

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 first insulative vessel and a second insulative vessel. Each of the first
5 insulative vessel and the second insulative vessel has an internal vapourizer and a gas outlet. The cryogenic storage system further comprises a gas withdrawal valve, and a pipe assembly for removably intercoupling and fluid communicating the first insulative vessel, the second insulative vessel and the gas withdrawal valve. Each of the first insulative vessel and the second insulative vessel is for storing liquefied natural gases and for vapourizing the
10 liquefied natural gas into vapourised natural gas at the gas outlet thereof for provision to the pipe assembly, the pipe assembly for providing the vapourised natural gas for dispensing from the gas withdrawal valve.

In accordance with a second aspect of the invention, there is disclosed a cryogenic storage
15 system comprising a first insulative vessel and a second insulative vessel with each of the first insulative vessel and the second insulative vessel having less than 1000 litres in storage capacity. Each of the first insulative vessel and the second insulative vessel has an internal vapourizer and a gas outlet. The cryogenic storage system further comprises a gas withdrawal valve, and a pipe assembly for removably intercoupling and fluid communicating
20 the first insulative vessel, the second insulative vessel and the gas withdrawal valve. Each of the first insulative vessel and the second insulative vessel is for storing liquefied natural gases and for vapourizing the liquefied natural gas into vapourised natural gas at the gas outlet thereof for provision to the pipe assembly, the pipe assembly for providing the vapourised natural gas for 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 an aspect of the invention.

Detailed Description

An 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 first insulative vessel 22 and a second insulative vessel 24. Each of the first insulative vessel 22 and the second insulative vessel 24 has an internal vapourizer and a gas outlet 28. The cryogenic storage system 20 further comprises a gas withdrawal valve 30 and a pipe assembly 32 for removably intercoupling and fluid communicating the first insulative vessel 22, the second insulative vessel 24 and the gas withdrawal valve 30. The pipe assembly 32 is further for communicating the first insulative vessel 22 and the second insulative vessel 24 to downstream systems or pipe assemblies 33 and/or to other insulative vessels, for example, other one or more of the first insulative vessel 22 and the second insulative vessel 24. Each of the first insulative vessel 22 and the second insulative vessel 24 is for storing liquefied natural gases and the internal vapouriser is for vapourizing the liquefied natural gas into vapourised natural gas at the gas outlet 28 thereof for provision to the pipe assembly 32. The pipe assembly is for providing the vapourised natural gas for dispensing from the gas withdrawal valve 30.

Preferably, each of the first insulative vessel 22 and the second insulative vessel 24 has less than 1000 litres in storage capacity for the liquefied natural gas. More specifically, each of the first insulative vessel 22 and the second insulative vessel 24 has less than or substantially 210 litres in storage capacity for liquefied natural gas.

Preferably, each of the first insulative vessel 22 and the second insulative vessel 24 a cryogenic storage dewar. For the avoidance of doubt, a plurality of insulative vessels may be employed for cryogenic storage system with the plurality of insulative vessels comprising the first insulative vessel 22 and the second insulative vessel 24.

The gas withdrawal valve 30 is preferably adapted for enabling coupling of a pressure regulator thereto for drawing vapourised natural gas from the pipe assembly 32. Preferably,

the pipe assembly 32 comprises headers for enabling removable coupling of the gas outlet 28 of each of the first insulative vessel 22 and the second insulative vessel 24 with the pipe assembly 32. For clarity, only vapor, specifically vaporized natural gas, is drawn from the gas outlet 28 of each of the first insulative vessel 22 and the second insulative vessel 24.

5 Therefore, use of an external vapouriser is excluded from the cryogenic storage system 20.

The cryogenic storage system 20 further comprises a cage structure 38 for containing and suspending the first insulative vessel 22 and the second insulative vessel 24 therewithin for forming a substantially rigid body therewith. In such a configuration, at least one of the pipe
10 assembly 32 and the gas withdrawal valve 30 are physically coupled to the cage structure 38. This enables easy handling and movement of the first insulative vessel 22 and the second insulative vessel 24 by way of just spatially manipulating the cage structure 38. For example, at a particular premise, the cage structure 38 can be easily moved into position to enable coupling of gas withdrawal valve 30 to a fixed supply-side manifold found on-premise. The
15 cage structure 38 also enable mobility and swapping of a depleted set of the first insulative vessel 22 and the second insulative vessel 24 with a filled set of the first insulative vessel 22 and the second insulative vessel 24. This saves time as swapping of the vessels by way of the cage structure 38 is much faster and convenient than bringing a larger tank on-premise to top up the first insulative vessel 22 and the second insulative vessel 24 when depleted.

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The cryogenic storage system 20 can further comprise another pair of the first insulative vessel 22 and the second insulative vessel 24 with the cage structure 38 being further shaped and dimensioned for further containing the other pair of the first insulative vessel 22 and the second insulative vessel 24. The cage structure 38 will then be adapted to take on a 2x2
25 configuration for containing the two sets of the first insulative vessel 22 and the second insulative vessel 24 as opposed to a 1x2 configuration for accommodating a single set of the first insulative vessel 22 and the second insulative vessel 24. For avoidance of doubt, the cryogenic system 20, and consequently the cage structure 38, can comprise and accommodate any multitude and quantity of the first insulative vessel 22 and the second

insulative vessel 24 with the number of the first insulative vessel 22 not having to match the number of the second insulative vessel 24.

5 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 first insulative vessel 22 and the second insulative vessel 24 therewithin. The compartment further comprises at least one door being operable between open and closed positions to one of enable and impede access to the enclosure through the opening. The at least one door defining louveres for venting the inside of the enclosure.
10 Preferably, the plurality of walls of the compartment are formed from concrete.

The cryogenic storage system 20, 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
15 or dewar cylinders of less than 1000 litres enable disposing of the LNG system, specifically the cryogenic storage system 20 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
20 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.
25 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,
30 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 first insulative vessel and a second insulative vessel, each of the first
 - 5 insulative vessel and the second insulative vessel having an internal vapourizer and a gas outlet;
 - a gas withdrawal valve; and
 - a pipe assembly for removably intercoupling and fluid communicating the first insulative vessel, the second insulative vessel and the gas withdrawal valve,
 - 10 wherein each of the first insulative vessel and the second insulative vessel is for storing liquefied natural gases and the internal vapouriser is for vapourizing the liquefied natural gas into vapourised natural gas at the gas outlet thereof for provision to the pipe assembly, the pipe assembly for providing the vapourised natural gas for dispensing from the gas withdrawal valve.
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2. The cryogenic storage system as in claim 1, each of the first insulative vessel and the second insulative vessel having less than 1000 litres in storage capacity.
3. The cryogenic storage system as in claim 1, each of the first insulative vessel and the
- 20 second insulative vessel having substantially 210 litres in storage capacity.
4. The cryogenic storage system as in claim 1, each of the first insulative vessel and the second insulative vessel being a cryogenic storage dewar.
- 25 5. 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 vapourised natural gas from the pipe assembly.

6. The cryogenic storage system as in claim 1, the pipe assembly comprises headers for enabling removable coupling of the gas outlet of each of the first insulative vessel and the second insulative vessel with the pipe assembly.
- 5 7. The cryogenic storage system as in claim 1, further comprising a cage structure for containing and suspending the first insulative vessel and the second insulative vessel therewithin for forming a substantially rigid body therewith.
8. The cryogenic storage system as in claim 7, at least one of the pipe assembly and the
10 gas withdrawal valve being coupled to the cage structure.
9. The cryogenic storage system as in claim 7, further comprising another pair of the first insulative vessel and the second insulative vessel with the cage structure being further shaped and dimensioned for further containing the other pair of the first
15 insulative vessel and the second insulative vessel.
10. 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
20 the first insulative vessel and the second insulative vessel therewithin, the compartment further comprises at least one door being operable to one of enable and impede access to the enclosure through the opening, the at least one door defining louveres for venting the inside of the enclosure.
- 25 11. The cryogenic storage system as in claim 10, the plurality of walls of the compartment are formed from concrete.

12. A cryogenic storage system comprising:

a first insulative vessel and a second insulative vessel, each of the first insulative vessel and the second insulative vessel having an internal vapourizer and a gas outlet, each of the first insulative vessel and the second insulative vessel having less than 1000 litres in storage capacity;

a gas withdrawal valve; and

a pipe assembly for removably intercoupling and fluid communicating the first insulative vessel, the second insulative vessel and the gas withdrawal valve,

wherein each of the first insulative vessel and the second insulative vessel is for storing liquefied natural gases and the internal vapouriser is for vapourizing the liquefied natural gas into vapourised natural gas at the gas outlet thereof for provision to the pipe assembly, the pipe assembly for providing the vapourised natural gas for dispensing from the gas withdrawal valve.

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

a cage structure for accommodating and suspending the first insulative vessel and the second insulative vessel therewithin for forming a substantially rigid body therewith, at least one of the pipe assembly and the gas withdrawal valve being coupled to the cage structure; and

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 cage structure with the first insulative vessel and the second insulative vessel contained therewithin, the compartment further comprises at least one door 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.

14. The cryogenic storage system as in claim 13, further comprising another pair of the first insulative vessel and the second insulative vessel with the cage structure being further shaped and dimensioned for further containing the other pair of the first insulative vessel and the second insulative vessel.

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15. The cryogenic storage system as in claim 13, the plurality of walls of the compartment are formed from concrete.

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