

A CRYOGENIC STORAGE SYSTEM

TECHNICAL FIELD

5 This invention relates generally to a cryogenic storage system for storing and provisioning of natural gases.

Background

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higher alkanes, and sometimes a small
10 percentage of carbon dioxide, nitrogen, hydrogen sulfide, or helium. Natural gas is a fossil fuel used as a source of energy for heating, cooking, and electricity generation. It is also used as a fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals. Natural gas is often informally referred to simply as "gas", especially when compared to other energy sources such as oil or coal.
15 However, it is not to be confused with gasoline, especially in North America, where the term gasoline is often shortened in colloquial usage to gas.

Liquefied natural gas (LNG) is a composition of methane and some mixture of ethane used to convert natural gas to liquid form for ease and safety of storage transport. It is cooled to
20 approximately -256 degrees Fahrenheit so that it can be transported from countries with a large supply of natural gas to countries that demand more natural gas than they produce. In its liquid state, natural gas takes up 1/600th of the space, making it much easier to ship and store when pipeline transport is not feasible. Liquefied natural gas is primarily used to transport natural gas from one source to another. The main method of transportation
25 is storage tanks ashore to vessel tanks. Once the cargo is delivered, the natural gas is allowed to expand and convert back to its gaseous form. Regasification terminals are used to help convert temperatures back to a natural gas state.

One approach to the storage of LNG is through the use of cryogenic storage dewars, a
30 specialised type of vacuum flask used for storing cryogenics (such as liquid nitrogen or liquid

helium), whose boiling points are much lower than room temperature. Cryogenic storage dewars may take several different forms including open buckets, flasks with loose-fitting stoppers and self-pressurising tanks. All dewars have walls constructed from two or more layers, with a high vacuum maintained between the layers. This provides very good thermal insulation between the interior and exterior of the dewar, which reduces the rate at which the contents boil away. Precautions are taken in the design of dewars to safely manage the gas which is released as the liquid slowly boils. The simplest dewars allow the gas to escape either through an open top or past a loose-fitting stopper to prevent the risk of explosion. More sophisticated dewars trap the gas above the liquid, and hold it at high pressure. This increases the boiling point of the liquid, allowing it to be stored for extended periods. Excessive vapour pressure is released automatically through safety valves.

Nonetheless, cryogenics still present several safety hazards and storage vessels are designed to reduce the associated risk. Firstly, no dewar can provide perfect thermal insulation and the cryogenic liquid slowly boils away, which yields an enormous quantity of gas. For example, the expansion ratio of cryogenic argon from the boiling point to ambient is 1 to 847, liquid hydrogen 1 to 851, liquid helium 1 to 757, liquid nitrogen 1 to 696, and liquid oxygen 1 to 860. In dewars with an open top, the gas simply escapes into the surrounding area. However, very high pressures can build up inside sealed dewars, and precautions are taken to minimise the risk of explosion. One or more pressure-relief valves allow gas to vent away from the dewar whenever the pressure becomes excessive. If a dewar is left open to the air for extended periods, atmospheric chemicals can condense or freeze on contact with the cryogenic material. This can introduce contaminants. If these materials freeze, for example, water vapor becoming ice, they can block the openings, leading to pressure buildup and the risk of an explosion. Further, the gas escaping from a dewar can gradually displace the oxygen from the air in the surrounding area, which presents an asphyxiation hazard. Users are trained to only store dewars in a well-ventilated area and before transporting dewars in an elevator, the excess gas pressure is vented away and the dewars are sent unaccompanied to their destination. Therefore, there exists a need for a system for addressing the foregoing problems.

Summary

In accordance with a first aspect of the invention, there is disclosed a cryogenic storage system comprising a plurality of insulative vessels with each of the plurality of insulative vessels having an internal vapourizer and a discharge outlet. The cryogenic storage system further comprises a first external vaporizer, a first manifold for removably intercoupling and fluid communicating each of the plurality of insulative vessels with the first external vaporizer, and a gas withdrawal valve. Each of the plurality of insulative vessels is for storing liquefied natural gases and the internal vapouriser thereof is for initiating vapourizing the liquefied natural gas into natural gas at the discharge outlet thereof for provision to the first external vaporizer via the first manifold, the first external vaporizer for further vaporizing the natural gas for provision to and subsequent dispensing from the gas withdrawal valve.

In accordance with a second aspect of the invention, there is disclosed a cryogenic storage system comprising a first plurality of insulative vessels and a second plurality of insulative vessels, with each of the first plurality of insulative vessels and each of the second plurality of insulative vessels having an internal vapourizer and a discharge outlet. The cryogenic storage system further comprises a first external vaporizer, a first manifold for removably intercoupling and fluid communicating each of the first plurality of insulative vessels with the first external vaporizer, a second external vaporizer, a second manifold for removably intercoupling and fluid communicating each of the second plurality of insulative vessels with the second external vaporizer, and a gas withdrawal valve. Each of the first plurality of insulative vessels and each of the second plurality of insulative vessels is for storing liquefied natural gases and the internal vapouriser thereof is for initiating vapourizing the liquefied natural gas into natural gas at the discharge outlet for provision to a respective one of the first external vaporizer and the second external vaporizer via a respective one of the first manifold and the second manifold, each of the first external vaporizer and the second external vaporizer for further vaporizing the natural gas for provision to and subsequent dispensing from the gas withdrawal valve.

Brief Description of the Drawings

FIG. 1 shows an exemplary system diagram of a cryogenic storage system in accordance with a first embodiment of the invention; and.

FIG. 2 shows an exemplary system diagram of the cryogenic storage system of FIG. 2 based on a second embodiment of the invention.

Detailed Description

A first exemplary embodiment of the present invention, a cryogenic storage system 20, is described hereinafter with reference to FIG. 1.

The cryogenic storage system 20 comprises a plurality of insulative vessels 22. Each of the plurality of insulative vessels 22 has an internal vapourizer and a discharge outlet 24. The cryogenic storage system 20 further comprises a first external vaporizer 26, a first manifold 28 for removably intercoupling and fluid communicating each of the plurality of insulative vessels 22 with the first external vaporizer 26, and a gas withdrawal valve 30. In many implementations, the discharge outlet 24 of each of the plurality of insulative vessels 22 can be one of a gas discharge outlet and a liquid discharge outlet and is dependent of the setup configuration of each of the plurality of insulative vessels 22 when coupled with the first manifold 28. Each of the plurality of insulative vessels 22 is for storing liquefied natural gases and the internal vapouriser thereof is for initiating vapourizing the liquefied natural gas into natural gas at the discharge outlet 24 thereof for provision to the first external vaporizer 26 via the first manifold 28. The first external vaporizer 26 is for further vaporizing the natural gas for provision to and subsequent dispensing from the gas withdrawal valve 30.

The cryogenic storage system 20 further comprises a second external vaporizer 32 and a second manifold 34 intercoupling and fluid communicating the first external vaporizer 26 with the second external vaporizer 32. The second external vaporizer 32 further vaporizes

the natural gas received from the first external vaporizer 26 for provision to the gas withdrawal valve 30.

Each of the first external vaporizer 26 and the second external vaporizer 32 being one of an ambient vaporizer and a water bath vaporizer. Further, each of the plurality of insulative vessels 22 being a cryogenic storage dewar and having less than 1000 litres in storage capacity. Specifically, each of the plurality of insulative vessels 22 being a cryogenic storage dewar and having substantially 210 litres in storage capacity.

Preferably, the gas withdrawal valve 30 being adapted for enabling coupling of a pressure regulator thereto for drawing the natural gas therefrom. Further, the first manifold 28 comprises headers for enabling removable coupling of the discharge outlet 24 of each of the plurality of insulative vessels 22 with the first manifold 28. Each of the first manifold 28 and the second manifold 34 is preferably a pipe assembly.

The cryogenic storage system 20 further comprises a compartment comprising a plurality of walls for defining an enclosure and an opening to the enclosure. The enclosure is shaped and dimensioned for receiving the plurality of insulative vessels 22. The compartment 36 further comprises at least one door being operable to one of enable and impede access to the enclosure through the opening with the at least one door defining louvres for venting the inside of the enclosure. The plurality of walls of the compartment are preferably formed from concrete.

A second exemplary embodiment of the present invention, a cryogenic storage system 20a, is described hereinafter with reference to FIG. 2. In the second embodiment of the invention, the cryogenic storage system 20 comprises a first plurality of insulative vessels 22a and a second plurality of insulative vessels 22b. Each of the first plurality of insulative vessels 22a and each of the second plurality of insulative vessels 22b has an internal vapourizer and a discharge outlet 24a. The cryogenic storage system 20a further comprises a first external vaporizer 26a, and a first manifold 28a for removably intercoupling and fluid communicating

each of the first plurality of insulative vessels 22a with the first external vaporizer 26a. The cryogenic storage system 20a also further comprises a second external vaporizer 26b, a second manifold 28b for removably intercoupling and fluid communicating each of the second plurality of insulative vessels 22b with the second external vaporizer 26b, and a gas withdrawal valve 30a.

Each of the first plurality of insulative vessels 22a and each of the second plurality of insulative vessels 22b is for storing liquefied natural gases and the internal vapouriser thereof is for initiating vapourizing the liquefied natural gas into natural gas at the discharge outlet 24a for provision to a respective one of the first external vaporizer 26a and the second external vaporizer 26b via a respective one of the first manifold 28a and the second manifold 28b. Each of the first external vaporizer 26a and the second external vaporizer 26b is for further vaporizing the natural gas for provision to and subsequent dispensing from the gas withdrawal valve 30a.

The cryogenic storage system 20a further comprises a third external vaporizer 40 and a third manifold 42 intercoupling and fluid communicating the first external vaporizer 26a and the second external vaporizer 26b with the third external vaporizer. The third external vaporizer 40 is for further vaporizing the natural gas received from the first external vaporizer 26a and the second external vaporizer 26b for provision to the gas withdrawal valve 30a.

Preferably, each of the first external vaporizer 26a, second external vaporizer 26b and the third external vaporizer 40 being one of an ambient vaporizer and a water bath vaporizer. Further, each of the first plurality of insulative vessels 22a and each of the second plurality of insulative vessels 22b is a cryogenic storage dewar and having less than 1000 litres in storage capacity. Specifically, each of the first plurality of insulative vessels 22a and each of the second plurality of insulative vessels 22b being a cryogenic storage dewar and having substantially 210 litres in storage capacity.

The gas withdrawal valve 30a is adapted for enabling coupling of a pressure regulator thereto for drawing the natural gas therefrom. Preferably, each of the first manifold 28a and the second manifold 28b comprises headers for enabling removable coupling of the discharge outlet 24a of each of the first plurality of insulative vessels 22a and the second plurality of insulative vessels 22b with the respective one of the first manifold 28a and the second manifold 28b. It is also preferred that each of the first manifold 28a and the second manifold 28b is a pipe assembly.

Similarly, the cryogenic storage system 20 further comprises a compartment 36a comprising a plurality of walls 38a for defining an enclosure and an opening to the enclosure. The enclosure is shaped and dimensioned for receiving each of the first plurality of insulative vessels 22a and the second plurality of insulative vessels 22b. The compartment 36 further comprises at least one door being operable to one of enable and impede access to the enclosure through the opening with the at least one door defining louvres for venting the inside of the enclosure. The plurality of walls 38a of the compartment 36a are preferably formed from concrete.

It is preferred that the operating draw rate or volumetric discharge rate of each of the first plurality of insulative vessels 22a and each of the second plurality of insulative vessels 22b is substantially 10 m³/h (metre cube per hour) with the first plurality of insulative vessels 22a being four insulative vessels and the second plurality of insulative vessels 22b being also four insulative vessels. This will result in the natural gas having a volumetric flow rate of approximately 40 m³/h at the first external vaporizer 26a and approximately 40 m³/h at the second external vaporizer 26b. The volumetric flow rate of the natural gas at the third external vaporizer 40 will therefore be approaching approximately 100 m³/h. The first external vaporizer 26a, second external vaporizer 26b and the third external vaporizer 40 forms a multi-stage progressive vaporization pathway especially for our application where the discharge flow rate at each of the first plurality of insulative vessels 22a and each of the second plurality of insulative vessels 22b is high.

The cryogenic storage system 20/20a further comprises a cage structure for containing and suspending each of the first plurality of insulative vessels 22a and each of the second plurality of insulative vessels 22b therewithin for forming a substantially rigid body therewith. In such a configuration, the discharge outlet 24a may be physically coupled to the cage structure. This enables easy handling and movement of the first plurality of insulative vessels 22a and the second plurality of insulative vessels 22b by way of just spatially manipulating the cage structure. For example, at a particular premise, the cage structure can be easily moved into position to enable coupling of the discharge outlet 24a to a fixed supply-side manifold found on-premise. The cage structure also enable mobility and swapping of a depleted set of the first plurality of insulative vessels 22a and the second plurality of insulative vessels 22b with a filled set thereof. This saves time as swapping of the vessels by way of the cage structure is much faster and convenient than bringing a larger tank on-premise to top up t the first plurality of insulative vessels 22a and the second plurality of insulative vessels 22b, when depleted.

The cryogenic storage system 20/20a, as aforementioned, is a small scale liquid natural gas (LNG) system for dense cities like Singapore where space shortage makes it difficult for storage of typical LNG in containers of 20ft (18,000L) orft (36,000L). By providing vessels or dewar cylinders of less than 1000 litres enable disposing of the LNG system, specifically the cryogenic storage system 20/20a as aforementioned, at the user premises in a manifold of multiple cylinders or vessels enabling the LNG to be directly utilized for various purposes such as heating, gas for cooking, power production, cooling and other industrial processes. As LNG is flammable and explosive when vapourised, storing the LNG in smaller vessel and across multiple vessels reduces the effects of such risks and allows pre-emptive safety-measures to be employed and designed into the system for use.

Aspects of particular embodiments of the present disclosure address at least one aspect, problem, limitation, and/or disadvantage associated with existing cryogenic storage systems. While features, aspects, and/or advantages associated with certain embodiments have been described in the disclosure, other embodiments may also exhibit such features, aspects,

and/or advantages, and not all embodiments need necessarily exhibit such features, aspects, and/or advantages to fall within the scope of the disclosure. It will be appreciated by a person of ordinary skill in the art that several of the above-disclosed structures, components, or alternatives thereof, can be desirably combined into alternative structures, components, and/or applications. In addition, various modifications, alterations, and/or improvements may be made to various embodiments that are disclosed by a person of ordinary skill in the art within the scope of the present disclosure, which is limited only by the following claims.

Claims

1. A cryogenic storage system comprising:

a plurality of insulative vessels, each of the plurality of insulative vessels
5 having an internal vapourizer and a discharge outlet;

a first external vaporizer;

a first manifold for removably intercoupling and fluid communicating each of
the plurality of insulative vessels with the first external vaporizer; and

a gas withdrawal valve;

10 wherein each of the plurality of insulative vessels is for storing liquefied
natural gases and the internal vapouriser thereof is for initiating vapourizing the
liquefied natural gas into natural gas at the discharge outlet thereof for provision to
the first external vaporizer via the first manifold, the first external vaporizer for
further vaporizing the natural gas for provision to and subsequent dispensing from the
15 gas withdrawal valve.

2. The cryogenic storage system as in claim 1, further comprising:

a second external vaporizer; and

a second manifold intercoupling and fluid communicating the first external
20 vaporizer with the second external vaporizer,

wherein the second external vaporizer further vaporizes the natural gas
received from the first external vaporizer for provision to the gas withdrawal valve.

3. The cryogenic storage system as in claim 2, each of the first external vaporizer and
25 the second external vaporizer being one of an ambient vaporizer and a water bath
vaporizer.

4. The cryogenic storage system as in claim 1, each of the plurality of insulative vessels
being a cryogenic storage dewar and having less than 1000 litres in storage capacity.

5. The cryogenic storage system as in claim 1, each of the plurality of insulative vessels being a cryogenic storage dewar and having substantially 210 litres in storage capacity.
- 5 6. The cryogenic storage system as in claim 1, the gas withdrawal valve being adapted for enabling coupling of a pressure regulator thereto for drawing the natural gas therefrom.
7. The cryogenic storage system as in claim 1, the first manifold comprises headers for
10 enabling removable coupling of the discharge outlet of each of the plurality of insulative vessels with the first manifold.
8. The cryogenic storage system as in claim 1, each of the first manifold and the second manifold being a pipe assembly.
- 15 9. The cryogenic storage system as in claim 1, further comprising:
a compartment comprising a plurality of walls for defining an enclosure and an opening to the enclosure, the enclosure is shaped and dimensioned for receiving the plurality of insulative vessels, the compartment further comprises at least one door
20 being operable to one of enable and impede access to the enclosure through the opening, the at least one door defining louvres for venting the inside of the enclosure.
10. The cryogenic storage system as in claim 10, the plurality of walls of the compartment are formed from concrete.

11. A cryogenic storage system comprising:

a first plurality of insulative vessels;

a second plurality of insulative vessels, each of the first plurality of insulative
5 vessels and each of the second plurality of insulative vessels having an internal
vapourizer and a discharge outlet;

a first external vaporizer;

a first manifold for removably intercoupling and fluid communicating each of
the first plurality of insulative vessels with the first external vaporizer;

10 a second external vaporizer;

a second manifold for removably intercoupling and fluid communicating each
of the second plurality of insulative vessels with the second external vaporizer; and

a gas withdrawal valve;

wherein each of the first plurality of insulative vessels and each of the second
15 plurality of insulative vessels is for storing liquefied natural gases and the internal
vapouriser thereof is for initiating vapourizing the liquefied natural gas into natural
gas at the discharge outlet for provision to a respective one of the first external
vaporizer and the second external vaporizer via a respective one of the first manifold
and the second manifold, each of the first external vaporizer and the second external
20 vaporizer for further vaporizing the natural gas for provision to and subsequent
dispensing from the gas withdrawal valve.

12. The cryogenic storage system as in claim 11, further comprising:

a third external vaporizer; and

25 a third manifold intercoupling and fluid communicating the first external
vaporizer and the second external vaporizer with the third external vaporizer,

wherein the third external vaporizer further vaporizes the natural gas received
from the first external vaporizer and the second external vaporizer for provision to the
gas withdrawal valve.

13. The cryogenic storage system as in claim 12, each of the first external vaporizer, second external vaporizer and the third external vaporizer being one of an ambient vaporizer and a water bath vaporizer.
- 5 14. The cryogenic storage system as in claim 11, each of the first plurality of insulative vessels and each of the second plurality of insulative vessels being a cryogenic storage dewar and having less than 1000 litres in storage capacity.
- 10 15. The cryogenic storage system as in claim 11, each of the first plurality of insulative vessels and each of the second plurality of insulative vessels being a cryogenic storage dewar and having substantially 210 litres in storage capacity.
- 15 16. The cryogenic storage system as in claim 11, the gas withdrawal valve being adapted for enabling coupling of a pressure regulator thereto for drawing the natural gas therefrom.
- 20 17. The cryogenic storage system as in claim 11, each of the first manifold and the second manifold comprises headers for enabling removable coupling of the discharge outlet of each of the first plurality of insulative vessels and the second plurality of insulative vessels with the respective one of the first manifold and the second manifold.
- 25 18. The cryogenic storage system as in claim 11, each of the first manifold and the second manifold being a pipe assembly.