

DEP SPECIFICATION

LNG STORAGE AND FUELLING INSTALLATIONS AT RETAIL AND COMMERCIAL SITES

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DESIGN AND ENGINEERING PRACTICE

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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for LNG storage and fuelling installations at retail and commercial stations handling LNG. It covers equipment and safety systems for LNG receipt, storage and vehicle refuelling facilities.

Requirements and recommendations are given for the layout, location, safety and operability aspects of fixed above ground LNG pressure vessel storage, forecourt dispensers, delivery pumps and associated piping, electrical installation, valves and fittings, and fire prevention and protection.

In this DEP, LNG pressure vessel storage is at cryogenic temperatures in vacuum insulated cylindrical vessels. The capacity of vessels installed at automotive sites is limited to 120 m³ (30,000 US gal) and the net inventory of LNG in the tank is limited to 90% of the gross capacity.

This DEP does not cover:

- LNG mobile fuel station (e.g., Chart 'ORCA')
- LNG ISO containers / Transportable vessels
- Conventional insulation bulk storage, e.g., tanks with polyurethane single wall insulation

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 - Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2014, see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in distribution/marketing installations. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

NOTE: In this DEP, the term **Supplier** is used. The term **Supplier** shall be understood to mean the Manufacturer/Supplier.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

NOTE: In this DEP, the term **Purchaser** is used. The term **Purchaser** shall be understood to mean the Principal.

The word **shall** indicates a requirement

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
LPG	Any material having a vapour pressure not exceeding that allowed for commercial propane that is composed predominantly of the following hydrocarbons, either by themselves (except propylene) or as mixtures: propane, propylene, butane (normal butane or isobutene), and butylenes

1.3.3 Abbreviations

Term	Definition
BOG	Boil-off gas
CED	Cause and Effect Diagram
CF	Compliance framework
CNG	Compressed Natural Gas
COE	Center of excellence
CSU	Commissioning and start-up
DEM	Design and engineering manual
DEP	Design and Engineering Practice
dP	Differential pressure
EFA	Enterprise Framework Agreements
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
ESD	Emergency Shut-Down
FAT	Factory Acceptance Test
FGS	fire, gas and smoke
FMC	Facilities Management Company
GDS	Global Design Standard
HART	Highway Addressable Remote Transducer
HC	Hydrocarbon
HMI	Human-Machine Interface
HP	high pressure
HSSE	Health, Safety, Security and Environment
ID	inner diameter
IE	Instrument Earth
IS	Intrinsically Safe
ITP	Inspection and Test Plan

Term	Definition
LEL	Lower Explosive Limit
LN2	Liquid nitrogen
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MAWP	Maximum Allowable Working Pressure
MDMT	Minimum Design Metal Temperature
MID	Measuring instruments directive
MOP	Maximum Operating Pressure
MOV	Motor Operated Valve
NDE	Non-Destructive Examination
NRTL	Nationally Recognized Testing Laboratory
NTEP	National Type Evaluation Program
P&ID	Process and Instrumentation Diagram
PE	Protective earthing
PED	(European)Pressure Equipment Directive
PEFS	Process Engineering Flow Scheme
PFS	Process Flow Scheme
PLC	Programmable logic control
PORV	Pilot Operated Relief Valve
POS	Point of sale
PQR	Procedure Qualification Record
PS	Process Safety
PS	Process Stop
PSV	Pressure Safety Valve
PTFE	Polytetrafluoroethylene
PZA	Pressure trip
QA/QC	Quality Assurance / Quality Control

Term	Definition
RTD	Resistance Temperature Detector
SAT	Site Acceptance Test
SGM	Safeguarding Memorandum
SIL	Safety Integrity Level
TA	Technical Authority
TRV	Thermal Relief valve
VFD	Variable Frequency Drive
VIP	Vacuum insulated piping

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents, referenced by this DEP are listed in (13).

1.5 SUMMARY OF MAIN CHANGES

This is a minor revision of the DEP Specification of the same number dated February 2014. The DEP has been reformatted and restructured to allow upload to the requirements database.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

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DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

1.9 STANDARDS

Where possible, International (ISO), European (CEN) and/or American (UL, EPA, API or ASTM) standards are referenced in this DEP, to specify requirements for each item of plant or equipment. Occasionally, a national standard is referenced (e.g., BS, DIN, AS), if no definitive European or American standard exists.



2. PROCESS SYSTEM DESIGN PRINCIPLES

2.1 GENERAL

1. LNG storage and fuelling installations may consist of, but is not limited to, the following:
 - a. LNG storage tank;
 - b. trailer offloading equipment;
 - c. heat exchanger saturation vaporizer;
 - d. LNG dispensing pump with dry run protection;
 - e. LNG dispenser with flow meter;
 - f. interconnecting piping (vacuum insulated and/or mechanical cold insulation);
 - g. instrumentation, control and safeguarding systems;
 - h. emergency control system (fire & gas detection, ESD);
 - i. BOG management system (e.g., re-liquefaction coil with LN2, CNG system, HP pump, HP vaporizer and CNG storage (bottles) or Cryo-cooling (Stirling) system;
 - j. vent stack system for cold and dry and an optional separate vent stack system for warm and wet streams, e.g., off loading hose purging;
 - k. on the fly saturation system.
2. LNG shall be stored at pressure, either as cold as possible, or at a higher pressure up to MOP depending on the saturation and operation methodology agreed for the station.
3. Minimum and maximum operating temperature shall be specified for all components in the component listing as part of the document deliverable.
4. All process piping shall be designed for -196 °C (-238 °F) minimum design temperature to +50 °C (122 °) maximum design temperature.
5. All manual service isolation valves shall be car sealed or pad-locked in their normal operating position with the exception of instrumentation valves.
6. Drain valves shall be provided at low points in pipelines and equipment.
 - a. Drain valves shall be fitted with a blind flange.
7. P&IDs shall be provided indicating all necessary details as per (Appendix 4).
8. As built P&ID's shall be provided to depict the actual installation, and updated with any changes made in the field.

2.2 LNG STORAGE

1. LNG shall be stored at pressure, either as cold as possible, or at a higher pressure up to MOP depending on the saturation and operation methodology agreed for the station.
2. If saturation on the fly (SoF) is a functional requirement, LNG shall be delivered to the customer fuel tank at different pressure levels up to 9 barg, preferably from one storage tank with SoF.
3. Storage tanks shall be sized to allow for full delivery tanker offload.
 - a. Tank sizing rules/toolkit shall be provided in GDS.
4. The top fill line SHALL [PS] end at a height equal to 97% full of LNG to ensure effectiveness of the high pressure trip.
5. The storage tank shall be equipped with a device to adequately spray liquid into the tank.
6. Tanks should be vertical.
7. Horizontal tanks may be used if footprint and functional requirements allow.

Scope only covers above ground.
8. LNG storage tanks SHALL [PS] be double walled vacuum insulated with supplementary insulation in annular space being perlite/powder or multi-layer insulation.
9. Equipment that is part of a pressure system protected by a relief valve discharging into a vent system shall have a minimum design pressure of at least 3.5 bar (50 psi).
10. Hoses wound on reels shall be a single, continuous length of hose.
11. ESD valves shall not be provided with hand wheels or lever operators.

2.3 BOG Management

1. If functional requirements/GDS requires, a BOG management system shall be provided.
2. The BOG management system shall consist of a liquid nitrogen recondensing coil with all welded stainless steel circuits to be provided in the tank.
 - a. Alternate systems may be proposed by Supplier if suitability is demonstrated.
3. Liquid nitrogen vent shall be located near LNG vent and be as high or use dispersion/noise modelling to set lower height.
4. When a Boil-off gas control system is required, it shall be designed with appropriate control system to avoid venting during normal operation.

2.4 LNG BULK TRANSFER

1. LNG bulk delivery shall be transferred via hose or a loading arm.
2. Transfer shall take place with a trailer mounted pump or with an on-site ground mounted pump.

In both cases, appropriate safeguarding is required.

The preferred solution for a particular project is described in the GDS/function requirements.

Some safety distances are affected by which option is implemented.
3. The logic in the station PLCs shall indicate when the transfer hose/arm is ready for disconnection after transfer.
 - a. The automatic logic shall be linked to hose pressure.
 - b. When the pressure is still high, the driver/operator shall be informed that the hose/arm cannot be disconnected.
4. The bulk offloading area shall have a gradient to stop LNG spill from going outside site boundary.

2.5 DISPENSER

1. For providing LNG to the dispensers, one or more sealless variable flow sump mounted submersible pumps on a skid with complete control infrastructure shall be provided.
2. Dispensers shall be capable of providing LNG at multiple pressures depending on functional requirements.
3. Design shall offer the facility to accept hot vapour from the customer fuel tank for de-pressuring before dispensing or during dispensing depending on functional requirements.
4. The vapour should be sent to storage tank top or bottom as per Supplier's design (i.e., not be vented to atmosphere in line with the venting philosophy).
5. Vapour return prior to dispensing shall be pressure controlled to minimize the warm vapour back into the fuel station storage tank.
6. Dispenser shall have the facility to depressurise customer tank by allowing vapour return from customer through the main nozzle or via a separate vent hose connection.

3. LNG INFRASTRUCTURE – TECHNICAL SAFETY

3.1 OVERPRESSURE PROTECTION – GENERAL

1. The system design pressure shall not be higher than the pressure rating of any system component.
2. Where a single relief device is protecting a system, it shall be set at a pressure no higher than the system design pressure (or MAWP, if known).
3. Thermal relief valves shall be installed to protect sections of liquid service piping that can be isolated on both ends by valves.
4. If approved by the Principal, padlocking valves in open position may be used as a means of guaranteeing an open pass that does not require a TRV.
5. Balanced bellows relief valves shall not be used in cryogenic services.
6. Block or control valve designs that have the potential to trap small volumes in the valve bonnet shall have cavity vent holes to prevent valve bonnet overpressure.
 - a. The designer shall indicate on the P&ID which side of the valve should have the cavity vent so that these are installed in the correct orientation.
 - b. Field check of correct position shall be done during installation and commissioning checks.

See (Appendix A), A.2 for more details on P&ID.

7. For all relief valves other than TRVs, relief valve inlet line pressure drop calculations shall be performed.
8. Based on the rated relief valve capacity at the allowable overpressure, the pressure drop in the relief valve inlet piping and fittings shall not exceed 3% of the relief valve set pressure.
9. For all relief valves other than TRVs, relief valve discharge line pressure drop shall be calculated.
10. Backpressure should not exceed 10% of relief valve set pressure nor exceed the allowable backpressure for the type of valve selected.
11. A standalone SGM SHALL [PS] be developed in the course of the design and ultimately included in the Technical HSE Deliverables for individual projects.

For SGM details, see (Appendix B).

3.2 OVERPRESSURE PROTECTION – LNG STORAGE TANK

1. The LNG storage tank relief system shall be designed such that each pressure relief device can be isolated for maintenance while keeping the tank in service.
2. Installed spare relief devices shall be provided.
3. Relief devices shall be sized for normal upset scenarios, fire and for remote (i.e., to prevent exceeding hydrotest) liquid overfill scenario.
4. Relief systems shall be RVs or rupture discs or a combination.
5. As per isolation philosophy, relief devices shall be equipped with upstream block valves where necessary.

3.3 OVERPRESSURE PROTECTION – DISPENSER

1. Safeguarding shall be provided to prevent overpressuring vehicle fuel tank and to avoid release of LNG to the atmosphere through vehicle tank's relief devices.
2. Design shall consider that malfunction of variable speed driver is a credible scenario (i.e., maximum discharge to be based on maximum speed, LNG density and MOP of LNG storage tank).
3. Safeguarding shall be provided by one of the three options listed below:
 - a. maximum discharge pressure of pump is less than relief device setting on the vehicle fuel tank;
 - b. a relief device that prevents the pump maximum discharge pressure from exceeding the vehicle fuel tank's MAWP or relief device setting (if set below MAWP);
 - c. an instrument safeguarding design provided that reduces the likelihood of overpressure when the dispenser pumps maximum discharge pressure is capable of lifting the vehicle fuel tank's first relief valve (the lowest set relief valve; see section 8.7).
4. If Safeguarding is provided by an instrument safeguarding design, the following requirements apply:
 - a. the first relief valve on the vehicle's fuel tank shall be routed to a safe location (e.g., it discharges above the top of the truck cab);

This relief valve is not sized for full dispensing flowrate. Its activation provides a warning that tank is being overfilled and allows for driver intervention.
 - b. the maximum pump discharge pressure at maximum speed shall not exceed the vehicle tank hydrotest conditions or the secondary relief device setting whichever is lower;
 - c. the maximum operating pressure shall be calculated as follows:

$$MOP \leq P_{\text{vehicle}} - (H_{\text{tank level}} + H_{\text{shutoff}}) * g * \rho_{\text{max}}$$

With

MOP	=	maximum operating pressure of storage tank
P_{vehicle}	=	vehicle tank hydrotest conditions or the secondary relief device setting whichever is lower
$H_{\text{tank level}}$	=	maximum liquid level in storage tank (from grade)
H_{shutoff}	=	Pump shutoff head at maximum pump speed
g	=	gravitational acceleration constant
ρ_{max}	=	LNG density at minimum delivery temperature

3.4 DISPENSER DESIGN

1. All dispenser components that might be exposed to the operating environment during installation and/or maintenance activities shall also be resistant to the impact of these conditions.
2. Self service use of dispenser shall require a deadman button that needs to be reset every 60 seconds in order to avoid a Process Stop.
 - a. In case of no reset of deadman button in 120 seconds after a Process Stop, the transaction shall be terminated.
3. Dispenser hose shall have break away coupling.
4. Dispenser shall have dry break nozzles for customer connection for LNG and vapour return.

DISPENSER INSTALLATION:

5. Dispensers should be designed to allow safe lifting of the dispenser from underneath the canopy for future removals.
6. Dispenser design shall include the incorporation of lifting lugs or connection points which are located above the centre of gravity of the dispenser to avoid tipping of dispenser when being lifted.
7. Attachment and detachment of lifting slings shall be accomplished without the technician working at height.
8. Specific instructions should be supplied with each dispenser for proper securing and lifting of the dispenser.

3.5 SITE LAYOUT

1. The LNG fuel station layout SHALL [PS] meet the minimum safety distances shown in Table 1.

Local regulations may have additional distances beyond those listed in Table 1.

The minimum distances in sections A and B of Table 1 are based on the key design features listed below:

- *a hose diameter no larger than 76 mm (3 in) when offloading with a ground mounted pump;*
- *a hose diameter no larger than 51 mm (2 in) when offloading with a truck mounted pump;*
- *stainless steel braided hose with threaded end connections. Use of quick connects require additional safeguards and/or larger safety distances;*
- *truck with a manual ESD;*
- *manually activated onsite ESD button near off-loading point;*
- *truck ESD linked to station ESD system;*
- *low pressure trip to indicate loss of hose;*
- *gas monitoring tied to ESD.*

Trailers provided with offload cabinet and air brake interlocks which prevent offloading unless the offload cabinet is open and the trailer air brakes are engaged.

The term "Truck Parking" in Table 1 is a designated parking area for trucks within 100 m (330 ft) of the offloading point; it does not include refuelling lanes. Sites that have designated parking that consist of only a single row that has less than four side by side parking spots can use safety distances for single bulk storage ground mounted pump regardless of the number of LNG storage tanks of station throughput.

Dispenser distances are based on a maximum dispenser pump flow of 15 m³/hr through a failed dispenser piping component.

2. LNG pumps shall be located within 2 meters (6.5 ft) of LNG storage tanks.
3. LNG tanks and their associated equipment shall not be located underneath electric power lines operating 600 volts.
4. Where required by the local code, fire resistance ratings of the onsite buildings shall be in accordance with the local industry standards and guidelines.

Table 2 includes other industry/requirements that can be considered by the user, if local regulations lack guidance in these areas.

Table 1 Shell Retail LNG Minimum Safe Distance Requirements

Horizontal Distances (in meters)	Single Bulk Storage ground /on truck pump	Double Bulk Storage ground/on truck pump	Three Tanks+ ground/on truck pump
A. From Offloading Points (fixed nozzle and trailer nozzle)			
Building below 10 persons (e.g., convenience store, maintenance bldg.)	11/20	11/20	11/20
Building between 10 and 100 persons (restaurant)	30	40	50
Building greater than 100 persons (hotels, apartments, multi-story buildings)	50	75	100
Important building, buildings that cannot be evacuated quickly, and sensitive areas	100	100	100
Workshop (ignition points, hazardous material)	20	22	35
Truck Parking	15/20	15/20	15/20
Property fence	7.6	7.6	7.6
Public roads	20	20	20
Freight railway	20	20	20
Exclusion zone during off-load	7.6	7.6	7.6
B. From Truck Parking within 100 m radius of transfer point			
Building below 10 persons (Convenience Store)	15	15	15
Building between 10 and 100 persons (Restaurant)	15	15	20/25
Building greater than 100 (Hotels, Apartments, Multi-Story Buildings)	15	20	25
C. From Storage Tank, Edge of Storage Tank Impoundment and LNG Pump			
Buildings	15	15	15
Truck Parking (parking spaces)	15	15	15
Property Boundary	use local codes	use local codes	use local codes
D. From Storage Tank Vent Location			
Building below 10 persons	15	15	15
Building greater than 10 persons	30	30	30
Truck Parking	15	15	30
Property Boundary	use local codes	use local codes	use local codes

E. Other			
Adjacent LNG tank	2 or $\frac{1}{2}$ diameter	2 or $\frac{1}{2}$ diameter	2 or $\frac{1}{2}$ diameter
F. Dispenser to			
Buildings	15		
Ignition Sources	7.6		

Table 2 Other – LNG Retail Site Safe Distance Requirements

Distances (in meters)	Single Storage ground/on truck pump	Double Storage ground/on truck pump	Three Tanks+ ground/on truck pump
A. From Storage Tank to:			
Public railway (China regulation)	50	60	80
Power generation building (not for the LNG site); (China regulation)	12	12	15
Firewater building; (China regulation)	15	15	20
LNG offloading connections to tank	2	3	5
Petrol and diesel vents	8	10	12
LPG vent	10	12	15
AG or UG diesel or petrol storage tank UG LPG tank	10	12	15
AG LPG tank	20	20	20

5. In case of restricted site conditions due to proximity of LNG infrastructure to site boundary, a vapour barrier shall be used to limit the hazard zone.
6. The vapour barrier shall comply with following conditions:
 - a. be non-combustible and provide a solid obstacle to vapour flow;
 - b. be of substantial fabrication and erection to ensure it remains in situ as an effective barrier;
 - c. not less than 2 m (6.5 ft) high;
 - d. must not impede the egress of personnel nor access of emergency services in an emergency.
7. Barriers should not be erected on more than two sides of the storage area unless the ventilation of the site remains unimpaired.

4. STORAGE TANK INFRASTRUCTURE

4.1 LNG VESSELS DESIGN AND FABRICATION

4.1.1 Materials

1. All materials shall be in accordance with ASME Boiler Pressure Vessel Section II.
2. Quenched and tempered ferritic materials, micro-alloyed steel or ferritic steel in excess of 80,000 psi specified minimum tensile strength shall not be used.
3. Inner vessel material shall be Type 304/316 SS.
4. Austenitic stainless steel shall be in solution annealed conditions.
5. Gaskets shall be stainless steel spiral wound with graphite filler complete with stainless steel inner ring.

4.1.2 Design

1. LNG pressure vessels shall be designed, fabricated and tested in accordance with the latest ASME Section VIII Div 1 or Div 2 vessels.
2. Supplier shall comply with local jurisdictional requirements, if necessary.
3. LNG vessel design pressure shall be properly outlined in the vessel data sheets (Appendix 3) based on liquid properties.
4. MAWP of the storage vessel shall allow sufficient pressure increase due to pressure fluctuations without the need for boil off gas management or venting.
5. Vessels shall be designed for internal pressure, hydrostatic heads, wind load, seismic load, snow load, and erection load.
6. Suppliers shall submit drawings, calculations, welding procedures, non-destructive examination (NDE) procedures, and test plan for review.
 - a. Construction shall not commence without the approval of these submittals.
 - b. Proprietary information shall be reviewed at Suppliers premises.

7. Documentation shall include as a minimum the following information:
 - a. design data and pressure vessel datasheet;
 - b. weld joint efficiency;
 - c. corrosion allowance;
 - d. material list and specifications;
 - e. nozzle list;
 - f. weld maps, including welding procedure specifications;
 - g. detailed dimensions;
 - h. heat treatment and forming instructions;
 - i. impact testing requirements;
 - j. test pressure;
 - k. weight of equipment when empty;
 - l. operating, cleaning, surface preparation, painting, and marking requirements;
 - m. NDE procedures;
 - n. dimensions of nozzles in reference to vessels support, earth lugs, nameplate;
 - o. code and standards;
 - p. capacity and volumes;
 - q. seismic data;
 - r. wind data;
 - s. foundation loading including shear force and moments at the base for empty, full, and hydrostatic (process fluid) conditions.
8. As-built drawings of the above shall be submitted to the Purchaser.
9. Minimum Design Metal Temperature (MDMT) for the inner vessel SHALL [PS] be -196 °C (-320 °F).
10. The MDMT for the outer jacket shall be -45 °C (-49 °F) or lower, regardless of the climatic conditions.
11. Supplier SHALL [PS] submit engineering calculations to substantiate that their design is adequately protected against brittle fracture that could lead to structural instability in the event that the outer jacket is in direct contact with cryogenic fluid if there is a leak within the annular space.

A credible upset scenario is a leak from a 5 mm (0.2 in) diameter hole that could conceivably develop in piping within the tank annulus.
12. The analysis shall consider the effect of transient thermal stress, local mechanical stresses at structure supports, and dead weight.
13. If the proposed tank design could lead to accumulation of liquid LNG within the tank annulus due to unit upset, the buoyancy force of the tank and dead weight redistribution shall also be considered.
14. The report shall contain expected weld flaw sizes in the tank jacket, weld residual stresses, and materials toughness variations through the cryogenic temperature range.
15. Fracture mechanic methods in accordance with API RP 579 shall be followed.

Outer jacket is not in general registered or certified as an ASME vessel.

16. The basic design, fabrication and installation shall be in accordance with ASME Section VIII Div 1.

Local jurisdiction adaptation to alternate design and construction code is acceptable to the Principal.

17. Insulation system designed and provided by Supplier shall limit boil off rate to 0.25% volume or less per day loss.
18. Vessel jacket and insulation shall remain intact and functional during a fire.
19. Vacuum lift plates SHALL [PS] be provided on the outer jacket.
20. Size, locations and number of lift plates shall be calculated for individual tanks design.
21. When powder insulation is used, the design SHALL [PS] be such that the powder will not flow out if the plate is activated.
22. Expansion and contraction of inner and outer shell shall be accounted for in design calculations of vessels, including both internal and external supports for the inner vessel and external saddle/leg supports, and in the flexibility analyses of the internal and external piping supplied by the Supplier.
23. Nozzle connections shall be accompanied with calculation of allowable nozzle loading.
24. Supplier SHALL [PS] provide additional calculation for LNG nozzles that make physical connections to the outer jacket, substantiating the thermal gradient along with the externally applied piping load having sufficient fatigue life of 3 cycles per day over the full 20 year lifetime.
25. If the substantiating calculations are considered proprietary, a non-disclosure agreement can be signed, and they shall be made available to the Principal for review.
26. Corrosion allowance shall be 1.0 mm (0.04 in) on the outer jacket.

A corrosion allowance is not required for the inner vessel.

27. Straps at the outer jacket supporting the inner vessels shall demonstrate sufficient fatigue life due to change in stored content.

The design specification states a level change from 90% full to "nearly" empty condition with a frequency of 4 cycles per week over the full 20 year lifetime.

28. Head types for the inner vessels shall be 2:1 ellipsoidal heads.
29. Supplier shall supply computer flexibility analysis of internal piping in the annular space.
30. Even if this analysis is considered proprietary, they shall be made available to the Principal for review.
31. Unless specified otherwise, the nozzle loading shall meet the criteria of Table 3.

These are for manholes or pump sumps inside tank.