CONTRACT No. 8753

FRONTIER LPG

GENERIC VLGC REFRIGERATED LPG TERMINAL

EPIC SCOPE OF WORKS

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REVISION CONTROL SHEET

Rev. No.	Date	Clause /Page	Description
1	30/03/22	2.2/P7	Tank Code and ESD Valves Amended
1	30/03/22	2.5.2/P10	Line sizes increased

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1.0 EXECUTIVE SUMMARY

1.1 General

This document has been commissioned by Frontier LPG to establish the basis for a generic VLGC scale LPG Refrigerated Terminal at most developing market locations in Africa and Asia.

The budgets presented are based on local manual and semi skilled local labour with expat supervision and normal risk profiles for developing world projects. Escalation should be considered for very isolated locations with higher risk, poor supply chains, poor local skill levels and punitive tax regimes.

Lloyd Jones Construction, who have extensive design experience of all terminals through connected common shareholding to both BC&T Consultants (www.bct-consultants.co.uk) and JM Dixon (www.jmdixon.com) in the UK, are a specialist EPC Contractor offering liquefied gas terminals (LPG, Ammonia, DME, CO_2, Ethane, LNG, etc) on a turnkey basis.

1.2 LPG Berth

This document is based upon the implementation of facilities on an existing site with deep water berth (12.5m LAT) suitable for berthing modern VLGC carriers 84-93,000m^3 capacity along with an access trestle carrying a service road and pipe rack.

For simplicity it has been assumed the pipeline distance from the jetty to the terminal facility will be around 300m in length and a further platform alongside the main jetty access trestle shall also act as a location for firewater to be extracted.

Should a greenfield location have no existing berth then a steel piled quay with mooring dolphins, firewater platform and 300m trestle can be created generally for approximately $20-30m depending on local conditions.

1.3 LPG Terminal

Fundamentally the reader should be aware that higher integrity lower QRA (Quantitive Risk Assessment) risk profile LPG terminals carry a greater cost. Should a terminal be deployed in a generous site, say in excess of 300m x 500m, then the risk profile may be contained within the site boundary and external risk is mitigated to a large degree.

Should the facility be sited in a congested port with neighbours in close proximity, then further mitigation may be required. Mitigation of the QRA risk level, usually known as the LSIR (location specific incident risk) contours, is usually achieved by the following.

- EN 14620 defines a number of containment systems for liquefied gases ranging from single containment to double containment and onwards to full containment with a choice of materials (steel or concrete) for the secondary shell and roof. The ultimate design (on a safety basis) is considered full containment with an outer concrete shell and roof. A

further step which minimises landscape impact and eradicate external fire risk completely is to inset the tank inground and use a proprietary membrane system.

- A higher integrity practice is to use submersible pumps in the tank as the system is then not prone to a liquid leak from the suction flange. This however is difficult to achieve using a steel outer containment tank as the pump and stilling well roof loads are significant for the roof to support and a secondary structure is required. For a concrete roof design, the pump in tank load is not an issue. Having external pumps also allows maintenance and repair which in a developing country is a significant consideration.

The design proposed in this document is based on the following.

- Large sites > 500m x 300m with total land requirements determined by QRA
- VLGC berth for 55-60,000 DWT, 230-240m LOA, 84-93,000 m³, 12.5m draft LAT
- Double containment steel outer / steel inner tank
- External pumps with dual internal safety valves
- High Integrity Safety Instrumented System (SIS)

The anticipated cost for such a facility would be around $85m at current market conditions and would take 27-33 months to implement on a standalone basis.

Should risk and planning permissions be a major factor, the business case needs to evaluate whether the project is viable using inset full concrete containment for the two tanks along with in tank pumps which will increase the EPC valve for the terminal to around $100m at current market conditions.

2.0 SCOPE OF WORKS

2.1 General

The investment scope of works is based upon the provision of the following major assets.

- LPG Storage (2 x 50,000m³)
- LPG Export Pumps
- LPG Compressors
- LPG Liquefaction Plant
- LPG Road Tanker Loading
- LPG Ship Import/Re-Export Pipelines
- LPG Ground Flare
- Odorant Storage and Injection
- Plant Control and Monitoring System (PCMS)
- Safety Instrumented System (SIS)
- Enterprise Resource Planning (ERP) System
- Emergency Power Generation (Diesel)
- Photovoltaic Arrays
- Uninterruptable Power System (UPS)
- Power System
- Lighting Protection System
- Earthing System
- Instrument Air System
- Firewater Pumps
- Firewater Mains, Deluges and Monitors
- Buildings
- Roads, Kerbing and Site Finishes

- Drainage
- Fencing
- Lighting

2.2 LPG Storage

2.2.1 General

The storage shall be designed to operate on all LPG grades.

2.2.2 LPG Storage Tanks

- 2 off 50,000m³ gross volume
- EN 14620 full containment steel/steel tanks
- Foam glass insulation to foundation
- Polyurethane spray foam to primary shell
- Polyurethane spray foam to secondary shell
- Mineral wool insulation to suspended deck extending to secondary shell
- +180 mBarg /-50°C
- Design liquid density 750 kg/m³ (Future proof design for Ammonia 682 kg/m³at -33°C and DME 735 kg/m³ at -25°C)
- Primary internal hydraulic safety valves
- Secondary all welded hydraulically actuated vale within annulus

2.2.3 Foundation

The tank shall be sited upon a piled foundation with reinforced concrete raft as determined by local geotechnical conditions.

2.2.4 Access Staircases

Each tank will have an external access staircase from the secondary shell.

2.2.5 Solar Arrays

The rooves to both tanks, which are normally classed as safe area, shall be fully covered with photovoltaic panels to provide more than 300kW of peak power per tank based on a surface area of 1800m² per tank for a 50m diameter tank in regions of high solar gain.

Areas around the PRVs and process connections shall be devoid of panels in accordance with LPG Codes for siting electric apparatus.

The panels shall provide further shading effect and diminish heat ingress into the tank further also providing a carbon offset to the operation.

2.3 LPG Process Area

2.3.1 General

The majority of process plant shall be sited between the two storage tanks under a shaded process area.

2.3.2 LPG Pumps

Each tank is paired with two variable speed drive transfer pump which enables all operations to be undertaken from one LPG storage tank should segregated grades be required.

- 4 off LPG Pumps
- 300 m³/hr @ 160m head 1450 rpm
- 90 kW Variable Speed Drive
- API Plan 11 Seal System

2.3.3 LPG Compressors

Boil off management from heat ingress into the facility is normally provided by LPG compressors injecting vapour into the loading lines. This essentially provides free refrigeration with some limited heating effect to the cold loading operation.

The compressors and liquefaction plant then predominantly operate during the daytime operating on solar power derived from the PV roof of the storage tanks. At night the tank pressure is allowed to rise and then reduced again during the day.

The facility is then equipped with six (6) air cooled dry lubricated compressors with each compressor belt driven and provided with suction knock out pot protection.

- 108 m³/hr @ 890 RPM
- 22 kW 1450 rpm DOL Start

The compressors provide other maintenance services such as line clearing and vapour recovery.

2.3.4 LPG Liquefaction Plant

The major heat load in a refrigerated facility is derived during import.

During this operation additional boil may be derived by the following.

- Cooling import lines (can be minimised by line cooling in advance)
- Reliquefying displaced vapour in the tank (can be minimised by vapour balancing to the ship)
- Energy used in pumping LPG by the ship
- Falling atmospheric barometric pressure from bad weather fronts

To manage this process two large oil injected economised screw compressor packages with water condensers shall be deployed for boil off control during imports.

- Approx. 4,000 m³/hr @ 1450 RPM
- 350-450 kW 1450 rpm VFD Start

The liquefaction plant normally only operates once or twice per month during a ship import.

A cooling circuit shall be deployed to provide cooling for the LPG liquefaction plant using a cooling tower and freshwater circulation.

2.3.5 LPG Heating

An LPG heating plant to heat LPG to a duty point of -5°C for loading six road loading bays to 300m³/hr shall be provided. The heating plant shall use air heating using an intermediate heat transfer fluid.

The plant is only to be utilised when mixtures with a content greater than 20% Propane are handled otherwise direct cold loading is deemed acceptable. Should this not be required for initial operations it may be engineered as a retrofit.

2.4 LPG Road Tanker Loading

2.4.1 General

Six fully automated loading positions shall be provided.

2.4.2 Weighbridges

Each loading position shall utilise a three (3) panel galvanised steel frame 60 Tonne capacity weighbridge using 12 load cells to provide individual axle weights for both tractive unit and LPG trailer. The weighbridge shall be to internationally recognised metrology requirements.

2.4.3 Road Loading Bays

Each loading position shall have the following configuration.

- 1 off per bay 3" 300# Liquid Line, 3" breakaway to 3" composite hose to 3" full bore valve with 3" dry break coupler (or local equivalent connection)

Vapour balancing may not be required due to the cold loading process and lines shall be cleared at the end of the loading sequence to minimise the weight of the hose assembly.

2.4.4 Earth Interlock

Each road loading bay shall be interlocked with an earth grounding system.

2.4.5 Deluge System

Each bay shall be deployed with a deluge system to provide a minimum of 10.2 l/min/m² coverage.

Each bay shall be activated by the central safety instrumented system (SIS) on confirmed fire. All bays shall be activated concurrently using a latching deluge valve.

2.4.6 Sunshade

No sunshades are required for the loading operation. This shall enable further firewater to be deployed in the event of a fire using a fixed monitor or hoses.

2.5 LPG Jetty Import/ Re-Export

2.5.1 General

The berth shall be equipped with an import system designed to receive refrigerated imports at 2,000m³/hr from Mid Size Gas Carriers (MGC), Large Gas Carriers (LGC) or Very Large Gas Carriers (VLGC).

2.5.2 Import Lines

Two 12" A333 Grade 6 low temperature service import line pipe stressed to ANSI B31.3 for cold contraction shall be deployed from the berth area to the storage tanks.

2.5.3 Loading Hoses with Emergency Release Coupling

The loading berth shall be equipped with the following ship connection facilities.

- 10" lightweight composite loading hose
- 10" emergency release coupler
- 10" Self Closing ESD (Emergency Shutdown) Valve

2.5.4 Re-Exports

Heated exports from the storage to pressure / semi-refrigerated ships shall be achieved at a maximum flow rate of 300 m³/hr based on the limitations of the heating plant.

Cold exports up to 1,200m³/hr, assuming road loading is dormant, may be achieved.

2.5.5 Piperack

A high-level pipe rack shall be provided to support the new lines.

2.6 LPG Flare

2.6.1 General

The LPG flare shall be naturally aspirated and designed to provide boil off management during total loss of power or repeat mechanical failure of boil off handling equipment. It shall not be rated to provide boil off management during a ship import where multiple redundancy already exists. Should both power (grid/emergency) and/or the reliquefication plant not be available then the import operation shall be suspended.

The flare shall be rated for 200% of the calculated heat ingress to the storage tanks and anticipated to be no more than 500m³/hr capacity due to the high levels of insulation in the full containment tankage.

2.7 Odorant Storage and Injection

2.7.1 Odorant Tank

A stainless steel horizontal Pressure Vessel for storage of Ethyl Mercaptan or other stanching agents shall be provided with the following attributes.

- EN 13445
- 6 Bar(g) / Full Vacuum
- 6m³ Capacity
- Carbon Vent
- 1 x 100% PRV
- Level Gauge and Transmitter

2.7.2 Odorant Pumps

Stenching shall be undertaken on import at 25 mg/kg.

Stenching shall be achieved using two (duty/standby) positive displacement diaphragm metering pumps. Pumps shall be variable speed drive to allow ratio matching to the import flow rates by the plant control system.

2.7.3 Bunding

The odorant storage and pumps shall be bunded for spill containment complete with two offloading piers to receive Intermodal Bulk Containers (IBCs). Transfer shall be means of Nitrogen pressurisation of the IBC using cylinder Nitrogen with a regulator.

2.7.4 Shading

The tank and pumping facilities shall be contained in an insulated galvanised steel enclosure providing secondary containment for any releases of odorant during maintenance.

2.8 Plant Control and Monitoring System (PCMS)

2.8.1 General

Process instrumentation shall be deployed continuously monitoring pressure, temperature, level, and flow for all major process movements (import, storage and export).

This data shall be cabled back to an instrument room within the Control and Utility Building and monitored by dedicated Plant Control and Monitoring System (PCMS) providing safeguarding, control, monitoring and event logging.

The Plant Control and Monitoring System (PCMS) shall be based upon a Single Mode Redundant platform (approx. 500 I/O) with Scada graphics mimics (approximately 40 screen pages).

The PCMS shall be integrated with a server-based database archiving process movements and reconciliation of LPG Inventory to an ERP (Enterprise Resource Planning) Management System normally deployed in an operation business for accounting purposes.

2.9 Safety Instrumented System (SIS)

2.9.1 General

A central dual mode redundant Safety Instrumented System (SIS) designed to SIL2 shall be deployed on a second platform with approximately 200 I/O (input/output). The Safety System shall be housed in a separate area of the cabinet suite with field cabling for safety loops segregated from PCMS wiring.

The SIS and PCMS systems will communicate with the SCADA system and with each other via recognised communication protocols.

The Safety Instrumented System consolidates several systems together and provides real time information graphically for the following function groups.

2.9.2 Point Gas Detectors

Infrared cell point gas detection shall be provided to all high-risk areas for advanced detection of release of LPG to the following areas.

- LPG Storage Tank Annulus (12)
- LPG Tank External ESD (2)
- LPG Pump Seals (4)
- Road Loading Bays (6)
- Manifold Riser Flanges (2)
- Jetty Area (3)

2.9.3 Fire Detectors

Triple IR fire detectors shall be deployed to the following zones

- LPG Road Loading Gantries (12)
- Process Manifold Area (4)
- Jetty Area (2)

2.9.4 Emergency Shutdown Devices

The facility will feature further instruments allowing shutdown of the plant in a safe manner by operational personnel.

- Localised ESD Push Button (16)
- Site Wide ESD Push Button (4)
- Beacons (10)
- Sounders (10)

2.9.5 ESD Valves

All major process lines shall be automatically isolated on ESD activation using fail safe self closing pneumatic fire safe antistatic ESD valves with position switches to confirm open / close status and line monitored solenoid valves for activation.

2.9.6 CCTV System

All fire detectors shall be dual function and CCTV enabled to provide plant monitoring in the control room.

Further CCTV shall be provided to all process areas and the perimeter boundary. A further 20 cameras are envisaged.

2.10 Citect Database Server

To consolidate all project data two servers will be provided that will act as the main SCADA servers. All plant data (alarms, trends, events) will be stored redundantly on the servers. Data regarding product movements will be available and can be stored locally on the server database or can be pushed to the client's database.

2.11 Operations Workstations

Two SCADA client PC's will be provided to allow operator access to the system.

A third engineering workstation will be provided containing all the engineering tools to perform faultfinding / diagnostics tasks on the systems.

2.12 IT Network

A secondary network for ERP operations shall be implemented with a dedicated server for general company communications.

Normal corporate IT functions such as email shall not be undertaken on operations workstations in the interest of avoiding viruses and cyber-attack.

2.13 Power System

Power shall be provided at 11 kV directly from an HV feed to switch room.

Within the switch room the following has been allowed for:

- One 1200 KVA HV/LV resin encapsulated transformer
- HV protection and switching
- Generator auto switching function
- Motor control center
- Segregated distribution board for non-essential service
- Segregated distribution board for essential services
- UPS (15 minutes) for changeover to solar or emergency power
- Solar Inverters
- Battery Back Up for critical operations 20 hours duration

2.14 Emergency Power

Emergency power shall be provided by 2-3 diesel generators suitably sized to cater for all operations including ship offloading during nighttime operations.

2.15 Lighting System

2.15.1 Road Lighting

Site lighting using high level flood lights shall be provided to all areas.

2.15.2 Mound Lighting

Mound lights shall be LED Exe suitable for hazardous area applications.

2.15.3 Emergency Lights

Battery supported emergency lights shall be provided to the tank staircases, loading areas exit routes and process area exit routes.

2.16 Earthing and Lightning Protection System

2.16.1 Earthing

Earthing shall be provided to all electrical apparatus.

2.16.2 Lightning Protection

Lightning protection shall be provided for the LPG Storage, Road Loading Gantries and Control and Utility Building.

2.17 Instrument Air System

Two 11kW 7 Bar(g) oil free screw compressor packages each with air receiver shall be provided dimensioned to support opening all ESD valves after a shutdown within 2 minutes.

Instrument Air shall be segregated and only serve the new mound and loading facility. Distribution shall be by means of a 1 ½" stainless steel piping system.

2.18 Firewater System

2.18.1 General

Firewater shall be provided extracting seawater from the berth.

2.18.2 Firewater Pumps

Two (duty/standby) diesel firewater pumps to NFPA 20 shall be provided to deliver 630 m^3/hr at 7 Bar(g). The pumps shall be submerged vertical units made from seawater resistant materials such as cupronickel or gunmetal.

2.18.3 Firewater Piping

All above surface piping shall be carbon steel.

Jetty firewater feed lines shall constructed with a higher corrosion allowance in Sch 80 piping. On site piping shall be spooled galvanised construction in Sch 40.

All piping shall be painted red in a high build epoxy paint system.

2.18.4 Firewater Main

The above ground jetty firewater line shall be 12" and shall split into a site wide buried 10" polyethylene firewater ring main.

2.18.5 Deluge Valves

All deluges shall be activated using a latching deluge valve with manual bypass in parallel. There shall be one deluge valve per road bay to minimize water demand in a fire.

2.18.6 Road Deluges

Road loading facilities shall be protected using automated deluge systems.

Each deluge shall be fabricated from galvanized steel piping and be a free-standing self-supported structure. The deluge shall be designed based on full uniform impingement of the LPG Road Tanker shell without reliance on rundown.

2.18.7 Monitors

Twelve (12) 4" inlet high range monitors each with integral riser isolation ball valve and high flow variable stream 2½" nozzle shall be deployed.

2.19 Buildings

2.19.1 General

All building shall be constructed from concrete roof and frame, concrete block infill and rendered.

Insulation shall be deployed to all rooves with waterproof heat reflective silver or white membrane tanking above.

Parapet walls shall be deployed throughout with solar shading to windows by concrete cantilever shading.

All buildings shall be provided with an individual septic tank/percolation area facilities per building. No sewer network shall be provided.

2.19.2 Control and Utility Building

The control and admin building shall feature the following facilities.

- Control room

- Engineering room
- Instrument room
- Switch room
- Solar Inverter, Battery, and UPS Room
- Toilet
- Kitchenette

The building shall have a shallow basement foundation and suspended floor to facilitate the extensive field cabling to the switchgear and instrument rooms.

Individual split unit ACs shall be deployed to the building with condensers roof mounted and not visible by means of an extended parapet to the building or wall mounted to the rear of the building facing the site boundary.

2.19.3 Operations Building

A further building for administration of the terminal shall be provided featuring.

- Offices (4)
- Toilets
- Shower
- Lockers
- Kitchen
- Mess

2.19.4 Generator Building

A separate building housing generators shall be provided.

2.19.5 Firewater Building

The firewater pumps shall be housed in a concrete frame/block/render building alongside the jetty access trestle. This platform is assumed to be existing.

Pumps shall be vertical and long shafted to extract seawater directly from the sea below. The platform should be sited where seawater depth is at least 5m at low tide to minimize sand entrainment when pumps are extracting seawater.

2.19.6 Instrument Air Building

Instrument Air shall be housed in a permanent building.

2.19.7 Gatehouse

A gatehouse with main CCTV control facilities and a toilet shall be provided.

2.20 Potable Water Storage

2.20.1 General

A centralized freshwater storage of 36m³ shall be provided using fiberglass or polyethylene tankage.

Water shall be distributed by pumped polyethylene mains to all consumer locations and shall allow flushing of the jetty firewater mains.

2.21 Diesel Storage

2.21.1 General

Double skin diesel tanks shall be provided at the following locations.

- Firewater Pumps
- Emergency Generators

Each tank will be sized to give 48 hours of continuous operation.

No vehicle bunkering is envisaged.

2.22 Roads and Gravel Finishes

All roads shall be macadam finish with pin and flush kerbs. Surface water shall shed by cross falls wherever possible to avoid subterraneous drains which may collect LPG vapour.

All residual surfaces shall be gravel finish with weed prevention fabric to prevent propagation of weeds.

2.23 Drainage

Drainage shall be by French drain to the site perimeter with discharge to sea. Areas where diesel may be handled shall be bunded with oil/water separator before effluent can progress to localized drains.

2.24 Boundaries

2.24.1 General

Galvanised steel palisade fencing 2.9m in height shall be deployed along with access gates fabricated in matching style where required.