2.3.3.2 Marine Facilities for LNG Carrier Transfer Alternatives

Two alternatives were considered for the marine facilities to support the transfer of LNG between the LNG carriers and onshore storage tanks. One alternative is a pier with traditional transfer arms. The other alternative is a sub-sea pipeline.

2.3.3.2.1 Receiving Pier

The receiving pier for the transhipment facility will consist of a number of berths connected to the shore via a series of access trestles. The construction of the facility will be phased in as demand requires however for the final build-out there will be three berths.

The LNG will be transferred from carrier to shore and visa versa through fixed loading/unloading arms that are mounted on the service platform associated with each berth. The transfer arms connect the onshore LNG process piping system to the shipboard piping system. Pipelines will distribute the LNG and vapor between the carriers and the land based LNG storage tanks. During transfer, the carriers will be moored to the piers. Transfer systems and controls will be designed to ensure safe practices with regard to weather conditions.

During the initial stages of the facility operations the LNG will be transferred from carrier to carrier. Both carriers will be moored to a single berth or one carrier to a berth if two berths are built during the initial stages. The off loading systems will be designed to operate within the environmental and operational conditions specified for the site.

Dredging for the berths will not be required since the berths will be located in water depths sufficient for the design vessel. Limited dredging will be required at the tug basin.

2.3.3.2.2 Sub-sea Pipeline

Alternative means of connecting a ship to shore include sub-sea pipelines to which the ship may connect while maintaining some distance offshore. Generally, the pipeline originates from an LNG facility onshore, runs along the seabed, and approaches the surface at an offshore platform or buoy. Maintaining the LNG circulation loop as is normally done with traditional systems will be difficult with an offshore system. If the circulation loop cannot be maintained, cool down of the transfer line will have to be completed prior to each transfer. This technology is limited in its development at this time.

2.3.3.2.3 Preferred Transfer System for Grassy Point

The preferred alternative for LNG carrier unloading/loading facility at Grassy Point is the traditional pier option. This will facilitate the multiple types of LNG transfer (ship-to-shore, shore-to-ship, and ship-to-ship) expected at Grassy Point with no hindrance to area shipping. Further, since dredging is not necessary and only a short access trestle is required, there is no potential advantage in an offshore system deploying sub-sea technology. Additionally, the sub-sea pipeline technology for LNG transfer is limited in its development at this time.

The pier location as chosen confers several advantages including:

1) The waters adjacent to the berth are large enough and deep enough to accommodate the largest LNG carrier transits currently under consideration,
2) The local pilotage authority is familiar with petroleum product shipping in this vicinity.

Figure below shows an example of LNG unloading arms.

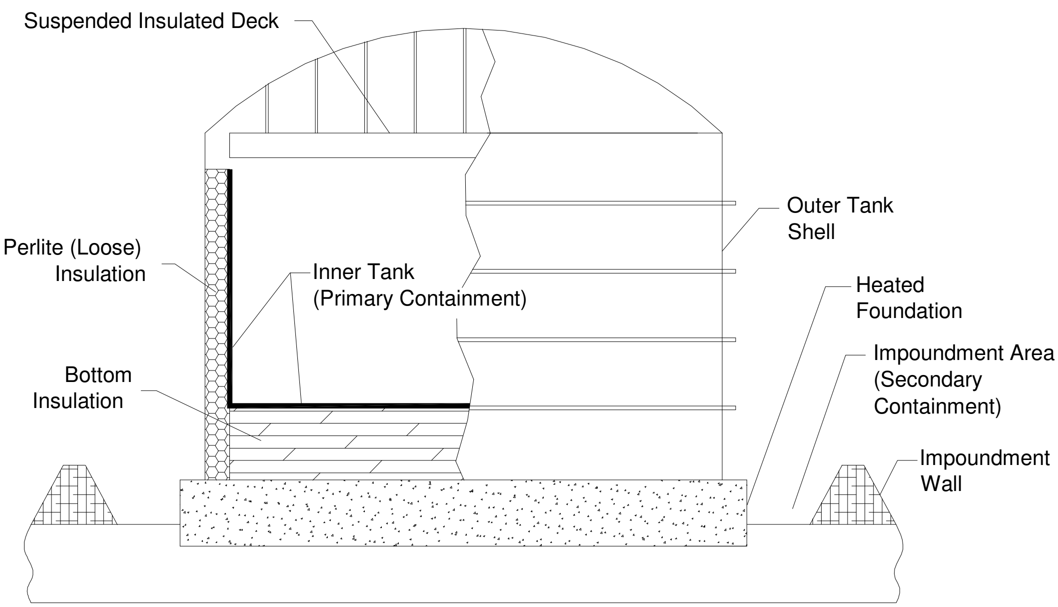
LNG Unloading Arm Installation Example

2.3.3.3 LNG Tank Options

LNG tanks are usually classified as one of three types: single containment tank, double containment tank, and full containment tank. The type of tank chosen depends largely on the remoteness and size of the site. The choice of tank type affects the design leak scenarios, impoundment necessity/design, and vapor dispersion calculations associated with the LNG storage area. Full-containment tanks are of the heaviest and costliest construction, but are generally unwarranted in cases when LNG storage facilities are remote from neighbors. For example, in North America, where LNG facilities are usually remotely located, single-containment tanks are most common. In Europe where it is more difficult to site LNG facilities remotely, full-containment tanks are prevalent.

2.3.3.3.1 Single-Containment Tanks

A single containment tank is a double tank where only the inner tank is designed for cryogenic LNG. The inner tank is made of metal alloy and contains the LNG. The outer tank is made of carbon steel and encloses the inner tank and its insulation. The outer shell of a single containment tank will not withstand significant LNG contact, but is designed to contain the vapor associated with LNG storage. Therefore, secondary impoundments that will contain the tank's entire contents are required for single containment tanks. Since thermal radiation is a function of LNG pool area, and since the LNG pool is assumed to spread across the entire secondary impoundment during a design leak scenario, thermal radiation exclusion zones are largest for single containment tanks. Figure below shows a cross-sectional view of a typical single containment tank.

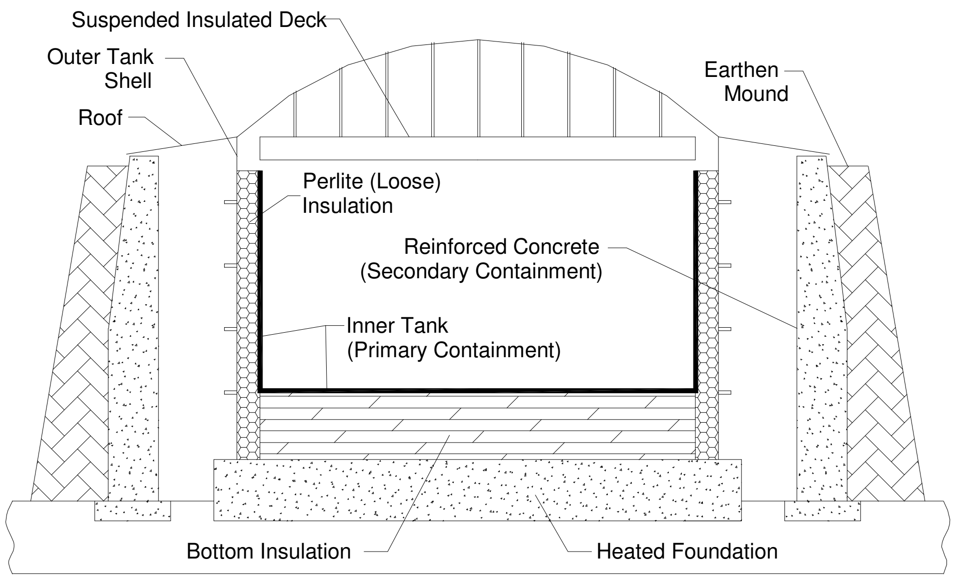


Single-Containment Tank

2.3.3.3.2 Double-Containment Tanks

A double containment tank is essentially a single containment tank with a full-height concrete wall surrounding it. If the inner alloy tank breaches and the carbon steel second tank breaches, the concrete wall will contain LNG, but not LNG vapor. If the inner tank is breached, the LNG will be contained by the outer tank, but vapor will leak from the outer tank. Per CSA Z276-01 section 4.2.2.4, the outer concrete tank of a double containment tank can be classified as a secondary impoundment if it is constructed correctly. Therefore, the surface area of the secondary impoundment for a double containment tank is much smaller than that of a single containment tank. As a result, the vapor dispersion and thermal radiation exclusion zones for a double containment tank are smaller than those for a single containment tank.

Considering the possible siting advantages offered by a double containment tank over a single containment tank one might expect to see the double containment tank design more widely adopted. However, the negatives associated with the outer concrete wall tend to make the double containment tank option less desirable. The cost is more than for a single containment tank plus a traditional impoundment, but the major difficulties involve ventilating, equipping, and maintaining the space between the concrete wall and the carbon steel outer tank. Ventilation fans, explosion-proof equipment, additional instrumentation, access and egress means, special operating procedures related to accessing the confined space, etc. are required to operate and maintain a double containment tank's annular space. Figure shows a cross-sectional view of a double containment tank.

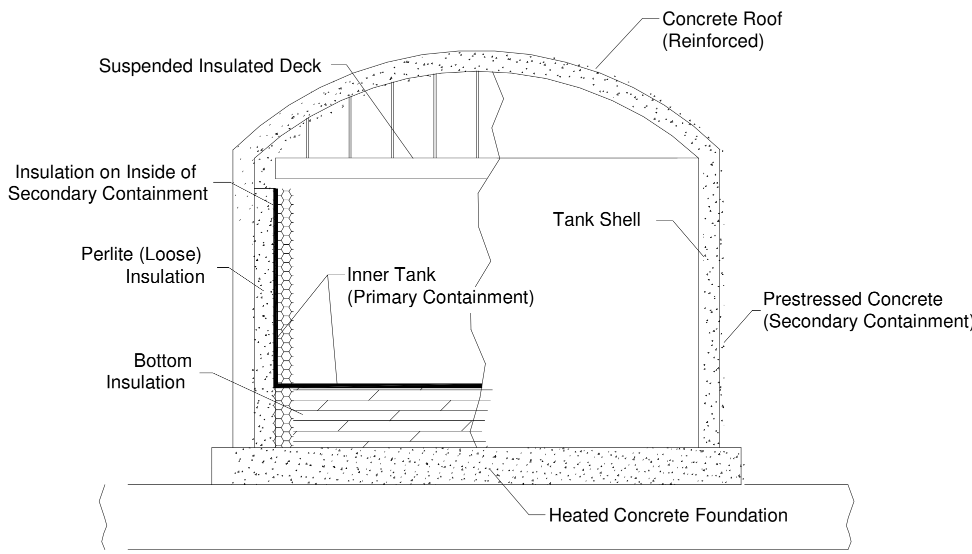


Double-Containment Tank

2.3.3.3.3 Full-Containment Tanks

A full containment tank is designed so that both the inner tank (metal alloy) and the outer tank (reinforced concrete) will contain LNG. However, only the outer tank will contain vapor. Like the double containment tank, the full containment tank's outer concrete tank serves as a secondary impoundment. However, unlike the double containment tank, the full containment tank's outer tank will contain vapor. Generally, the full containment tank is capable of higher operating pressure than either the single containment or double containment tanks.

Like the double containment tank, the full containment tank minimizes thermal radiation exclusion and vapor dispersion zones and, since its secondary impoundment is integral to the tank, its land requirement is relatively small. Therefore, the full containment tank has the footprint and exclusion zone advantages of the double containment tank, but not the disadvantages of operating and maintaining an annular space inside the concrete outer tank. Figure below shows a cross-sectional view of a full containment tank.



Full-Containment Tank

2.3.3.3.4 Preferred Option

Each of the three tanks has a metal alloy inner tank in common. They differ according to their means of secondary impoundment. The single containment tank uses a dike-like system while the double containment and full containment tanks use a more integral concrete wall. All three secondary containment systems are effective, but the dike structure of the single containment tank is the most fundamental and maintainable. The dike can be easily inspected and repaired without undue operational interruptions and with minimum risk to workers. Also, given the extra exclusion zone associated with a single containment tank, the system is just as safe for surrounding neighbors as the double containment or full containment tanks. The choice of tank technology is then a matter of real estate availability.

If the site is large enough, then single containment tanks are the LNG tank of choice for both economic viability and secondary impoundment maintainability reasons. In the Grassy Point Case, the site is large enough and remote enough to allow for single containment tank use. No safety or environmental advantage would be gained by installing double or full containment tanks at Grassy Point. When it comes to the safety of workers and neighbors, distance is failsafe and distance is available at Grassy Point. Therefore, single containment tanks are preferred for the Grassy Point Transshipment Terminal.

2.3.3.4 Re-liquefaction Alternatives

Heat flow into the cold space is inherent to cold storage. In a LNG facility, the heat in-leak provides the energy necessary to vaporize a small portion of the LNG (pumping and frictional effects also contribute). To maintain LNG in its liquid state, heat must be removed from the system. Heat removal is accomplished when BOG (boil-off-gas) is liquefied and returned to LNG storage.

There are numerous licensors and manufacturers of LNG refrigeration/liquefaction processes. Two re-liquefaction processes considered for this project were:

- Nitrogen Expander System
- Mixed Refrigerant System

These processes are described below:

2.3.3.4.1 Nitrogen Expander System

The nitrogen expander system utilizes a separate, single-component refrigeration loop which uses nitrogen as the working fluid. Natural gas or BOG is compressed at the entrance to the liquefaction system and cooled by heat exchange with the refrigerated nitrogen. This process is not as energy efficient as other options, but it is simpler to operate, contains fewer components, requires no handling of flammable refrigerants, and is better suited to intermittent operation than the mixed refrigerant system.

2.3.3.4.2 Mixed Refrigerant System

The mixed refrigerant system mixes refrigerants into a single working fluid and, thereby, reduces the number of compressor trains and other equipment that would be required for multiple refrigerant loops. The mixed refrigerant's ratio of components can be changed so that the temperature difference between the working refrigerant and the process fluid are more constant throughout the main cryogenic heat exchanger. Therefore, the mixed refrigerant is potentially more efficient than the nitrogen expander cycle. If the composition of the BOG feed changes, the refrigerant mixture must be adjusted. Therefore, multiple hydrocarbon refrigerants must be stored on site.

2.3.3.4.3 Preferred Alternative

The expander cycle with a nitrogen refrigeration loop is being chosen for this project. The relative ease of operation, reliability, and the inherent safety associated with fewer components and fewer refrigerants make it a good fit for the Grassy Point Transshipment project.

2.3.3.5 Electrical Energy Supply

2.3.3.5.1 Electrical Source for Operation

The estimated continuous electrical power requirement for the LNG facility is estimated to be between 18 MW with four (4) tanks in operation and 21 MW with eight (8) tanks in operation. During the transhipment operation the demand load increases to 65 MW for a single transfer operation and 120 MW for two (2) transfer operations.

Two alternatives were considered for the supply of electrical power for the facility. These are:

- Connect to the existing Newfoundland Hydro power grid.
- Construct an on-site power generating facility.

The obvious fuel source for an on-site generating plant is natural gas. A simple cycle gas fuelled turbine generator could produce the electrical energy required to operate the facility and provide the peak power demand during transfer operation. Although a simple cycle generator is less efficient than a combined cycle, a simple cycle plant is quicker and cheaper to construct, and has some operational advantages.

A key advantage of a gas-fired, simple cycle plant is its operational flexibility. It can be started up quickly, to bring electricity on line whenever it's required. Due to these advantages, simple cycle power plants are often used to provide peak power requirements or standby power.

Construction of an on-site power generating plant is generally considered where existing power capacity is insufficient to meet the demand requirements of a facility. Presently, Newfoundland Hydro has the capacity to supply the estimated operating demand load. However, there are several large projects that are being proposed for the same region that may limit Newfoundland Hydro to providing the estimated peak demand load. Therefore, a power generating plant may be required. A simple cycle power generating plant may be constructed to meet this peak demand, or a more efficient combined cycle power plant may be built and operated with the excess power sold back to Newfoundland Hydro. The power would be transmitted through a new 230 kV transmission line from Grassy Point to an existing 230 kV transmission lines located at Come-By-Chance refinery. The economics of constructing a combined cycle versus a simple cycle power plant would be required before a final decision is made.

To meet the base power requirements for the facility, a new 25 kV transmission line will be required to be built from the existing Sunnyside substation. The type of transmission line, a radial or looped line will have a bearing on the reliability.

The existing Newfoundland Hydro electrical power grid provides sufficient reliability for the base load requirements for the facility. The largest electrical user in the area is the existing Come-By-Chance refinery, which has a longest power outage of ______ minutes.

Planned power outages for maintenance purposes may last up to eight (8) hours. Therefore, the risk of substantial release of LNG caused by a sustained power outage is very low. Back-up power supply can be brought on very quickly, thus mitigating issues associated with the loss of hydropower.

Based on the existing conditions, a new 25kV transmission line will be required to be constructed from Sunnyside to the facility with a substation located near the site to a new substation where the voltage will be transformed down to 4160 V as required for the facility to provide base power requirements. An on-site generating power will be required to provide the peak power requirement when LNG is being transferred to or from storage tanks to ship tankers.

2.3.3.5.2 Electrical Source for Back-up Power

With the high reliability of the electrical power grid including the availability of on-site power plant, the occurrence of an unplanned power outage lasting over 24 hours is extremely remote. However, a back-up source of electrical power is required for the facility. Two options were considered to meet these criteria:

- Install a diesel generator to operate the vapour handling equipment.
- Install an interruptible power source (UPS) for emergency power only.

During a blackout, the operations at the facility would be shut down, due to the large volumes of cryogenic LNG in the storage tanks including the insulating materials; a power outage of 6 to 12 hours would have minimal effect on the facility. Beyond a power outage of 12 hours an alternate source of energy would be required to operate the plant blowers or compressors to minimize vapour losses. The amount of vapour losses would not be sufficient to deliver and utilize this gas for gas powered generator. Therefore, a diesel powered backup generator in the range of 1.5 MW would provide the necessary power requirements to reduce the loss of product through vapour losses.

A UPS system, complete with ample supply of batteries, was considered as an alternative. The UPS would supply sufficient power for the computer system at the facility; however, it could not supply sufficient power to operate the blowers required to return boil-off gas to the storage tanks. If a UPS were used as backup power, the majority of the boil-off gas would require to be vented through the cold stack during extended power blackout. Venting product to the atmosphere is an acceptable solution but to save product and to reduce or eliminate these emissions a diesel driven or similar generator is recommended. A smaller UPS system will still be required to supply the computer network until the generator is up and running.

Based on the above, an on-site generator is recommended for emergency backup power.