacuum inlet port and the vacuum outlet port when the control is in a second position, and a notch communicating between the vacuum outlet port and the vent when the control is in the first position.

3. A dual fuel system according to claim 2, wherein the first actuator comprises a first diaphragm having one side communicating with the vacuum outlet port and the opposite side communicating with the external atmosphere and a valve linkage communicating between the first diaphragm and the liquified fuel inlet valve; and wherein the second actuator comprises a second diaphragm of substantially the same size as the first diaphragm having one side exposed to the gaseous pressure within the gaseous fuel chamber and the opposite side communicating with the external atmosphere, a valve actuator communicating between the gaseous fuel inlet valve and the second diaphragm and a yieldable

means for resisting diaphragm deflection induced by increased pressure in the gaseous fuel chamber and for urging the second diaphragm against the valve actuator.

4. A dual fuel system according to claim 3, further comprising means for automatically providing a lean fuel mixture of gas and air to the engine during cruise conditions by reducing the pressure of fuel in the gaseous fuel chamber, comprising:

- (a) a bellows and a means for yieldably forcing the bellows against the external atmosphere side of the second diaphragm, and
- (b) a means for contracting the bellows in response to a drop in engine manifold pressure to reduce the force exerted by the yieldable forcing means and bellows on the second diaphragm.

5. A dual fuel system according to claim 4, wherein:

- (a) the bellows contracting means comprises a second duct within the converter body structure communicating between the bellows and an engine manifold pressure chamber formed by the body structure and one side of the first diaphragm, and
- (b) the converter body is provided with a means for circulating liquid in heat transfer relation with the gaseous fuel chamber.

6. A dual fuel system according to claim 2, wherein the plunger includes a piston defining said surface, the piston having an oppositely facing surface communicating with the air passage at the upstream side of the plunger, the mixer body includes a cylinder receiving the piston and the yieldable bias means comprises a spring urging the plunger toward the orifice.

7. A dual fuel system according to claim 6, wherein a portion of the plunger projects within the air passage for movement therein to variably restrict air flow through the passage and has a substantially oval cross section with the greater oval axis transverse to the air passage.

8. A dual fuel system according to claim 6, wherein the plunger has a cavity, and the orifice and a portion of the gaseous fuel passage is within the cavity, the needle being mounted to the plunger within the cavity and being carried by the plunger to project within the orifice.

9. A dual fuel system according to claim 2, wherein the needle is provided with a tunnel positioned through the needle surface above and below an annulus of contact between the valve needle and the orifice and a screw to variably obstruct the tunnel for providing limited flow of fuel during engine idle conditions while the needle is fully closed.

10. A dual fuel system according to claim 2, further comprising means to variably inhibit travel of the plunger to a minimum air flow restricting position for permitting flow of air and fuel during engine idle conditions.

11. A dual fuel system according to claim 2, further comprising means for urging the plunger against the yieldable bias means to permit free flow of air through the air passage, said urging means comprising a mechanical linkage between the control and a third actuator, which actuator moves the plunger, when the control is moved to the first position, against the yieldable bias means.

12. A dual fuel system according to claim 2, further comprising means for urging the plunger against the yieldable bias means to permit free flow of air through the air passage, said urging means comprising a second vacuum outlet port in the valve body communicating

with the plunger surface and, when the control is in the first position, communicating with the vacuum inlet port via the duct.

13. A dual fuel system according to claim 2, further comprising a mechanical linkage between the control and an air supply valve to open the air supply valve when the control is in the first position to permit flow of air to the engine's carburetor bypassing the air passage.

14. A dual fuel system according to claim 2, wherein an O-ring seated on the surface of the spool forms a seal between the spool and the valve body around the liquid inlet opening when the spool is in the second position.

15. A dual fuel system according to claim 2, wherein the needle is removably affixed to the plunger so that needles having various tapers may be interchangeably used with fuels having different properties.

16. A dual fuel system for an internal combustion engine comprising:

- (a) a first body forming a liquified fuel passage, a gaseous fuel chamber, a manifold pressure chamber, and a liquid passage for circulating liquid in heat transfer relation with the gaseous fuel chamber;
- (b) a plunger-type liquified fuel inlet valve yieldably biased toward a closed position by a first spring and actuated to permit liquified fuel to flow into the liquified fuel passage by a first diaphragm acting on a lever, said diaphragm having one side exposed to pressure in the manifold pressure chamber and the other side exposed to the external atmosphere;
- (c) a lever-type gaseous fuel inlet valve between the liquified fuel passage and the gaseous fuel chamber yieldably biased toward a closed position by a second spring and actuated to permit fuel to flow into the gaseous fuel chamber by a second diaphragm of substantially the same diameter as the first diaphragm acting on a valve actuator removably contacting the gaseous fuel inlet valve, said second diaphragm having one side communicating with the external atmosphere and the other side communicating with the gaseous fuel chamber;
- (d) a diaphragm spring and a bellows and a bellows spring resisting second diaphragm deflection induced by increased pressure in the gaseous fuel chamber and urging the second diaphragm against the valve actuator, said bellows communicating with the duct to contract in response to a pressure reduction in the manifold pressure chamber to reduce resistance to deflection of the second diaphragm induced by increased pressure in the gaseous fuel chamber;
- (e) a second body forming an air passage, a pressurized gaseous fuel tube communicating with the gaseous fuel chamber and with the air passage via an orifice, and a cylinder;
- (f) a plunger having a portion of substantially oval cross section projecting within the air passage for movement therein to variably restrict air flow through the passage and a piston for movement within the cylinder, said piston having a surface communicating with the air passage at the downstream side of the plunger to move the plunger in a direction opposite resistance imposed by a piston spring and an oppositely facing surface communicating with the air passage at the upstream side of the plunger, said oval portion having a cavity, a portion of the wall of which contacts the tube to guide the plunger;

- (g) a needle removably affixed to the plunger within the cavity and positionable within the orifice to control the flow of gaseous fuel through the orifice;
- (h) an adjustable stop to variably inhibit travel of the plunger structure to its fully projecting position to permit flow of air and gas during engine idle conditions;
- (i) a third body having a liquid inlet opening, a liquid outlet opening, a vacuum inlet port for communication with the engine's intake manifold, a vacuum outlet port communicating with the manifold pressure chamber, and a vent;
- (j) a spool manually rotatable within the third body in response to a control, said spool having a tunnel communicating between the liquid inlet opening and the liquid outlet opening when the spool is in a first position; a second duct communicating between the vacuum inlet port and the vacuum outlet port when the spool is in a second position, a notch communicating between the vacuum outlet port and the vent when the spool is in the first position, and an O-ring seated on the surface of the spool to form a seal between the spool and the third body around the liquid inlet opening when the spool is in the second position; and
- (k) a mechanical linkage between the control and an air supply valve to open the air supply valve when the control is in the first position to permit flow of air to the engine's carburetor bypassing the air passage.
17. A dual fuel system for an internal combustion engine comprising:
- a converter for converting liquified fuel to a gaseous fuel, said converter having a gaseous fuel chamber with a liquified fuel inlet aperture, an engine vacuum inlet aperture and an outlet aperture adapted for communication with the carburetor of an internal combustion engine, said converter being operable responsively to engine manifold vacuum and to the pressure within said fuel chamber to pass gaseous fuel from said inlet aperture to said outlet aperture under a positive pressure;
 - a mixer for mixing air with a gaseous fuel for application to a combustion chamber, said mixer having a mixing chamber with an air inlet passageway adapted for fluid communication with a source of air, a gaseous fuel inlet aperture in fluid communication with the outlet aperture of said converter, an outlet aperture adapted for fluid communication with the carburetor of an internal combustion engine, air valve means for restricting the passage of air from said air inlet aperture to said outlet aperture responsively to engine venturi vacuum, and fuel valve means for restricting the passage of gaseous fuel from said fuel inlet aperture to said outlet aperture responsively to movement of said air valve means; and
 - a manually operable valve adapted for fluid communication with a source of liquified gas, a source of gasoline, atmospheric pressure and engine manifold vacuum, said valve being operative in a first position to pass gasoline to the carburetor of the internal combustion engine and being operative in a second position to pass liquified gas to the inlet aperture of said converter, and to apply engine vacuum to the engine vacuum inlet aperture of said converter.

18. The system of claim 17 wherein the response of said second valve means to the pressure within said fuel chamber is modulated as a direct function of engine manifold vacuum.

19. The system of claim 17 including means for adjusting the idle position of said mixer without adjusting the response characteristics thereof to engine demand.

20. The system of claim 17 wherein said fuel valve means is located within an axial passage in said air valve means.

21. The system of claim 17 wherein said air valve means includes a cylinder having a flat bladed extension, said extension apertured to receive a portion of said fuel valve means.

22. The system of claim 17 wherein said mixer includes:

- a mixing chamber having a generally rectangular air inlet passageway in fluid communication with a source of air, a fuel inlet tube adapted for fluid communication with a source of a gaseous fuel, and an outlet passageway adapted for fluid communication with a combustion chamber; and

- valve means for restricting the passage of air through said air inlet passageway to said outlet passageway and for restricting the passage of gaseous fuel from said fuel inlet tube to said outlet aperture,

- said valve means including a piston slidable within a chamber and having a generally flat bladed projection, the axis of said cylinder being normal to said air inlet passageway and said chamber being disposed relative to said air inlet passageway so that said flat bladed projection variably restricts the flow of air through said air inlet passageway responsively to the position of said piston in said cylinder,
- said fuel inlet tube supporting said piston within said cylinder.

23. The system of claim 22 wherein said converter comprises:

- a gaseous fuel chamber having an inlet aperture adapted for communications with a source of liquified gas, an outlet aperture adapted for communications with the carburetor of an internal combustion engine, and a plurality of internal partitions defining a convoluted passageway between said inlet and outlet apertures;

- first valve means being operable responsively to engine manifold vacuum to pass liquified gas from said inlet aperture to said second valve means, and
- second valve means being operable responsively to the pressure within said fuel chamber to pass liquified gas to said fuel chamber, said second valve means includes a diaphragm the movement of which is responsive to the pressure differential between atmospheric pressure and the pressure within said fuel chamber of less than about one third pounds per square inch;

- means for modifying the response of said second valve means to the pressure in said fuel chamber in response to engine vacuum, the effects of an increase into engine manifold vacuum being opposed to the effects of an increase in the pressure within said fuel chamber;

- a passageway adapted for fluid communication with a source of engine coolant, the walls of said passageway being in a heat transfer relationship to the partitions in said fuel chamber,

whereby liquified gas may be passed from said inlet aperture through the heated and convoluted passageway in said fuel chamber for conversion to a gaseous fuel and for subsequent passage through said outlet aperture under a positive pressure to the carburetor of an internal combustion engine.

24. The system of claim 17 wherein said converter comprises:

a gaseous fuel chamber having an inlet aperture adapted for communications with a source of liquified gas, an outlet aperture adapted for communications with the carburetor of an internal combustion engine, and a plurality of internal partitions defining a convoluted passageway between said inlet and outlet apertures;

first valve means being operable responsively to engine manifold vacuum to pass liquified gas from said inlet aperture to said second valve means, and second valve means being operable responsively to the pressure within said fuel chamber to pass liquified gas to said fuel chamber, said second valve means includes a diaphragm the movement of which is responsive to the pressure differential between atmospheric pressure and the pressure within said fuel chamber of less than about one third pounds per square inch;

means for modifying the response of said second valve means to the pressure in said fuel chamber in

response to engine vacuum, the effects of an increase into engine manifold vacuum being opposed to the effects of an increase in the pressure within said fuel chamber;

a passageway adapted for fluid communication with a source of engine coolant, the walls of said passageway being in a heat transfer relationship to the partitions in said fuel chamber,

whereby liquified gas may be passed from said inlet aperture through the heated and convoluted passageway in said fuel chamber for conversion to a gaseous fuel and for subsequent passage through said outlet aperture under a positive pressure to the carburetor of an internal combustion engine.

25. A method of operating an internal combustion engine on a liquified fuel comprising the steps of:

- (a) manually positioning a fuel selector switch;
- (b) converting a liquified fuel to a gaseous fuel responsively to the position of the fuel selector switch, to engine manifold vacuum, and to the pressure of the converted fuel;
- (c) metering air to the carburetor of the internal combustion engine responsively to carburetor venturi vacuum; and
- (d) metering gaseous fuel to the carburetor of the internal combustion engine responsively to the metered flow of air.

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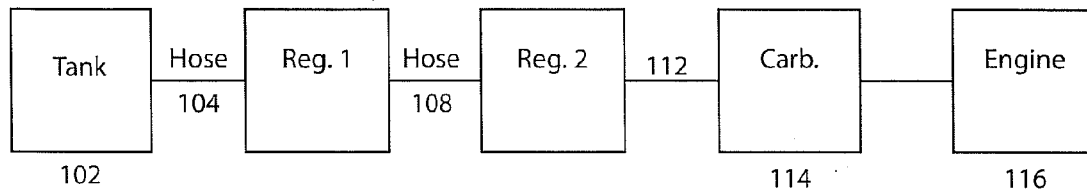
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F02B 43/00 (2006.01)(52) **U.S. Cl. 123/511; 123/527**(73) Assignee: **Marine Green, LLC**(57) **ABSTRACT**(21) Appl. No.: **12/612,776**

A method and system for fuel delivery. The method and system may include one or more fuel storage tanks housing propane, one or more regulators through which fuel may flow and one or more fuel metering devices or systems. The flow of fuel from a fuel storage tank to an engine may be such that the engine runs in a clean and efficient manner.

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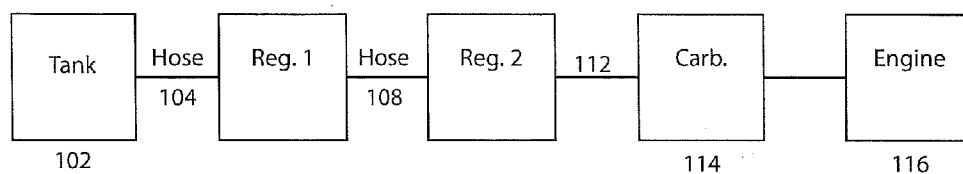


Fig. 1

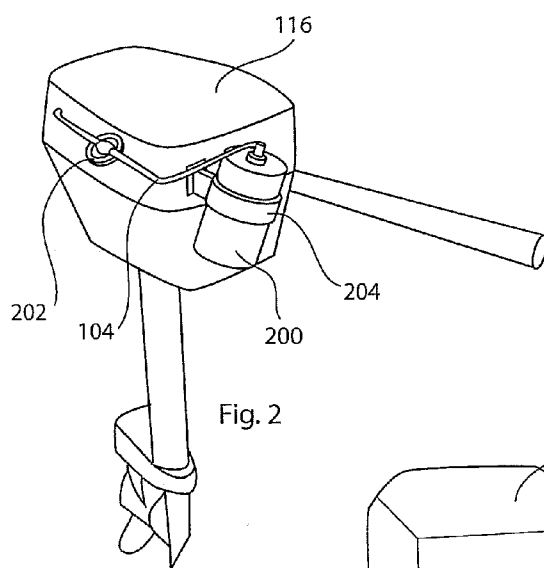


Fig. 2

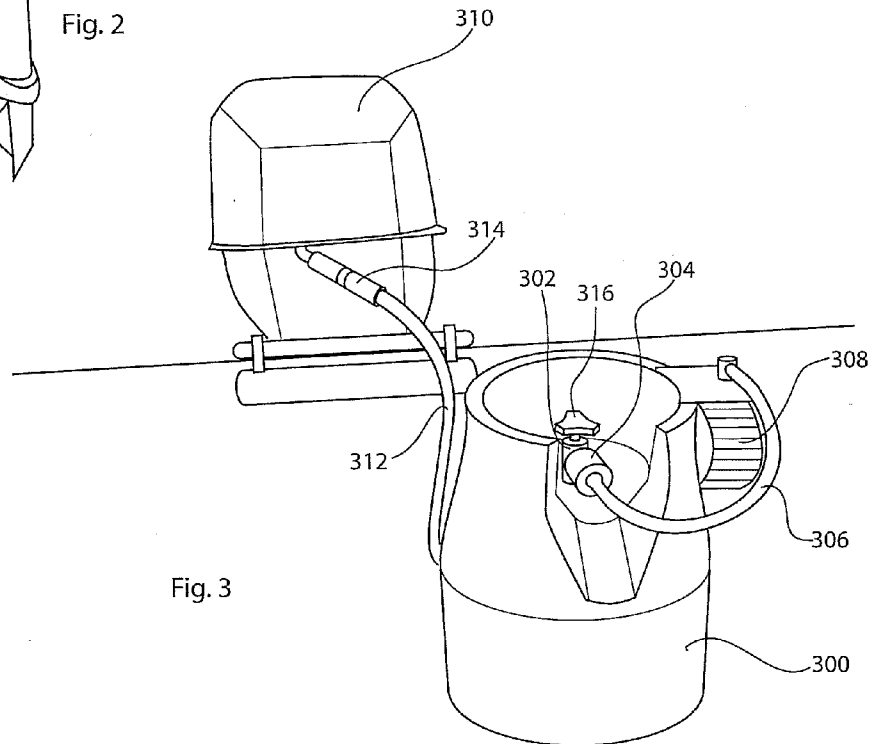


Fig. 3

FUEL DELIVERY SYSTEM

BACKGROUND

[0001] Engines used in any application are known to utilize fuel. In many applications, such as in two and four stroke marine outboard engines, fossil fuels have been used as the primary source of fuel. However, modern engines are typically criticized for their use of fossil fuels as they are claimed to not be environmentally friendly. Two stroke engines are further criticized due to their running and use characteristics. Thus, in many applications where two stroke engines are used to be prevalent, such as in marine outboard engines, designers and manufacturers are now switching to four stroke outboard engines.

[0002] However, as is well known and publicized, four stroke engines remain somewhat inefficient and suffer from a variety of potential drawbacks, specifically with regard to the environment. A number of solutions have been proposed to increase both the efficiency and environmental friendliness of such engines. For example, some marine outboard engines now utilize alternative fuels, such as ethanol-infused gasoline, or bio-gas. These alternatives cause a variety of problems in many applications, however. The use of ethanol in gasoline can absorb water which can cause onboard fuel supplies to eventually contain water as a result of condensation or other means, causing significant problems in engines that are used less frequently. Additionally, for users who wish to safeguard their outboard engines from these problems, fuel disposal is often viewed as a solution but environmentally-unfriendly manners of disposing of unused fuel are often implemented.

[0003] Additionally the decreased effective shelf life of alternative fuels, such as bio-gas can pose problems in engines that are used less frequently as the fuel may not properly combust if it is not used within a limited time period.

[0004] Other attempted solutions, for example the use of liquid propane delivery systems, have not proved successful. In such uses of propane, the vaporization of propane from its liquid state causes a significant amount of heat to be absorbed, ultimately freezing the regulator through which the propane flows from a tank to the engine and rendering the engine inoperable.

SUMMARY

[0005] One exemplary embodiment describes a fuel delivery system. The fuel delivery system may include a fuel tank that houses propane; a first regulator coupled to the fuel tank; a second regulator coupled to the first regulator; and a fuel metering system coupled to the second regulator and delivering propane to an engine.

[0006] Another exemplary embodiment can include a method for providing fuel to an engine. The method for providing fuel to an engine can include storing liquid propane in a tank; flowing the liquid propane to a first regulator; converting the liquid propane to a propane vapor by the first regulator; flowing the propane vapor to a second regulator; metering the flow of the propane vapor from the second regulator to an engine; and maintaining the temperature of the propane at about an ambient temperature.

BRIEF DESCRIPTION OF THE FIGURES

[0007] Advantages of embodiments of the present invention will be apparent from the following detailed description

of the exemplary embodiments thereof, which description should be considered in conjunction with the accompanying drawings in which:

[0008] FIG. 1 shows an exemplary block diagram of a fuel delivery system.

[0009] FIG. 2 shows an exemplary diagram of components of a fuel delivery system and engine.

[0010] FIG. 3 shows another exemplary diagram of components of a fuel delivery system and engine.

DETAILED DESCRIPTION

[0011] Aspects of the invention are disclosed in the following description and related drawings directed to specific embodiments of the invention. Alternate embodiments may be devised without departing from the spirit or the scope of the invention. Additionally, well-known elements of exemplary embodiments of the invention will not be described in detail or will be omitted so as not to obscure the relevant details of the invention. Further, to facilitate an understanding of the description discussion of several terms used herein follows.

[0012] The word “exemplary” is used herein to mean “serving as an example, instance, or illustration.” Any embodiment described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other embodiments. Likewise, the term “embodiments of the invention” does not require that all embodiments of the invention include the discussed feature, advantage or mode of operation.

[0013] Generally referring to FIGS. 1-3, a propane vapor delivery system may be described and shown. The fuel vapor delivery system may be such that clean, economical use of an engine may be achieved with minimal complexity.

[0014] In one exemplary embodiment and as shown in the exemplary diagram in FIG. 1, a gas, such as liquefied petroleum gas or propane, may be supplied to an engine as fuel. The gas may be stored in a bottle or tank, such as LPG tank 102. In a further exemplary embodiment, the gaseous form of liquefied propane may be used as a fuel for marine outboard four-stroke propulsion engines, as well as two stroke engines or any other type of engine with a pressurized lubricating injection system. An exemplary fuel system may use liquefied petroleum gas (LPG or propane) which may be stored in a vapor gaseous state in LPG tank 102 and which may not utilize engine coolant to keep regulators from freezing or otherwise malfunctioning.

[0015] LPG, as implemented or utilized in the exemplary embodiments described herein, may provide any of a number of advantages over other fuels. For example, LPG may act as a higher octane fuel source as well as decrease potentially harmful emissions while also offering substantially the same or better performance over other known fuels. An increase in fuel economy and a decrease in potentially harmful emissions may be up to 20% or more. Additionally, LPG may reduce wear on an engine and some components, for example extending the life of spark plugs, reducing varnish build-up on a carburetor and increasing the amount of time needed between oil changes. Further, LPG may be stored in any number of environments without the use of additives or unique storage conditions without affecting its usefulness or performance.

[0016] In a further exemplary embodiment, the LPG tank 102 may be connected to a regulator, such as a primary regulator 106, converter or vaporizer. This connection may be made using a hose 104, such as a high pressure hose, or any

form of pipe, for example a rigid pipe. The primary regulator **106** may step down the pressure of any stored propane vapor energy in tank **102**, and may further output this lowered pressure to a secondary regulator **110**. For example, the primary regulator **106** may be such that it reduces pressure of the propane from a high pressure state while the propane is in the LPG tank **102**, which may be approximately 180-250 psi, to a sub-atmospheric pressure, approximately 10 psi. The secondary regulator **110** can act as a vacuum-controlled flow rate regulator. Further, the secondary regulator **110** can meter propane gas to an engine **116**, for example, through a negative pressure signal, such as a vacuum signal, from the air-fuel mixer on a carburetor **114** designed or modified to use propane as a fuel source.

[0017] Still to exemplary FIG. 1, and in a further example, the carburetor **114** may include both an air-fuel mixer and a throttle body. When the engine **116** is being cranked or otherwise running, a partial vacuum may be generated in the throttle body of carburetor **114**. This partial vacuum may be passed on from the throttle body to the fuel vapor hose to the secondary regulator **110**. The secondary regulator **110** may sense the vacuum and open, letting fuel vapor flow into the carburetor **114**. As the throttle is opened, a butterfly valve inside the carburetor **114** may open further, thus allowing for more fuel to be drawn in and allowing the engine **116** to accelerate or increase revolutions. Further, the air-valve implementation of the carburetor **114** may allow for a safe and accurate method of supplying propane gas from LPG tank **102** while also allowing for the fuel metering in the mixer to be self-contained. Additionally, it may be envisioned that a mechanical or electrical fuel injection system could be used in lieu of carburetor **114** while achieving similar results.

[0018] In further exemplary embodiments, and referring to FIG. 2, the regulator arrangement of the primary regulator **106** and the secondary regulator **110** may be such that they are combined as a single, two-stage, regulator **202**. In this exemplary embodiment the combined regulator **202** would then feed the vaporized propane into carburetor **114** through hose **112**. Additionally, as shown in exemplary FIG. 2, LPG tank **200**, in some examples, may be coupled directly to engine **116**, using any desired coupling, such as mounting bracket **204**.

[0019] The exemplary embodiment shown in FIG. 2 may be utilized in any desired situation, such on a small or single-cylinder outboard engine. The mounting of LPG tank **200** on the engine may provide many advantages. For example, this embodiment may be beneficial in some desired situations, for example when utilizing compact fuel supplies on a general yacht tender service or for any other similar-sized application, such as generators or personal watercraft where storage space or space of a fuel tank may be limited.

[0020] In still further exemplary embodiments, and referring to FIG. 3, the LPG tank **300** may be located separate, but coupled to, an engine **310**. The LPG tank **300** may be connected to the primary regulator **304** as described previously, for example by connector **302**. Additionally, a low pressure output of the secondary regulator **308** may be attached to a propane carburetor (not pictured) on the engine **310** in any of a variety of manners, for example through hose **312** and coupling **314**. Further, a low pressure output of the secondary regulator **308** may be attached to the propane carburetor either permanently or releasably.

[0021] Still referring to exemplary FIG. 3, the primary regulator **304** and the secondary regulator **308** may be two

separate regulators that can be based on the design and size of an engine. The primary regulator **304** in this exemplary embodiment may be connected to LPG tank **300** as described above. Additionally, the primary regulator **304** may be connected to the secondary regulator **308** by a hose **306**, pipe, tube or the like, such as that described above.

[0022] In each of the exemplary embodiments described herein the arrangement of the regulators **106** and **110**, **202** and **304** and **308**, as shown in FIGS. 1-3, respectively, can maintain about an ambient temperature from the surrounding air temperature rather than utilizing an interface with a cooling circuit of the engine **116** or other heat source to function as desired. In some other exemplary embodiments, the temperature maintained by any regulators described herein may be such that the flow of propane is allowed as desired. This may be accomplished as a result of the vapor delivery nature of the system as well as a design match of the system to fit specific air-fuel requirements of an engine size, for example for a marine engine. The maintenance of the regulator at about an ambient temperature may be facilitated by both the design of the regulator or regulators which may be sized to a specific engine, for example a marine engine having a known or desired horsepower rating. Additionally, the maintenance of the about ambient temperature may be such that the regulator or regulators are not affected, for example, by freezing as a result of the conversion of the LPG from tank **102** to a gaseous state and the flow of the fuel is not negatively affected or impacted.

[0023] In still further examples, any of the embodiments described herein may include a fuel shut-off valve, such as a safety fuel shut-off valve **316** or switch. For example, a standard propane tank shut-off valve may be utilized in some embodiments. Additionally, in other embodiments, such as embodiments where a larger, electrically actuated engine is utilized, an electric solenoid shut-off valve may be used.

[0024] In still other exemplary embodiments, for example engines as shown in FIG. 3, which may be large or powerful engines, or any situation where more fuel may be desired, an LPG tank may be mounted or located in any desired position or location. Whereas the LPG tank shown in exemplary FIG. 2 may be mounted on the side of an engine, here other locations for mounting an LPG tank may be used as desired. As shown in FIG. 3, a mounting bracket (not pictured) may be secured to LPG tank **300** and any other desired member of a vessel or craft associated with engine **310**. Also the LPG tank **300** may be formed out of any desired material, for example aluminum or a composite construction. Additionally, the LPG tank **300** may be coupled with any conduit described herein, such as a high pressure hoses, rigid tubes, pipes and the like in any desired manner, such as a screw fitting. Additionally, should it be desired, any number of fuel tanks may be coupled together to provide any desired amount of available fuel. Any coupling of additional tanks may be done in a manner known in the art.

[0025] Further, as described herein, the LPG applications may be used on any desired form of engine, such as marine outboard engines, and may further operate independently of an engine's cooling circuit. This may be accomplished through the use of vapor fuel delivery rather than the delivery of liquid propane gas. Additionally, on some engine types, such as engines of smaller displacement, smaller amounts of propane may be utilized to achieve a desired operation, thus

further issues pertaining to cooling and freezing, such as those known to affect the conversion of propane from liquid to gas, may be avoided.

[0026] The foregoing description and accompanying drawings illustrate the principles, preferred embodiments and modes of operation of the invention. However, the invention should not be construed as being limited to the particular embodiments discussed above. Additional variations of the embodiments discussed above will be appreciated by those skilled in the art.

[0027] Therefore, the above-described embodiments should be regarded as illustrative rather than restrictive. Accordingly, it should be appreciated that variations to those embodiments can be made by those skilled in the art without departing from the scope of the invention as defined by the following claims.

1. A fuel delivery system, comprising:
a fuel tank that houses propane;
a first regulator coupled to the fuel tank;
a second regulator coupled to the first regulator; and
a fuel metering system coupled to the second regulator to deliver propane vapor to an engine.
2. The fuel delivery system of claim 1, wherein the engine is a marine outboard engine.
3. The fuel delivery system of claim 1, wherein the fuel is reduced in pressure by the first regulator.
4. The fuel delivery system of claim 1, wherein the second regulator receives a signal from the fuel metering system and delivers fuel to the fuel metering system.
5. The fuel delivery system of claim 4, wherein the signal is a vacuum signal.
6. The fuel delivery system of claim 1, wherein the fuel metering system is a carburetor.
7. The fuel delivery system of claim 1, wherein the fuel is propane.
8. The fuel delivery system of claim 1, wherein the first regulator and the second regulator are combined as a two stage regulator.
9. The fuel delivery system of claim 1, wherein the coupling of the first regulator with the second regulator is such

that fuel flowing between the first regulator and the second regulator is kept at an about ambient temperature.

10. The fuel delivery system of claim 1, wherein the second regulator is coupled to the fuel metering system with a releasable coupling.

11. The fuel delivery system of claim 1, further comprising at least one shut-off valve.

12. A method for providing fuel to an engine, comprising:
storing liquid propane in a tank;
flowing propane to a first regulator;
decreasing the pressure of the propane by the first regulator;
flowing the propane to a second regulator;
metering the flow of the propane from the second regulator to an engine; and
maintaining the temperature of the propane at an about ambient temperature.

13. The method of claim 12, wherein the flow of the propane vapor from the second regulator to the engine is metered by a carburetor.

14. The method of claim 12, further comprising reducing the pressure of the liquid propane in the tank from about 180-250 psi to about 4-12 psi by the first regulator.

15. The method of claim 12, further comprising one of releasably coupling the second regulator to the engine and releasably coupling the first regulator to the second regulator.

16. The method of claim 12, wherein the flow of the propane vapor from the second regulator to the engine is metered by a vacuum signal.

17. The method of claim 12, wherein the flow of the propane vapor from the second regulator to the engine is metered by a carburetor.

18. The method of claim 12, wherein the flow of the propane vapor from the second regulator to the engine is metered by a fuel injection system.

19. The method of claim 12, further comprising securing the tank to the engine.

20. The method of claim 12, wherein the engine is a marine outboard engine.

* * * * *

EXHIBIT 1009

LP-Gas Code Handbook



LP-Gas Code Handbook

EIGHTH EDITION

Edited by

Theodore C. Lemoff, P.E.

Principal Gases Engineer, NFPA

With the complete text of the 2008 edition of NFPA[®] 58, *Liquefied Petroleum Gas Code*



National Fire Protection Association[®]
Quincy, Massachusetts

Product Manager: Debra Rose
Project Editor: Irene Herlihy
Permissions Editor: Josiane Domenici
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Art Coordinator: Cheryl Langway
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Manufacturing Manager: Ellen Glisker
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This handbook is dedicated to the people who led the NFPA Technical Committee on Liquefied Petroleum Gases from NFPA 58's first edition in 1932 to the present. In the early days the committee truly wrote the standard (it became a code in 1998), with NFPA staff taking a larger role beginning in 1956.

Those who chaired the committee in the past are recognized here for their foresight, dedication, and vision, which shaped the Code into the complete document it is today.

H. E. Newell*, National Board of Fire Underwriters, 1932–1955

Franklin R. Featherston*, Liquefied Petroleum Gas Association, 1956–1967

H. V. Keepers*, Fire Prevention & Engineering Bureau of Texas, 1968–1975

Connor L. Adams*, City of Miami Bldg. Dept., 1976–1996

E. E. (Al) Linder, Watsonville, CA, 1997–2004

NFPA 58 would not be *the* internationally recognized propane code were it not for the work of these dedicated people. Their contributions are appreciated.

*deceased

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Preface

The eighth edition of the *LP-Gas Code Handbook* continues the tradition begun by Wilbur L. Walls, editor of the first edition in 1986. The handbook provides commentary that brings the legalistic language of the code to life. The code must be written using a technically clear, usable, and enforceable style. It cannot include the guidance and explanations that the Technical Committee on Liquefied Petroleum Gases would like to include.

The purpose of this handbook is to assist you, the enforcer or user of NFPA 58, *Liquefied Petroleum Gas Code*. The commentary and supplements provide guidance, recommendations, and common practices for the use of LP-Gas as a fuel.

The 2008 edition of the code contains several important changes, including the following:

1. Revised table of container appurtenance requirements
2. New section on patio heaters
3. New requirements for notification prior to transfer of liquid LP-Gas from rail cars to tank cars without intermediate storage
4. New requirements for operation of small LP-Gas pipeline vapor systems with 10 to 99 users (such as might be located at a mobile home park) that is consistent with U. S. Department of Transportation requirements

An NFPA code handbook is never complete. In order to stay current, it must change as technology and code requirements change. Users will find that problems they encounter may not be addressed fully in the handbook commentary, tables, illustrations, or photographs, or that the commentary appears incomplete when applied to real problems. Therefore, the editor invites suggestions, examples, new illustrations, and photographs from all readers for use in the next edition.

History of NFPA 58

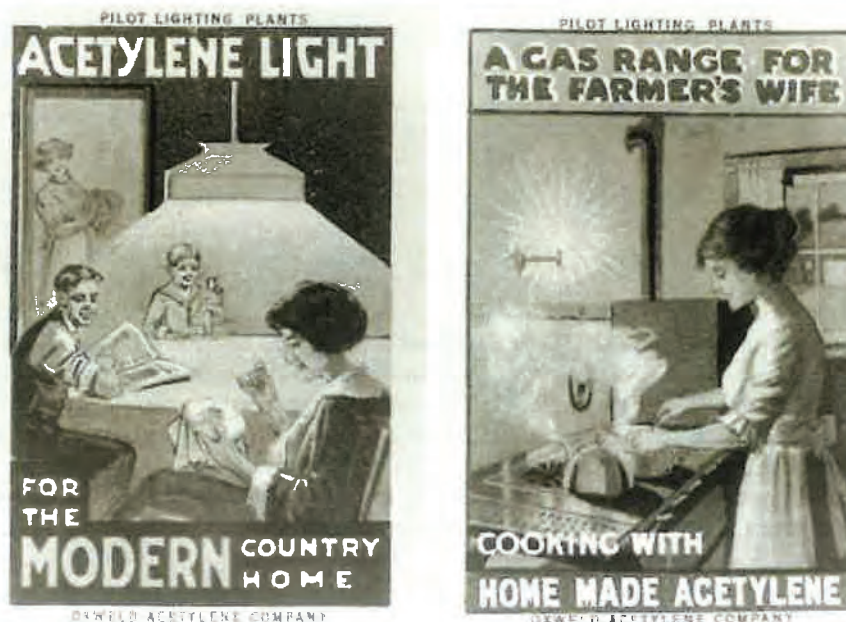
NFPA standards concerned with gases date from 1900, only four years after the establishment of NFPA itself. The first standards were concerned with acetylene, which was actually used in those days as a household cooking, lighting, and heating fuel, and with manufactured, or “city,” gas derived from coal and oil.

The NFPA Technical Committee on Gases developed the early standards. By 1924, the use of liquefied petroleum gas (LP-Gas), primarily as a cooking and heating fuel in rural areas, had become common, and the need for a national fire safety standard was recognized. The LP-Gas for these systems was stored in compressed gas cylinders. Because of their cylindrical shape, the LP-Gas they contained was widely referred to simply as “bottled gas,” an identification rather lacking in specificity (acetylene was also a “bottled gas”) but one still used today.

In 1927, the Committee on Gases secured NFPA approval of the first NFPA standard on LP-Gas, a four-page document with a title — *Regulations for the Installation and Operation of Compressed Gas Systems Other than Acetylene for Lighting and Heating* — that comprised a fair proportion of the text of the standard itself. The standard covered only systems in which

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EXHIBIT P.1 Early Magazine Advertisements for Acetylene Lighting and Cooking.



the LP-Gas was stored in cylinders fabricated to regulations of the U.S. Interstate Commerce Commission (ICC), today known as the U.S. Department of Transportation (DOT).

In those days, NFPA published its standards only in the Proceedings of the Annual Meeting at which the standards were adopted. To make them more available to users, the National Board of Fire Underwriters (NBFU), now known as the American Insurance Association, obtained NFPA permission to publish many of them in pamphlet form. These were identified as standards of the NBFU "as recommended by the NFPA." In those days, NFPA did not identify many of its standards by number. However, the NBFU did, and the standard was thus designated NBFU 52. Amended editions of the standard were adopted in 1928, 1933, and 1937.

Because the LP-Gas "bottles" had to be refilled (in those days, only at a plant built for that purpose), which required the use of a much larger container for plant storage, new specifications had to be developed. In addition, major consumers found a container larger than an ICC cylinder to be advantageous. These larger containers required different design and siting criteria.

In 1931, NFPA tentatively adopted *Regulations for the Design, Installation and Construction of Containers and Pertinent Equipment for the Storage and Handling of Liquefied Petroleum Gases*, which was officially adopted at the next NFPA meeting in 1932. This standard covered the larger containers, which are the ASME containers of today. Also published by the NBFU, under the designation NBFU 58, this standard had 14 pages, 10 more than NBFU 52.

At the 1931 Annual Meeting, committee chairman Harry E. Newell of the NBFU noted in his report that the proposed standard had been prepared by a joint subcommittee of the Committee on Gases and the Committee on Flammable Liquids. He attributed this to the fact that "it was difficult to decide whether liquefied petroleum gases were flammable liquids or gases." Even today, confusion exists on this score. Some municipal ordinances, undoubtedly of considerable vintage, equate them, and many communities have failed to adopt LP-Gas regulations under the erroneous impression that their flammable liquid regulations apply to LP-Gas.

For many years, the Committee on Gases was composed of 11 to 20 members. In 1932, there were 15 members, representing the Associated Factory Mutual Fire Insurance Compa-

nies, American Gas Association, Board of Fire Underwriters of Allegheny County, Western Factory Insurance Association, Conference of Special Risk Underwriters, Manufacturing Chemists Association, Boston Board of Fire Underwriters, International Acetylene Association, Underwriters Laboratories Inc., Compressed Gas Manufacturers Association, American Petroleum Institute, Railway Fire Protection Association, and the U.S. National Bureau of Standards, as well as the NBFU. With 6 of the 15 members, including the chairman, representing the insurance industry, the standard could be presumed to be rather conservative and thus lacked the balance of interests that is required under today's NFPA procedures.

The extreme versatility of "gas in a bottle" soon led to more and more complex uses, and the Committee on Gases was hard-pressed to keep up. Amended editions of the 1931 standard were adopted in 1934, 1937, 1938, and 1939.

In 1935, a standard on LP-Gas cargo vehicles, whose use had become widespread in the early 1930s, was adopted and published by NBFU as NBFU 59. In 1937, a standard was adopted to regulate the use of LP-Gas as a fuel to power vehicles, a practice that had become prevalent by the mid-1930s. In 1938, however, this became a part of the ASME Code container standard (NBFU 58).

By now, it was apparent that the various standards contained considerable duplicate material and could be combined into a single standard. This was done in 1940. The resulting 47-page standard (in the NBFU 58 pamphlet version) combined the 1937 edition of NBFU 52 and the 1939 editions of NBFU 58 and 59. This single standard also replaced the *Liquefied Petroleum Gas Code*, which was adopted in 1937 in response to a request by regulatory and insurance interests to provide container siting and basic fabrication criteria that were not as detailed as those found in the existing standards. This code ultimately proved inadequate from the industry's point of view, and it was withdrawn when the combined standard was introduced. The 1943 edition of the standard was the first edition to be designated NFPA 58. The first pamphlet edition of NFPA 58 was published in 1950.

The dates of each edition of NFPA 58 are given in the "Origin and Development" section of each edition. To date, there have been 31 editions since the 1940 edition, an average of about one every two years. From 1950 to 1961, in fact, a new edition was adopted each year. This is a very high rate, and it placed an impossible burden upon its usefulness as a public safety regulatory instrument. Since 1961, new editions have been adopted about every three years, except for the 2008 edition, which took four years due to controversy, which resulted in a last-minute deletion of proposed coverage of cabinet heaters.

The Committee on Gases itself developed NFPA 58 until 1956. By that time, the number and variety of NFPA standards covering various gases had grown so large that the size of the committee was becoming difficult to manage. The solution was to establish a number of smaller committees, known as sectional committees, composed of experts on the different gas applications. The developmental and interpretative responsibilities for NFPA 58 were thus assigned to the Sectional Committee on Liquefied Petroleum Gases. However, the sectional committee could only recommend amendments, Formal Interpretations, or Tentative Interim Amendments (TIAs) for adoption by the Committee on Gases.

Because the sectional committee lacked authority, its membership essentially duplicated that of the Committee on Gases, and the purpose of the sectional committee was defeated. It was also becoming evident that the Committee on Gases seldom overturned a sectional committee recommendation.

In 1966, the sectional committees — there were four at the time — were organized into three full-fledged technical committees, and the Committee on Gases ceased to exist. NFPA 58 thus became the complete responsibility of the Technical Committee on Liquefied Petroleum Gas.

From 1940 to 1969, NFPA 58 consisted of a chapter entitled Basic Rules, followed by a number of chapters entitled Divisions and by appendixes. The Introduction and Basic Rules included all material common to all applications, such as scope statements, retroactivity, definitions, odorization, approval requirements, container fabrication, siting, design criteria for

pipng, valves, hoses and fittings, filling levels, and ignition source controls. The eight divisions amplified and sometimes modified the basic provisions for specific applications, some on the basis of kinds of containers and others on the basis of the environment in which the system was used.

As a new application was developed, it was essentially treated as a package and added as a new division, which was easier to do and allowed for the timely inclusion in the standard of new applications. The problem with this approach was that similar hazards were being treated differently, and the basic rules were becoming less and less basic.

In the late 1960s, the Technology and Standards Committee of the National Propane Gas Association (NPGA) undertook the development of a format that would provide consistency in hazard evaluation, would reduce the extent to which particular interests would have to study the entire standard, and would make the format more like that used in other NFPA standards.

In the current format, **Chapters 1 through 4** include only material truly relevant to all applications.

Chapters 5 and 6 address the fundamental breakdown of interest that experience has shown exists between manufacturers of equipment and those who assemble this equipment into systems and actually install them. Fire experience clearly reveals that incidents are nearly always due to failure to comply with one or more provisions and that many of these failures are the result of confusion between manufacturers and installers as to who should do what. To help reduce this confusion, **Chapter 5** is aimed at the equipment manufacturer and **Chapter 6** at the installer.

The same experience has also shown that the great majority of nonappliance-related accidents occur when LP-Gas liquid is being transferred from one container to another. An essential aspect of such operations is the presence and performance of a person or persons conducting the transfer operation: An accident generally involves human behavior, as well as equipment. **Chapter 7** addresses LP-Gas liquid transfer.

Chapter 8, Storage of Cylinders Awaiting Use, Resale, or Exchange, and **Chapter 9**, Vehicular Transportation of LP-Gas, retain the old format of Divisions V and III.

Chapter 10 was essentially new in the 1972 edition. Earlier editions had not considered the role of the structural behavior of a room or building in an explosion.

Chapter 11 was created in the 1992 edition by relocating the coverage of engine fuel systems from Chapter 6 to this chapter.

Drawn largely from NFPA 59 and NFPA 59A, **Chapter 12** was added in the 1989 edition to provide requirements for the new coverage of refrigerated storage containers.

Coverage of marine shipping and receiving was relocated from Chapter 4 to create Chapter 13 in the 1992 edition.

Chapter 14, Operations and Maintenance, was added in the 2001 edition. It contains only operations and maintenance requirements that were new in the 2001 edition. In the current edition, a new section was added, Small LP-Gas Systems, covering vapor systems of 10 to 99 users connected to a common supply system. These requirements essentially duplicate requirements in U. S. Federal Law applicable to these pipeline systems. The intent is to make them more easily available to operators of these relatively small systems, which may be located in mobile home parks, campgrounds, and housing developments.

Chapter 15 was added in the 1998 edition. It consists of tables used to size propane vapor piping. The tables were extracted from NFPA 54, *National Fuel Gas Code*. The chapter was added because some pipe sizing in buildings is now included in the scope of NFPA 58, because it was deleted from NFPA 54 in the 1996 edition.

While the 1972 edition went a long way toward bringing the format of NFPA 58 into line with other NFPA standards, it still did not properly segregate mandatory and nonmandatory provisions, and it used a different paragraph numbering system. These differences were corrected in the 1983 edition.

Experience with the format of the 1972 edition and with subsequent editions indicates that it has led to improved comprehension and application. However, it is more difficult to re-

view existing provisions to see if a new application is in fact already covered than it is to start from scratch. Furthermore, there is always pressure to include all provisions applicable to a new and “hot” application in one place. This temptation must be resisted lest the standard evolve into the conflicting and cumbersome document it once was.

The administration of the committees responsible for NFPA 58 has been remarkably stable over its history. Harry E. Newell of the NBFU was chairman from 1932 until 1956, when he retired from NBFU. As an indication of the respect the committee and NFPA had for him, the position of honorary chairman was created for him, the only time this position has existed. He served in this capacity until 1958.

Newell’s dedication was even more remarkable in that he also performed the chores of committee secretary, albeit anonymously. It wasn’t until 1954 that NFPA was able to assign a staff member, Clark F. Jones, as committee secretary. Jones served in this post until his untimely death in 1962. Wilbur L. Walls succeeded him in September 1962. Walls was the committee secretary until his retirement from NFPA in 1984. In May 1985, Theodore C. Lemoff became the NFPA staff secretary.

Franklin R. Fetherston succeeded Newell as chairman of the Committee on Gases in 1956. Initially representing the Liquefied Petroleum Gas Association (now the National Propane Gas Association), he later represented the Compressed Gas Association until he retired in 1966. During Fetherston’s tenure, the Sectional Committee on Liquefied Petroleum Gases was chaired by Harold L. DeCamp of the Fire Insurance Rating Organization of New Jersey from 1956 to 1964, and by Myron Snell of the Hartford Accident and Indemnity Company from 1964 to 1966.

Hugh V. Keepers of the Fire Prevention and Engineering Bureau of Texas became the first chairman of the current committee in 1966 and served for 10 years until his retirement. He was followed by Connor Adams of the City of Miami, who served as chair from 1975 to 1996. The immediate past chairman, E. E. (Al) Linder, a safety consultant and former propane company employee, took over the reins in 1996 and served through the 2004 edition. He was replaced by Frank Mortimer of Federated Mutual Insurance Company.

Acknowledgments

A book that compiles the history, intent, and application of an NFPA standard, as the *LP-Gas Code Handbook* does, is the work of many contributors, many of whom are members of the Technical Committee on Liquefied Petroleum Gases, and all of whom work with LP-Gas daily. The foundation for this sixth edition was laid by the three authors who contributed to the first edition in 1986: Wilbur L. Walls, who represented, at the time, the expertise of NFPA on flammable gases; Walter H. Johnson, who possessed a broad knowledge of the LP-Gas industry from the industry association viewpoint; and H. Emerson Thomas, who offered his perspective as one of the founders of the propane industry in the United States.

The preparation of this eighth edition was enhanced by the contributions of Bruce Swiecicki, Senior Technical Advisor for the National Propane Gas Association. Bruce, as the contributing editor, provided draft commentary on the entire code and made many important contributions. He is a registered professional engineer in Illinois and has an M.S. in Mechanical Engineering from the University of Illinois. Bruce has been a member of the Technical Committee on Liquefied Petroleum Gases since 1994, and his efforts on this publication are appreciated.

Also deserving of special thanks for their work on this handbook are Sam McTier of McTier Supply Co. and Richard Fredenburg of the North Carolina Department of Agriculture, who provided insight into how enforcers use the code and handbook.

In addition, I wish to thank the many contributors of new artwork that makes this handbook more useful. These contributors include the following companies and individuals: Algas-SDI; Alternate Energy Installations; American Welding and Tank Company; Ameri-Gas; Amano Pioneer Eclipse Corporation; Anderson Greenwood; Blackmer, A Dover

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Company; Brian Clayton; Cavagna North America, Inc.; Cenex, a brand name of CHS Inc.; ChefMaster, a division of MR. Bar-B-Q, Inc.; CleanFuel USA; Corken, Inc.; Cornerstone Propane; Eastern Propane Corp; Engineered Controls International, Inc. (Rego); Ely Energy; Elster Perfection Corp.; Ferrellgas; First Virginia Propane Company; Fisher Controls International, LLC; Flame Engineering; Foster-Miller, Inc.; Full Circle; Gas Equipment Co., Inc.; Gastite Division, Titeflex Corporation; H. Emerson Thomas; Heath Consultants Incorporated; H&H Gas; Hoffman & Feige; Illinois Propane Gas Association; IMPCO Technologies, Inc.; Independent Propane Co.; J&N Enterprises, Inc.; Lin's Propane Trucks; Liquid Controls; Lite Cylinder; Manchester Tank; Mississippi Tank Co.; National Board of Boiler and Pressure Vessel Inspectors; National Propane Gas Association; North Carolina Dept. of Agriculture; the Propane Education and Research Council (PERC); Pioneer Eclipse Corp.; Perfection Corporation; Permagas; Propane Technical Services; Ragasco; Ransome Manufacturing; Revere Gas & Appliance; Rochester Gauges, Inc; R.W. Lyall & Company, Inc.; Screen Graphics of Florida; SEA-3 Inc.; Sensidyne; Sherwood; Harsco Gas & Fluid Control Group; Smith Precision Products Co., Inc.; Superior Energy Systems; Texas Trailer Corp.; Trinity Containers, LLC; U.S. DOT; Wilbur Walls; Worthington Cylinder Corp.

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This handbook is built on the foundation laid by the Technical Committee on Liquefied Petroleum Gases, which writes NFPA 58. The editor appreciates the work the committee members do in carefully considering each proposal and comment and the discussions on other topics, which is the basis of the book.

I would also like to again thank Wilbur Walls, NFPA gases engineer emeritus, who, though retired, volunteered his time and energy to assist me when I joined NFPA and took over responsibility for the NFPA gases project. Bill continues to be a valuable resource for the historical questions that arise.

I also appreciate the efforts of the NFPA staff who made this book possible. Particular thanks go to Josiane Domenici, permissions editor, Marla Marek, copy editor, Irene Herlihy, developmental and project editor, and Debra Rose, product manager.

Theodore C. Lemoff, P.E.
Editor

About the Contributors

Ronald R. Czischke

Ronald R. Czischke is principal engineer, compressed and fuel gas equipment, at Underwriters Laboratories Inc. He has over 19 years of engineering experience and over 11 years of experience in laboratory quality management. He is a member of the American Society of Mechanical Engineers, the American Society for Quality, and the National Fire Protection Association, for which he serves on the LP-Gas Code Technical Committee, Vehicular Alternate Fuel System Technical Committee, and the Industrial and Medical Gas Technical Committee. Ronald has a bachelor's degree in mechanical engineering from Michigan Technological University and is a registered professional engineer in the state of Illinois.

Pravinray D. Gandhi

Pravinray D. Gandhi is global business development director for the fire and security division of Underwriters Laboratories Inc. During his tenure at UL, he has been involved in hazard and risk assessment; standards development; small-scale and large-scale fire testing; thermal, structural, and fire modeling; and data acquisition and instrumentation. He has also been involved with national standards (ASTM, NFPA) and international standards (ISO, IEC) development. He has been a member of the NFPA Technical Committees on Hazards and Contents and Fire Tests. Pravinray received his Ph.D. in mechanical engineering from the University of Notre Dame and is a registered professional engineer in the state of Illinois.

Eric Kuster

Eric Kuster is currently Loss Control Specialist for the Fairmont Specialty Group. He was a fire fighter/hazmat responder/crash injury medical tech for the Raritan Township Fire Co. for several years, where he served as first lieutenant. He has served on numerous committees for the Mid-Atlantic Propane Gas Association, National Propane Gas Association, and Propane Education & Research Council. He has presented to many organizations on emergency response and propane issues, including the 2005 EPA emergency preparedness/ prevention and HAZMAT spills conference and NPGA's pinnacle conference.

Rodney L. Osborne

Rod Osborne has been with Battelle for 20 years, performing and managing a wide range of energy-related projects. Rod's work has been in materials/structural mechanics, risk assessment, and integrity management of U.S. and international natural gas and propane pipelines; appliance energy, thermal, and failure analyses; and propane regulator and stationary and cargo tank testing and failure analyses. Rod has a Ph.D. in nuclear engineering from the Ohio State University and is a registered professional engineer.

John Roberts

John Roberts has a bachelor's degree in chemistry and mathematics from St. Olaf College and a Ph.D. in organic chemistry from the University of North Dakota. He worked at Phillips

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Petroleum Company in Research and Development as a product development chemist in sulfur chemicals and also did new product development and technical support for gas odorization for Phillips 66 Chemical Company. He has worked for Engineering and Fire Investigations in Kingwood, Texas, and currently has his own firm, Materials & Chemicals Consulting, in Kingwood, Texas. He currently consults on gas odorization matters in natural gas and propane, natural gas and propane quality, and other chemical-related matters.

Bruce Swiecicki

Bruce Swiecicki has worked 14 years at the National Propane Gas Association as vice president of technical services and now as senior technical advisor. His work experience includes 10 years at Building Officials and Code Administrators, International, where he was senior staff engineer. He has been a member of the Technical Committee on Liquefied Petroleum Gases since 1994 and a member of several other NFPA committees as well as other codes and standards organizations. Bruce holds bachelor's and master's degrees in mechanical engineering from the University of Illinois and is a registered professional engineer in the state of Illinois.

Stuart Weidie

Stuart Weidie is President and CEO of Blossman Gas. He is a member of the Board of Directors of the National Propane Gas Association and Chairman of the PERC Research and Development Advisory Committee.

Kenneth Wood

Ken Wood has 38 years of experience in LP-Gas and pipeline gas. He worked 20 years at various positions for a gas utility with a propane business. He spent the last ten years as the company vice president and general manager before moving on to become Vermont PSD's gas safety program manager. He has been a member of the National Fire Protection Association, NARUC Gas Safety Subcommittee, National Association of Pipeline Safety Reps., New England Pipeline Safety Reps., Vermont LP Gas Education & Safety Committee, and an associate staff member of the Transportation Safety Institute as an LP-Gas trainer. Ken was a member of the committee that produced the *Training Guide for Operators of Small LP-Gas Systems*. He has helped investigate gas incidents resulting in fire and/or explosion and carbon monoxide poisonings. Ken is also one of the instructors at the New England Institute of Fire Science teaching the relationship of propane and other gases during fires, to aid in the investigation process. Ken is currently a co-owner of Education, Training and Safety Associates.

About the Editor

After graduating from the City College of New York with a Bachelor of Engineering (Chemical) degree, Theodore C. Lemoff was employed in the chemical and petrochemical industry by Proctor and Gamble Company, Sun Chemical Corporation, and Badger Engineers, Inc., in various engineering positions. He joined NFPA in 1985 and currently serves as NFPA's principal gases engineer. He serves as the NFPA staff liaison to the National Fuel Gas Code Committee, and he is also responsible for other NFPA standards on flammable gases.

In addition to being the editor of the *LP-Gas Code Handbook*, Lemoff is the editor of the *National Fuel Gas Code Handbook* and co-author of the *NFPA Pocket Guide to Fuel Gas Storage and Use*.

Lemoff represents NFPA on the ASME Code for Pressure Piping Committee (National Interest Review Group) (B31), the pipeline safety advisory committee of the U.S. Department of Transportation, and the IAPMO Mechanical and Plumbing Code Committees.

Lemoff is a registered professional engineer in the Commonwealth of Massachusetts and is a member of the American Institute of Chemical Engineers and Society of Fire Protection Engineers, the American Society of Plumbing Engineers, and the International Association of Plumbing and Mechanical Officials.

PART ONE

NFPA[®] 58, *Liquefied Petroleum Gas Code,* with Commentary

Part One of this handbook includes the complete text of the 2008 edition of NFPA 58, *Liquefied Petroleum Gas Code*, which is made up of 15 mandatory chapters and 12 nonmandatory annexes. Working within the framework of NFPA's consensus codes- and standards-making process, the Technical Committee on Liquefied Petroleum Gases prepared the mandatory provisions found in Chapters 1 through 15.

The Technical Committee on Liquefied Petroleum Gases also developed the material found in the annexes of the code. The annex material is designed to assist users in interpreting the mandatory code provisions. It is not considered part of the requirements of the code; it is advisory or informational in nature. An asterisk (*) following a code paragraph number indicates that advisory annex material pertaining to that paragraph appears in Annex A. For the reader's convenience, in this handbook Annex A material has been repositioned to appear immediately following its base paragraph in the body of the code text.

The explanatory commentary in this handbook was prepared by the handbook editor, with the assistance of those persons mentioned in the acknowledgments, and is intended to provide the reader with an understanding of the provisions of the code and to serve as a resource and reference for implementing the provisions of or enforcing the code. It is not a substitute for the actual wording of the code or the text of the many codes and standards that are incorporated by reference. The commentary immediately follows the code text it discusses and is set in blue type for easy identification.

This edition of the handbook includes a frequently asked questions feature. The marginal FAQs are based on the questions most commonly asked of the NFPA 58 staff. The handbook also features a tool designed to help users easily identify important new or revised elements in the code. New or revised material is identified with a "new" icon in the margin of the book next to that material.

Definitions

CHAPTER 3

Since the 2004 edition, all definitions that apply to subjects covered throughout the code have been located in Chapter 3.

The sections in Chapter 3 are outlined as follows:

- General (See Section 3.1.)
- NFPA Official Definitions, which apply to all NFPA codes and standards (See Section 3.2.)
- General Definitions, which apply to NFPA 58 only (See Section 3.3.)

3.1 General

The definitions contained in this chapter shall apply to the terms used in this code. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

Generally, if terms used in the code are not defined in Chapter 3, then *Merriam-Webster's Collegiate Dictionary* [1] is the source for common usage.

3.2 NFPA Official Definitions

Section 3.2 contains definitions that are used in other NFPA documents and are not specifically related to the propane industry. NFPA attempts to make all of its documents consistent with respect to terms used to describe the enforcement authority and approval process.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

Equipment, materials, or services can be listed, approved, or both. *Listed*, defined in 3.2.5, means that the item has been reviewed by an independent testing organization that evaluates products and continues to evaluate their production. Listed products are included in "lists" maintained by the testing agency. *Approved*, as defined in 3.2.1, means that the equipment, material, or services have been accepted by the authority having jurisdiction. Listed products

◀ FAQ

What is the difference between the terms *listed* and *approved*?

must comply with standards, while approved products may or may not comply with standards.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

FAQ ►
What is the meaning of “authority having jurisdiction” as used in NFPA 58?

An authority having jurisdiction is a governmental agency responsible for protecting the public welfare through its activities to enforce the codes and standards that have been enacted into law. The propane industry can be regulated through a number of governmental agencies, including the state or local fire marshal’s office, the state or local building department, or the federal or state department of transportation. Notably, many enforcement agencies, including the U.S. Occupational Safety and Health Administration, promulgate rules that reference earlier editions of NFPA 58 than the 2008 edition. As noted in **A.3.2.2**, nongovernmental bodies can be the authority having jurisdiction by virtue of the conditions of a private contract (e.g., an insurance policy).

Each propane retail marketing business should become familiar with which authorities have jurisdiction over each operation of its business. The following are examples of authorities having jurisdiction for different parts of a propane business:

- Bulk plant — Fire marshal or fire chief
- Vehicles — State vehicle bureau or state police
- Residential installations — Building or gas official

3.2.3* Code. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.

A.3.2.3 Code. The decision to designate a standard as a “code” is based on such factors as the size and scope of the document, its intended use and form of adoption, and whether it contains substantial enforcement and administrative provisions.

3.2.4 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

FAQ ►
What information should be on a label?

A product is labeled to indicate that a third-party, independent agency has either conducted testing or otherwise evaluated the performance or the design of a product or system. The label indicates the name of the evaluating organization (such as Underwriters Laboratories Inc. or CSA-America) as well as the manufacturer’s name or trademark and the model number and/or serial number and should list the applicable standard under which the product or equipment was evaluated or tested.

3.2.5* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

A.3.2.5 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

The AHJs customarily accept or even require (depending on whether or not NFPA 58 requires) the use of listed equipment whenever it is available. In the United States and Canada, the major LP-Gas equipment listing agencies customarily recognized as such by the authorities having jurisdiction are Underwriters Laboratories Inc., Underwriters' Laboratories of Canada, FM Global, CSA-International, and others. Many other organizations perform such services, however, and equipment listed by them is acceptable provided that the organization is acceptable to the authority having jurisdiction.

A point of some confusion is that not all the above organizations use the term *listed*. For example, CSA-America uses the term *certified* and FM Global uses the term *approved*. The terms *certified* and *approved* are synonymous with the term *listed* in this definition.

3.3 General Definitions

3.3.1 Actuated Liquid Withdrawal Excess-Flow Valve. An excess-flow valve for liquid withdrawal applications that remains in a closed position until actuated by a pipe nipple or adapter, as recommended by the manufacturer, and that is used with a shutoff valve attached to the actuator.

The definition of *actuated liquid withdrawal excess-flow valve* was added in the 1995 edition. These valves are required in ASME containers of 125 gal to 2000 gal (0.5 m³ to 7.6 m³) water capacity manufactured after July 1, 1961. The valve is designed to eliminate the need to roll a container on its side to remove liquid from it. Since the early 1960s, at least three manufacturers have made valves that accomplish the requirements related to this definition under the names of Check-Lok® and Check-Mate®. Prior to the 1995 edition, this specific function valve had no name or definition. The term *actuated* is used to indicate that the valve remains closed until the insertion of the mating connection opens it.

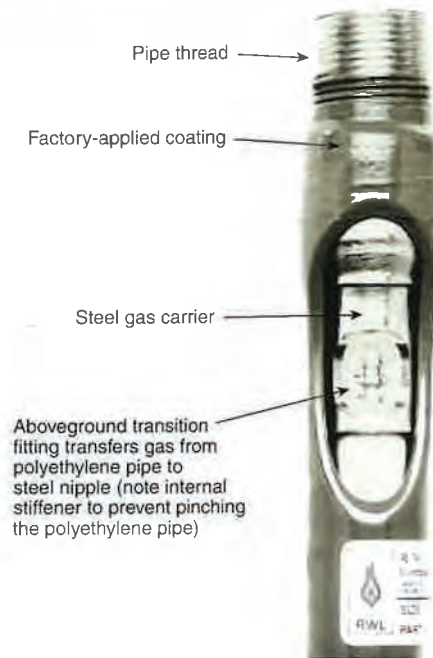
3.3.2 Anodeless Riser. A transition assembly where polyethylene or polyamide pipe or tubing is permitted to be installed underground and is terminated above ground outside of a building.

An anodeless riser is a piping component that connects to polyethylene (or polyamide) pipe under ground and terminates in a metal threaded connection above ground (see [Exhibit 3.1](#)). It is anodeless because it provides no metallic surface that contacts the soil, thereby protecting the riser against corrosion. Typically, anodeless risers are manufactured of steel-encased polyethylene liners. The steel is coated with an epoxy covering that protects the inner components. (See [6.9.4.3](#).)

3.3.3 ANSI. American National Standards Institute.

The American National Standards Institute (ANSI) is a private, nonprofit organization that administers and coordinates the U.S. voluntary standardization and conformity assessment

EXHIBIT 3.1 *Cutaway View of Riser Assembly. (Courtesy of R.W. Lyall & Company, Inc.)*



system. ANSI does not develop its own standards but sanctions those prepared by committees and organizations that are ANSI members and that use procedures approved by ANSI.

NFPA is recognized as a standards-developing organization under ANSI and issues codes and standards with the ANSI designation because its regulations are accepted by ANSI.

3.3.4 API. American Petroleum Institute.

The American Petroleum Institute (API) is a trade association composed largely of U.S. oil companies. Many oil companies produce and distribute LP-Gas because it is a byproduct of the refining of crude oil as well as the processing of natural gas. API also develops standards that can be useful for those involved in the LP-Gas industry.

3.3.5 API-ASME Container (or Tank). A container constructed in accordance with the pressure vessel code jointly developed by the American Petroleum Institute and the American Society of Mechanical Engineers.

Until 1961 a joint API-ASME code was used for designing propane tanks. A small number of these vessels are still in service, and they remain acceptable for service. After the joint code was discontinued, API addressed the refining industry's need for large storage vessels, while ASME addressed pressure vessels for all applications.

3.3.6 ASME. American Society of Mechanical Engineers.

The American Society of Mechanical Engineers (ASME) is a membership organization of mechanical engineers.

3.3.7 ASME Code. The American Society of Mechanical Engineers Boiler and Pressure Vessel Code.

3.3.8 ASME Container. A container constructed in accordance with the ASME Code.

3.3.9 ASTM. American Society for Testing and Materials.

The American Society for Testing and Materials (ASTM) promulgates the largest body of private-sector standards in the United States. As is evident in 2.3.5, many ASTM standards that address piping and castings are adopted by mandatory reference in NFPA 58.

3.3.10* Bulk Plant. A facility where the primary function is to store LP-Gas prior to further distribution. LP-Gas is received by cargo tank vehicle, railroad tank car, or pipeline, and then distributed by portable container (package) delivery, by cargo tank vehicle, or through gas piping.

A.3.3.10 Bulk Plant. Bulk plants receive gas through a variety of methods, such as railroad tank car, transport, cargo tank vehicle, gas piping, or watercraft. These plants are generally utilized for domestic, commercial, agricultural, institutional, and industrial applications, or for the storage of product awaiting delivery to the end user. A facility that transfers LP-Gas from railroad tank cars from a private track directly into cargo tank vehicles is also in this category. Such plants could have container-filling and truck loading/unloading facilities on the premises. Normally, no persons other than the plant management or plant employees have access to these facilities.

As defined in 3.3.10, bulk plants are facilities where LP-Gas is stored before it is delivered to the end-use customer. Frequent liquid transfer operations take place at bulk plants. These include cylinder filling, transport truck unloading, rail tank car unloading, and bobtail (retail bulk delivery truck) filling. See Exhibit 3.2 for an example of a typical bulk plant. Exhibit 3.3 shows a larger bulk plant with the capability to unload LP-Gas from rail cars. See also F.I. 58-04-3.

3.3.11 Cargo Tank. A container that is used to transport LP-Gas as liquid cargo and either is mounted on a conventional truck chassis or is an integral part of a cargo transporting vehicle.

Cargo tanks are typically installed on truck chassis (cargo tank motor vehicles), which are built to comply with DOT requirements (MC-330 and MC-331 specifications) [2,3]. Cargo tank vehicles include bobtails (see Exhibit 3.4) and transports (see Exhibit 3.5). Cargo tanks differ from DOT containers, which are “portable” and are transported on trucks.

3.3.12 CGA. The Compressed Gas Association.

In 1913, a nonprofit service organization was incorporated in New York as the Compressed Gas Manufacturers' Association to promote, develop, represent, and coordinate technical and standardization activities in the compressed gas industries in the interest of safety and effi-

◀ **FAQ**

What is meant by the term *bulk plant*?



EXHIBIT 3.2 Aerial View of a Bulk Plant. (Courtesy of Revere Gas and Appliance)

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EXHIBIT 3.3 Large Bulk Plant. (Courtesy of Eastern Propane Corp.)



Formal Interpretation
NFPA 58
Liquefied Petroleum Gas Code
2008 Edition

Reference: 3.3.10

F.I. No.: 58-04-3

Question: Is it the intent of the Committee, based on the definition provided in 3.3.10 of NFPA 58, that a building, at a bulk plant, containing cylinders for distribution or buildings at bulk plants where LP-Gas cylinders are filled, is part of the bulk plant?

Answer: Yes

Issue Edition: 2004

Reference: 3.3.10

Issue Date: November 30, 2005

Effective Date: December 19, 2005

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ciency. Today, among the Compressed Gas Association's (CGA's) members are companies and individuals producing compressed, liquefied, and cryogenic gases and their containers (including cargo containers), container appurtenances, and other system components.

From its inception, a major activity of CGA has been the development of standards through the efforts of more than 40 technical committees. The 1932 edition of what is now NFPA 58 was based on a draft prepared by CGA's Test and Specification Committee in 1930 and 1931. (See "History of NFPA 58" in the **Preface**.) Much of this work has now passed on



EXHIBIT 3.4 Bobtail. (Courtesy of CENEX, a brand name of CHS Inc.)



EXHIBIT 3.5 Transport Vehicle. (Courtesy of Mississippi Tank Co.)

to the National Propane Gas Association (NPGA). CGA continues to provide valuable technical assistance to the NFPA Technical Committee on Liquefied Petroleum Gases.

3.3.13 Container. Any vessel, including cylinders, tanks, portable tanks, and cargo tanks, used for the transporting or storing of LP-Gases.

As noted in the definition of *container*, there are several different pressure containers used to store and transport LP-Gas, and each must comply with specific fabrication requirements. The word *container* is a generic description in NFPA 58 for pressure vessels that store LP-Gases and is used by itself in the code whenever it is not necessary to cite a specific type. A container may be either a DOT cylinder or an ASME tank.

3.3.14 Container Appurtenances. Devices installed in container openings for safety, control, or operating purposes.

3.3.15 Container Assembly. An assembly consisting of the container and fittings for all container openings such as shutoff valves, excess-flow valves, liquid level gauging devices, pressure relief devices, and protective housings.

3.3.16 Cylinder. A container designed, constructed, tested, and marked in accordance with U.S. Department of Transportation specifications, Title 49, Code of Federal Regulations, or in accordance with a valid DOT exemption.



The definition of *cylinder* was revised in the 2008 edition to include the stipulation that the cylinder be designed, tested, and marked to comply with DOT requirements, in addition to the previous requirement that the cylinder be constructed in accordance with DOT requirements. Therefore, a container is not a cylinder unless it complies with all DOT requirements.

3.3.17 Design Certification. The process by which a product is evaluated and tested by an independent laboratory to affirm that the product design complies with specific requirements.

3.3.18 Diameter. The length of a straight line passing through the center of a circle, terminating at the periphery.

3.3.19 Direct Gas-Fired Tank Heater. A gas-fired device that applies hot gas from the heater combustion chamber directly to a portion of the container surface in contact with LP-Gas liquid.

3.3.20 Dispensing Station. Fixed equipment in which LP-Gas is stored and dispensed into portable containers.

The definition of *dispensing station* was extracted from NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2003 edition [4], and first appeared in the 1992 edition of NFPA 58.

The fundamental feature differentiating vehicle fuel dispensers and dispensing stations from bulk plants or industrial plants is that persons other than management or employees have access to the vehicle fuel dispensing facility. The distinct provisions for dispensing fuel into portable containers are included in [Section 6.24](#).

Dispensing stations include cylinder refilling facilities, which are open to the public; cylinder refueling facilities at recreational vehicle parks; facilities at hardware, equipment rental, and sporting goods stores for filling gas grill cylinders; and facilities at marinas. Refueling of industrial truck cylinders could be at a bulk plant where exchange cylinders are refilled or at an industrial plant where either exchange cylinders or containers mounted on the industrial truck are refilled.

3.3.21 DOT. U.S. Department of Transportation.

3.3.22 Filling.

All LP-Gas containers have a maximum permitted filling limit to prevent the container from becoming “liquid full” if the temperature of the gas rises. If a container becomes “liquid full,” gas can be released into the atmosphere, possibly resulting in a fire or explosion if a source of ignition is present. If liquid LP-Gas is released through a pressure relief valve, it will expand to 270 times its liquid volume. Two fundamental methods are allowed for filling LP-Gas containers — *volumetric* and *weight*.

3.3.22.1 Volumetric Method Filling. Filling a container to not more than the maximum permitted liquid volume.

The volumetric method filling limits the volume of liquid LP-Gas to 80 percent for cylinders and smaller ASME containers, or to a level determined by the density and temperature of the liquid LP-Gas for ASME containers over 1200 gal (4.5 m³) (see [7.4.3](#)). Volumetric filling is typically performed using a fixed maximum liquid level gauge, which comprises a dip tube protruding into the container and a knurled nut or slotted screw that opens the dip tube to the atmosphere. When the liquid LP-Gas level contacts the bottom of the dip tube, liquid is transported out of the cylinder and vaporizes outside the cylinder at the lower pressure of the atmosphere. The act of vaporization causes moisture in the surrounding air to condense and appear as a white fog. The appearance of this fog indicates that the container has been filled to its maximum limit.

3.3.22.2 Weight Method Filling. Filling containers to not more than the maximum permitted filling limit by weighing the LP-Gas in the container.

The weight method for filling cylinders is used for smaller size cylinders and limits the amount of liquid propane gas to 42 percent of the water capacity (in pounds) marked on the cylinder. Using the weight filling method for cylinders requires the use of a scale to measure the weight of the gas in the container.

3.3.23* Fire Protection. Fire protection for the purposes of this code shall be defined in the broad sense to include fire prevention, fire detection, and fire suppression.

A.3.3.23 Fire Protection. *Fire prevention* covers measures directed at avoiding the inception of fire or the escalation of an incident following the accidental or inadvertent release of LP-Gas. Such measures could include product control equipment and the insulation, mounding, or burial of containers.

Fire detection covers equipment that detects the presence of fire or heat either to initiate automated operation of the product control or other process equipment or to initiate local or remote alarms.

Fire suppression covers means of supplying water or other agents providing for fire control, exposure protection, or fire extinguishment.

The definition of *fire protection* was added to the code in 2004 to clarify the intent of the term as it relates to the provisions contained in **Section 6.25**, Fire Protection. Fire protection systems can include methods for fire prevention, fire detection, or fire suppression. Methods of fire prevention include requirements that are specified in the code, such as restricting the separation distance between propane containers and combustible materials or tanks containing flammable liquids. Fire detection methods may be traditional systems, such as smoke or heat detectors, but they may also be systems specifically required by the code, such as thermal activation links for internal valves and emergency shutoff valves. Fire suppression systems are traditionally recognized as being active systems, such as water spray or deluge systems. However, “passive” systems, such as insulating, burying, or mounding containers, also fall into this category.

3.3.24 Fixed Piping System. Piping, valves, and fittings permanently installed in a location to connect the source of the LP-Gas to the utilization equipment.

3.3.25 Flexible Connector. A short [not exceeding 60 in. (1.52 m) overall length] piping system component that is fabricated from a flexible material and equipped with connections at both ends.

The definition of *flexible connector* was revised in the 2008 edition, and new subdefinitions were added for related connectors to allow the user to discern between different materials used for flexible connectors.

The definition of *flexible connector* recognizes an increase in the permitted length up to 60 in. because flexible connectors are necessarily longer than 36 in. in order to achieve the necessary separation between the containers and the appliances they connect to. Previously, the 36 in. maximum was insufficient to maintain the 36 in. separation required by the code. Flexible connectors in permanent installations are restricted to flexible metallic connectors for durability.

3.3.25.1 Flexible Hose Connector. A component fabricated from LP-Gas hose that meets the requirements of UL 569, *Standard for Pigtails and Flexible Hose Connectors for LP-Gas*, or the following requirements of UL 21, *Standard for LP-Gas Hose*: (1) The tube or lining of a hose shall be made from a material compatible with LP-Gas. (2) The hose reinforcement shall be of cotton, synthetic fibers, or corrosion-resistant material such as stainless steel, or any combination thereof, evenly applied over the tube.

3.3.25.2 Flexible Metallic Connector. A component fabricated from flexible metal such as stainless steel wire braid or soft copper tubing.

Flexible hose connectors or flexible metallic connectors are allowed for portable and exchange cylinders. This construction is successfully used in many applications, including recreational vehicles. Flexible hose connectors up to 60 in. in length would only be used for portable exchange cylinders. Flexible hose connectors and flexible metallic connectors longer than 36 in. are successfully being used in areas subject to seismic forces for piping system flexibility. The additional length avoids overstressing the connector in order to maintain required separation distances between the appliance and the container.

The use of stainless steel wire braid hose is an accepted practice for motor fuel supply lines. The stainless steel reinforced tube provides extra protection for the tube assembly within the flexible hose connector.

3.3.26 Gallon. U.S. Standard. 1 U.S. gal = 0.833 Imperial gal = 231 in.³ = 3.785 L.

3.3.27 Gas. Liquefied petroleum gas in either the liquid or vapor state. The more specific terms *liquid LP-Gas* or *vapor LP-Gas* are used for clarity.

3.3.28* Gas–Air Mixer. A device or a system of piping and controls that mixes LP-Gas vapor with air to produce a mixed gas of a lower heating value than the LP-Gas.

A.3.3.28 Gas–Air Mixer. A gas–air mixture normally is used in industrial or commercial facilities as a substitute for another fuel gas.

Gas–air mixers are used to provide substitute fuel gas in natural gas systems. They are commonly referred to as “peak shaving” installations where the economics of the system make the temporary or permanent use of diluted LP-Gas more economically attractive than using natural gas.

3.3.29 Gauge.



3.3.29.1 Fixed Liquid Level Gauge. A liquid level indicator that uses a positive shutoff vent valve to indicate that the liquid level in a container being filled has reached the point at which the indicator communicates with the liquid level in the container.

3.3.29.2 Fixed Maximum Liquid Level Gauge. A fixed liquid level gauge that indicates the liquid level at which the container is filled to its maximum permitted filling limit.

An *outage gauge* is a common term for a fixed maximum liquid level gauge. A *10 percent gauge* is a common term for a fixed maximum liquid level gauge located at the 90 percent fill level of a container (leaving 10 percent empty space). A *20 percent gauge* is a common term for a fixed maximum liquid level gauge located at the 80 percent fill level of a container (leaving 20 percent empty space). **Exhibit 3.6** shows the components of a fixed maximum liquid level gauge.

3.3.29.3 Float Gauge. A gauge constructed with an element installed inside the container that floats on the liquid surface and transmits its position to a device outside the container to indicate the liquid level.

3.3.29.4 Magnetic Gauge. See **3.3.29.3**, Float Gauge.

A magnetic gauge is a type of float gauge that relies on a magnetized coupling to display the liquid level in the container. With a magnetic gauge, there is no possible leakage of LP-Gas through a seal since there is no penetration of the container wall.

3.3.29.5 Rotary Gauge. A variable liquid level gauge consisting of a small positive shutoff vent valve located at the outside end of a tube that has a bent end inside the container and can be manually rotated to determine the liquid level in the container. It is equipped with a pointer and an outside dial to indicate the liquid level.

A rotary gauge is a manually operated gauge that is used in both stationary and mobile storage containers. It comprises a vent to the atmosphere (a small tube with a valve) that is normally closed and a tube within the container that is manually rotated from outside. The gauge is operated by locating the tube in its uppermost position and opening the valve. A small stream of LP-Gas vapor is released, which is not visible. The tube is rotated until the stream turns white, indicating that liquid is being released, and the position of the gauge is read from the scale. For a more accurate reading, the tube rotation is continued, and the point at which the stream turns clear again is noted. The two measurements are averaged, compensating for any bending of the tube in the container.

3.3.29.6* Slip Tube Gauge. A variable liquid level gauge in which a relatively small positive shutoff valve is located at the outside end of a straight tube, normally installed vertically, that communicates with the container interior.

A.3.3.29.6 Slip Tube Gauge. The installation fitting for the tube is designed so that the tube can be slipped in and out of the container and so that the liquid level at the inner end of the tube can be determined by observing when the shutoff valve vents liquid.

EXHIBIT 3.6 Fixed Maximum Liquid Level Gauge.



3.3.29.7 Variable Liquid Level Gauge. A device that indicates the liquid level in a container throughout a range of levels.

3.3.30 GPA. Gas Processors Association.

3.3.31 ICC. U.S. Interstate Commerce Commission.

3.3.32 Ignition Source. See 3.3.67, Sources of Ignition.

3.3.33 Industrial Occupancy. Includes factories that manufacture products of all kinds and properties devoted to operations such as processing, assembling, mixing, packaging, finishing or decorating, and repairing.

Industrial occupancies may sometimes have large LP-Gas storage on hand. In that respect, an industrial occupancy may be similar to a retail bulk plant. The primary difference between the two is that a retail bulk plant typically has many more liquid transfer operations.

This definition is taken from *NFPA 5000*[®], *Building Construction and Safety Code*[®] [5], and is also used in *NFPA 101*[®], *Life Safety Code*[®] [6].

3.3.34 kPa. Absolute pressure in kilo-Pascals.

3.3.35 kPag. Gauge pressure in kilo-Pascals.

3.3.36 Liquefied Petroleum Gas (LP-Gas). Any material having a vapor pressure not exceeding that allowed for commercial propane that is composed predominantly of the following hydrocarbons, either by themselves or as mixtures: propane, propylene, butane (normal butane or isobutane), and butylenes.

LP-Gas can comprise any of a number of different hydrocarbons, but within the scope of NFPA 58, it is limited to a material with a vapor pressure for commercial propane. ASTM D 1835, *Standard Specification for Liquefied Petroleum Gases* [7], defines the vapor pressure for commercial propane to be 208 psig at 100°F (1.43 MPa at 38°C). By the same standard, commercial propane must be “predominantly propane,” while HD-5 propane grade must be at least 90 percent propane.

3.3.37* Low Emission Transfer. Establishes a maximum fugitive emissions standard for certain product transfer operations. Low emission transfer specifications might be employed to comply with environmental regulations or to determine certain minimum distance requirements.

A.3.3.37 Low Emission Transfer. Specifications for low emission transfer might be employed to comply with environmental regulations or to determine certain minimum distance requirements.

Low emission transfer is a method of transferring LP-Gas into containers with significantly reduced emission of hydrocarbon vapors. It is accomplished with specialized dispensing nozzles and corresponding transfer fittings that limit the amount of vapor released to the atmosphere to 4 cc (0.24 in.³) of product (liquid equivalent).

3.3.38 LP-Gas System. An assembly consisting of one or more containers with a means for conveying LP-Gas from a container to dispensing or consuming devices that incorporates components that control the quantity, flow, pressure, and physical state (liquid or vapor) of the LP-Gas.

LP-Gas systems include LP-Gas transfer facilities such as bulk plants.

3.3.39 Maximum Allowable Working Pressure (MAWP). The maximum pressure at which a pressure vessel is to operate as described by the ASME *Boiler and Pressure Vessel Code*.

◀ FAQ

Is propane the same as LP-Gas?



3.3.40 Minimum Design Metal Temperature (MDMT). As described by the ASME *Boiler and Pressure Vessel Code*.

3.3.41 Mobile Container. A container that is permanently mounted on a vehicle and connected for uses other than supplying engine fuel.

The term *mobile container* defines permanently mounted, non-engine fuel containers on vehicles, such as recreational and catering vehicles. [Exhibit 3.7](#) shows a mobile container designed for use in recreational vehicles. The definition does not include cargo tank motor vehicles.

EXHIBIT 3.7 *Recreational Vehicle Propane Tank.*
(Courtesy of Manchester Tank)



3.3.42 Mounded Container. An ASME container designed for underground service installed above the minimum depth required for underground service and covered with earth, sand, or other material, or an ASME container designed for aboveground service installed above grade and covered with earth, sand, or other material.

Mounded containers are aboveground or partially aboveground containers covered with earth, sand, or other material so that the container itself is not visible. Mounding provides protection from exterior flame impingement.

3.3.43* Movable Fuel Storage Tender. A container equipped with wheels (including a farm cart) not in excess of 1200 gal (4.5 m³) water capacity that is moved from one location to another.

A farm cart is shown in [Exhibit 9.12](#).

A.3.3.43 Movable Fuel Storage Tender. Movable fuel storage tenders or farm carts are basically non-highway vehicles but can occasionally be moved over public roads or highways for short distances to supply fuel for farm tractors, construction machinery, and similar equipment.

3.3.44 MPa. Absolute pressure in mega-Pascals.

3.3.45 MPag. Gauge pressure in mega-Pascals.

3.3.46 Multipurpose Passenger Vehicle. A motor vehicle with motive power, with the exception of a trailer, designed to carry 10 or fewer persons that is constructed on a truck chassis or with special features for occasional off-road operations.

The definition of *multipurpose passenger vehicle* is needed because the term, as used in [Chapter 11](#), is not self-evident. A label affixed to the vehicle in accordance with U.S. federal regulations identifies a multipurpose passenger vehicle.

3.3.47 NFPA. National Fire Protection Association.

3.3.48 NPGA. National Propane Gas Association.

The National Propane Gas Association (NPGA), originally the National Bottled Gas Association and later the National LP-Gas Association, is the national association for the liquefied petroleum gas industry. NPGA members include producers of LP-Gas, wholesale and retail marketers, gas appliance and equipment manufacturers and distributors, tank and cylinder fabricators, transport firms, and others. NPGA has 3500 members throughout the United States and 228 other countries.

One of the primary reasons for the association's establishment in 1931 was to afford all interested segments of the industry full opportunity to aid in making the rules that safeguard it. The NPGA was first affiliated with the Compressed Gas Manufacturers' Association (now the Compressed Gas Association), the only technical association in existence that could manage the problems involving gases in cylinders, the primary method of handling LP-Gases at that time.

Today, the NPGA is a separate and distinct organization that carries on its own technical activities through its technical committees. One of these committees, the Technology and Standards Committee, has engineering and technical representation from all segments of the industry. In addition, there are advisory members representing other related industry associations, testing laboratories, regulatory officials, insurance organizations, and others that greatly assist the technical committee in its standards development work. The technical committee initiates many recommendations for new provisions and amendments of existing provisions in NFPA 58 as industry-sponsored recommendations. The NFPA Technical Committee on Liquefied Petroleum Gases, which reflects a broader interest, in turn considers these recommendations. Because the NPGA Technology and Standards Committee has at its disposal a large amount of technical talent, the NFPA Technical Committee on Liquefied Petroleum Gases has at times referred matters to this group for initial study and recommendations.

3.3.49 Overfilling Prevention Device (OPD). A safety device that is designed to provide an automatic means to prevent the filling of a container in excess of the maximum permitted filling limit.

The definition of *overfilling prevention device (OPD)* was added in the 1998 edition to describe a device that is required in cylinders with a propane capacity of 4 lb (2 kg) through 40 lb (18 kg) and in engine fuel containers fabricated after January 1, 1984. There are different designs in use, but all of them shut off flow into the container when the liquid within reaches a specific level. (See 5.7.3 and 11.4.1.13 for requirements for overfilling prevention devices.) Exhibit 3.8 shows an OPD.

3.3.50 Overpressure Shutoff Device. A device that shuts off the flow of LP-Gas vapor when the outlet pressure of the regulator reaches a predetermined maximum allowable pressure.

NFPA 58 requires protection against excessive vapor pressure in propane piping systems in buildings. This protection is in the form of an overpressure shutoff device, which is usually incorporated into pressure regulators used in vapor distribution systems. The outlet pressure of a first-stage pressure regulator is 10.0 psig (69 kPag), and a second-stage pressure is 11 in. water column (2.7 kPag). Regulators require a feature (which can be an overpressure shutoff device) to prevent the pressure at the discharge of the second-stage regulator from exceeding 2.0 psig (14 kPag). [See 5.8.1.2(1) and its related commentary.]

3.3.51 Permanent Installation. See 3.3.71, Stationary Installation.

3.3.52 Permitted. Allowed or acceptable, and not requiring a permit (a document granting permission) to be secured.



The definition of *permitted* is new to the 2008 code and is intended to clarify a misconception regarding the issuance of formal permits. The term, as used in NFPA 58, does not require or imply a need for a permit from a local or state official. It means that something is permissible according to NFPA 58.

EXHIBIT 3.8 *Overfilling Prevention Device. (Courtesy of Cavagna North America, Inc.)*



3.3.53 Piping Systems. Pipe, tubing, hose, and flexible rubber or metallic hose connectors with valves and fittings made into complete systems for conveying LP-Gas from one point to another in either the liquid or the vapor state at various pressures.

3.3.54 Point of Transfer. The location where connections and disconnections are made or where LP-Gas is vented to the atmosphere in the course of transfer operations.

Point of transfer is a term used to identify the location of the temporary connection between a liquid transfer supply tank, such as a bobtail or a dispenser tank, and the storage container that is being filled. (See [Exhibit 3.9](#).) This connection establishes the point from which clearance must be maintained to sources of ignition and other equipment. It was introduced in the 1972 edition of NFPA 58.

3.3.55* Portable Container. A container designed to be moved readily, as opposed to a container designed for stationary installations.

A.3.3.55 Portable Container. Portable containers, designed for transportation, include *cylinders*, *cargo tanks*, and *portable tanks*, which are defined separately in this code. Containers that are designed to be readily moved from one location of use to another but that are substantially empty of product are *portable storage containers* and are also defined separately in this code.

3.3.56* Portable Storage Container. A container that is designed and constructed to be moved over a highway from one usage location to another.

A.3.3.56 Portable Storage Container. Portable storage containers have legs or other supports attached or are mounted on running gear (such as trailer or semitrailer chassis), with suitable supports that can be of the fold-down type. Such supports allow them to be placed on a reasonably firm and level surface. For large-volume, limited-duration product usage (such

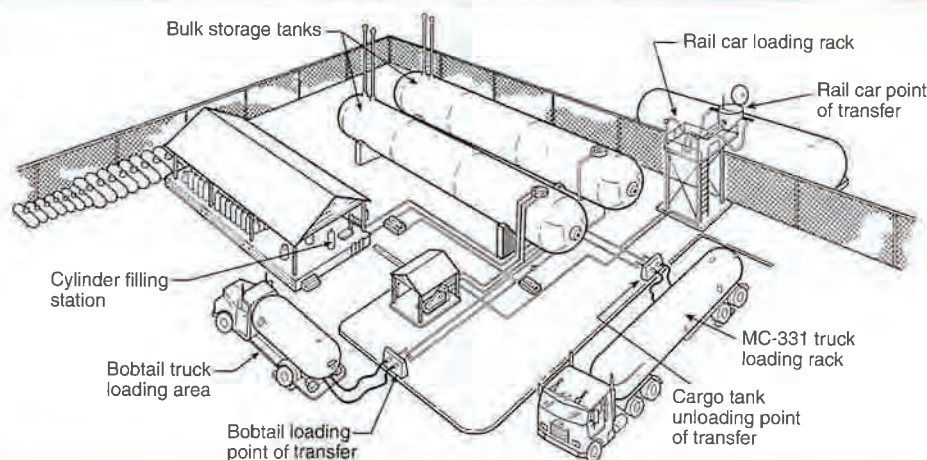


EXHIBIT 3.9 *Points of Transfer at a Propane Bulk Plant. (Courtesy of National Propane Gas Association)*

as at construction sites and normally for 12 months or less), portable storage containers serve as permanently installed stationary containers.

3.3.57 Portable Tank (or Skid Tank). A container of more than 1000 lb (454 kg) water capacity that is equipped with protected container appurtenances, is used to transport LP-Gas, and is designed and fabricated with permanently mounted skids or runners or is fabricated and installed within a full framework.

The definition of *portable tank* was revised in the 2008 edition to ensure that it is consistent with the terminology used by DOT in Title 49 of the Code of Federal Regulations. A portable tank differs from a portable storage container in that the portable tank complies with DOT requirements and can be shipped entirely filled with LP-Gas. However, a portable storage container is an ASME container but not an approved DOT shipping container and therefore must be transported with no more than 5 percent liquid within it.

3.3.58 Pressure Relief Device. A device designed to open to prevent a rise of internal pressure in excess of a specified value due to emergency or abnormal conditions.

All cylinders and ASME containers used for LP-Gas are equipped with pressure relief devices. These are designed to prevent failure of the container due to overpressurization. Overpressurization may occur when the container becomes “liquid full,” due to the heating of the container by a fire or, in some cases, if the container has been overfilled. Although opening of the pressure relief device will prevent the container from failure due to overpressure, the released flammable LP-Gas may also present a hazard.

In addition to containers, pressure relief devices are used in segments of hose or piping where liquid can be trapped between shutoff valves.

3.3.59 psi. Pounds per square inch.

3.3.60 psia. Pounds per square inch, absolute.

3.3.61 psig. Pounds per square inch gauge.

Units of pressure measurement used in the code are pounds per square inch (psi) and Pascals (Pa). When metric units of measurement were added to the code in the 1980s, pressure measurements were converted into Pascals (and kilo-pascals and mega-pascals because the Pascal is a small unit). Pressure measurements are usually given in one of two forms, either gauge or absolute. *Absolute pressure* is the pressure of the gas in the container plus the atmospheric



◀ FAQ

What is the difference between a portable storage container and a portable tank?

◀ FAQ

When is a pressure relief device likely to activate?

◀ FAQ

What is the difference between gauge pressure and absolute pressure?

pressure. *Gauge pressure* is the absolute pressure of a gas minus the local atmospheric pressure, or the pressure one would read on an accurate gauge connected to a tank. A pressure gauge at sea level will read 0, even though a pressure of 14.7 psi is present. Traditionally, pressure in tanks and piping systems is expressed in gauge pressure.

3.3.62 Quick Connectors. Fittings used to connect hose assemblies to piping and valves without the use of tools.

Quick connectors are used to connect transfer hose to piping and valves for loading and unloading cargo tank vehicles or railroad tank cars. They can also be used as connectors on swivel-type transfer piping. Quick connectors are also used in other LP-Gas systems, such as those used for engine fuel refueling and cylinder filling, connecting cylinders to gas-fired barbecue grills, and connecting gas systems between two sections of mobile homes.

3.3.63 Refrigerated LP-Gas. LP-Gas that is maintained as a liquid at temperatures below ambient temperature to reduce the storage pressure including fully refrigerated LP-Gas at pressures near atmospheric pressure but not exceeding 15 psig (103 kPag) and semi-refrigerated LP-Gas at pressures above 15 psig (103 kPag).

Refrigerated LP-Gas is just what the term implies — LP-Gas that has been refrigerated or cooled. When the gas is propane, the liquid is typically at a temperature of about -40°F (-40°C). At that temperature propane is a liquid that exerts no pressure on its container, thus providing a way to store propane in a nonpressurized (and usually insulated) container, which is less expensive than a pressure vessel. The economics are such that refrigerated storage is normally used for very large containers (1,000,000 gal is not unusual), and refrigerated LP-Gas storage is normally found at pipeline and marine terminals and occasionally at larger storage facilities.

3.3.64 Regulator.

The various types of regulators defined in NFPA 58 are shown in Exhibits 3.10 to 3.13 and listed in Commentary Table 3.1.

3.3.64.1* Automatic Changeover Regulator. An integral two-stage regulator that combines two high-pressure regulators and a second-stage regulator into a single unit designed for use with multiple cylinder installations.

A.3.3.64.1 Automatic Changeover Regulator. An automatic changeover regulator incorporates two inlet connections and a service-reserve indicator. The system automatically changes the LP-Gas vapor withdrawal from the designated service cylinder(s) when depleted to the designated reserve cylinder(s) without interruption of service. The service reserve indicator gives a visual indication of the cylinder(s) that is supplying the system.



EXHIBIT 3.10 Automatic Changeover Regulator.
(Courtesy of Sherwood, Harsco Gas & Fluid Control Group.)

EXHIBIT 3.11 Cutaway of First-Stage Regulator.
(Courtesy of Engineered Controls International, Inc.)



COMMENTARY TABLE 3.1 Regulators

Type	Location	Description or Use
Automatic changeover (Exhibit 3.10)	Outdoor	Changes service cylinder to reserve cylinder automatically
First stage (Exhibit 3.11)	Outdoor	Reduces tank pressure to 10 psig or less
High pressure	Outdoor	Reduces tank pressure to lower pressure above 1 psig
Integral 2 psi service	Outdoor	Reduces tank pressure in two stages to 2 psig
Integral two-stage (Exhibit 3.12)	Outdoor	Reduces tank pressure in two stages to 11 in. w.c.
Line pressure	Indoor	Reduces 2 psig inlet pressure to 11 in. w.c.
Second-stage (Exhibit 3.13)	Outdoor/indoor*	Reduces first-stage pressure to 11 in. w.c.
Single-stage	Outdoor	Reduces tank pressure to 11 in. w.c.
2 psi service	Outdoor	Reduces first-stage pressure to 2 psig
2 psi system	Outdoor/indoor**	Reduces first-stage pressure to 2 psig

* Regulator vent is piped to outdoors.

** Only the line pressure regulator is installed indoors.

3.3.64.2 First-Stage Regulator. A pressure regulator for LP-Gas vapor service designed to reduce pressure from the container to 10.0 psig (69 kPag) or less.

3.3.64.3 High-Pressure Regulator. A pressure regulator for LP-Gas liquid or vapor service designed to reduce pressure from the container to a lower pressure in excess of 1.0 psig (6.9 kPag).

3.3.64.4 Integral 2 psi Service Regulator. A pressure regulator for LP-Gas vapor service that combines a high-pressure regulator and a 2 psi service regulator into a single unit.

3.3.64.5 Integral Two-Stage Regulator. A pressure regulator for LP-Gas vapor service that combines a high-pressure regulator and a second-stage regulator into a single unit.

3.3.64.6 Line Pressure Regulator. A pressure regulator in accordance with the *Standard for Line Pressure Regulators*, ANSI Z-21.80/CSA 6.22, with no integral overpressure protection device for LP-Gas vapor service designed for installation inside a building to reduce a nominal 2 psig inlet pressure to 14 in. w.c. (4.0 kPa) or less.

3.3.64.7 Second-Stage Regulator. A pressure regulator for LP-Gas vapor service designed to reduce first-stage regulator outlet pressure to 14 in. w.c. (4.0 kPag) or less.

3.3.64.8 Single-Stage Regulator. A pressure regulator for LP-Gas vapor service designed to reduce pressure from the container to 1.0 psig (6.9 kPag) or less.

3.3.64.9 2 psi Regulator System. An LP-Gas vapor delivery system that combines a first-stage regulator, a 2 psi (14 kPag) service regulator, and a line pressure regulator(s).

3.3.64.10 2 psi Service Regulator. A pressure regulator for LP-Gas vapor service designed to reduce first-stage regulator outlet pressure to a nominal 2 psig (14 kPag).

3.3.64.11 Two-Stage Regulator System. An LP-Gas vapor delivery system that combines a first-stage regulator and a second-stage regulator(s), or utilizes a separate integral two-stage regulator.

3.3.65 Service Head Adapter. A transition fitting for use with polyethylene or polyamide pipe or tubing that is recommended by the manufacturer for field assembly and installation at the aboveground termination end of an anodeless riser.

A service head adapter is a fitting that connects plastic pipe or tubing inserted inside a non-pressure-containing steel jacket to steel piping.



EXHIBIT 3.12 Integral Two-Stage Regulator. (Courtesy of Engineered Controls International, Inc.)



EXHIBIT 3.13 Second-Stage Regulator. (Courtesy of Engineered Controls International, Inc.)

3.3.66 Skid Tank. See 3.3.57, Portable Tank.

3.3.67 Sources of Ignition. Devices or equipment that, because of their modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable LP-Gas vapor–air mixtures when introduced into such a mixture or when such a mixture comes into contact with them, and that will permit propagation of flame away from them.

Although the code has addressed the control of ignition sources since its inception, this definition for *sources of ignition* was added in the 1979 edition. The definition became necessary because of the existence of electrical devices and equipment that could ignite a flammable LP-Gas–air mixture under certain conditions. In addition, the definition clarifies that other devices might produce ignition but would not permit a flame to propagate away from them, in which case they are not a hazard. Examples of such devices include certain Class I, Division 1, Group D electrical equipment in which devices are installed in enclosures using gap flame-quenching principles and devices or enclosures equipped with flame arresters.

Some sources of ignition are as follows:

- Devices or equipment — such as gas- or oil-burning appliances, torches, matches, and lighters — producing, or capable of producing, flame
- Devices or equipment — such as motors, generators, switches, lights, and wiring and welding machines — producing, or capable of producing, electrical arcs or sparks of sufficient energy (Devices or equipment listed for Class I, Group D locations are not sources of ignition when properly used and maintained in the classified areas prescribed in this code.)
- Devices or equipment having, or capable of having, surfaces at temperatures exceeding 700°F (371°C)
- Devices or equipment — such as grinders, metal saws, chipping hammers, and flint lighters — producing, or capable of producing, mechanical (struck) sparks of sufficient energy (Unpowered hand tools used only by one individual at a time and for their intended purposes are not considered sources of ignition.)
- Cigarettes and other smoking materials
- Gravity or mechanical air intakes and exhaust terminals of ventilation systems for structures housing the ignition sources described, because they constitute a readily communicating pathway (These include air intakes and exhaust terminals for gas- or oil-burning appliances such as those for direct-vent appliances, and air intakes and exhaust terminals for air conditioners.)

Operating spark-ignition internal combustion engines do not appear, based on experience, to be an ignition source. However, they have been an ignition source during the act of being started. Operating diesel engines have been identified as the ignition source in fire reports, usually as the result of burning carbon being blown out of their exhausts. Such engines tend to speed up when LP-Gas is drawn into their intake manifolds.

3.3.68* Special Protection. A means of limiting the temperature of an LP-Gas container for purposes of minimizing the possibility of failure of the container as the result of fire exposure.

A.3.3.68 Special Protection. Where required in this code, special protection consists of one of the following:

- (1) Applied insulating coating
- (2) Mounding
- (3) Burial
- (4) Water spray fixed systems
- (5) Fixed monitor nozzles that meet the criteria specified in this code
- (6) Any means listed for this purpose

See [Section 6.25](#) for more information on fire protection and special protection.

In the late 1960s and early 1970s, the propane industry in the United States experienced a number of BLEVEs (Boiling Liquid Expanding Vapor Explosions) of LP-Gas railroad tank cars (some following derailments). Most of these incidents were caused by container failure from overheating of the container metal (steel) through contact with flames from flammable or combustible materials released from other cars. These incidents were accompanied by fire fighter fatalities.

Although this hazard was beyond the scope of NFPA 58, these accidents resulted in widespread fear of all large LP-Gas containers among the fire service and the public. Notable in this respect was an increasing reluctance by fire fighters to approach an LP-Gas container exposed to fire in order to limit the container temperature by the application of water from hose streams. Because this procedure was, and is, a fundamental and universal BLEVE prevention tactic, the NFPA Technical Committee on Liquefied Petroleum Gases and the industry were concerned that a reduction in its use would increase the frequency and severity of BLEVEs.

A joint task force of the NFPA technical committee and the NPGA's Technology and Standards Committee (augmented by representatives of railroad and DOT groups studying the tank car problem) concluded that additional provisions were needed to reduce the chances for BLEVEs caused by fire exposure. As a result, the following two provisions were first included in the 1976 edition of NFPA 58.

1. The first provision was for the installation and use of emergency shutoff valves as described in [Section 6.10](#). These valves were considered important enough to require retroactive installation in all of the larger facilities as prescribed in [Section 6.10](#).
2. The second provision was for special protection as stipulated in [6.25.5](#). It is noted, however, that the need for this protection is predicated on the results of a required fire safety analysis.

The six modes of special protection cited in [A.3.3.68](#) represent those currently recognized and for which standards exist. However, the definition is broad enough to recognize other means, provided those means are listed for the purpose.

3.3.69 Standard Cubic Foot (SCF). The volume of gas in cubic feet at the standard atmospheric conditions at 60°F (15.6°C) and 14.7 psia (101 kPa).

3.3.70 SCFM. Standard cubic feet per minute. [1901, 2003]

3.3.71 Stationary Installation (Permanent Installation). An installation of LP-Gas containers, piping, and equipment for indefinite use at a particular location; an installation not normally expected to change in status, condition, or location.

3.3.72 UL. Underwriters Laboratories Inc.

Founded in 1894, Underwriters Laboratories Inc. (UL) was chartered as a not-for-profit, independent organization performing testing for public safety. The organization maintains laboratories for the examination and testing of devices, systems, and materials to determine their relation to life, fire, casualty hazards, and crime prevention.

UL-listed materials within the scope of NFPA 58 are included in the following UL Product Directories: *Hazardous Location Equipment* [8]; *Marine Products* [9]; *Automotive, Burglary Protection, and Mechanical Equipment* [10]; and *Flammable and Combustible Liquids & Gases Equipment* [11].

Where NFPA 58 requires listing of a product, any listing agency acceptable to the authority having jurisdiction can be used.

3.3.73 Universal Cylinder. A cylinder that can be connected for service in either the vertical or the horizontal position, so that the fixed maximum liquid level gauge, pressure relief device, and withdrawal appurtenances function properly in either position.



FAQ

Is UL the only agency that can test and list products, devices, and systems for use within the scope of NFPA 58?



EXHIBIT 3.14 Universal Cylinder. (Courtesy of Worthington Cylinder Corp.)

A universal cylinder is shown in **Exhibit 3.14**.

3.3.74 Valve.

3.3.74.1 Emergency Shutoff Valve. A shutoff valve incorporating thermal and manual means of closing that also provides for remote means of closing.

3.3.74.2 Excess-Flow Valve (or Excess-Flow Check Valve). A valve designed to close when the liquid or vapor passing through it exceeds a prescribed flow rate.

3.3.74.3 Internal Excess-Flow Valve. An excess-flow valve constructed and installed so that damage to valve parts exterior to the container does not prevent closing of the valve.

3.3.74.4* Internal Valve. A container primary shutoff valve having the following features: (1) The seat and seat disc remain inside the container so that damage to parts exterior to the container or mating flange does not prevent effective sealing of the valve; (2) The valve is designed for the addition of a means for remote closure and is also designed for automatic shutoff when the flow through the valve exceeds its maximum rated flow capacity or when pump actuation differential pressure drops to a predetermined point.

A.3.3.74.4 Internal Valve. An internal valve has provision for the addition of a means of remote closure. An internal valve closes when flow through the valve exceeds its rated excess-flow capacity or when pump actuation differential pressure drops to a predetermined point.

An internal valve is a valve that is installed in ASME container openings. It is typically installed in the liquid inlet/outlet of propane containers of 4000 gal (15.1 m³) and larger, but can also be used to protect openings used for vapor inlet and outlet. An internal valve allows flow to be stopped remotely in the event of failure in the piping system. Remote operation can be by a mechanical, pneumatic, or electrical means. Internal valves are required in all new installations of containers larger than 4000 gal (15.1 m³) and must be installed on all existing containers larger than 4000 gal (15.1 m³) by July 1, 2011 (see **5.7.4.2**).

By halting the flow of gas, a fire or the potential fuel for a fire is eliminated. In addition, internal valves can be operated at their installed locations, and they have an excess flow valve incorporated into them to stop the flow should it exceed the rating of the valve. **Exhibit 3.15** shows an internal valve.

3.3.74.5 Pressure Relief Valve. A type of pressure relief device designed to both open and close to maintain internal fluid pressure.

3.3.74.5.1* External Pressure Relief Valve. A pressure relief valve that is used on older domestic containers, on pressure relief valve manifolds, and for piping protection where all the working parts are located entirely outside the container or piping.

EXHIBIT 3.15 Internal Valve. (Courtesy of Engineered Controls International, Inc.)



A.3.3.74.5.1 External Pressure Relief Valve. See Figure A.3.3.74.5.1.

3.3.74.5.2* Flush-Type Full Internal Pressure Relief Valve. An internal pressure relief valve in which the wrenching section is also within the container connection, not including a small portion due to pipe thread tolerances on makeup.

A.3.3.74.5.2 Flush-Type Full Internal Pressure Relief Valve. See Figure A.3.3.74.5.2.

3.3.74.5.3* Full Internal Pressure Relief Valve. A pressure relief valve, for engine fuel and mobile container use, in which all working parts are recessed within the container connection, and the spring and guiding mechanism are not exposed to the atmosphere.

A.3.3.74.5.3 Full Internal Pressure Relief Valve. See Figure A.3.3.74.5.3.

3.3.74.5.4* Internal Spring-Type Pressure Relief Valve. A pressure relief valve, for use on ASME stationary containers, that has a low profile and is similar to a full internal relief valve except the wrenching pads and seating section are above the container connection. The adjusting spring and the stem are below the seat and are not exposed to the atmosphere.

A.3.3.74.5.4 Internal Spring-Type Pressure Relief Valve. See Figure A.3.3.74.5.4.

3.3.75 Vaporizer. A device, other than a container, that receives LP-Gas in liquid form and adds sufficient heat to convert the liquid to a gaseous state.

Vaporizers are heat exchangers that transfer heat to convert LP-Gas liquid to vapor, just as boilers convert water into steam. The heat provided to a vaporizer converts the liquid to a gaseous state in pipes, coils, or chambers within the vaporizer. There are several styles of listed vaporizers that perform this function. Section 5.21 provides detailed requirements for different vaporizer styles.

Exhibit 3.16 shows principal features and operating characteristics of a typical vaporizer installation. Liquid flows from the bottom of the tank into the direct-fired vaporizer (shown on the left). A float controls the liquid level in the vaporizer. Flames provide heat to the liquid through the shell. Vapor travels from the upper part of the vaporizer to a tee where it goes to the equipment. Excess pressure is returned to the tank through the optional vapor line. If the tank pressure is high enough, it will supply the load, and the vaporizer will no longer be required to operate.

3.3.75.1 Direct-Fired Vaporizer. A vaporizer in which heat furnished by a flame is directly applied to some form of heat exchange surface in contact with the liquid LP-Gas to be vaporized. This classification includes submerged-combustion vaporizers.

Direct-fired vaporizers convert liquid propane into propane vapor, just as boilers convert water into steam. In a direct-fired vaporizer the flame is directed on piping or a vessel containing liquid propane. This differs from an indirect vaporizer where the liquid propane is vaporized in a coil immersed in a heated fluid (see 3.3.75.3).

Submerged combustion vaporizers are vaporizers in which a flame is directed into a non-flammable fluid, usually water, which surrounds pipe coils containing liquid propane. This type of vaporizer is usually used for very large vaporizing loads. Although they do not meet the definition of direct-fired vaporizers in 3.3.75.1, for purposes of this code, submerged combustion vaporizers may be treated as direct-fired.

3.3.75.2 Electric Vaporizer. A vaporizer that uses electricity as a source of heat.

Because electric vaporizers can be designed so that they are not a source of ignition (unlike a vaporizer using fuel-fired burners), they can be installed differently and thus need to be defined separately. Electric vaporizers are separated into two types — direct immersion, described in 3.3.75.2.1, and indirect, described in 3.3.75.2.2.

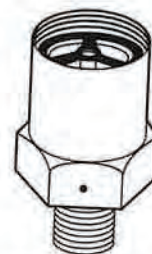


FIGURE A.3.3.74.5.1
External Pressure Relief Valve.

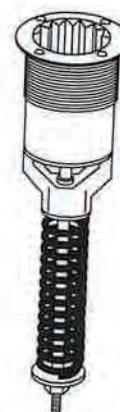


FIGURE A.3.3.74.5.2
Flush-Type Full Internal Pressure Relief Valve.



FIGURE A.3.3.74.5.3 Full Internal Pressure Relief Valve.



FIGURE A.3.3.74.5.4
Internal Spring-Type
Pressure Relief Valve.

3.3.75.2.1 Direct Immersion Electric Vaporizer. A vaporizer wherein an electric element is immersed directly in the LP-Gas liquid and vapor.

3.3.75.2.2 Indirect Electric Vaporizer. An immersion-type vaporizer wherein the electric element heats an interface solution in which the LP-Gas heat exchanger is immersed or heats an intermediate heat sink.

3.3.75.3 Indirect (or Indirect-Fired) Vaporizer. A vaporizer in which heat furnished by steam, hot water, the ground, surrounding air, or other heating medium is applied to a vaporizing chamber or to tubing, pipe coils, or other heat exchange surface containing the liquid LP-Gas to be vaporized; the heating of the medium used is at a point remote from the vaporizer.

3.3.75.4 Waterbath (or Immersion-Type) Vaporizer. A vaporizer in which a vaporizing chamber, tubing, pipe coils, or other heat exchange surface containing liquid LP-Gas to be vaporized is immersed in a temperature-controlled bath of water, water-glycol combination, or other noncombustible heat transfer medium that is heated by an immersion heater not in contact with the LP-Gas heat exchange surface.

A waterbath vaporizer is shown in Exhibit 3.17.

3.3.76 Vaporizing Burner (Self-Vaporizing Liquid Burner). A burner that also vaporizes liquid LP-Gas prior to burning it.

3.3.77 Vehicle Fuel Dispenser. A device or system designed to transfer and measure LP-Gas into engine fuel and mobile containers on vehicles.

3.3.78 Volumetric Loading. See 3.3.22.1, Volumetric Method Filling.

3.3.79 Water Capacity. The amount of water at 60°F (16°C) required to fill a container.

The water capacity of a container is the maximum amount of water the container can hold at 60°F (15.6°C). The water capacity (full of water) is expressed in pounds (kilograms) for cylinders and gallons (cubic meters) for ASME containers.

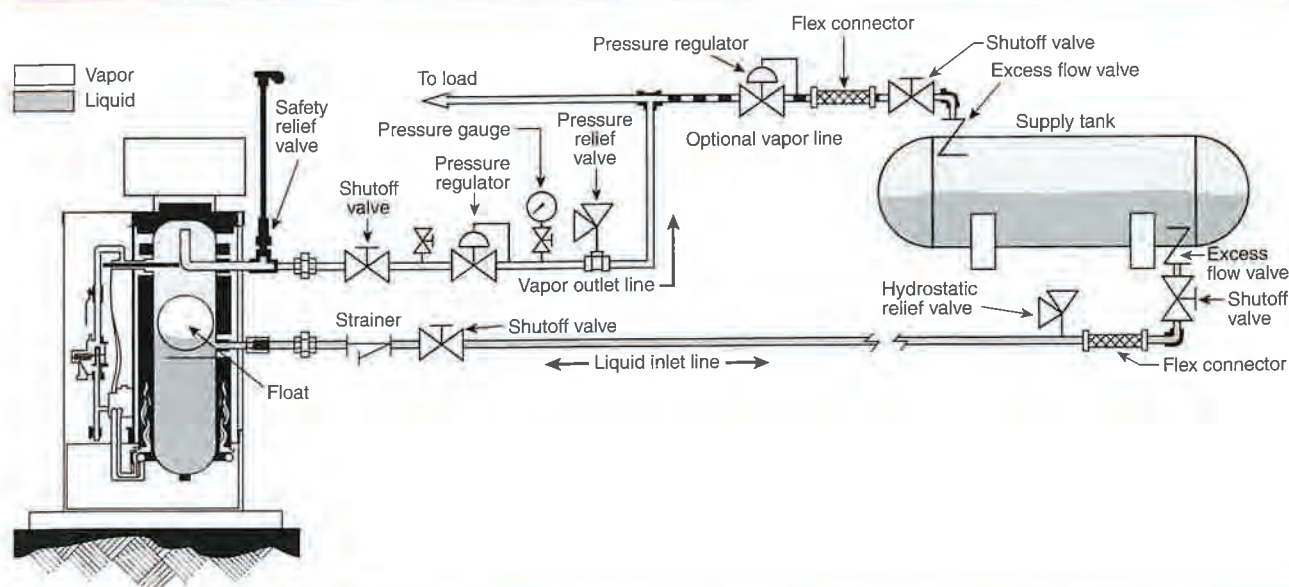


EXHIBIT 3.16 Typical Vaporizer Installation. (Courtesy of Ransome Manufacturing)

The water capacity is different from the propane capacity of a container. Water capacity is measured with the container 100 percent full, whereas the maximum permitted filling limit allowed for propane is typically set at 80 percent of the water capacity, although there are exceptions to this practice as described in [Chapter 7](#). For example, the typical 1000 gal (3.8 m³) water capacity ASME container is allowed to hold about 800 gal (3.0 m³) of propane (80 percent). However, a 30,000 gal (114 m³) container can be filled to 25,800 gal (86 percent at 40°F) of propane because its large size minimizes extreme swings in the temperature of the product (and therefore expansion and contraction are minimized) due to daytime solar heating and night cooling.

The maximum propane capacity of a cylinder is also based on its water capacity, but since the water capacity is given in pounds, the multiplying factor for propane is 42 percent because propane is about half the density of water. If the water capacity of a cylinder is marked as being 48 lb (36 kg), the propane capacity is 42 percent of 48 lb (36 kg), or about 20 lb (9 kg).

REFERENCES CITED IN COMMENTARY

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7. ASTM D 1835 *Standard Specification for Liquefied Petroleum Gases*, 2005 edition, American Society for Testing and Materials, West Conshohocken, PA.
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EXHIBIT 3.17 Waterbath Vaporizer. (Courtesy of Ransome Manufacturing)

General Requirements

CHAPTER 4

Chapter 4 covers general requirements that apply to the entire code. In the 2001 and previous editions of the code, these requirements were included in [Chapter 1](#). The sections in Chapter 4 cover the following:

- Acceptance of Equipment and Systems (See [Section 4.1](#).)
- LP-Gas Odorization (See [Section 4.2](#).)
- Notification of Installations (See [Section 4.3](#).)
- Qualification of Personnel (See [Section 4.4](#).)
- Ammonia Contamination (See [Section 4.5](#).)
- Minimum Requirements (See [Section 4.6](#).)

4.1 Acceptance of Equipment and Systems

4.1.1 Systems or components assembled to make up systems shall be approved as specified in [Table 4.1.1](#).

Approval of systems using cylinders applies to the following:

- The cylinder itself, which must meet DOT specifications and have the dates of manufacture and retest (if done) stamped in the collar, as shown in [Exhibit 5.13](#) (See [Annex C](#) for information on requalification of cylinders.)

TABLE 4.1.1 Containers

Containers Used	Capacity, Water		Approval Applies to . . .
	gal	m ³	
Cylinders	<120	0.445	Container valves and connectors Manifold valve assemblies Regulators and pressure relief devices
ASME containers	≤2000	≤7.6	Container system* including regulator, or container assembly* and regulator separately
ASME containers	>2000	>7.6	Container valves Container excess-flow valves, backflow check valves, or alternate means of providing this protection such as remotely controlled internal valves Container gauging devices Regulators and container pressure relief devices

*Where necessary to alter or repair such systems or assemblies in the field in order to provide for different operating pressures, change from vapor to liquid withdrawal, or the like, such changes shall be permitted to be made by the use of approved components.

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- Cylinder valves, which must comply with DOT regulations, which reference CGA V-1, *Standard Compressed Gas Cylinder Valve Outlet and Inlet Connections* [1]
- Cylinder connectors, manifold valve assemblies, regulators, and pressure relief devices, which must be approved

The approval of systems using ASME containers of 2000 gal (7.6 m³) or less includes one of the following:

- The container, which must be designed, fabricated, and marked in accordance with the *ASME Boiler and Pressure Vessel Code* [2], and its appurtenances, which may be approved as a unit
- The container, which may be approved separately, in which case the container appurtenances and pressure regulator must also be approved separately

The approval of systems using ASME containers of more than 2000 gal (7.6 m³) includes the following:

- Container valves
- All other container appurtenances, as listed in [Table 4.1.1](#), and the pressure regulator(s)

Larger systems using ASME containers with capacities greater than 2000 gal (7.6 m³) capacity are not approved as a system. Instead, the individual parts are approved. The reason is that there are many variations on how a container may be used, and approval of the entire unit as a system would be very difficult, possibly requiring many different approvals to cover all possible applications.

4.1.2 Where necessary to alter or repair containers or container assemblies in the field, such changes shall be made using approved components.

4.1.3 Acceptance applies to the complete system or to the individual components of which it is comprised as specified in [Table 4.1.1](#).

4.2 LP-Gas Odorization

4.2.1* All LP-Gases shall be odorized prior to delivery to a bulk plant by the addition of a warning agent of such character that the gases are detectable, by a distinct odor, to a concentration in air of not over one-fifth the lower limit of flammability.

A.4.2.1 It is recognized that no odorant will be completely effective as a warning agent in every circumstance.

It is recommended that odorants be qualified as to compliance with [4.2.1](#) by tests or experience. Where qualifying is by tests, such tests should be certified by an approved laboratory not associated with the odorant manufacturer. Experience has shown that ethyl mercaptan in the ratio of 1.0 lb (0.45 kg) per 10,000 gal (37.9 m³) of liquid LP-Gas has been recognized as an effective odorant. Other odorants and quantities meeting the provisions of [4.2.1](#) can be used. Research on odorants has shown that thiophane (tetrahydrothiophene) in a ratio of at least 6.4 lb (2.9 kg) per 10,000 gal (37.9 m³) of liquid LP-Gas might satisfy the requirements of [4.2.1](#).

NOTE: Odorant research includes *A New Look at Odorization Levels for Propane Gas*, BERC/RI-77/1, United States Energy Research and Development Administration, Technical Information Center, September 1977.

FAQ ►
Why is ethyl mercaptan a good choice for an odorant in propane?

The note to [A.4.2.1](#) provides additional information on the important subject of odorization. It must be remembered that the code requires the gas to have an odor that serves as a “distinctive” warning agent, but it does not specify the type of odorant or the quantity of odorant. While specific recommendations for odorization levels are made in [A.4.2.1](#), LP-Gas is re-

quired to be odorized prior to delivery to a bulk plant or other bulk storage where a bulk plant is bypassed in the chain of distribution. There are several odorants that have been tested through many research projects, but ethyl mercaptan remains as the odorant of choice for its distinctive smell and its chemical and physical properties, which match up well with those of propane. (See the commentary following A.4.2.3.)

4.2.2 Odorization shall not be required if it is harmful in the use or further processing of the LP-Gas or if such odorization will serve no useful purpose as a warning agent in such further use or processing.



LP-Gas used as a feedstock in the manufacture of petrochemicals and for use as an aerosol filling are two examples of situations in which the gas is not required to be odorized. Another potentially large application of propane in the future may be the fuel cell. Fuel cells convert hydrocarbon fuels to electricity through a chemical process. LP-Gas is being considered as a potential fuel for this application, but the sulfur added in the form of odorant to the gas may present a problem for the fuel cell stack and can possibly damage it. Therefore, it may be necessary to strip the odorant and sulfur from LP-Gas prior to introducing it to the fuel cell. This procedure, however, would most likely have to be done on site and as part of the fuel conversion process to remain in compliance with the code requirement for odorant to serve as a warning agent.

4.2.3* If odorization is required, the presence of the odorant shall be determined by sniff-testing or other means, and the results shall be documented as follows:

- (1) When LP-Gas is delivered to a bulk plant
- (2) When shipments of LP-Gas bypass the bulk plant

A.4.2.3 Another method of determining the presence of odorant is the stain tube test. This method involves using a small hand-held pump to draw a sample across a filled glass tube and reading the length of color change. For additional information, see GPA Standard 2188, *Tentative Method for the Determination of Ethyl Mercaptan in LP-Gas Using Length of Stain Tubes*, and CAN/CGSB-3.0 No. 18.5, *Test for Ethyl Mercaptan Odorant in Propane, Field Method*. At the time of the preparation of this code, additional analytical methods were under development.

LP-Gas is stored in pressure vessels, or containers, that contain both liquid LP-Gas and vapor. The pressure in the container depends on the temperature of the LP-Gas in the container, with higher pressure at higher temperature. (See **Annex B** for pressure-temperature charts.) When this pressure is reduced (e.g., by vapor being drawn out of the container to supply an appliance) the liquid in the container begins to boil, producing additional vapor to raise the pressure back to equilibrium. In the process of this boiling, the temperature of the liquid is reduced as it vaporizes, which in turn reduces the equilibrium vapor pressure. This temperature reduction is sometimes seen as ice forming on the outside of a container on a humid day.

The odorant used with propane is ethyl mercaptan, which is a liquefied flammable gas that is mixed with the liquid propane and which, in turn, boils with the propane. The boiling point of ethyl mercaptan is higher than that of propane [95°F (35°C) for ethyl mercaptan versus -44°F (-42°C) for propane], which means that as propane is first withdrawn from a full cylinder with ethyl mercaptan more propane will boil than ethyl mercaptan. The result is that 15 to 25 percent of the amount of ethyl mercaptan in the liquid (depending on the temperature of the propane) is found in the vapor. More ethyl mercaptan than propane is left in the container, and the concentration of ethyl mercaptan in the vapor increases as more propane is vaporized and will exceed the concentration added to the liquid near the end of vapor withdrawal. The amount of ethyl mercaptan added to the propane takes this fact into account. A sufficient amount of odorant is in the gas phase, throughout the entire useful temperature range to meet code requirements.

◀ FAQ

How does the odorant in LP-Gas get into the vapor?

Determining the presence of an odorant in LP-Gas is important and is required by the code to be done on each shipment to a bulk plant. Shipments that bypass a bulk plant and are delivered directly to the end user must also be tested. Sniff testing, in which a human with a normal sense of smell verifies the odor, is common practice. In some cases, however, an evaluation method with a quantifiable result may be desired.

The odorization of gas started as early as 1880 in Europe, where it was used to prevent injuries or fatalities resulting from escaping gas. The first reported odorant used was ethyl mercaptan, a prevalent compound still used to odorize LP-Gas. Ethyl mercaptan has a characteristic smell that has been described as garlic or rotten eggs. Regardless of dosage levels, it is impossible to warn 100 percent of the population of gas leaks by the use of odorant systems. Some individuals may simply not be able to discern the odor. Others may have their sense of smell temporarily impaired due to a cold, sickness, or other condition. Odorization is a valuable practice, because it does serve as a useful warning in the vast majority of cases. In a study conducted by inserting a “scratch and sniff” card in its magazine, *National Geographic* reported that gas was one of the most recognized odors [3].

Odorization for bottled propane and LP-Gases began in the late 1920s and early 1930s in the United States. Around this same time, the companies that sold LP-Gases into home-use markets began using odorants. The work of the Bureau of Mines [4], which was funded by the American Gas Association, and research conducted by those companies developing this new market showed that ethyl mercaptan was the best odorant for propane because of its volatility, odor properties, and chemical properties. The concentration of ethyl mercaptan required was also determined by research and calculation during this same period.

Ethyl mercaptan and later thiophane (tetrahydrothiophene or THT) were used at a rate of at least 1.0 lb per 10,000 gal (0.45 kg per 37.9 m³) until the late 1970s, when an industry group funded a study at the Bartlesville Energy Research Center [5]. The main action resulting from this study was an increase in the amount of THT from 1.0 lb per 10,000 gal (0.45 kg per 37.9 m³) to 6.4 lb per 10,000 gal (2.9 kg per 37.9 m³) of propane (0.012 kg/m³ to 7.7 kg/m³). This study measured values for the distribution coefficients of ethyl mercaptan and THT from propane at a variety of temperatures. Because THT has a much higher boiling point than ethyl mercaptan, its odor is not as striking as that of ethyl mercaptan. For this reason and because of its cost, THT is not used in the U.S. propane market.

Further research funded by companies that were part of the propane industry — the Gas Processors Association (GPA), the Canadian Propane Gas Association (CPGA), and the National Propane Gas Association (NPGA) — and by the Consumer Product Safety Commission (CPSC) indicated that there was a potential problem with “odor fade” in the use of ethyl mercaptan in propane. The GPA, CPGA, and the NPGA funded another series of tests, which evaluated alternative odorants for use in propane. This study and the results of the summation of industry research were synthesized into a document issued by the Joint Industry Task Force on Propane Odorization [6]. This group verified that ethyl mercaptan was the best choice for propane odorization.

A result of an engineering study funded by the CPSC was the incorporation of 4.2.3 into NFPA 58 [7]. This requirement stipulates that the presence of odorant in LP-Gas should be determined and also documented. Although the code requires only that the presence of odorant be verified, there are laboratory methods and field test methods that may be used to determine the amount of odorant present in the gas. The note to A.4.2.3 contains information regarding “length-of-stain” tube tests, which were developed by the GPA and by the CPGA, as part of the activity of the Joint Industry Task Force on Propane Odorization. In the stain tube test, a sample of the propane is drawn through a glass tube (see Exhibit 4.1), which changes color in the presence of ethyl mercaptan or other mercaptan. The length of the changed color indicates the concentration of the odorant.

The odorant level can also be determined through the use of an instrument called an Odorator®, which is shown in Exhibit 4.2. The Odorator mixes odorized gas with air in vary-



EXHIBIT 4.1 Stain Tubes and Pump. (Courtesy of Sensidyne, Inc., www.Sensidyne.com)



EXHIBIT 4.2 Odorator®. (Courtesy of Heath Consultants Incorporated)

ing amounts, as the operator sniffs the gas. When the odor is detected, the operator presses a button and reads the concentration of the odorant.

Another method used to verify the odorant concentration is by the gas chromatographic analysis of a liquid propane sample. This laboratory method takes more time and is complicated by sampling and shipping issues. A knowledgeable chemist, familiar with the properties of propane and odorants, should be consulted before taking samples of propane for gas chromatographic analysis.

Those interested in odorization are encouraged to review the latest available work in the field. (See “Additional Readings on Odorization,” a list of published papers and magazine articles on the subject at the end of this chapter. The additional readings cover odorization of both natural gas and propane.)

4.3 Notification of Installations

4.3.1 Stationary Installations.

Plans for stationary installations utilizing storage containers of over 2000 gal (7.6 m³) individual water capacity, or with aggregate water capacity exceeding 4000 gal (15.1 m³), and all rooftop installations of ASME containers shall be submitted to the authority having jurisdiction by the person or company that either installs or contracts to have the containers installed before the installation is started. [See also 6.19.11.1(F).]

Plans should be submitted to the authority having jurisdiction (AHJ), which is usually a fire department. In the absence of specific requirements from the AHJ, plans should include a site plan showing key distances and references to the code, along with information regarding key equipment (i.e., container specifications, investigation of reused equipment, etc.). Subsection 6.25.3 also requires a written fire safety analysis to be submitted for installations that have an aggregate water capacity of more than 4000 gal (15.1 m³) subject to exposure from a single fire in heavily populated or congested areas. (See Supplement 1, Guidelines for Fire Safety

FAQ ►
Why are plans only required to be submitted for installations of containers of over 2000 gal individual water capacity or 4000 gal aggregate water capacity?

Analysis, and the *Fire Safety Analysis Manual for LP-Gas Storage Facilities* [8] for more information.)

Installations smaller than 2000 gal individual / 4000 gal aggregate do not require plans to be submitted because they are relatively simple and standard installation procedures are used. Smaller installations include most one- and two-family homes and typical smaller commercial services that use DOT cylinders and/or ASME 500 gal or 1000 gal capacity containers. Some authorities, however, do require approval of these small installations in heavily populated or congested areas. In such instances, the authorities will either amend 4.3.1 or adopt specific wording in the document that requires approval.



4.3.2 Temporary Installations.

The authority having jurisdiction shall be notified of temporary (not to exceed 12 months) installations of the container sizes covered in 4.3.1 before the installation is started.

Subsection 4.3.2 recognizes that some installations are of a temporary nature. These temporary installations of the sizes covered in 4.3.1 must be brought to the attention of the AHJ prior to installation so that the fire service can be made aware of them. Such notice is important for emergency response planning. Temporary installations are found at construction sites if temporary heating is needed. They are also found at fairs, where they are used for heating tents and cooking, and at other similar locations.

FAQ ►
What happens after the 12-month period for a temporary installation has passed?

Twelve months is now the maximum period for temporary installations. This change in the 2008 edition resolves a conflict that existed in the 2004 edition, where temporary installations were defined as 6 months in one section and 12 months in another. Twelve months was chosen because many construction projects use propane for heating during the construction phase, which often takes longer than 6 months to complete. However, it is not unusual for a new permit application to be submitted after the 12-month period has expired, due to the fact that the job may be ongoing. Under such circumstances, the authority would conduct a review of the submittal as if it were a new temporary installation.

Specific requirements for containers in all temporary services are found in 5.2.7.2 and 6.6.5.

Installations that are removed and then reinstalled in the same specific location might not be considered temporary. For example, a 5-month installation at a cabin used only in the winter might not be considered temporary beyond the first year if the installation is removed after the heating season. However, many summertime fairs require propane for cooking, and these installations are made and removed after a few days in the same location year after year. These are temporary installations and must be approved by the AHJ every year. The AHJ is responsible for determining the nature of all such installations.



4.3.3 Notification of intent for transfer of LP-Gas directly from railcar to cargo tank shall be submitted to the authority having jurisdiction before the first transfer. The authority having jurisdiction shall have the authority to require inspection of the site or equipment for such transfer prior to the initial transfer.

Subsection 4.3.3 has been added to the 2008 edition. It requires anyone planning to transfer LP-Gas directly from a railcar to a cargo tank to notify the authority having jurisdiction of the installation. The authority having jurisdiction can require that the system be inspected before the first transfer. This requirement applies to both transfers from a railcar to a cargo tank vehicle at rail sidings and to such transfers at a bulk plant. The intent of this requirement is not to discourage such transfers, as long as all the required safety equipment is in place, but to ensure that the authorities having jurisdiction are aware of them.

While not specifically stated in the code, in an emergency situation where the transfer must be done promptly, such as a derailment, notification should be as soon as practical following the incident, which may be the following day or the following business day.

4.4* Qualification of Personnel

Persons who transfer liquid LP-Gas, who are employed to transport LP-Gas, or whose primary duties fall within the scope of this code shall be trained in proper handling procedures. Refresher training shall be provided at least every 3 years. The training shall be documented.

A.4.4 The term *refresher* indicates that the periodic training could be less intensive than the original training, whose primary purpose is to reinforce initial training rather than repeat it.

A requirement for training in proper handling and operation procedures has been included in NFPA 58 since the first edition in 1932. This requirement has been revised over the last decade, as shown in **Commentary Table 4.1**.

COMMENTARY TABLE 4.1 Changes in Qualification of Personnel Requirement

<i>Edition Year</i>	<i>Nature of Change</i>
1992	Each employee required to carry written certification of his or her job qualifications issued by the training agent or to carry a written document issued by the authority having jurisdiction identifying the functions each employee is authorized to perform
1995	Training required to be documented, but employee no longer required to carry proof of training
1998	Required training limited to those — Who transfer liquid LP-Gas — Who are employed to transport LP-Gas — Whose primary duties fall within the scope of NFPA 58
2001	Refresher training required every three years added

The evolution of the requirements of **Section 4.4** shows how difficult it can be to convey the intent of any technical committee. The change in 1992 that required documentation of training was well received by all parties as a way to verify that training was being conducted. The requirement to carry proof of training, however, was not well received, except in areas that had state licensing requirements in place. Because it merely duplicated employee and company records, the requirement was removed in 1995.

Questions regarding who should be trained led to the 1998 revision, which excluded those who handle cylinders as an incidental part of their jobs from being trained in the hazards of LP-Gas. For example, drivers of propane-powered industrial trucks who exchange fuel cylinders and clerks at retail stores who exchange empty propane cylinders for full ones are exempt from the training requirements. By the same token, office workers in a propane plant are not required to be trained to fill cylinders if that operation is not associated with their job.

The 2001 requirement for refresher training every three years recognizes that ongoing reinforcement of training is needed, especially for tasks that are not normally part of the job function, but that the employee may be called on to do. For example, a bobtail driver may occasionally be called on to fill cylinders at a dispensing station at the propane company's plant. The driver clearly must have been trained on filling stationary tanks, but must also be trained to fill cylinders.

Complete retraining of all employees on a three-year cycle is not required. Refresher training should cover the normal job functions the employee is expected to perform, any new equipment and procedures introduced since the last training, and the operating procedures established by the company. Note that **Chapter 14**, Operations and Maintenance, requires each LP-Gas bulk plant and industrial plant to have an operating plan and a maintenance plan. Training should follow the procedures in these plans.

◀ FAQ

Are all employees of a propane company required to be trained to handle LP-Gas?

4.5* Ammonia Contamination

A.4.5 To test for the presence of ammonia, allow a moderate vapor stream of the product to be tested to escape from the container. A rotary, slip tube, or fixed level gauge is a convenient vapor source. Wet a piece of red litmus paper by pouring distilled water over it while holding it with clean tweezers. Hold the wet litmus paper in the vapor stream from the container for 30 seconds. The appearance of any blue color on the litmus paper indicates that ammonia is present in the product.

NOTE: Because the red litmus paper will turn blue when exposed to any basic (alkaline) solution, care is required in making the test and interpreting the results. Tap water, saliva, perspiration, or hands that have been in contact with water having a pH greater than 7, or with any alkaline solution, will give erroneous results.

NOTE: For additional information on the nature of this problem and conducting the test, see NPGA Safety Bulletin 122, *Recommendations for Prevention of Ammonia Contamination of LP-Gas*, published by the National Propane Gas Association.

Because anhydrous ammonia and LP-Gas are liquefied gases that have about the same vapor pressure characteristics at the same temperature, the same transportation and storage equipment can be used for either ammonia or LP-Gas. In warmer months, when the demand for LP-Gas for heating falls, LP-Gas tanks are commonly used for ammonia in agricultural areas where ammonia is used as a fertilizer. When switching from ammonia back to LP-Gas service, the tank must be cleaned properly. If not cleaned properly, serious consequences can result.

Specifically, brass fittings are commonly used on tanks in LP-Gas service, particularly on consumers' and dealers' containers. Ammonia can cause these brass fittings to fail while in service through a process known as stress corrosion cracking. If ammonia gets into an LP-Gas distribution system, the ammonia will spread through the system and may damage any brass fittings it contacts.

The maximum concentrations of ammonia that can be tolerated in LP-Gas have been determined through a research project, "A Study of Cleaning Methods for LP-Gas Transports," conducted by Battelle Memorial Institute of Columbus, Ohio [9]. This research indicates that the red litmus paper test for ammonia in LP-Gas, if performed properly, is a much better indicator than simply trying to detect the absence of ammonia odor, and it will ensure that tolerable limits are not exceeded. Litmus paper will detect ammonia to a concentration of 1 to 2 parts per million. This procedure is referenced only in **A.4.5** because the test is not mandated for ammonia but rather is informative material for the user. Other test methods can be used, and it is the responsibility of the user to verify that any alternative method will be equally effective in identifying ammonia concentrations that will cause corrosion.

4.5.1 LP-Gas stored or used in systems within the scope of this code shall contain less ammonia than the quantity required to turn the color of red litmus paper to blue.

4.5.2 The initial fill of LP-Gas in a transportation or storage system that has been converted from ammonia to LP-Gas service shall be tested for ammonia contamination prior to being used or transferred from that system.

Testing for ammonia is not required to be performed prior to or after every transfer of LP-Gas from one container to another. **Subsection 4.5.2** does require, however, that a test be performed on the LP-Gas transferred into a container that has just undergone a change in service from ammonia to LP-Gas.

4.6* Minimum Requirements

For any purpose or application addressed within the scope of this code, where the minimum requirements of the code are met, additional features or components of equipment not prohibited by the code shall be permitted to be used.

A.4.6 The installation of safety-enhancing equipment that is not otherwise required by the code is permitted by the code. This includes any device that performs a safety-related function even though the device is designed or named to perform a required function. For example, an emergency shutoff valve (ESV) is installed in a location where it is not required to provide all the safety functions of an ESV. Even though the installer uses it to provide a specific feature that can be common to all ESVs, the code would still not require compliance with all of the ESV provisions — for example, the closing requirements described in **5.12.4**.

Section 4.6 was added to the 2004 edition. It is intended to permit the installation and use of equipment that is not specifically required by the code, even if that particular piece of equipment, which may be commonly used within a specific system, is not installed with the other components of that system. For example, if an installation were made using an emergency shutoff valve where the code did not necessarily require one to be installed, the installation could be made without requiring a thermal element to be installed to operate the valve in the event of a fire.

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LP-Gas Equipment and Appliances

CHAPTER 5

Chapter 5 provides the information necessary for the design, manufacture, marking, and performance requirements for individual LP-Gas components or complete systems, with the exception of cargo tank vehicles, which are covered in Chapter 9, and engine fuel systems, which are covered in Chapter 11.

The chapter is organized by numbering many of the sections to align with the sections in Chapter 6, Installation of LP-Gas Systems. This organization makes it easy to go from product to installation requirements, because they will carry similar numbering. For example, Section 5.9, Piping (Including Hose), Fittings, and Valves, contains the requirements for all piping materials, and Section 6.9, Piping Systems, contains requirements for the installation of piping systems. Because of the alignment of subject matter, a number of sections in Chapter 5 are reserved (not used).

Chapter 5 includes detailed information and requirements for the following topics:

- Containers — cylinders and ASME containers (See Section 5.2.)
- Container appurtenances, such as pressure relief devices, regulators, pressure regulators, overfilling prevention devices, container connections, and various gauges (See Section 5.7.)
- Pressure regulators and regulator vents (See Section 5.8.)
- Piping (including hose), fittings, and valves (See Section 5.9.)
- Valves other than container valves (See Section 5.12.)
- Hydrostatic relief valves (See Section 5.13.)
- Equipment, such as pumps, compressors, meters, engines, and sight flow indicators (See Section 5.17.)
- Appliances (See Section 5.20.)
- Vaporizers, tank heaters, vaporizing burners, and gas-air mixers (See Section 5.21.)

5.1* Scope

This chapter applies to individual components and components shop-fabricated into sub-assemblies, container assemblies, and complete container systems.

A.5.1 The field assembly of components, subassemblies, container assemblies, or complete container systems into complete LP-Gas systems is addressed in Chapter 6. (See 3.3.38, *LP-Gas System*.)

5.2 Containers

5.2.1 General.

5.2.1.1* Containers shall be designed, fabricated, tested, and marked (or stamped) in accordance with the regulations of the U.S. Department of Transportation (DOT); the ASME *Boiler and Pressure Vessel Code*, Section VIII, "Rules for the Construction of Unfired Pressure

Vessels”; or the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases*, except for UG-125 through UG-136.

DOT has approved a new type of cylinder for use in the United States — a composite cylinder fabricated from reinforced fiberglass. Only composite cylinders fabricated under a DOT special permit can be used. They have a 15-year service life and must be requalified every 5 years. These cylinders can be used for all applications not prohibited by NFPA 58, such as outdoor gas grills, industrial trucks, and other applications not located in buildings.

(A) Adherence to applicable ASME Code case interpretations and addenda that have been adopted and published by ASME 180 calendar days prior to the effective date of this code shall be considered as compliant with the ASME Code.

The text of 5.2.1.1(A) was revised in the 2001 edition of NFPA 58 to ensure that the NFPA Technical Committee on Liquefied Petroleum Gases had an opportunity to review any “code case” amendments to the ASME *Boiler and Pressure Vessel Code* [1] before being accepted in NFPA 58. According to ASME procedures, a code case (similar to a Tentative Interim Amendment) is effective when issued by the ASME committee.

(B) Containers fabricated to earlier editions of regulations, rules, or codes listed in 5.2.1.1 and of the Interstate Commerce Commission (ICC) *Rules for Construction of Unfired Pressure Vessels*, prior to April 1, 1967, shall be permitted to be continued to be used in accordance with Section 1.4.

The intent and application of 5.2.1.1(B) are often misinterpreted with regard to containers that were built to the API-ASME Code (specification U-200 and U-201) and pre-1949 editions of the ASME Code (specification U-68 and U-69). Because these ASME containers have a very long service life when properly maintained, many remain in use and are sometimes relocated and reinstalled. However, not all containers built to these older editions of the ASME Code can be continued in use and reinstalled, regardless of their condition. Before it is filled, a container must be found suitable for continued use, as required in 7.2.2, which states:

7.2.2 Filling and Evacuating of Containers.

7.2.2.1 Transfer of LP-Gas to and from a container shall be accomplished only by qualified individuals trained in proper handling and operating procedures meeting the requirements of Section 4.4 and in emergency response procedures.

7.2.2.2 When noncompliance with Section 5.2 and Section 5.7 is found, the container owner and user shall be notified in writing.

7.2.2.3 Injection of compressed air, oxygen, or any oxidizing gas into containers to transfer LP-Gas liquid shall be prohibited.

7.2.2.4 When evacuating a container owned by others, the qualified person(s) performing the transfer shall not inject any material other than LP-Gas into the container.

7.2.2.5* Valve outlets on cylinders of 108 lb (49 kg) water capacity [nominal 45 lb (20 kg) propane capacity] or less shall be equipped with a redundant pressure-tight seal or a listed quick-connect coupling. Where seals are used, they shall be in place whenever the cylinder is not connected for use.

7.2.2.6 Nonrefillable (disposable) and new unused cylinders shall not be required to be equipped with valve outlet seals.

7.2.2.7 Containers shall be filled only after determination that they comply with the design, fabrication, inspection, marking, and requalification provisions of this code.

7.2.2.8 “Single trip,” “nonrefillable,” or “disposable” cylinders shall not be refilled with LP-Gas.

7.2.2.9 Containers shall comply with the following with regard to service or design pressure requirements:

- (1) The service pressure marked on the cylinder shall be not less than 80 percent of the vapor pressure of the LP-Gas for which the cylinder is designed at 130°F (54.4°C).

- (2) The maximum allowable working pressure for ASME containers shall be in accordance with [Table 5.2.4.2](#).

7.2.2.10 Transfer of refrigerated product shall be made only into systems that are designed to accept refrigerated product.

7.2.2.11 A container shall not be filled if the container assembly does not meet the requirements for continued service.

7.2.2.12 Transfer hoses larger than $\frac{1}{2}$ in. (12 mm) internal diameter shall not be used for making connections to individual cylinders being filled indoors.

A.5.2.1.1 Prior to April 1, 1967, regulations of the U.S. Department of Transportation were promulgated by the Interstate Commerce Commission. In Canada, the regulations of the Canadian Transport Commission apply and are available from the Canadian Transport Commission, Union Station, Ottawa, Canada.

Construction of containers to the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases*, has not been authorized after July 1, 1961.

The requirements for the construction of pressure vessels used to store LP-Gases are referenced in [5.2.1.1](#). (Requirements for nonpressurized refrigerated containers are located in [Chapter 12](#), Refrigerated Containers.) The referenced codes provide a level of safety such that the NFPA Technical Committee on Liquefied Petroleum Gases has not needed to develop its own requirements for pressure vessels for LP-Gas. In referencing the ASME *Boiler and Pressure Vessel Code* [1], the committee has made an exception to sections UG-125 through UG-136, which cover pressure relief devices. The requirements for pressure relief devices in the ASME *Boiler and Pressure Vessel Code* are more conservative than those in UL 132, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas* [2], which requires larger pressure relief valves.

Pressurized LP-Gas containers in the United States, Canada, and other countries served by marketers based in the United States and Canada comply with [5.2.1.1](#). Many other countries that use NFPA 58 have their own container requirements. In the event that a container constructed to a different standard, such as one used in a foreign country, is to be filled in a jurisdiction that enforces NFPA 58, approval to fill that container must be obtained from the authority having jurisdiction. For cylinders, the authority having jurisdiction is the U. S. Department of Transportation (DOT), and approval to fill is not likely to be given. Given the relatively low cost of cylinders, it is easier to purchase a new cylinder than to petition DOT for a variance. Small foreign vessels and campers that travel internationally provide a source of cylinders built to specifications of other countries. Cylinders manufactured to other than DOT specifications can be used in the United States, but cannot be refilled.

If the container is a pressure vessel, the authority having jurisdiction is the state in which the container is installed. Because most states adopt and enforce the ASME *Boiler and Pressure Vessel Code* [1], the state boiler agency must be contacted. For example, when packaged propane equipment is imported with propane tanks, the authority having jurisdiction should be contacted to determine how to proceed. The following paragraphs provide more detailed information on the specific types of containers used in the LP-Gas industry.

U.S. Department of Transportation (DOT) Cylinders. DOT cylinders first used for LP-Gas were built to specifications of the Interstate Commerce Commission (ICC). DOT restricts cylinders to 1000 lb (454 kg) water capacity or less. Prior to 1967, ICC specifications were used, but they have not been used for many years. The current basic cylinders for reusable service are DOT 4BA-240 (steel construction) and DOT 4E (aluminum construction) cylinders, specifications for which are found in 49 CFR 178.50 [3] and 49 CFR 178.68 [4], respectively. Disposable cylinders, such as hand torch cylinders, have different DOT specifications.

The regulations for DOT cylinders [and similar cylinders built to Transport Canada (TC) specifications] are concerned with transportation, whereas much of NFPA 58 is concerned

◀ FAQ

Is it permissible to use containers that have been fabricated and marked in accordance with regulations in foreign countries?

with container usage and storage. Several DOT/TC cylinders are shown in Exhibits 5.1 and 5.2. Nevertheless, there are compelling reasons why NFPA 58 must recognize these cylinders as storage containers. Because DOT specifications are developed for transportation applications only, the NFPA technical committee continuously monitors DOT and TC standards to ensure that the standards are adequate for the applications covered by NFPA 58. For example, the committee did not permit the use of 4E (aluminum) cylinder for several years, until the cylinder's use and storage safety were demonstrated by tests and experience.

All DOT/TC cylinders are portable and designed to be transported when filled with product. Cylinders hold from 1 lb to 420 lb (0.5 kg to 191 kg) of propane. (See Exhibit 5.3.) Cylinders can be moved with reasonable ease by an individual or by vehicles that are equipped with lifting devices that can transport the larger portable cylinders.

Cylinders are filled at the location where they are installed or used. It is common to see 100 lb (45 kg) cylinders "permanently" installed at residential and commercial locations being filled on site. When the cylinder is permanently installed, the standard cylinder valve is replaced with a multipurpose valve so that the cylinder can be refilled without disconnecting the piping.

Commentary Table 5.1 lists types of popular cylinders, their applications, water and propane capacities, and specification numbers. The information listed in Commentary Table 5.1 is especially useful because the capacity of cylinders is rated by weight, in pounds (kilograms), and their spacing is determined by the volumetric capacity, in gallons (cubic meters), by Table 6.3.1. Commentary Table 5.1 allows conversions from pounds to gallons so that the proper spacing distances can be easily determined.

A DOT cylinder must be marked with certain information, usually on the cylinder itself or on its collar, as shown in Exhibit 5.4. This information is especially vital in determining the suitability of the cylinder for continued service, as indicated by the requalification date.

EXHIBIT 5.1 DOT/TC Cylinders. Top: Typical Industrial Truck Motor (Engines) Fuel Cylinders; Bottom: Typical Stationary and Portable Cylinders for Residential and Commercial Uses. (Courtesy of Manchester Tank)





EXHIBIT 5.2 DOT/TC Cylinders. (Courtesy of Manchester Tank)

Industrial/Commercial	Consumer	Industrial Truck/Fork Lift
Description/Size Openings A. Safety relief valve 1 in. B. NPT float gauge 1 in. C. Fill valve .75 in. D. Vapor service valve .75 in. E. Multi-valve .75 in.		Description A. Universal float gauge B. Liquid service valve C. Safety relief valve D. Fixed liquid level E. Vapor service (plugged) F. Liquid fill port (plugged)
420 lb LP-Gas cap. 100 gal Tare wt. 289 lb/131 kg Water cap. 1000 lb/454 kg DOT-4BW240	20 lb 5 gal 18 lb/8.2 kg 47.7 lb/21.6 kg DOT-4BA240	20 lb 5 gal 26.5 lb/12 kg 47.7 lb/21.6 kg DOT-4BA240
200 lb 47 gal 150 lb/71 kg 474 lb/215 kg DOT-4BW240	6 lb 1.5 gal 9.2 lb/4.1 kg 15.5 lb/7 kg DOT-4BA260	33-1/2 lb 8 gal 34.5 lb/15.5 kg 80 lb/36.3 kg DOT-4BW240
100 lb 23 gal 72 lb/32.6 kg 240 lb/108 kg DOT-4BW240		43-1/2 lb 10 gal 40 lb/18 kg 103.6 lb/47 kg DOT-4BW240

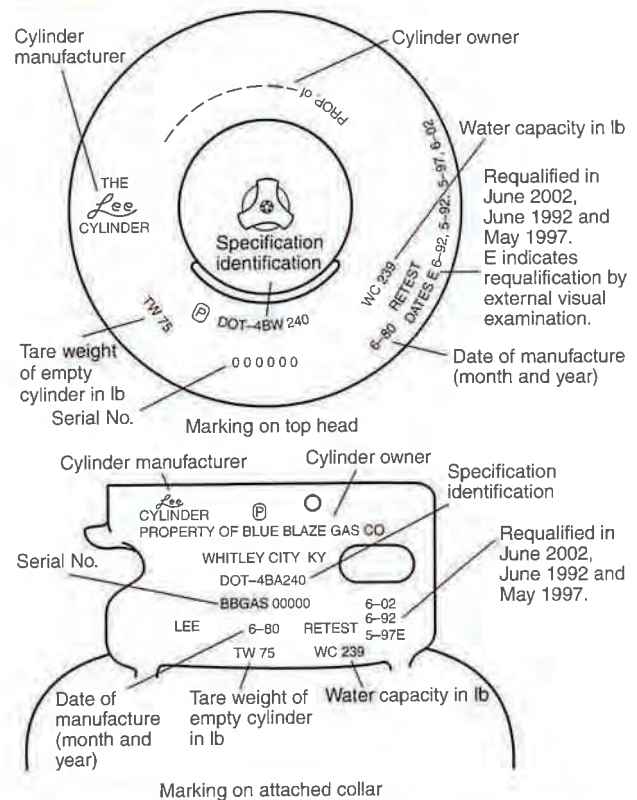
EXHIBIT 5.3 Dimensions and Capacities of Typical DOT Cylinders. (Courtesy of Worthington Cylinder Corp.)

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COMMENTARY TABLE 5.1 DOT/TC Cylinder Applications

Type of Service	Typical Use	Propane Capacity			Water Capacity			Common DOT Mfg. Code
		Pounds	Kilograms	Gallons	Pounds	Kilograms	Gallons	
Stationary	Homes, business	420	191	99	1000	454	119	4B, 4BA, 4BW
Stationary	Homes, business	300	136	71	715	324	86	4B, 4BA, 4BW
Stationary	Homes, business	200	91	47	477	216	57	4B, 4BA, 4BW
Stationary	Homes, business	150	68	35	357	162	43	4B
Exchange	Homes, business	100	45	24	239	108	29	4B, 4BA, 4BW
Exchange	Homes, business	60	27	14	144	65	17	4B, 4BA, 4BW
Engine fuel	Forklift	43.5	19.7	10	104	47	12	4B, 4BA, 4BW, 4E
Engine fuel	Forklift	33.5	15.2	8	80	36	9.6	4B, 4BA, 4BW, 4E
Engine fuel	Forklift	20	9	4.7	48	22	5.7	4B, 4BA, 4BW, 4E
Engine fuel	Forklift	14	6.4	3.3	34	15.4	4.1	4B, 4BA, 4BW, 4E
Portable	Rec. vehicles	40	18	9.5	95	43	11	4B, 4BA, 4BW, 4E
Portable	Rec. vehicles	30	13.6	7.1	72	32.7	8.6	4B, 4BA, 4BW, 4E
Portable	Rec. vehicles	25	11.3	5.9	59.5	27	7.1	4B, 4BA, 4BW
Portable	Rec. vehicles, grills	20	9	4.7	48	22	5.7	4B, 4BA, 4BW, 4E
Portable	Rec. vehicles, and small appliances	10	4.5	2.4	23.8	10.8	2.8	4B, 4BA, 4BW, 4E
Portable	Indoors, trailers	5	2.3	1.2	12	5.4	1.4	4B, 4BA, 4BW, 4E
Portable	Torches, RV	0.93	0.42	0.2	2.2	1	0.3	39 (disposable), 4B240 (refillable)

EXHIBIT 5.4 Typical DOT Cylinder Marking. (Courtesy of National Propane Gas Association)



ASME Containers. ASME containers, often referred to as bulk containers, are unfired pressure vessels built to the ASME Code, Section VIII, Division 1 or 2. Division 1 is a “prescriptive” approach to container design that lays out the requirements in “cookbook” fashion. Division 2 is a “performance” approach that allows the designer more latitude in the choice of materials, but requires a more extensive analysis to demonstrate compliance. ASME Code containers are usually found in stationary installations but can also be mounted on trucks for use as a cargo tank motor vehicle. (See [Exhibit 5.5](#).)



EXHIBIT 5.5 Small ASME Container Commonly Used in Residential and Commercial Applications. (Courtesy of Trinity Containers)

Prior to World War I, the first LP-Gas bulk containers in use were riveted, but keeping these containers leak-free around the rivets and the seams was difficult. Forge-welded containers came into use after World War I as the technology became available in the United States. In the 1930s, the current-style fusion-welded pressure vessels were used. At that time, the ASME Code specifications were U-68 and U-69. These specifications had a design margin (safety factor) of 5 to 1 — the ratio of the theoretical burst pressure to the design operating pressure. The normal working pressure of U-68 and U-69 containers was 200 psig (1.4 MPag). At that time, NFPA 58 allowed the pressure relief valve setting to be 125 percent of the working pressure, or 250 psig (1.7 MPag). Pressure relief valves prevent the excessive buildup of pressure in the containers in case of overfilling, or excessive heating of the propane due to fire impingement on the container.

ASME specifications U-200 and U-201, which were developed in conjunction with the American Petroleum Institute (API), were also applied prior to 1949. ASME specifications U-200 and U-201 were known as the API-ASME Code. These API-ASME Code specifications applied to containers that were restricted in use to installations such as refineries, gas processing plants, and tank farms.

In 1949, ASME adopted the current ASME Code precept with a design margin (safety factor) of 4 to 1. At that time, the requirement for the pressure relief valve setting was changed to the working pressure of a container, 250 psig minimum (1.7 MPag minimum) for propane. In effect, the 4 to 1 safety factor and the previous 5 to 1 safety factor are comparable, with the same ultimate burst pressure, as 250×4 and 200×5 both equal 1000. Many pre-1949, 200 psig (1.4 MPag) ASME tanks are still in service.

In the mid-1990s, the ASME Code design margin (safety factor) was further reduced from 4 to 1 to 3.5 to 1. The ASME Boiler and Pressure Vessel Code Committee took this action because of the improvement in both material quality control and welding technology since the 1950s. The design margin in pressure vessel design anticipates minor defects in materials (thickness variation, imperfections, and inclusions in the metal) as well as less than perfect welding. Because both materials and welding have improved since the 1950s, it was determined that the design margin was excessive and was reduced. This reduction does not

decrease safety in pressure vessels designed to the ASME Code. [See Annexes C and D for further descriptions of DOT (ICC) and ASME containers.]

Commentary Table 5.2 shows popular ASME container sizes, their applications, and their water and propane capacities. The table also lists the capacities, in pounds, of smaller size containers for easy comparison to cylinder capacities. It is important to note that the ranges given for LP-Gas capacity in the table are not all at the same reference temperature. For example, the LP-Gas capacity for a bulk plant tank of 12,000 gal (45.4 m³) is shown to be 10,800 gal (41 m³), which is 90 percent of the container water capacity. However, 7.4.3.2(B), and referenced Table 7.4.2.3(b), only permit volumetric filling to 90 percent when the propane is at a temperature of 70°F (21°C). Therefore, it is important to realize that the capacities shown in **Commentary Table 5.2** are those at assumed propane temperatures.

Intermodal Containers. Intermodal containers, as shown in Exhibit 5.6, are shipping containers larger than cylinders that are mounted within a frame for shipment on railroads, trucks, and ships. The containers are similar to dry shipping containers. The United Nations accepts intermodal containers for international shipping. These containers must meet DOT specifications and ASME Code requirements. LP-Gas is shipped via intermodal containers to islands and inland areas that are accessible only by rivers or other bodies of water.

Container Ownership. Usually, the LP-Gas marketer leases residential and commercial LP-Gas containers to the customer. However, NFPA 58 does not prevent consumers from purchasing their own containers. Industrial and other large users are more likely to own their containers. When residential consumers and industrial LP-Gas users own their containers, they are responsible for complying with the code requirements concerning container maintenance. The propane supplier is responsible for taking reasonable steps to verify that a container is fit for service before filling it and should not fill a container that is unfit for service. This applies equally to a 20 lb (9.1 kg) gas grill cylinder, a 500 gal (1.9 m³) ASME container at a residence, and a 30,000 gal (14 m³) ASME container at an industrial facility.

5.2.1.2 Containers that have been involved in a fire and show no distortion shall be requalified for continued service before being used or reinstalled.

COMMENTARY TABLE 5.2 Typical Stationary ASME Container Applications

Service	Water Capacity		LP-Gas Capacity		
	Gallons	Liters or Cubic Meters	Gallons*	Liters or Cubic Meters	Pounds
Domestic	100	379 L	80	301 L	338
Domestic	125	473 L	100	379 L	423
Domestic	150	568 L	120	454 L	508
Domestic	250	946 L	200	757 L	848
Domestic	325	1230 L	260	984 L	
Domestic	500	1893 L	400	1514 L	
Domestic	1,000	3.8 m ³	800	3 m ³	
Industrial/agricultural/commercial	1,000–5,000	3.8–19 m ³	800–4,500	3–17 m ³	
Service stations	1,000–6,500	3.8–24.6 m ³	800–5,850	3–22 m ³	
Bulk plant or standby storage	12,000–18,000	45.4–68 m ³	10,800–16,200	41–61 m ³	
Bulk plant or standby storage	20,000–30,000	76–114 m ³	18,000–27,000	45.4–102 m ³	
Bulk plant or standby storage	30,000–60,000	114–227 m ³	27,000–54,000	102–204 m ³	
Bulk plant or standby storage	60,000–120,000	227–454 m ³	48,000–96,000	182–364 m ³	

*Based on propane specific gravity of 0.508 at 70°F (21°C). Actual filling level depends on the specific gravity and temperature of the propane.



EXHIBIT 5.6 Intermodal Container. (Courtesy of Permugas)

(A) Cylinders shall be requalified by a manufacturer of that type of cylinder or by a repair facility approved by DOT.

(B) ASME or API-ASME containers shall be retested using the hydrostatic test procedure applicable at the time of the original fabrication.

Older containers can continue to be used when evidence of design or construction flaws, or dents, pits, and corrosion, is not evident. When these containers were built, they incorporated the latest technology in design, metallurgy, and fabrication techniques. Although technology has improved significantly over the years, there is no evidence that older containers are less safe now than when they were built, as long as they have been properly maintained.

Other nondestructive test methods may be considered as alternatives to the hydrostatic test required in 5.2.1.2(B). The following methods are listed in the ASME *Boiler and Pressure Vessel Code* [1] and may be useful for finding flaws in the container that would prevent it from being placed back into service after a fire:

- Radiography
- Ultrasonics
- Magnetic particle
- Liquid penetrants
- Visual inspection
- Leak testing
- Electromagnetic testing
- Acoustic emission

It is important to remember that the ASME Code is a construction code, and not a maintenance or an inspection code, and other codes (e.g., DOT, NFPA 58) may allow or require hydrostatic pressure testing as a nondestructive test when needed. While a hydrostatic pressure test is considered nondestructive, it can result in damage to the pressure vessel if a significant flaw is detected. The person performing such tests must be familiar both with the code requirements used to construct the container and with the test methods used to test the container.

(C) All container appurtenances shall be replaced.

(D) DOT 4E specification (aluminum) cylinders and composite cylinders involved in a fire shall be permanently removed from service.

If a cylinder has been subjected to fire, the metal shell, which is usually steel or aluminum, can be weakened, and the cylinder must be requalified by a properly qualified repair facility authorized by DOT (in the United States) or TC (in Canada). When an ASME container has been subjected to fire, it must be retested using the hydrostatic test procedure applicable at the time the container was originally made. The testing is required because the fire heat can alter the properties of the steel, reducing its ability to contain pressure. Container appurtenances must also be replaced after a container has been exposed to fire.

Paragraph 5.2.1.2(D) was not located here in the 2004 edition, where it was paragraph 5.2.3.2. It was moved to this more appropriate location in the 2008 edition. DOT 4E aluminum cylinders may not be returned to service after a fire because even exposure to moderately high temperatures can affect the structural properties of aluminum and severely decrease its tensile strength.

Exhibit 5.7 shows a container that has been exposed to fire.

EXHIBIT 5.7 ASME Container Damaged by Fire.
(Courtesy of Independent Propane Co., Pine, CO)



5.2.1.3 ASME paragraph U-68 or U-69 containers shall be permitted to be continued in use, installed, reinstalled, or placed back into service. Installation of containers shall be in accordance with all provisions listed in this code. (See Section 5.2, Table 5.2.4.2 and Table 5.7.2.4(A), and Annex D.)

FAQ ►
Can ASME containers constructed to U-68 and U-69 requirements be installed into a new service?

The requirement in 5.2.1.3 clearly and specifically states ASME paragraph U-68 or U-69 containers may be continued in service and reinstalled. This addition to the 1995 edition of NFPA 58 was intended to clarify the NFPA technical committee's opposition to one state's interpretation of the code that would not permit ASME containers built under ASME U-68 and U-69 to be reinstalled. [See the commentary following 5.2.1.1(B) for more information on ASME U-68 and U-69.]

5.2.1.4 Containers that show excessive denting, bulging, gouging, or corrosion shall be removed from service.

All containers that show excessive dents, bulges, gouges, or corrosion must be removed from service because these defects can reduce the pressure capability of the container. Once removed from service, the container should be scrapped, or repaired using methods that are in accordance with the code of manufacture.

5.2.1.5 Repairs or alteration of a container shall comply with the regulations, rules, or code under which the container was fabricated. Repairs or alteration to ASME containers shall be in accordance with the *National Board Inspection Code*.

5.2.1.6 Field welding shall be permitted only on saddle plates, lugs, pads, or brackets that are attached to the container by the container manufacturer.

The heat of welding directly to the container can affect the strength of the material and change its characteristics so that it may no longer meet the requirements of the ASME *Boiler and Pressure Vessel Code* [1]. Such heating can set up localized stresses that can reduce the material's strength. Repairs to pressure vessels must meet the requirements of the *National Board Inspection Code* (NBIC) [5], and must be performed by a repair organization accredited by the National Board and authorized to utilize the "R" code symbol stamp. Following a repair and final inspection by a National Board Commissioned Inspector, the repair organization will affix a "Repair" nameplate to the pressure vessel that is similar to the ASME nameplate. The requirements in the NBIC were developed to maintain the integrity of the pressure vessel after it has been placed in service. (See [Exhibit 5.8](#).)

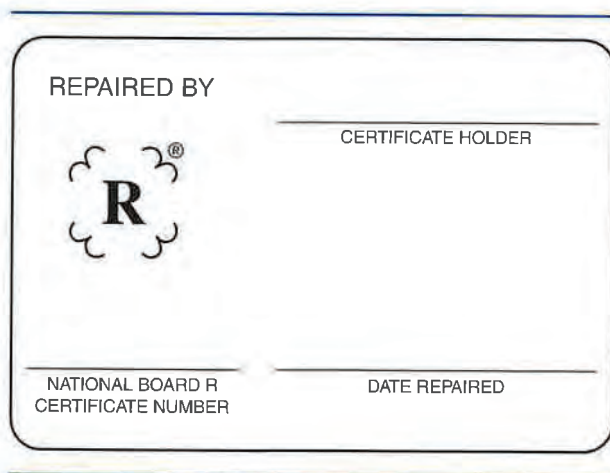


EXHIBIT 5.8 National Board "R" Stamp. (This material is taken from the National Board Inspection Code and is reprinted with permission of the National Board of Boiler and Pressure Vessel Inspectors.)

5.2.1.7 Containers for general use shall not have individual water capacities greater than 120,000 gal (454 m³).

Containers installed for general use and in dispensing stations are limited in size per [5.2.1.7](#). However, the number of containers in general use is not limited. The term *general use*, which is not defined in the code, refers to installations where LP-Gas is being stored for an end use application, such as for use as a fuel. Thus an LP-Gas bulk plant, where most employees can be expected to be aware of the proper procedures for handling LP-Gas, is not general use, whereas a container used as an alternate fuel supply at a manufacturing plant, whose product is not related to LP-Gas, would be considered to be general use.

5.2.1.8 Containers in dispensing stations not located in LP-Gas bulk plants, industrial plants, or industrial applications shall have an aggregate water capacity not greater than 30,000 gal (114 m³).

The 30,000 gal (114 m³) water capacity limit on total storage in dispensing stations provides a limit on storage capacity at locations where only cylinders are filled or LP-Gas is dispensed.

5.2.1.9 Heating or cooling coils shall not be installed inside storage containers.

Internal container components, such as heating and cooling coils, can be inspected only when the container is emptied, purged, and declared safe for entry. It is possible that a container's components may not be inspected during the container's normal life of service. If not inspected, corrosion or other container component failure will not be observed. If heating or cooling coils installed inside the storage container leak, the gas could enter the piping of the

heating or cooling system, because the LP-Gas pressure is normally higher than the pressure in the internal coil. Leakage into the system could result in a pressure that could rupture or create leaks in the heating or cooling system. Even if a break does not occur, a flammable product will be present in the heating or cooling system that could escape near an ignition source.

5.2.2 Cylinders.

5.2.2.1* Cylinders shall be continued in service and transported in accordance with DOT regulations.

A.5.2.2.1 See CGA Publication C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, or C-6.3, *Guidelines for Visual Inspection and Requalification of Low Pressure Aluminum Compressed Gas Cylinders*, for further information regarding cylinder inspection.

5.2.2.2 A cylinder with an expired requalification date shall not be refilled until it is requalified by the methods prescribed in DOT regulations.

An important safety provision of NFPA 58 is that all LP-Gas containers be safe before they are filled. Cylinders that are built to DOT requirements can be filled for 12 years from the date of manufacture and subsequently must be recertified periodically. Until the 2004 edition, the question of recertification of cylinders that were used outside of the scope of DOT (not in transportation) was not completely clear. This issue has been resolved by 5.2.2.2 and 5.2.3, which address cylinders that are filled on site and not subject to DOT regulation.

There are three different methods by which to requalify a cylinder:

Requalification Method	Time Before Next Recertification
Water-jacket hydrostatic test method	12 years
Modified hydrostatic	7 years
Visual	5 years

Refer to Annex C for a detailed description of these methods.

Requalification of cylinders under DOT regulations using the visual method could have been done by anyone up until August 8, 2002, when DOT issued Final Rule HM-220D, which requires registration of requalifiers using the visual method. The rule requires facilities or individuals that requalify cylinders to register with DOT in order to obtain a requalifier identification number (RIN). Registration of a business facility covers individual employees at the facility. The following also applies to cylinder requalification using the visual method:

- Beginning May 31, 2004, only facilities that held an RIN were permitted to requalify cylinders by external visual inspection.
- Inspections must have been performed in accordance with CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders* [6], and/or C-6.3, *Guidelines for Visual Inspection and Requalification of Low Pressure Aluminum Compressed Gas Cylinders* [7].
- Cylinders passing requalification by external visual inspection must be marked as described below
- Cylinder markings must be made by stamping, engraving, scribing, or any other method that produces a legible, durable mark. Interpretations obtained from DOT allow the mark to be on a “durable pressure adhesive label.”
- Each facility that requalifies cylinders must maintain records at the facility where the requalification is performed.

The requirement for an RIN applies only to those who requalify cylinders for use “in transportation” and does not apply to those who visually inspect stationary cylinders per the procedures in 5.2.3.

The following is reprinted from 49 CFR Part 180.213 [8]:

49 CFR Part 180 — CONTINUING QUALIFICATION AND MAINTENANCE OF PACK-
AGINGS

Subpart C — Qualification, Maintenance and Use of Cylinders
180.213 Recertification markings.

(a) *General.* Each cylinder or UN pressure receptacle recertified in accordance with this subpart with acceptable results must be marked as specified in this section. Required specification markings may not be altered or removed.

(b) *Placement of markings.* Each cylinder must be plainly and permanently marked on the metal of the cylinder as permitted by the applicable specification. Unless authorized by the cylinder specification, marking on the cylinder sidewall is prohibited.

(1) Recertification and required specification markings must be legible so as to be readily visible at all times. Illegible specification markings may be remarked on the cylinder as provided by the original specification. Recertification markings may be placed on any portion of the upper end of the cylinder excluding the sidewall, as provided in this section. Recertification and required specification markings that are illegible may be reproduced on a metal plate and attached as provided by the original specification.

(2) Previous recertification markings may not be obliterated, except that, when the space originally provided for recertification dates becomes filled, additional dates may be added as follows:

(i) All preceding recertification dates may be removed by peening provided that—

(A) Permission is obtained from the cylinder owner;

(B) The minimum wall thickness is maintained in accordance with manufacturing specifications for the cylinder; and

(C) the original manufacturing test date is not removed.

(ii) When the cylinder is fitted with a footring, additional dates may be marked on the external surface of the footring.

(c) *Recertification marking method.* The depth of recertification markings may not be greater than specified in the applicable specification. The markings must be made by stamping, engraving, scribing or other method that produces a legible, durable mark.

[NOTE: Although DOT has not published a rulemaking to this effect, it has stated in letters to the propane industry that a “durable pressure adhesive label is acceptable” to be used to mark the cylinder]

(1) and (2) [not applicable to propane cylinders]

(3) For a composite cylinder, the recertification markings must be applied on a pressure sensitive label, securely affixed in a manner prescribed by the cylinder manufacturer, near the original manufacturer’s label. Stamping of the composite surface is not authorized.

(d) *Recertification markings.* Each cylinder successfully passing recertification must be marked with the RIN set in a square pattern, between the month and year of the recertification date. The first character of the RIN must appear in the upper left corner of the square pattern; the second in the upper right; the third in the lower right, and the fourth in the lower left.

Example: A cylinder recertified in September 2006, and approved by a person who has been issued RIN “A123”, would be marked plainly and permanently into the metal of the cylinder in accordance with location requirements of the cylinder specification or on a metal plate permanently secured to the cylinder in accordance with paragraph (b) of this section. An example of the markings prescribed in this paragraph (d) is as follows:

A1

9

06 X

32

◀ FAQ

How must the recertifier identification number be applied to a cylinder?

Where:

“9” is the month of requalification,

“A123” is the RIN,

“06” is the year of requalification, and

“X” represents the symbols described in paragraphs (f)(2) through (f)(9) of this section.

(1) Upon a written request, variation from the marking requirement may be approved by the Associate Administrator.

(2) *Exception.* A cylinder subject to the requirements of §173.301(l) of this subchapter may not be marked with a RIN.

(e) *Size of markings.* The size of the markings must be at least 6.35 mm (1/4 in.) high, except RIN characters must be at least 3.18 mm (1/8 in.) high.

(f) *Marking illustrations.* Examples of required requalification markings for DOT specification and special permit cylinders are illustrated as follows:

(1) For designation of the 5-year volumetric expansion test, 10-year volumetric expansion test for UN cylinders and cylinders conforming to §180.209(f) and (h), or 12-year volumetric expansion test for fire extinguishers conforming to §173.309(b) of this subchapter and cylinders conforming to §180.209(e) and 180.209(g), the marking is as illustrated in paragraph (d) of this section.

(2) and (3) [not applicable to propane cylinders]

(4) For designation of the proof pressure test, the marking is as illustrated in paragraph (d) of this section, except that the “X” is replaced with the letter “S”.

(5) For designation of the 5-year external visual inspection for cylinders conforming to Sec. 180.209(g), the marking is as illustrated in paragraph (d) of this section, except that the “X” is replaced with the letter “E”.

(5) through (9) [not applicable to visual requalification of propane cylinders]

DOT initially underestimated the number of companies that would be registering as cylinder requalifiers and ran out of four-digit numbers to assign. A seven-digit numbering system was started. Facilities using the seven-digit number must display it, along with the date of inspection, using one of the following formats:

V100001	0907	V100001 0907
0907	V100001	

5.2.3 Cylinders Filled on Site.

DOT cylinders in stationary service that are filled on site and therefore are not under the jurisdiction of DOT either shall be requalified in accordance with DOT requirements or shall be visually inspected within 12 years of the date of manufacture and within every 5 years thereafter, in accordance with 5.2.3.1 through 5.2.3.3.

FAQ ►

Are all cylinders, whether or not they are under DOT jurisdiction, required to be requalified in accordance with DOT procedures?

Subsection 5.2.3 was added to the 2004 edition of the code. It addresses the need to inspect stationary cylinders and provides a method to recertify cylinders filled on site. Cylinders not “in transportation” are not subject to DOT regulations for recertification; however, they are required to be recertified by NFPA 58. Cylinders “in transportation” include cylinders transported by common carriers (trucking companies); by someone in the LP-Gas business; or by those who use them as a material of trade, such as a caterer or a roofer using propane fuel.

The need for this requirement, which differs from DOT regulations, stems from the difficulty involved in recertifying cylinders filled on site without disconnecting piping, emptying the cylinder, and inspecting and weighing the cylinder, as required by DOT regulations. Weighing is deleted here, because the committee was advised that CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders* [6] (which is referenced by DOT), was being revised to drop the re-weighing requirement, and the committee saw

potential safety disadvantages to the additional gas transfers that emptying the cylinder would require.

The need for the new requirement was recognized prior to the processing of the 2004 edition with TIA (01-1), which was issued in 2002 on the 2001 edition. The TIA delayed the implementation of the requalifications until July 1, 2004, for cylinders of 100 lb and larger that are filled on site. The delay resulted from the recognition of the burden to propane marketers and their customers, because all cylinders that needed recertification would have been required to be pulled from the field immediately for requalification.

5.2.3.1 Any cylinder that fails one or more of the criteria in **5.2.3.3** shall not be refilled or continued in service until the condition is corrected.

5.2.3.2 Personnel shall be trained and qualified to perform inspections. Training shall be documented in accordance with **Section 4.4**.

Per **5.2.3.2**, training received by persons visually inspecting stationary cylinders filled on site must be documented. As with any documentation required by the code, training documentation should be placed in the employee's file so that it can be located if needed.

5.2.3.3 Visual inspection shall be performed in accordance with the following:

- (1) The cylinder is checked for exposure to fire, dents, cuts, digs, gouges, and corrosion according to CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, except that paragraph 4.2.1.1(1) of that standard (which requires tare weight verification) shall not be part of the required inspection criteria.
- (2) The cylinder protective collar (where utilized) and the foot ring are intact and are firmly attached.
- (3) The cylinder is painted or coated to minimize corrosion.
- (4) The cylinder pressure relief valve indicates no visible damage, corrosion of operating components, or obstructions.
- (5) There is no leakage from the cylinder or its appurtenances that is detectable without the use of instruments.
- (6) The cylinder is installed on a firm foundation and is not in contact with the soil.
- (7) A cylinder that passes the visual examination shall be marked with the month and year of the examination followed by the letter "E" (example: 10-01E, indicating requalification in October 2001 by the external inspection method).
- (8) The results of the visual inspection shall be documented, and a record of the inspection shall be retained for a 5-year period.

The procedures for visual inspection listed in **5.2.3.3** are simple and will identify cylinder defects and conditions that require correction. Several are taken from CGA C-6 [6], the standard for visually inspecting steel cylinders.

In **5.2.3.3(3)**, the phrase "retard corrosion" was revised to read "minimize corrosion." The technical committee intends that the painting or coating prevent excessive corrosion from occurring.

Paragraph 5.2.3.3(5) states that using an electronic or other gas detection device is not required.

Paragraph 5.2.3.3(6) addresses an important installation requirement, namely, that the cylinder be installed on a firm foundation, not in contact with the soil. "Firm" is not defined but in the context of the usage, it is intended to require the foundation to remain substantially intact and level while it supports the cylinder.

The marking requirements of **5.2.3.3(7)** are similar to those used for cylinders that are requalified. An important difference is that a requalifier identification number is not required to be marked on the cylinder.

Paragraph 5.2.3.3(8) provides a definite five-year term for retaining the records of all inspected cylinders.

5.2.4 Container Service Pressure.



5.2.4.1 The service pressure of cylinders shall be in accordance with the appropriate regulations published under 49 CFR, “Transportation.”

See **Annex C**, Design, Construction, and Requalification of DOT (ICC) Cylinders, for information on the DOT requirements for cylinder design and fabrication.

5.2.4.2 The maximum allowable working pressure (MAWP) for ASME containers shall be in accordance with Table 5.2.4.2.

FAQ ►

Can a container having a maximum allowable working pressure of 200 psi be used in propane service?

Table 5.2.4.2 provides minimum MAWP for ASME containers in LP-Gas service. Most containers require a MAWP of 250 psig (1.7 MPag). The higher pressure of 312 psig (2.2 MPag) [125 percent of 250 psig (1.7 MPag)] is now required for all engine fuel container installations, including automobiles, industrial trucks, buses, recreational vehicles, school buses, and multipurpose passenger vehicles.

Note that containers constructed to the ASME *Boiler and Pressure Vessel Code* [1] up to the 1946 edition, and paragraphs U-68 and U-69 in the 1949 edition, are permitted to be used even though the MAWP is 200 psi. The reason for this allowance is due to the design margin (safety factor) of 5 that was used to design those containers. The recognized benefits of modern technologies and material science have resulted in a reduced design margin for the current ASME *Boiler and Pressure Vessel Code*.

5.2.4.3 In addition to the applicable provisions for horizontal ASME containers, vertical ASME containers over 125 gal (0.5 m³) water capacity shall comply with 5.2.4.3(A) through 5.2.4.3(E).

(A) Containers shall be designed to be self-supporting without the use of guy wires and shall be designed to withstand the wind, seismic (earthquake) forces, and hydrostatic test loads anticipated at the site.



(B) Maximum allowable working pressure (see **Table 5.2.4.2**) shall be the pressure at the top head with allowance made for increased pressure on lower shell sections and bottom head due to the static pressure of the product.

TABLE 5.2.4.2 Maximum Vapor Pressures and MAWP

Maximum Vapor Pressure in psig (MPag)		MAWP Pressure in psig (MPag)					
		Current ASME Code ^a		Earlier Codes			
				API-ASME		ASME ^b	
At 100°F	At 37.8°C	psig	MPag	psig	MPag	psig	MPag
80	0.6	100	0.7	100	0.7	80	0.6
100	0.7	125	0.9	125	0.9	100	0.7
125	0.9	156	1.1	156	1.1	125	0.9
150	1.0	187	1.3	187	1.3	150	1.0
175	1.2	219	1.5	219	1.5	175	1.2
215	1.5	250	1.7 ^c	250	1.7 ^c	200	1.4
215	1.5	312	2.2 ^c	312	2.2 ^c	—	—

Note: See Annex D for information on earlier ASME or API-ASME codes.

^aASME Code, 1949 edition, paragraphs U-200 and U-201 and all later editions (see D.2.1.5).

^bAll ASME codes up to the 1946 edition and paragraphs U-68 and U-69 of the 1949 edition (see D.2.1.5).

^cSee 6.23.3.1(A), 6.23.3.1(C), and 6.23.3.1(D) for required maximum allowable working pressure (MAWP) for ASME engine fuel and mobile containers.

(C) Wind loading on containers shall be based on wind pressures on the projected area at various height zones above ground in accordance with ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. Wind speeds shall be based on a mean occurrence interval of 100 years.

(D) Seismic loading on containers shall be in accordance with ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. A seismic analysis of the proposed installation shall be made that meets the approval of the authority having jurisdiction.

(E) Shop-fabricated containers shall be fabricated with lifting lugs or other means to lift the container.

Where a container is installed in a vertical rather than a horizontal position, the loading dynamics of the container differ. The methods of support for the vertical container must be designed to account for the increased possibility of toppling the taller container in high wind and seismic conditions. These methods of support are addressed further in 5.2.7.1.

Paragraph 5.2.4.3(B) was changed editorially to employ terms that are commonly used in the ASME *Boiler and Pressure Vessel Code* [1]. The intent remains the same — that is, to require a container to be designed with a maximum allowable working pressure sufficient to encompass all of the pressures present at the bottom of the container.

Paragraph 5.2.4.3(E) requires lifting lugs, but does not require the lugs to carry a specific weight. It must be assumed that the lifting lugs are not adequate to carry the entire weight of the container when filled with LP-Gas or water, so additional support, such as a strapping system, must be used to lift ASME tanks that contain product.

5.2.4.4* ASME engine fuel and mobile containers shall have a MAWP of 312 psig (2.2 MPag) or higher.

A.5.2.4.4 ASME mobile fuel containers constructed prior to April 1, 2001, were required to have a maximum allowable working pressure (MAWP) of 250 psig (1.7 MPag).



The maximum allowable working pressure (MAWP) for engine fuel and mobile containers was changed from 250 psig (1.7 MPag) to 312 psig (2.2 MPag) or higher in the 2004 edition in order to resolve a conflict with NFPA 1192, *Standard on Recreational Vehicles* [9], which required the higher design pressure. The following two safety benefits resulted from this change:

1. The higher design pressure provides a stronger container, which could be important in a vehicle accident.
2. The higher design pressure reduces the remote possibility of pressure relief valve opening in the event of high internal vehicle temperature.

5.2.4.5 Cylinders shall be designed and constructed for at least a 240 psig (1.6 MPag) service pressure.

5.2.5 ASME Container Openings.

5.2.5.1 ASME containers shall be equipped with openings for the service for which the container is to be used.

NFPA 58 does not limit the number of container openings because a properly installed plug, cap, or blind flange will provide an effective seal to maintain the integrity of the container.

5.2.5.2 The openings required by 5.2.5.1 shall be located either in the shell, in the heads, or in a manhole cover.

5.2.5.3* ASME containers of more than 30 gal (0.1 m³) through 2000 gal (7.6 m³) water capacity that are designed to be filled volumetrically shall be equipped for filling into the vapor space.

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FAQ ►
Why is it desirable to fill into the vapor space of the container rather than the liquid space?

A.5.2.5.3 Prior to December 1, 1963, ASME containers greater than 30 gal (0.11 m³) water capacity, up to and including 2000 gal (76 m³) water capacity, were not required to be equipped for filling into the vapor space of the container.

Filling only into the vapor space, but not into the liquid space, more rapidly achieves equilibrium between the vapor and the liquid in the container. Lower container pressure results when filling into the vapor space, compared to filling into the liquid space. Filling only into the vapor space allows containers to be filled more rapidly, because the pump does not have to overcome a greater pressure in the container.

5.2.5.4* ASME containers of 125 gal (0.5 m³) through 2000 gal (7.6 m³) water capacity shall be provided with an opening for an actuated liquid withdrawal excess-flow valve with a connection not smaller than 3/4 in. national pipe thread.



A.5.2.5.4 Containers fabricated on or before July 1, 1961, are exempt from this requirement.

An actuated liquid withdrawal excess-flow valve is defined in **Chapter 3** as follows:

3.3.1 Actuated Liquid Withdrawal Excess-Flow Valve. An excess-flow valve for liquid withdrawal applications that remains in a closed position until actuated by a pipe nipple or adapter, as recommended by the manufacturer, and that is used with a shutoff valve attached to the actuator.

This valve (see **Exhibit 5.9**), which is required by **5.2.5.4**, is needed to remove liquid from ASME containers before they are transported to another location. The DOT regulations require that such tanks can only be transported when the liquid volume is 5 percent or less of the water capacity of the tank. However, a special permit was issued by DOT in 2006 (see Special Permit No. 13341) that allows the transportation of ASME containers with more than 5 percent liquid volume in the container, subject to several limitations. The special permit may be obtained at the following website: http://hazmat.dot.gov/sp_app/special_permits/spec_perm_index.htm

The actuated liquid withdrawal excess-flow valve is more commonly known by the trade names Chek-Lok®, Checkmate®, and SafEvac®, as well as by liquid withdrawal valve with excess flow. An actuated liquid withdrawal valve is operated by removing the valve cap and threading a pipe nipple or adapter (available from the manufacturer) into the valve. As the nipple or adapter turns, the valve opens, liquid flows through the valve until the flow exceeds the excess flow, and the valve closes. (See **Exhibit 5.10**.) A manual valve is then installed to the pipe nipple or adapter, and the valve is closed. A small bypass allows a small amount of vapor to bypass the excess-flow valve, and pressure increases on the outlet side of the adapter. When pressure on both sides of the excess flow disc is about equal, the excess flow valve opens with an audible “click.” The liquid can then be removed.

EXHIBIT 5.9 Actuated Liquid Withdrawal Excess-Flow Valve; Old Style (Left) and Current Style (Center and Right). (Courtesy of Engineered Controls International, Inc.)



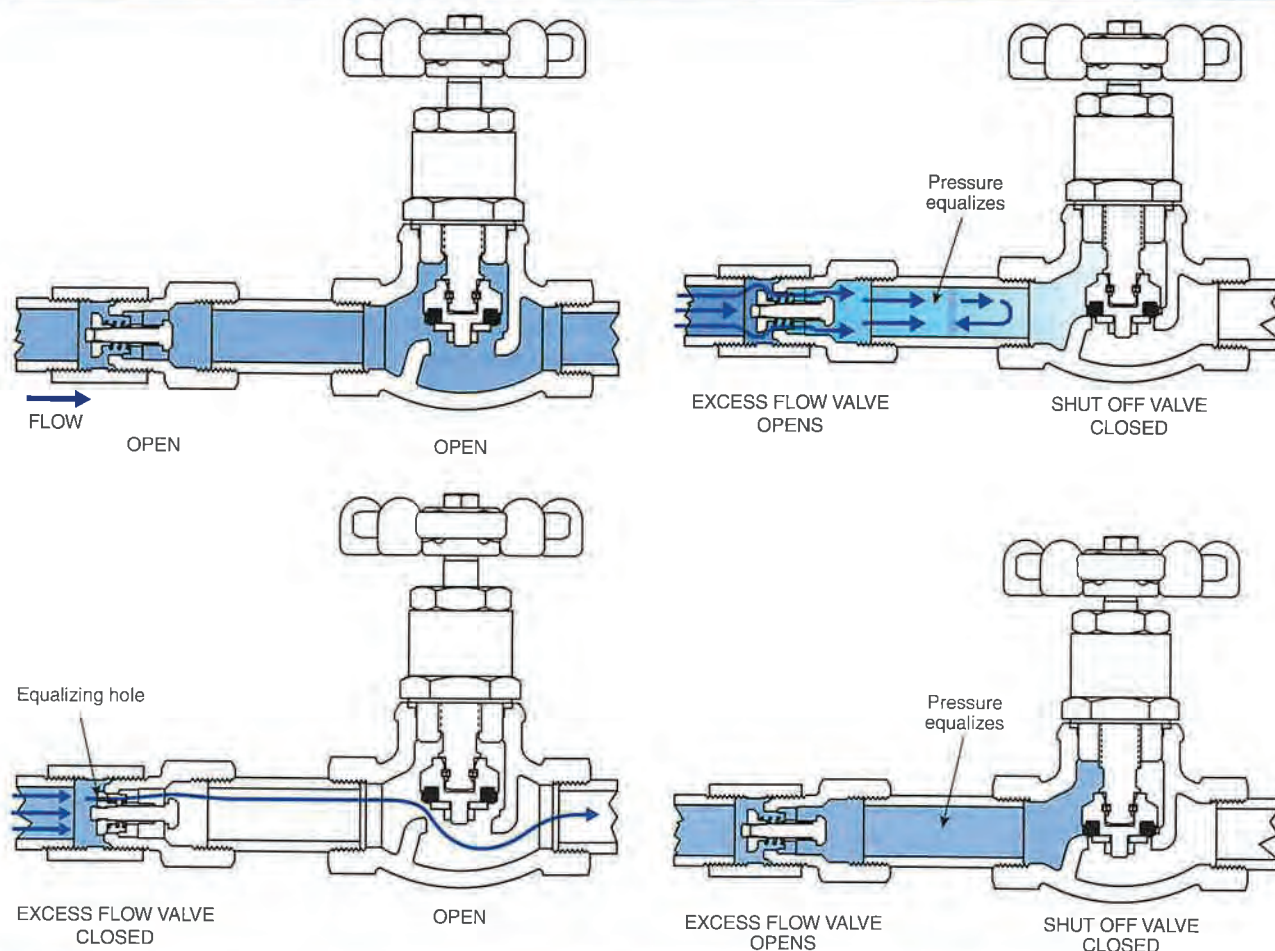


EXHIBIT 5.10 Operation of an Actuated Liquid Withdrawal Excess-Flow Valve. (Courtesy of Fisher Controls Intl, LLC)

Section A of Exhibit 5.10 shows an excess-flow valve in the open position, with a manually operated shutoff valve connected also in the open position. The flow through the excess-flow valve is less than the rate that will close the valve. Section B shows an excess-flow valve in the closed position, because the flow has exceeded the rate that will close the excess-flow valve. Note that a small amount of propane, shown as a blue line, continues to flow through the closed excess-flow valve through a designed bypass, such as a small hole drilled in the valve. The manually operated valve remains in the open position. Section C shows the shut-off valve closed, which has allowed the bypass flow to begin to pressurize the space between the shutoff valve and the excess-flow valve. The spring tension retains the excess-flow valve in the closed position. Section D shows the shutoff valve closed, which has allowed the bypass flow to fully to pressurize the space between the shutoff valve and the excess flow valve. With equal pressure (force) on both sides of the excess flow valve, the spring tension opens the excess flow valve. The shutoff valve can now be opened (slowly) to restart the flow.

In 5.7.4.1(B) and 5.7.4.1(D), the code recognizes that the valves are usually intended for only occasional use and that the valve manufacturer may or may not recommend them for continuous use.

Can an actuated liquid withdrawal excess-flow valve be used on a permanent basis to convert a container to liquid withdrawal service?

◀ FAQ

5.7.4.1(B) Containers of 125 gal through 4000 gal (0.5 m³ through 15.2 m³) water capacity shall be provided with an actuated liquid withdrawal excess-flow valve with a connection not smaller than 3/4-in. national pipe thread.

5.7.4.1(D) The actuated liquid withdrawal excess flow valve shall not be connected for continuous use unless the valve is recommended by the manufacturer for such service.

To the editor's knowledge, the major valve manufacturers recommend that the old-style actuated liquid withdrawal excess-flow valves shown in **Exhibit 5.9** (left) should not be used for continuous liquid withdrawal operations. The new-style valves, shown in **Exhibit 5.9** (center and right), are more robust, and according to the editor's information, the manufacturers do recommend these new, listed valves for continuous service. To be sure, check with the valve manufacturer.

There is a difference between **5.2.5.4** and **5.7.4.1(B)**. The latter paragraph was changed in the 2001 edition to recognize that residential customers' tanks sometimes exceed 2000 gal (7.6 m³), and therefore the assumed upper limit for vapor service residential customers was increased to 4000 gal (15 m³). Tanks larger than 4000 gal (15 m³) were treated as a bulk plant or dispenser tank, for the purposes of establishing the requirements for appurtenances in **5.7.4.1**. This difference is minor, as there are relatively few containers in the size range greater than 2000 gal (7.6 m³) up to 4000 gal (15 m³).

5.2.5.5* ASME containers of more than 2000 gal (7.6 m³) water capacity shall have an opening for a pressure gauge.



A.5.2.5.5 See **5.7.8.6** for the pressure gauge requirement.

Knowledge of the pressure in larger containers is useful, especially during liquid transfer operations. When installing a pressure gauge, reference should be made to **5.7.6.2**, which reminds the user of an important safety feature requiring either a maximum opening of a No. 54 drill size between the container and the pressure gauge or installation of an excess-flow check valve. This safety feature prevents discharge of significant amounts of LP-Gas in case the pressure gauge is broken off. In the 2008 edition, Annex A text was added that refers to the requirement for pressure gauges in **5.7.8.6**.

5.2.5.6 ASME containers in storage or use shall have pressure relief valve connections that have direct communication with the vapor space of the container.

(A) If the pressure relief valve is located in a well inside the ASME container with piping to the vapor space, the design of the well and piping shall have a flow capacity equal to or greater than that of the pressure relief valve.

(B) If the pressure relief valve is located in a protecting enclosure, the enclosure shall be designed to minimize corrosion and to allow inspection.

(C) If the pressure relief valve is located in any position other than the uppermost point of the ASME container, the connection shall be internally piped to the uppermost point practical in the vapor space of the container.

FAQ ►

Why is it important that the relief valve be in communication with the vapor space of a container?

By discharging vapor through the relief valve, the total quantity of LP-Gas escaping to the atmosphere is reduced, compared to discharging liquid, and the pressure within the container is reduced more quickly. Because of the high liquid-to-vapor expansion ratio of LP-Gas (270 to 1 for propane), a liquid discharge through the relief valve represents a much greater quantity of gas discharging into the atmosphere. If vapor is discharged, the pressure is reduced inside the container and the remaining liquid boils, cooling the liquid and thus reducing the pressure in the container. If liquid is discharged, the following results:

- Vaporization occurs outside the container.
- There is no cooling effect from vaporization inside the container.
- Container pressure is higher.

These factors are significant if the valve is discharging as a result of fire exposure.

The relief valve must either be located at the uppermost point of the container or be internally piped to the uppermost point practical in the vapor space of the container. This provision recognizes that some containers used for engine fuel and recreational vehicle applications have been manufactured with the relief valve located just above the 80 percent liquid level. The provision that the relief valve be piped to the uppermost point practical in the container recognizes that, in some containers — for example, portable lift truck cylinders that are stored vertically and used horizontally — the relief valve inlet cannot be located at the uppermost point for use in both positions.

5.2.5.7* ASME containers to be filled on a volumetric basis shall be fabricated so that they can be equipped with a fixed maximum liquid level gauge(s) that is capable of indicating the maximum permitted filling level(s) in accordance with **7.4.2.3**.

A.5.2.5.7 Containers fabricated on or before December 31, 1965, are exempt from this requirement.

Variable liquid level gauges indicate liquid level over most of the container's capacity range but are not completely reliable. The float may develop a leak, the float arm may sag over time, the mechanism may bind, or the gauge may otherwise indicate an inaccurate reading. Therefore, a fixed maximum liquid level gauge is required by **5.2.5.7** to be used to accurately fill the container.

5.2.6 Portable Container Appurtenance Physical Damage Protection.

5.2.6.1 Cylinders of 1000 lb (454 kg) water capacity [nominal 420 lb (191 kg) propane capacity] or less shall incorporate protection against physical damage to cylinder appurtenances and immediate connections to such appurtenances when not in use by either of the following means:

- (1) A ventilated cap
- (2) A ventilated collar

The cap or collar described in **5.2.6.1** and shown in **Exhibit 5.11** is required to provide physical protection for the valves and any other appurtenances connected to the cylinder.

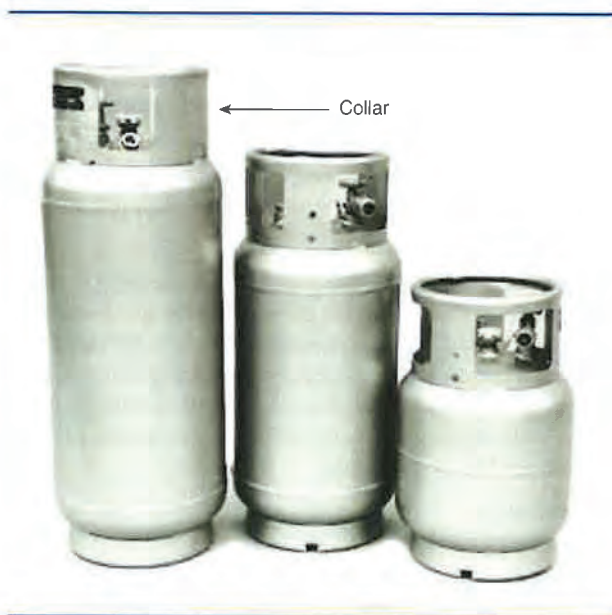


EXHIBIT 5.11 Cylinder Collars. (Courtesy of Manchester Tank)

Cylinders are portable and normally are transported from their normal use point to a filling point; there are inevitable occurrences where the cylinder is involved in a transportation incident, falls over, or is dropped. If a removable cap is used, it must be in place prior to moving the cylinder. The cap also provides a lifting point for the cylinder. The valve must never be used for lifting a cylinder. Ventilation openings are required to permit discharge from the pressure relief valve to dissipate.

5.2.6.2 Protection of appurtenances of portable containers, skid tanks, and tanks for use as cargo tanks of more than 1000 lb (454 kg) water capacity [nominal 420 lb (191 kg) propane capacity] shall comply with **5.2.6.2(A)** through **5.2.6.2(C)**.

(A) Appurtenance protection from physical damage shall be provided by recessing, by protective housings, or by location on the vehicle.

(B) Appurtenance protection shall comply with the provisions under which the containers are fabricated.



(C) Appurtenance protection shall be secured to the container in accordance with the ASME code under which the container was designed and built.

Paragraph **5.2.6.2(C)** was revised in the 2008 edition with regard to the design of appurtenance protection to refer to the code under which the container was built, instead of specifying the safety factors to be used. As the appurtenance protection is usually installed by the container manufacturer or assembler of a portable tank unit, it is reasonable to assume that the fabricator has access to the container construction code.

5.2.7 Containers with Attached Supports.

5.2.7.1 Vertical ASME containers of over 125 gal (0.5 m³) water capacity for use in permanent installations in stationary service shall be designed with steel supports that allow the container to be mounted on and fastened to concrete foundations or supports.

(A) Steel supports shall be designed to make the container self-supporting without guy wires and to withstand the wind and seismic (earthquake) forces anticipated at the site.

(B) Steel supports shall be protected against fire exposure with a material having a fire resistance rating of at least 2 hours.

(C) Continuous steel skirts having only one opening of 18 in. (460 mm) or less in diameter shall have 2-hour fire protection applied to the outside of the skirt.

Vertical containers, as shown in **Exhibit 5.12**, are used where space is not available for horizontal containers. Because the failure of a vertical tank's structural supports can result in severe damage to the container when it falls, there are special fire protection requirements for the supports. The two-hour fire resistance rating is obtained by using a protective material that has been tested to the requirements of ASTM E-119, *Standard Test Methods for Fire Tests of Building Construction and Materials* [10], a standard used to determine the fire resistance rating of structural elements. Vertical tanks are most often located at propane vehicle refueling stations where space is usually at a premium. Larger vertical tanks have also been installed where land cost is very high, such as near New York City.

Paragraph **5.2.7.1(C)** addresses vertical tanks equipped with continuous steel skirts, which are not normally found at propane dispensing locations, but are more common in refineries. Their use is permitted where the skirt is protected with fire resistance-rated insulation on its exterior.

5.2.7.2 ASME containers to be used as portable storage containers, including movable fuel storage tenders and farm carts for temporary stationary service (normally not more than 12 months duration at any location), shall comply with **5.2.7.2(A)** through **5.2.7.2(D)**.