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VENICE LNG
FEED – Venice LNG Terminal (Porto Marghera)

TECHINT ENGINEERING & CONSTRUCTION

Mechanical Engineering

LNG Storage Tank
Technical Specification

0469-TITA-V-SP-002-001

ESC.:

JOB: **0469**

03
REVISION

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1. SCOPE

1.1. Introduction

The purpose of this document is to define requirements for establishing the detailed Specification, Data Sheets, detailed design, construction and commissioning of the LNG storage tank for the LNG terminal.

The data contained in this specification should be understood as minimum requirements.

In case of conflicts between the requirements of this scope and referenced specifications, drawings, etc., they shall be referred for clarification.

The design and construction of the tank shall comply with all applicable national and local laws of Italy, statutory regulations and applicable EU directives if they are not covered by the codes and standards set for the design of the LNG Tank. All design and construction must be approved by Italian technical authorities.

1.2. Storage Tank Type

The storage tank for the terminal shall be full containment type with reinforced concrete floor slab, pre-stressed concrete wall and reinforced concrete roof. Definitions of full containment given in NFPA-59A (2019) 3.3.5.3 and EN-1473 (2015) Annex H shall apply.

Design of the storage tank and all their auxiliaries shall comply with EN 1473 (2015), EN 14620 (2006) and NFPA 59A (2019) as base codes.

EN14620 and/or API 620 (2018) shall also be followed for the inner tank design.

2. REFERENCED DOCUMENTS

The design and construction shall take into consideration the requirements of the national and local Legislation. Any conflict between all requirements shall be clearly identified by the TANK CONTRACTOR and, in case or contradiction, most restricting ones should be applied.

The design and construction shall follow the requirements stated on this document.

2.1. Main Code

At his place only the main codes are highlighted, namely those which most recent versions shall govern the design and construction:

EN 1473
Installation and equipment for liquefied natural gas – Design of onshore installations. (Ed. 2015)

API 620
Design and Construction of Large, Welded, Low-Pressure Storage Tanks. (12th Ed. 2018)

NFPA 59A
Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG) (Ed. 2019)

EN 14620
Design and manufacture of site built, vertical, cylindrical, flat bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between -5°C and -165°C. (Ed. 2006)

EN 10160
Ultrasonic Testing of Steel Flat Product of Thickness Equal or Greater than 6 mm (Reflection Method) (Ed. 1999)

EN 12066
Installations and equipment for liquefied natural gas – Testing of insulating linings for liquefied natural (Ed. 1997)

EN/IEC 62305-3
Lightning protection – Physical damage to structures and life hazard (Ed. 2011)

EN 1992-1-1:2004+A1:2014
Eurocode 2: Design of concrete structures. General rules and rules for buildings

EN 1998
Eurocode 8: Design of structures for earthquake resistance

UBC
Uniform Building Code.

API 2000
Venting of Atmospheric & Low Pressure Storage Tanks (7th Ed. 2014)

API 520
Sizing, Selection, and Installation of Pressure Relieving Devices:
Part I – Sizing and Selection (9th Ed. 2014);

API RP 520
Sizing, Selection, and Installation of Pressure Relieving Devices:
Part II – Installation (6th Ed. 2015)

The TANK CONTRACTOR must state in its BID the main codes and standards he proposes to adopt from the above list.

2.2. Project Specifications

BEDD (Basic Engineering Design Basis)	0469-TITA-G-SP-000-001
LNG Storage Tank Process DS	0469-TITA-R-DS-002-001
Technical Specification for Handling systems (cranes and lifts)	0469-TITA-M-SP-001-005
Electrical system general description	0469-TITA-E-DC-000-001
Technical Specification Electrical Requirements for Packaged Equipment	0469-TITA-E-SP-000-305
Serbatoio_GNL-Tipico_General_Arrangement	Attachment 1

And all other applicable project specifications.

3. CHARACTERISTICS OF SUPPLY

3.1. Location

The storage tank will be located inside the port and industrial area of Porto Marghera in Marghera (VE), Italy.

3.2. Scope of Supply

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One LNG storage tank shall be erected with a volume bottom to max NOL (Normal Operating Level) = LAH (Level Alarm High) of 32.000 m^3. The scope of works shall yield a completely operational storage tank, inclusive of all auxiliaries and spares.

The tank design shall include as a minimum:

- Tank foundations.
- Grading of tank area with paving and rainwater drainage systems.
- Concrete outer tank.
- Cryogenic steel inner tank (9% Ni alloy) or membrane inner tank.
- Thermal bottom and corner protection of outer tank reinforced concrete.
- Bottom slab heating system (for tank placed on raft foundation) to prevent frost heave (if necessary).
- Thermal insulation of floor, annular space (walls), suspended roof and nozzles.
- Vapour barrier inside of concrete outer tank or moisture barrier for membrane tank.
- Manholes for access through outer and inner tank.
- Ladder access into the inner tank (along pump columns).
- Pumps wells as per Datasheet.
- Roof nozzles for piping and instrumentation.
- Elevator designed for 4 persons and their equipment (min. 500 kg). It shall include the support steel work and weather protection which shall be suitable for the operation through out the year.
- Pump platform with permanently installed lifting device(s) for pumps and maintenance equipment.
- Platforms add walkways for access to roof mounted instruments and relief valves.
- Stairway to access pump platform from grade.
- Extra emergency ladder to exit/access tank roof from grade (away from pump platform).
- Process and utility piping, valves and accessories.
- Bottom and top fill nozzles (entering thought the roof) to prevent stratification.
- Spray ring for initial cool-down, and jet mixing to reduce roll-over risk.

- Relief valves to protect the tank against over – or under – pressure.
- Fire water system for roof mounted components.
- Instrumentation (and cameras of CCTV system).
- Electrical power distribution, lighting, and earthing systems.
- Electrical Heat Tracing (EHT) system (if any)
- Aircraft Warning Lighting system.
- Conservation of structures, piping and concrete outer tank.
- Thermal insulation of piping systems.
- Passive (concrete) fireproofing of essential roof mounted structures.
- Auxiliary equipment and tools (e.g. cradle for pump support).
- Manuals.
- As-built records and QC documents.

4. DESIGN INPUT

4.1. General

The TANK CONTRACTOR has the entire responsibility of the design, manufacture and tests of the LNG STORAGE TANK, as well as for the ancillaries equipment.
The Supplier shall ensure that all Sub-suppliers comply with all applicable parts of this specification and related documents, standards and codes and the selected quality level.

Compliance with the provisions of this specification does not relieve the Supplier's responsibility for the supply of equipment and accessories properly designed and mechanically fitted to meet the specified service conditions.

The tank shall consist of one liquid container. The container shall be capable of containing the cryogenic liquid stored without liquid leakage.

The inner tank will contain the cryogenic liquid under normal conditions. The outer will contain any potential liquid leakage from the inner tank. The vapour is contained by a combination of outer tank / inner tank depending on the technology adopted for the tank.

The overall tank height indicated in the datasheet must not be exceeded.

4.2. Data

Number of tanks	1
Design life main components	50 years
Design life auxiliary systems	25 years without major maintenance
Product to be stored	LNG
Number of pump columns	See LNG Storage Tank Process DS 0469-TITA-R-DS-002-001
Geotechnical data	See BEDD (Basic Engineering Design Basis) 0469-TITA-G-SP-000-001
Seismic design	OBE and SSE for main liquid container
Maximum boil-off rate	0,075% per day (The TANK CONTRACTOR shall propose technical solution to improve this value)
Sloshing over-height	OBE from Max. Tank Design Level and SSE from Normal Max. Op. Level
Initial protection overpressure	Pressure control to central vent
Second protection overpressure	PSVs to atmosphere (n+1) philosophy
Initial protection vacuum	N_2 supply
Second protection vacuum	Vacuum breakers to atmosphere. (n+1) philosophy
Level gauges	At least 3 (two independent systems)
Protection against overfill	By high integrity instrumentation
Leak detection	Yes, in outer tank

Passive fireproofing structures	Where member prevents progressive failure
PSV tail pipe elevation	Sufficient to avoid extra fireproofing tank roof
Roof mounted manifold/equipment	Covered by fire-water monitors/deluge
Full hydrostatic test	EN-14620
Concrete outer tank	High quality concrete
Waterproof membrane	Mandatory on tank roof

4.3. Design Loads

The tank shall be designed for all credible combinations of normal and emergency scenario loads which may take place during construction, testing, commissioning, operation, maintenance and de-commissioning of the tank.

Independent emergencies with low probability do not need combining with other emergency scenarios of similar infrequent nature.

The following specific loadings need to be considered in the design:

- Stored liquid load up to its maximum design level.
- Self-weight of concrete, steel, insulation materials, piping and ancillary equipment.
- All possible loading cases during construction. E.g. the roof liner may be used as formwork for the construction of the concrete roof and, consequently, shall be designed to support loads from the fresh concrete.
- An uniformly distributed load of 1,2 kN/m^2 over the projected fixed roof area. (Not to be combined with snow and negative pressure loadings).
- An uniformly distributed load of 2,4 kN/m^2 acting on platforms and walkways.
- A concentrated load of 5 kN over an area of 300 mm x 300 mm, placed at any point on platforms or walkways.
- Gas pressure load from minimum to maximum design pressure.
- Where appropriated, pressure load exerted by the insulation system.
- Hydrostatic and pneumatic testing loads according to EN 14620-5. E.g. hydro test of the inner tank to a height based on the hydro test pressure at the base of the inner tank.
- Snow loads.
- Wind loads.
- Loads expected from predicted maximum differential centre to edge settlements of the concrete bottom slab and between two points in the perimeter, based on interpretation of the geo-technical data at each tank site. The design must allow for total differential settlement through construction, hydro testing and operational lifetime.

- The external pressure on the inner tank shell, exerted by the perlite insulation in the annular space, shall also be taken into account, in particular for the situation of an empty tank.
- Pipe connection loads.
- All possible thermal effects during construction, testing, cool-down and operation.
- Load resulting from the internal negative pressure as specified on the tank datasheet.

4.4. Earthquake

Seismic design of the inner and outer tank shall be in accordance with EN 1473 and/or EN 1998 – Eurocode 8, the Site Seismic and Climatic Data.

Inner Tank:

The inner tank shall be designed using the methods in EN 14620 and API 620. In this case, the Operating Base Earthquake (OBE) and Safe Shutdown Earthquake (SSE) criteria specified in EN 1473 shall be used. It shall be assumed that the inner tank is filled with LNG to its maximum normal operating level (not an overfill or alarm level) for the SSE and to its Maximum design level for the OBE. When designing for the SSE condition, allowable stresses shall be determined in accordance with EN 14620.

Outer Tank:

The outer tank shall be designed using a dynamic lateral force procedure, utilizing a finite element model. The overall model shall include the inner tank, inner tank contents, outer concrete tank and foundation all modelled as a single multi-degree of freedom complex system. Specific combinations of components may be modelled and analysed separately.

The Outer concrete tank wall shall be designed to withstand an SSE event with no product in the annular space, and an OBE event with the annular space full of product as noted in NFPA 59A. The intent is that in the SSE event, the inner container might spill product into the annular space, and the tank must survive subsequent after shock, typified by an OBE event.

4.5. Hazard Design Conditions

Inner Tank Leakage:

The outer tank shall be capable of containing the full inner tank liquid content and vapour resulting from product leakage from the inner tank. The pre-stressed concrete tank wall and its connection to the base slab shall be designed to contain LNG in the annular space. All possible intermediate liquid levels shall be considered and combined with maximum internal pressure. The temperature gradient shall be analysed for critical spill levels.

In case of minor leak, as long as the LNG level in the annular space does not reach the top level of the thermal corner protection, no permanent damage shall occur.

For 9% nickel type, in case of outer tank carbon steel failure due to a major inner tank leak leading to liquid level in the outer tank above the corner protection, the concrete tank shall maintain its integrity. Sudden failure of the inner tank is not to be considered.

Loading Conditions Combination:

The inner tank and the outer concrete tank shall be designed for all specified service and hazard loading conditions. Combinations of loading conditions that produce the most severe design case(s) shall be considered. Hazard loading conditions can be considered as separate events; combinations of hazard conditions in addition to service loading cases are not required.

Heat Radiation:

The outer surface of the tank wall and roof shall be able to withstand a radiant heat flux of 32 kW/m^2 for a prolonged period (minimum 2 h).

The outer tank roof and side walls shall be capable of withstanding fire exposure and heat radiation from a relief valve discharge fire with the relief valves discharging at the maximum relieving rate.

4.6. Hazard Protection Conditions

LNG Spill Protection:

For minor LNG spills or leaks from flanged joints during start-up, TANK CONTRACTOR shall provide stainless steel or aluminium spill protection pans, troughs, or wrap. Each pan, trough, or wrap system shall be provided with one or more drain holes to assure that pools of LNG cannot be formed, and to direct the LNG to a concrete area for vaporisation.

Flammable Gas Detection:

a) At least, two flammable gas detectors shall be installed under the roof platform near flanged piping connections that have spill protection systems. An audible alarm clearly identified as a fire and gas alarm shall be installed at the outside periphery of the platform. The central control room warning system should be activated as well at the same time.

b) Tailpipes of relief valves discharging to atmosphere should be provided with a dry chemical injection system conforming to NFPA for RV discharge pipes to extinguish accidental fir during discharge. The system shall consist of two pressurised powder bottles for each tailpipe, one for automatic discharge in the event of fire and the other as reserve.

5. DESIGN INPUT

5.1. General

The entire LNG Storage Tank, related structures and devices shall be designed to the continuous and uninterrupted operation for a minimum of 25 years. Single point failures that would trigger a premature shutdown of the storage tank shall be avoided.

Items that require regular inspection and maintenance (like PSV, in-tank pumps and instrument) shall be installed with the necessary spares, and allow the intermediate change-out without shutting down the storage tank.

5.2. Foundations

The foundation system shall be designed to limit deformations of the outer (and inner) tank to the allowable limits for all credible load cases, both during the construction and the operations phase.

Care shall be taken to grade the tank surroundings to facilitate drainage of rainwater away from the tank and tank-pad. Moreover access shall be provided to the stairway base, and to the drop-areas next to the pump platform.

The TERMINAL shall be equipped with a dedicated seismic accelerometer near the tank area to allow tracking of actual events and local effects.

5.3. Bottom Slab Heater

If the base-slab of the outer tank is placed directly on subsoil (acting as a raft foundation), then an electric heating tape system with tape elements installed on stainless steel or galvanised conduits shall be installed as bottom slab heater system, destined to prevent freezing of the soil. In sizing the bottom insulation system, an adequate insulation value to minimise the reliance on the bottom heater system as far as practical shall be ensured.

Temperature sensors shall automatically control the heating system.

The system shall be split in two parts per tank to minimise the risk of a single component failure affecting the overall integrity of the storage tank.

The Bottom Slab Heater shall be designed taking into account the possibility of replacement, in operation, of each electrical heater.

See also description listed on next paragraphs 5.8/1 and 6.5.

5.4. Outer Tank

The outer concrete tank wall shall be post-stressed in horizontal (and possibly also

in vertical) direction. Monolithic connections shall be used between floor and wall, and between wall and roof. Roof and wall shall be of uniform thickness, or provided with gradual taper. Permanent penetrations are only allowed through the tank roof.

In designing the outer tank, finite element methods shall be used for static and dynamic modelling of construction elements or the complete outer tank, as appropriate. The design shall give due account to “ultimate limit state”, and “serviceability limit states” (deflection and crack width).

The concrete grade to be used for the outer tank shall have a maximum water/cement ratio of 0,42 in wall and roof and 0,45 in foundation slab base. The application of an additive to enhance plasticity and retarding properties will be accepted. Crack width beyond 0,2 mm (in pre-stressed wall) and 0,3 mm in reinforced structures shall not be allowed. Mixing of different grades of concrete (except for blinding) shall not be permitted. Before application of structural concrete on the outer tank, an extensive concrete testing program shall be executed to demonstrate all achieved properties, inclusive 28 days strength.

Tests shall include a low temperature and thermal cycling performance on the final composition of the concrete, covering:

1. Compressive strength after 1 thermal cycle at low temperature (-196°C).
2. Compressive strength after 20 thermal cycles between +5°C and -5°C.
3. Establishing the followings properties:
    - Dynamic modulus.
    - Compressive strength.
    - Static Young’s modulus at temperature range from -160°C to +30°C.
    - Thermal expansion coefficient.

Concreting of the foundation base slab and the concrete roof of tank will performed without interruption in order to avoid “cold joints”.

The concrete roof shall be cast in only one layer.

The concrete roof shall be provided with a waterproof coating, irrespective of the concrete type used, coating shall also improve fire proofing. If coatings are applied, colours will be defined.

In designing the reinforcement and pre-tensioning systems, due account shall be given to possible lowest temperatures after a (part) failure of the inner tank. Due consideration shall be given to relaxation and creep effects. In emergency conditions, plastic deformation of reinforcement and pre-stress tendons shall be avoided (even at elevated temperatures).

The outer container shall be provided with purge piping, that allows the drying and purging of the annular space and bottom insulation space (outside the bottom-corner protection area). For membrane tank, this system is called ISMS (insulation

space monitoring system) and allow controlling insulation space nitrogen pressure. Samples are analysed to monitor any ppm of methane into insulation space.

In a full containment tank, one extra nozzle shall be installed that allows lowering of a small pump should ever the annular space need to be emptied of LNG after a serious defect.

The outer tank of 9%Ni shall be equipped with a (metal 5 mm thick) inner vapour barrier which shall maintain the tightness of the outer tank under normal operating conditions. This vapour barrier may, provided its design is adjusted accordingly, act as lost form-work for construction of the concrete roof. Due attention shall be given to ensure tightness of the joints in this vapour barrier. Where welds are not accessible for full vacuum box testing (in addition to dye penetrant examinations) a minimum of double path welds shall be included in the design.

Vapour barrier of base slab tank will be set after the concreting of tank roof to avoid the entrance of water between steel liner and concrete slab if raining.

For membrane tank, the inner membrane itself ensure the gas tightness for wall and bottom. The concrete inner face is covered by a moisture barrier that prevent any moisture ingress to insulation.

The bottom slab and the bottom 5 m of the outer tank shall be provided by a “bottom corner protection”, consisting of a layer of insulation material, sealed by a metal membrane (resistant to cryogenic temperatures), which is connected to the vapour barrier. For the membrane tank this secondary membrane is composite. This construction prevents exposure of bottom corner connection of the concrete against low temperatures, and also acts as a kind of “drip-pan” in the event of small defects in the inner tank. The remainder part of bottom insulation and annular space insulation area shall be interconnected to allow combined purging and drying.

The roof perimeter shall be equipped with a handrail (with knee rail and toe-board). Access platforms shall be available to reach all roof mounted equipment.

During the construction, the LNG Storage Tank may have, temporary “doors” and manholes on the outer wall in order to provide access to the inside of the tank. All the temporary openings shall be located below the level protected by the corner protection system.

5.5. Tank Insulation

The thermal insulation installed inside the outer tank shall meet the required overall thermal performance of the LNG tank specified in the data sheet, in terms of boil-off rates. These shall be based on a full tank, exposed to the design ambient temperature. and maximum solar radiation for 12 hours per day, reference is made to meteorological data included in specific tender document. Verification of the thermal performance of the tank shall be via calculations and verified material properties. External condensation on the concrete roof shall not be permitted for more than 5% of all times.

The bottom insulation shall ensure that the reliance on the bottom heater (if any) system remains modest, with staggered joints, and for 9%Ni tank with levelling sand or lean concrete layer below and over the bottom insulation system. Roofing felt in-between the individual layers and joint-filler: as per Manufactures recommendations. Adequate mechanical/material safety factors shall be selected for the bottom insulation, generally following Manufacture recommendations.

Under normal operating conditions the minimum safety factor shall not be smaller than 3 for foam glass, 2 for PU foam.

The bottom insulation shall have a minimum thickness of 500 mm in case of Cellular Glass insulation.

For the 9%Ni tank the annular space shall be insulated with expanded perlite, placed against resilient blankets mounted on the inner tank. The purpose of the resilient blankets is to provide flexibility for thermal effects of the inner tank.

Due care shall be taken to properly detail the mounting of these blankets to prevent early collapse during placing of the perlite. In sizing the annular space consideration shall be given to the required access during construction.

The top of the annular space shall be equipped with an adequate capacity perlite hopper to store surplus perlite and avoid regular re-filling. The tank should allow at least 5 years of operation and two full thermal cycles without the need for intermediate re-filling of perlite (via roof installed nozzles).

The perlite powder, to be used in the insulation, shall have a density between 50 and 65 kg/m^3 and shall not have more than 0,5% (weight) of moisture content.

For the membrane tank the thermal insulation is ensured with panels made with PU foam.

For the suspended roof fibre glass blankets or loose perlite may be applied. If the latter option is selected, due attention shall be paid to the sealing of nozzle penetrations to the inner tank in order to avoid ingress into the LNG. The suspended deck shall not impose mechanical loads on piping nozzles that penetrate the ceiling (even under earthquake conditions) Adequate number and size of open vents shall penetrate the suspended roof to ensure equilibrium of pressure between inner and outer tank. The suspended roof shall be designed to carry permanent and temporary (construction) loads. A mobile point load of 900 N, at any point, shall not lead to a roof failure. Depending on the nozzle arrangement in inner and outer tank, permanent staging shall be installed to allow future access without the need to remove thermal insulation on the suspended roof.

During the application of thermal insulation in the annular space and on the suspended roof, care shall be taken to avoid the ingress of moist air into the outer tank.

For the membrane tank, the insulation on the suspended deck is glasswool.

Insulating Concrete (Criteria to be considered in detailed design where applicable)

Properties of Insulating Concrete

- *Insulating concrete shall be lightweight and utilise inert, impermeable aggregate, such as expanded polystyrene and have a thermal conductivity better than 0,2 W/m^2°C. Where necessary a dispersant admixture shall be used to ensure uniform distribution of the aggregate.*
- *The insulating concrete shall be reinforced with small gauge stainless steel mesh.*
- *To minimize thermal effects, an adequate number of through thickness joints shall be provided. Each joint shall be sealed with a stainless steel liquid stop plate and caulked using silicone/polyshulphide sealant.*
- *For protection completed sections of insulating concrete shall be coated with a flexible membrane, such as Decothane SP by Liquid Plastics Ltd.*

5.6. Inner Tank

For the 9%Ni type tank, the inner tank will be made of 9% Ni plate. Before placing the order for the plate material, it shall be demonstrated to that the plate material meets all code requirements, in terms of defect percentage, mechanical properties (inclusive at low temperatures), produced under a well proven and transparent QA system. All materials supplied for the inner tank shall be supported by a Mill test material according EN 10204 – 3.2. Weld materials (from a published list of Lloyds or alternative international inspection body) and weld procedure specifications shall be selected to ensure compatible weld properties.

The QA system that ensures full traceability of all plates until they are installed in the tank shall be demonstrated. All inner tank materials shall be transported and stored separately and provided with adequate marking.

Plate edges shall be prepared by machine, and if flame cutting is applied locally an 1,5 mm edge shall be removed by grinding. All horizontal and vertical welds shall be full penetration butt joints. Weld spacing shall be considered to minimise the risk of stress concentrations, and in assembly of internals with critical dimensions, distortion due to heat-flux shall be considered in the detailed design and subsequent inspection protocols.

If hardness, after flame cutting, is over 400 Vickers an addition 1 mm will be removed.

Shell plates and annular plates shall be butt welded from both sides. The bottom plates shall be butt welded using backing strips.

The number of the attachments/brackets (both permanent and temporary) to the inner tank shall be minimised as far as practical. The shop primer applied to plate material can remain in place, provided it is compatible with the future application for cryogenic service (i.e. no de-lamination or disbanding).

The inner tank shall be sized to provide the specified capacity, and have enough freeboard to avoid spilling of LNG due to sloshing under earthquake conditions.

For membrane tank, the inner tank is made of a corrugated stainless steel membrane to be designed and produced in accordance with appropriate specifications produced by experienced Companies.

Pump wells shall be designed and constructed with due consideration of dimensional tolerances (in diameter and length), as per pump VENDOR recommendations. Moreover, sharp edges shall be avoided on the inside to avoid the risk of pump-seal damage. A mock-up (dummy) pump shall be used to confirm overall dimensions before and after mounting of the pump wells.

Tank internals shall comprise of stilling wells, liquid inlets (top and bottom), spray ring for initial cooling down, jet nozzle for enhanced mixing of LNG, vapour outlets, and purge/vent systems In the annular space a ring header with perforation and filter shall be installed with connections to the roof top, to facilitate initial drying and purging. The pump wells shall be equipped with all auxiliaries, like foot valve, to allow retrieval of a pump without shutting down the main storage tank. Pump wells shall be subjected to a dynamic analysis to exclude the risk of vibrations during pump operations, and computed frequencies shall be at least 20% away from anticipated exiting frequencies.

In order to allow maintenance on condition for LP Pumps, Vibration sensors shall be permanently mounted and signals will be independently transmitted to Control Room.

The CTOD tests (Crack Tip Opening Displacement) to assure the quality of the 9% Ni material shall be carried out.

5.7. Piping

The calculation for all the piping systems connected between the LNG STORAGE

TANK and the surrounding terminal shall be performed.

Care shall be taken to ensure that all piping installed inside the tank can be inspected for tightness and cleanliness before boxing in the tank.

Supporting (dynamic) calculations shall be performed for piping support. Installation of cryogenic supports shall be planned and executed in a disciplined manner to avoid damage and/or ingress of moist.

The Piping Insulation shall be to the overall PROJECT standards, reference is made to a dedicated insulation requirements included in this Document. The detailed specification of its insulation process shall address amongst others:

- The insulation thickness calculation method.
- The Insulation material and application procedure.
- The piping outer surface preparation procedure.
- Quality assurance activities.
- Protection of finished sections against damage.

The scope of supply shall include all piping, valves, supports and ancillaries from the base of the tank.

5.8. Equipment

1. Electrical and Instrumentation

a) General

Refer to 0469-TITA-I-SP-000-009 “Specification for LNG Custody Transfer” for installed instrumentation.

Refer to 0469-TITA-E-DC-000-001 “Electrical System General Description” and relevant attachments for technical prescriptions to be followed for the electrical systems to be provided for Terminal and LNG Tank.

b) Local Distribution Panels/Junction Boxes

All electrical and instrumentation systems to be provided installed with LNG Tank shall be centralised in LP/LCP (Local Distribution/Control Panels), Isolation Switches and/or JBs (Junction Boxes), under shelter set, located on an access platform (easily accessible) at the level of the pipe rack.

All electrical equipment shall be provides as per technical characteristics described on doc. n. 0469-TITA-E-DC-000-001.

The instrumentation Junction Boxes shall be “EExe” Type.

c) Lighting systems

The lighting systems for the LNG Tank shall be provided in accordance with the requirements indicated on doc. n. 0469-TITA-E-DC-000-001 and reference standards, and shall be divided into different systems.

As per previous point b) all lighting systems shall be centralised to relevant Local Distribution Panels located on access platform.

<u>Normal Lighting system</u>

The normal lighting system shall be powered by the Normal Power Distribution System.

<u>Emergency Lighting system</u>

The Emergency lighting system shall be able to function even in the event of a failure of the Normal lighting system; the equipment shall be connected to the Emergency Distribution System, powered by the EDG Generator (Emergency Diesel Generator).

<u>Safety Lighting system</u>

The Safety lighting system shall allow the safety activities of the plant to be carried out, as well as the lighting of the escape routes to allow their safe evacuation.

The safety lighting system shall be able to operate even in the event of a failure of the Normal and Emergency lighting system.

The lighting fixtures, belonging to the Emergency and Safety Lighting System, shall be powered by the same relevant Local Emergency Lighting Panel.

In this case, the Emergency and Safety lighting fixtures shall be part of the same circuit, and therefore energized by the EDG emergency power

supply system; in the event of a power failure from the EDG, the safety fixtures shall remain powered by their local batteries for additional 60 minutes (autonomy of local batteries), guaranteeing the lighting of the escape routes.

Lighting levels at the access platform and roof-top platforms shall meet the normal requirements for manifold and process Plant areas, where regular operator access is anticipated.

As general rule Lighting fixtures shall be provided with LED lamps.

All electrical equipment shall be provides as per technical characteristics described on doc. n. 0469-TITA-E-DC-000-001 and relevant attachments.

d) Aircraft Warning Lighting System

An Aircraft Warning Lighting system shall be provided (if necessary), dedicated to the LNG Tank, in accordance with the prescriptions indicated by the Local Laws and Regulations, as well as according to ICAO Standards.

The system shall be equipped with its own Local Distribution Panel (LP), to be located on the access platform (see previous point b), powered by the Terminal Plant UPS (Uninterruptible Power System) located on Plant Electrical Substation.

Aircraft warning lighting fixtures shall be provided with LED lamps.

e) Convenient outlets and welding sockets

Welding sockets and convenient outlets shall be provided at roof-top platforms in order to be able to carry out normal maintenance operations:

- Welding sockets : 63A/32A 3PH+N+PE (complete with plugs).
- Convenient outlets : 16A 1PH+N+PE (complete with plugs).

The welding sockets shall be powered directly by its own dedicated Local Distribution Panel, to be located on the access platform (see previous point b), while the convenient outlets shall be powered by the Normal Lighting Local Distribution Panel, previously mentioned.

For additional information and technical characteristics of electrical equipment reference shall be made to doc. n. 0469-TITA-E-DC-000-001 and relevant attachments.

f) Cables and Cable Ways

All power and control cables of all electrical systems provided for LNG Tank (with relevant cable sizing criteria) and cable ways (cable trays and conduit with relevant fittings and supports materials) shall be provided as per technical characteristics described on doc. n. 0469-TITA-E-DC-000-001 and relevant attachments.

As general rule all cables shall be provided of armored type, with copper conductors, HEPR insulation (“G16” quality) and external sheath made of a “M16” quality thermoplastic compound, in accordance with the provisions of the relevant standards and the requirements prescribed by

the European Construction Products legislation (CPR UE 305/11) – Euroclass: Cca-s1b, d1, a1.

For other additional technical requirements reference shall be made to above mentioned specification.

All cables shall be laid in cable trays (cable ladders type), on two layers, and 20% of useful space of cable trays shall be kept for future.

Cable trays shall be provided in stainless steel material (AISI 316), completed with covers for the horizontal sections and for the vertical sections up to 2,5 m from the grade.

The electrical continuity of the elements of the metal structure shall be guaranteed by using connection joints with at least 4 bolts, in AISI 316.

All special pieces (curves, deviations, reductions, etc.), supports and other necessary accessories shall be provided, and shall have the same construction characteristics as the straight elements.

For other additional technical requirements reference shall be made to above mentioned specification.

The final path of the cable and the connection to the end user (from the main cable path to the end user: electric motor, MCS – Motor Control Station, Local Panel, etc.), shall be made with rigid protective pipe in hot dip galvanized steel (HDG) and relative fittings.

The connection to the electrical equipment will be made with the “open conduit”; this means that the entry of the armoured cable into the equipment enclosure shall be carried out by means of a cable gland.

Rigid conduit pipes shall be provided in carbon steel, Fe 360, heavy series, suitable for use in explosive atmospheres, according to UNI 7683, galvanized externally and internally according to UNI EN 10240 with ends having Metric thread (ISO 261) with 1,5 mm pitch.

Cable glands shall be provided in stainless steel (AISI 316L), double seal type suitable for armored cable, with Metric thread (ISO 261) with 1,5 mm pitch.

For other additional technical requirements of electrical bulk material reference shall be made to above mentioned specification.

g) Grounding System

General earth system and clean instrument earth system to a uniform standard for the whole Project shall be provided.

The grounding system and the protection system from atmospheric discharges shall be provided in accordance with the requirements indicated in Standards CEI 99-3, CEI EN 50522-5-54 and CEI EN 62305, for the safety of personnel and to provide a return path for earth fault currents.

In addition LNG Tank grounding system may meet the requirements of IEEE 45 “Recommended Practice for Grounding”, and API RP2003, “Protection Against Ignitions Arising Out of Static Lightning and Stray Currents”.

The main LNG Tank grounding system shall consist of a grounding ring, undergrounded around the tank, and dispersion stakes (if necessary), to which all structures and equipment shall be connected with earthing conductors.

As general rule, the following equipment and structures shall be connected to the grounding system:

- All LNG Tank steel structures (inner and outer grounding steel rebars earthing) and the exposed main metal structures.

  The inner tank and the internal metal vapour barrier shall be connected to earthing at least at three places.
- All secondary metal structures (stairs, walkways, supports, etc.) will be provided.
- All metal frames of electrical equipment such as motors, motor control station, local panels, JB, sockets, lighting fixtures and relevant poles/supports, cable trays, conduits, etc.

  In addition, the electrical equipment shall be earthed through the protective earth conductor present in the power supply cables (PE), in addition to what is provided locally and above mentioned.
- All pipes, at the battery limits of the tank.

In accordance with the requirements of the CEI-EN 60079-14 Standard, in hazardous areas all the metal parts installed shall be earthed, in order to ensure their equipotentiality, including valves, filters and other items in line, which are not in galvanic contact with the pipe/equipment (earthed), regardless of the product contained.

The Lightning Protection system (to be provided on the top of tank), the grounding system of main structures and the grounding system of electrical equipment with relevant frames (often connected to a local grounding bars: BTH), shall be connected to the tank underground earthing ring, by means of “disconnecting link”, in order to provide a sectioning and for measurement of earthing continuity of the aboveground earthing system (on the top of the tank) and of the underground earthing ring around the concrete slab of tank.

In addition, provisions shall be made to connect the main Terminal Plant earthing grid, in two locations, at the pipe racks leading into the tank.

For additional information about grounding system and technical characteristics of grounding materials reference shall be made to doc. n. 0469-TITA-E-DC-000-001 and relevant attachments.

h) Lightning Protection system

The study of the Lightning Risk Analysis, for the protection from atmospheric discharges and the possible sizing of the relative protection measures, shall be provided with the purpose of guaranteeing the safety of the personnel and the correct operating of systems installed on the LNG Tank, in case of damage and lightning failures that occur during normal operating functions.

The standard procedures and comparison values for the development of

the Risk Analysis shall be in accordance with the requirements indicated in the CEI EN 62305 Standards and determined by means of appropriate calculation software.

An uniform approach shall be selected throughout the Project; for that reason coordination with design of Terminal Plant shall be guaranteed.

The protection system against atmospheric discharges, where necessary, shall be obtained through the use of a system of air termination rods and/or suspended protection conductor, connected with a metal conduction path (conductor or other) to the points/ground stakes to be provided at the base of the LNG Tank, connected to the buried grounding network, to be foreseen around the tank.

In addition the electrical panels shall be equipped with atmospheric surge arresters on the incoming lines.

i) Electrical Heat Tracing system

An Electrical Heat Tracing system shall be provided (if necessary) dedicated to the LNG Tank process lines and instruments.

The system shall be centralised in a Local Distribution Panel (LP), to be located on the top of the LNG Tank; in addition an “Isolation Switch” shall be provided too (for possible interruption of the power supply, coming from Plant Electrical Substation, to the LP located on the top of tank), located on the access platform (see previous point b)

The EHT system shall be provided taking into account the following general requirements:

- The heating circuits shall be grouped together to one or more interconnection JB whose maximum absorbed current, provided by the upstream circuit on LP, shall not exceed 15A.
- The heating cables shall be self-regulating; these cables and all necessary installation accessories, as well as thermal insulation materials, shall be provided as per Std. requirements of tank Supplier.

j) CCTV Camera’s

As part of the TERMINAL Safety System each tank roof will receive at least one (remote-operated) camera to monitor the condition at the pump platform.

k) Telephones

As part of the Communications Systems, telephones should be installed at the pump platform (near the staircase, and at the entrance to the emergency escape ladder). A telephone near the bottom of the main staircase is needed as well.

2. Safety Valves and Vacuum Breakers

The LNG Storage Tank is connected to a common vapour balance line that acts as suction to the BOG compressor station. For protection against vacuum inside the tank (caused by pump-out in combination with rapid increase in atmospheric pressure) N_2 vapour shall be supplied to the tank dome. A rupture

disk shall be installed in the line as signalling device.

In addition to this PSV and vacuum breaker valves connect the tank dome space to the atmosphere as a final line of defence. These valves shall all have at least one installed spare valve (i.e. n+1 sparing philosophy), and their connecting manifolds shall have interlocked isolation valves to allow inspection and removal of individual valves without affecting the integrity of the tank.

Rupture disk type shall not be adopted for vacuum break valves.

The pressure relief valves shall be purchased only from manufacturers who can demonstrate that prototype testing of valves to the full size, and under full pressure and flow conditions has been performed successfully.

The relevant design scenarios that will be used for sizing the relief valve systems shall be part of the design development. Roll-over volumes are most likely governing, and these are assumed not to be relieved via the common vapour balance line, but exclusively via roof-top PSV relieving direct to atmosphere.

The PSV (relieving directly to atmosphere) shall be installed far away from the Pump Platform and taking in consideration the predominant wind directions and considering the HAZOP and Dispersion Study results.

All the PSV's shall discharge directly from the inside off the inner tank. That requires that the Inlet Pipe be placed below the suspended roof. TANK CONTRACTOR shall level the Inlet Pipe in such a way that overfill can not, block the vapour discharge.

All the PSV (relieving for atmosphere) shall be provided with a nitrogen connection to allow the fire extinction, in case of small fires.

The outlet pipes shall discharge vertically and shall have the sufficient height to allow a fire in the PSV without special protection on the concrete roof.

3. Miscellaneous

The tank shall be fully equipped for service and with tools that may be necessary for inspection and maintenance. Amongst others this shall include:

a) Nozzles

The nozzles and nozzles sleeves/plates shall be designed by properly evaluating the reaction forces applied by the piping on the sub-rack.

All LNG and BOG nozzles penetrating the tank roof or directly above the tank roof must be of welding connection type except those for PSV's, special instruments, tank blind flanges and pumps columns cover.

The lower part of nozzle sleeve such as the portion contacting with concrete roof shall be designed so as to avoid icing problem under the must adverse climacteric conditions.

b) Hoist to Pump Platform

The pump platform shall thus be equipped with a small hoist (up to 250 kg) to transfer tools and spares from grade to the pump platform level.

c) Pump Hoists

To lift the LP pumps from the tank to the pump platform or to grade, jib crane(s) or an overhead gantry crane shall be installed permanently on the pump platform.

This choice is made because of the elevation involved and the required high reliability of the hoist (thus ruling out mobile cranes or temporary hoists). The capacity shall be at least 200% of the weight of the complete pump assembly.

The hoist shall be detailed with a double hoist wire, of which one acts as backup.

Gantry crane shall be provided equipped with its own Local Distribution and Control Panel (LCP), located together with crane on the top of the LNG Tank and powered both by Normal Power System and by Uninterruptible Power System (UPS) from Terminal Plant Electrical Substation.

For that reason an “Isolation Switch Panel” shall be provided too (for possible interruption of the power lines, coming from Plant Electrical Substation, to the LCP located on the top of Tank), to be located on the access platform (see previous point b).

d) Pump Support Cradle

To temporarily locate the LP pump at the pump platform (or at grade) dedicated cradles shall be supplied.

e) Elevator

An elevator shall be provided for LNG Tank, designed for 4 persons and their equipment (min. 500 kg) and shall include the support steel work and weather protection, it shall be suitable for the operation throughout the year.

The elevator shall be provided equipped with its own Local Distribution and Control Panel (LCP), located together with the elevator e its structure at the bottom of the LNG Tank and powered both by Normal Power System and by Uninterruptible Power System (UPS) from Terminal Plant Electrical Substation.

For that reason an “Isolation Switch Panel” shall be provided too (for possible interruption of the power lines, coming from Plant Electrical Substation, to the LCP located at the bottom of Tank), to be located on the access platform (see previous point b).

6. CONSTRUCTION

6.1. General

All the necessary construction procedures for the various parts of the tank, detailing all the construction stages shall be specified.

6.2. Civil and Structural Works

Tank package scope of work shall include design, materials supply, and construction of the following:

- A review and interpretation of the Geotechnical Study Report together with any additional soil investigation work.
- Site preparation work necessary to provide adequate support to temporary works through out the construction of each tank.
- A reinforced concrete base slab supported on piles if necessary.
- Post-tensioned concrete outer tank wall. Outer wall shall be provided with vapour barriers at the inside or moisture barrier for membrane tank.
- Supports for piping, cable trays, equipment, etc, on tank wall and roof.
- Reinforced concrete outer tank roof.
- Reinforced concrete ring beam under inner tank shell.
- Foundation for stair tower.
- Foundation for pipe support tower if separate from stair/lift steel structure.
- Foundation for emergency staircase from tank roof to grade.
- Concrete (or steel) main operating platform.
- 9% Ni steel open top inner tank.
- A 9% Ni steel secondary bottom and 9% Nickel Steel Insulated “Thermal Corner Protection” (TCP).
- Low temperature steel liner for outer concrete roof resting on the top of concrete outer wall with low temperature steel compression zone inner liner.
- Low temperature steel liner vapour barrier to inside of concrete container wall and tank bottom.
- Suspended aluminium or approved equivalent deck inside inner tank supported by stainless steel suspension rods/hangers from outer concrete roof.
- Internal tank ladders, platforms and walkways.
- Access ways on tank roof including full handrail around circumference of tank, roof stairway with handrails to centre of roof.
- Supports for stilling wells, thermo wells, LNG spray ring, internal piping, etc.
- Supports, lugs, and base plates for piping, instrumentation, and electrical cable etc, to be directly installed on tank roof or outer tank wall.
- Pipe guides and supports for external pipes etc, as required.
- Circumferential (monorail) trolley beam and supports outside the tank along the perimeter of the roof for powered gondola.
- Spill protection plates.

- Design, fabrication, supply, and installation of steel (or concrete) pump platform.
- Supply, fabrication, and installation of swing/travelling cranes or hoists for pump maintenance.
- Design, fabrication, supply and installation of staircase and emergency escape stair.

6.3. Piping & Equipment Works

Scope of work includes design, material supply, fabrication, and installation of piping comprising:

- Internal tank piping for the liquid filling, tank cool down, and Nitrogen purging/venting.

- Internal tank pump columns (well).
- Pressure, Vacuum relief systems including block valves, safety/relief valves, vacuum relief valves, tail pipes complete with bolts, nuts, and gaskets.
- Nozzles for process piping, instruments, and gauges attached to tank, including stilling wells.
- Manholes and perlite refilling nozzles.
- Blind flanges complete with bolts, nuts, and gaskets for purge/vent nozzles, spare nozzles, manholes, and perlite refilling nozzles.
- Design, furnish, and install all internal and external pipe supports, guides, and clips.
- Design, fabrication, supply, and installation of external tank nozzles together with pipe work extending from roof down to the battery limit. External pipe work shall include all process and utility piping complete with valves and other accessories as defined in tank data sheets.
- Installation of LNG in tank Pumps and foot valves.

6.4. Insulation Works

Tank scope of works shall include design, supply, and installation of insulation as follows:

- Nominated grades of insulation from proved manufacturers.
- Perlite in annular space between inner and outer wall, including supply of perlite expanding equipment and subsequent removal of it.
- Fibreglass resilient blanket on the outside of the inner tank shell.
- Fibreglass or expanded perlite over suspended inner tank roof.
- On piping between nozzle necks and their sleeves.
- On process piping, in dome area between outer concrete roof and suspended aluminium deck.
- On all external process piping up to boundary limit.
- Critical appurtenances (e.g., aluminium RV's, vacuum breakers, instrumentation, etc.) on the tank roof area which are not protected with deluge water shall be provided with insulation, heat shielding, or similar for protection against short duration PRV fires and platform fires.

6.5. Electrical Works

The design, supply and installation inclusive of testing and commissioning of the following systems (as per previous Paragraph 5.8/1) shall be provided.

LNG Tank shall be provided including the following systems, each one to be supplied completed (and fully operating) with equipment and relevant accessories, JB, installation materials, supports, cable glands, electrical cables (power and

control), materials for the cable ways (walkways, conduits, fittings, supports,), etc. until the interface point with electrical Terminal Plants, identified with the "Local Distribution/Control Panels (LP/LCP)" and/or "Isolation Switch Panel (ISP)" located on the access platform at the level of the pipe rack (See prev. Par. 5.8/1).

Status and fault signal of each panel shall be available for DCS of Terminal Plant.

Both LP/LCP and ISP or JB shall be included on LNG Tank Scope of Supply and shall be completed with support frame and cable glands: battery limits between Terminal Plant systems and corresponding LNG Tank systems shall be the cable glands and the internal terminal strips of each Panel.

Systems/equipment to be provided – included in LNG Tank Scope of supply

- Power Distribution System (complete power distribution system to electrical users of each systems, including EHT and Slab heating system) with relevant interface Local Distribution Panels/Isolation Switches/JB.
- Lighting systems.
- Aircraft Warning Lighting System.
- Convenient outlets and Welding Socket system.
- EHT – Electrical Heat Tracing system (If any).

  (System shall be provided completed with electrical equipment and materials, as well as with heating materials, including insulation materials).
- Bottom concrete Slab Heating System (If any).

  Depending on STD system adopted by Supplier the Slab Heating System shall include all Power Distribution and Monitor/Control (PLC) Panels to be located in safe areas (Electrical Substation/Technical room), Distribution JB and Temperature Controller Panel (to be located on access platform), Local JB (located at the bottom of Tank for distribution to each heating resistor), and conduit with relevant heating elements (to be installed in bottom slab and ring beam of Tank).

  All power/control cables and cables ways with all necessary materials and supports shall be included on scope of Supply.
- Grounding System (Composed by a dedicate underground earthing loop and common grounding system for the Tank).
- Lightning Protection System (If any) to be implemented on grounding system (as described on Previous Par. 5.8/1).
- Cables and Cable Ways for distribution systems inside battery limits (as described on Previous Par. 5.8/1).
- All necessary Cable Trays extending from Tank roof to battery limits/pipe rack on the access platform, in order to lay power/control cables dedicated to equipment not in scope of LNG Tank supply, but which shall be provided and installed on Tank by Others (LP pumps, relevant MCS – Motor Control Station, MOV, etc.).

Exclusions from LNG Tank Scope of supply

- Interconnecting power and control cables coming from Terminal Plant Electrical Substation to LNG Tank systems/equipment (LP/LCP. ISP, JB) at battery limits, as well as electrical cables for equipment not in LNG Tank scope of supply: LP pumps, relevant MCS – Motor Control Station, MOV, etc.
- Grounding conductors for connecting the Tank underground earthing loop to Terminal Plant grounding system.

In addition, the scope of supply also includes the engineering documentation, any special equipment/tools, as well as all the services necessary for the complete preparation of the electrical systems, including, as a minimum, the following points.

Testing

The electrical equipment and materials included in the scope of supply shall be tested in accordance with the requirements prescribed in the reference standards indicated on reference documents listed at Chapter 2.

The following services shall be provided:

- Factory Acceptance Testing of main equipment/materials (FAT – Routine Test) with release of the relative Test Reports/Certificates.
- Test reports and Type/Special tests certificates (performed on prototypes or similar materials) of main equipment/materials.
- Site Acceptance Tests (SAT, on-site testing) with release of the related Test Reports/Certificates.
- On-site Installation/Commissioning/Site Start-up services.

Engineering Documents to be provided by Supplier

- Electrical equipment data sheets for each system (distribution & control panels, main equipment, etc.).
- Electrical loads/consumers list for each system (Elevator, Gantry Crane, Slab Heating system, EHT system, Lighting/Sockest system, etc.).

- Assembly drawings of electric equipment (LP/LCP, ISP, JB, etc.) complete with dimensions, weights, installation details, electrical diagrams, terminal blocks and cable entries.
- Electrical cable list and interconnecting list (power and control) for each system.
- LNG Tank Layouts and details for each system (equipment disposal layout, electrical cable ways and distribution layout, grounding layout, EHT system layout, Slab heating layout).
- Electrical materials list (MTO) – for each system.

6.6. Instrumentation Works

- Refer to 0469-TITA-I-SP-000-009 “Specification for LNG Custody Transfer”.

6.7. Welding

The welding procedures shall include, in particular:

- Welding Procedure Specification (with applicable codes and acceptance criteria clearly defined).
- Procedure Qualification Record.
- Welder Performance Qualification.
- The technique used.
- The filler metal which shall have the same mechanical characteristics as the base metal (with list of suppliers).
- The characteristics of the gas flux (with list of suppliers).
- The joint preparation, cleaning between passes and after welding.
- The expected mechanical characteristics for the joint.

Welding Procedures shall be qualified as required by EN 14620 and shall conform to the relevant Italian regulations and European Standards.

6.8. Protection of Metallic Parts

Every metallic part of the LNG Storage Tank shall be effectively protected against atmospheric corrosion.

7. TESTING OF TANK

A system for documentation implementation and maintenance Quality Assurance, shall be established.

The scope and specification for testing shall be approved by the relevant Italian

technical authorities.

7.1. Test Plans

The detailed Inspection and Test plans (ITP) for all tank components, shall be elaborated, amongst others these ITP shall the following subjects:

- Method and facilities utilised for testing;
- Control conditions, instruments used and their accuracy;
- Detailed tests schedule;
- Contents of test report.

7.2. Component Tests to Complete Systems

The testing and inspection will concentrate initially on individual materials, and part systems, like:

- Steel materials;
- Welds (integrity and leak tightness);
- Concrete materials and structures;
- Relief valve set points (and performance under flow);

As the tank construction reaches its end, tests will become more extensive, and cover larger systems, like:

- Pressure tests on piping systems;
- Air test of outer tank (primarily to confirm the structural roof integrity and tightness of nozzles);
- Hydrostatic test of inner tank to verify its tightness.

7.3. Hydrostatic Test

The hydrostatic test shall conform to EN 14620.

The hydrotest procedure shall pay particular attention to verification settlement predicted during the design. As a minimum, settlements shall be monitored every 5

m filling height at 16 locations around the circumference of the tank. A permanent settlement monitoring system (inclinometer) shall be installed to measure tilting as well as global and differential settlement of the tanks.

The maximum water level shall be maintained for a minimum of 48 hours.

The hydrostatic test (for the full containment tank) shall be executed with fresh water. Use of salt water isn't allowed by the Authorities.

Please take note that after hydraulic test, the test water can't be discharged in the Lagoon without authorization. For the specific discharge concentration limits please refer to DM 30/07/1999 «Limiti agli scarichi industriali e civili che recapitano nella laguna di Venezia e nei corpi idrici del suo bacino scolante, ai sensi del punto 5 del decreto interministeriale 23 aprile 1998 recante requisiti di qualità delle acque e caratteristiche degli impianti di depurazione per la tutela della laguna di Venezia».

TANK CONTRACTOR shall be responsible to request and obtain all necessary authorizations to source fresh water for hydraulic test, or to discharge water in the lagoon after hydraulic test, if necessary.

TANK CONTRACTOR is responsible for the disposal of the washing water. The washing water cannot be discharged into the lagoon or into the water storage tanks.

- <u>Fresh Water</u>

  TANK CONTRACTOR shall be responsible to supply and disposal of fresh water.

  Please consider that there are no sources of plant water, industrial water or firewater directly at the site. Therefore, TANK CONTRACTOR shall supply in another way the fresh water (for example from temporary connection, or with barges).
  Small-flow potable water is available, maximum 40-45 m^3/h (for further detail please refer to the BEDD), but to be agreed in advance with the public aqueduct.

  The water shall meet the following requirements:

  - pH > 7
  - SiO_2 on turbidity scale (clearness) < 10 ppm
  - H_2S No presence
  - Chloride < 100 ppm
  - Sulphate < 150 ppm
  - Total dissolved solids < 500 ppm
  - Residual Chlorine concentration< 0,6 ppm

Please note that requirements **for water discharge** may differ.

7.4. Ultrasonic Test

For 9%Ni type tank, the Inner Tank plates and shells, as well as ail plates and shells in cryogenic service, with thickness over 12 mm, shall be ultrasonically inspected in accordance with EN 10160:1999.

7.5. Radiograph Test

The radiographic test shall be done, as far as possible, immediately after the welding operations.

The complete record off all the radiographic tests shall be maintained.

7.6. Drying and Inerting

The Tank shall be, after final visual internal inspection and boxing up, dried and inerted. This to ensure that the maximum O_2 concentration is less than 5%, and dew point below minus 30°C, with the exception for annular space where dew point can be minus 10°C.

7.7. Purging

A detailed purging procedure shall be prepared.

The purge of tank will be done with nitrogen.

After completion of purging, the Tank shall be maintained under a positive nitrogen blanket until ready for cool down.

7.8. Cool-Down

To guide the process of controlled cool-down, a detailed procedure, stating the required rate of cool-down and the monitoring points for this shall be prepared. Utilization of nitrogen is required for the first cool-down of the tank.

First cool-down of tank shall be done with liquid nitrogen at -140°C.

7.9. Tank Performance Test

After the Storage Tank commissioning the tank performance test (e.g. BOG verification, and pumping/circulation rates) shall be performed.

TANK CONTRACTOR shall submit a tank performance test procedure.

8. DOCUMENTATION

TANK CONTRACTOR shall prepare and submit all necessary documents which shall include, but not be limited to the following:

- Calculations and drawings for the tank, including all structures, earthworks, foundations, etc., as are required to demonstrate to the CUSTOMER, national and local administration departments that the design, materials, fabrication, and erection satisfy the Specifications and Statutory Requirements.
- Design and engineering documents such as design calculations, design drawings, workshop drawings, etc.
- Equipment data.
- Fabrication, transport, and installation method statements including rigging plans.
- Quality Plans, inspection and test reports, etc.
- Welding procedures, qualifications records for the weld procedures and welders.
- Material and test certificates.
- As-built drawings.
- Operation and Maintenance Manuals.
- Spares list.

See also electrical documents listed on Par. 6.5.