Figure 1. The domed roof on the Single Containment tank at Eagle LNG's Maxville LNG facility is air-raised into place.

CHOOSING THE BEST CONTAINMENT

Bob Watson, Matrix PDM Engineering, USA, reviews flat-bottom tank containment types and highlights two single containment tanks for companies in the final stages of construction and commissioning.

Introduction

The abundance of natural gas resources in North America is a result of mastering and developing extraction technologies in gas producing shale plays throughout many regions, particularly in the US. Estimates of volume of reserves have many predicting hundreds of years of this clean burning fuel. The cost and stability of this well-known and understood fuel has resulted in lower costs that are predicted to remain low, relative to other fuel types, for the foreseeable future.

LNG's low cost and high reliability, coupled with its advantage of significantly reducing emissions, makes it the fuel of choice for many applications including marine bunkering, power generation, locomotive fuels and other energy industries. Markets are being created to use this energy locally and the need for smaller LNG facilities is growing at a fast pace.

In the small and medium LNG facility market, various approaches are available for storing the natural gas after liquefaction but before delivery to its intended use point. Depending upon the capacity required, this could be as small as a number of high pressure shop-built bullet tanks linked by a piping system. For larger needs, use of a single low pressure flat bottom double-wall tank is the most cost effective. These tanks, with an integrated insulation system, can be configured as single, double, or full containment in order to conform to the regulatory spill containment requirements at a given site and within the available space. This article will review flat-bottom tank containment types and highlight two single containment tanks for market leading companies that are now in the final stages of construction and commissioning.

Storage tank types

A single containment system consists of an inner primary liquid container and outer insulation and vapour container, designed and constructed so that only the inner container is required to contain liquid and be liquid-tight. The outer container, designed to contain product vapour pressure of the inner tank contents, retains and protects the insulation but does not contain liquid if the inner container leaks. These systems necessitate spill impoundment dikes that require onsite space that is remote from adjacent landowners and occupied structures, and from other tanks. Typical construction materials for the major components of a single containment tank configuration are cryogenic rated steels (such as 9% nickel or stainless steel alloys) for the inner tank and product piping, and general carbon steel for the outer tank which meet the ambient conditions of the tank site.

The double containment tank system consist of a liquid and vapour tight primary tank system built inside a liquid tight secondary liquid container. The secondary liquid container is liquid tight but not vapour tight.

The full containment tank system consists of a liquid tight primary container and a liquid and vapour tight secondary container. Both can independently contain the product. The secondary container also controls vapour release in case of a primary product leak. A key design feature of a full containment tank system is the Thermal Corner Protection (TCP) at the outer tank base-to-wall joint. The TCP provides liquid tightness and thermally isolates this joint from the cold liquid in case of a primary container leak. Regulatory requirements such as 49 CFR 193 may also require the secondary container to be concrete.

Double and full containment tanks are normally not required to have significant spill impoundments and, as a result, require less land. However, FERC-regulated facilities may be required to have full capacity spill impoundments even for full and double containment tanks.

Both are more costly to build however, due to their added complexities. As both the primary and secondary containers of a double or full containment tank are designed to be liquid tight, they are both typically constructed from cryogenic rated steels. Full containment tanks are often synonymously known to include an integrated concrete outer wall to help mitigate external objects from impacting or damaging the internal liquid container.

Figure 2. Eagle LNG's Maxville LNG facility near Jacksonville will be used to liquefy and store LNG used for ship bunkering.

Tank size ranges

Field-erected flat-bottom LNG tanks have been installed in the US in varying sizes, up to 52.8 million gallons. Single containment tanks are generally economical down to about 1 million gallon capacity.

Foundation options

Choice of the foundation type is affected by site soil properties, seismicity and climate, and owner selected tank containment type.

Good soil properties may lead to use of a ring wall or slab on grade. A ground heating system is typically utilised for storage tanks that utilise a ring wall and/or slab on grade. The ground heating system ensures creep between the tank and the soil does not occur that could result in foundation issues caused by freeze-thaw effects to the soil under the tank. In areas where poor soils exist, elevated tank foundations are used which incorporate piles and a concrete pile cap. Additionally, an elevated pile cap eliminates the need for a foundation heating system due to the air gap which prevents heat transfer to and from the soil. The final selection will depend upon an evaluation of the required installation costs and the operation and maintenance costs over the life of the tank.

Selection considerations

For sites with ample space for spill impoundments and sufficient distance to adjacent landowners and structures to accommodate calculated thermal and vapour dispersion effects due to a tank leak, the single containment tank type is the most economical. On smaller sites with less buffer distance, double or full containment tanks are normally required. Accordingly, calculations of thermal and vapour dispersion effects need to be addressed early in the design of the facility so that the most economical solution can be determined.

Two current projects that do have adequate space and are successfully using single containment LNG tanks are discussed below.

Maxville LNG facility

Location

The LNG tank for Eagle LNG is located at Maxville, Florida, just west of the Jacksonville harbour area.

Function

The Maxville LNG Facility and tank will be used to liquefy and store LNG to be used for ship bunkering. The tank will be filled using natural gas liquefaction systems on site and then LNG will be transferred by truck to the harbour for transfer to ships.

Capacity

This tank is considered to be small-to-medium size and will have a 1 million gallons working capacity.

Configuration

As is typical, this tank has an outer cylinder that is at ambient temperature and an inner cylinder that contains the LNG at -270°F. Between the two cylinders is an expanded perlite insulation system designed to limit boil-off to 0.15% of the tank contents per day.

The outer tank has a domed roof and is designed for an internal vapour pressure of 2.5 psig. The inner tank has a suspended insulation deck at the top and the deck is not pressure retaining. The insulation on the deck is fiberglass.

Pumps for transferring the LNG to the trucks are mounted inside the inner tank. Discharge from the in-tank pumps is piped upward through the insulation deck and dome roof and back down to grade through insulated lines mounted outside of the outer tank.

Here, the tank foundation is a concrete ring wall on grade, with stone column subsurface soil improvement. Since the foundation is on grade, it is electrically heated to prevent possible freezing of the soil and frost heave.

Regulatory jurisdiction

Since this facility is not associated with LNG import or export, the authority with jurisdiction is the US Pipeline and Hazardous Material Safety Administration (PHMSA). The facility is designed in accordance with 49 CFR 193 and NFPA-59A.

Construction

The common field erection sequence for tanks of this type starts with welded assembly of the outer tank cylinder, followed by air-raising of the dome roof and insulation deck. Then, the inner tank is assembled using the outer tank as weather protection. In this case, Matrix Service Company, the construction contractor, used proprietary construction processes that resulted in faster speed to market.

As of November 2017, the Maxville LNG facility tank has been erected, hydro-tested, insulated, and is ready for the start of commissioning. This will consist of purging the inner and outer tank with gaseous nitrogen prior to the first introduction of LNG and cooldown.

JAX LNG LLC

Location

The LNG tank for JAX LNG LLC (a joint venture of Northstar Midstream and Southern Company Gas) is also in the Jacksonville, Florida area, but this tank is at Dames Point directly on the Saint Johns River.

Function

The JAX LNG facility and tank will be also be used for ship bunkering, as well as trucking and small scale power generation via ISO containers. The tank will be filled using natural gas liquefaction systems on site and then LNG will be transferred to bunkering barges, which will then refuel ships.

Capacity

This tank is larger at 2 million gallons working capacity.

Configuration

The layout of this tank is very similar to the Maxville LNG facility tank, except for the larger diameters of the inner and out tanks and the larger overall height.

The design vapour pressure of the outer tank here is lower, at 2.0 psig.

Once again, the LNG transfer pumps are mounted inside the inner tank and discharge through piping to grade without penetrating the sidewalls of the tank.

Unlike the Maxville tank, this tank is supported on driven pre-stressed piles and an elevated concrete pile cap. With this arrangement, heating of the pile cap is not necessary since it is not in contact with the soil below.

Regulatory jurisdiction

The JAX LNG facility is also not associated with LNG import or export or interstate transfers. As a result, the authority having jurisdiction is the US Pipeline and Hazardous Material Safety Administration (PHMSA). The facility is again designed in accordance with 49 CFR 193 and NFPA-59A.

Construction

This tank was constructed in a similar manner to the LNG tank for the Maxville facility.

As of publication of this article, the JAX LNG tank has been erected and the inner tank hydro-tested. With hydro-testing completed, the perlite insulation on the sidewalls will be placed and the internal LNG pumps will be installed.

The design and construction duration for small and midscale LNG liquefaction facilities has in the past been limited by the time to install the LNG storage tank. In both of these early-to-market facilities in Jacksonville, the LNG single containment storage tank will be completed prior to the commissioning of the facility.

Summary

While full containment LNG tanks are popular in the international market and at domestic US sites with limited space, single containment tanks such as those described are cost effective and can be designed and constructed quickly. This type of LNG tank also is well-suited to the small and medium LNG market associated with marine bunkering, remote power generation and fuel gas supply peak shaving. Tanks like the Maxville LNG and JAX LNG facilities have been in reliable service for over 40 years and the materials used for construction are well understood and available. **LNG**