

VSL LNG AND LPG CONTAINMENT STRUCTURES



POST-TENSIONING
ENGINEERING
HEAVY LIFTING
FORMWORK
REPAIR AND
STRENGTHENING

VSL: KNOW-HOW TO BUILD ON

Leader in specialist construction



Ras Laffan LNG, Qatar - 1996



Barge N'Kossa, France - 1997



Tokyo LNG, Japan - 1993



Taichung LNG, Taiwan - 2005

VSL: a worldwide network

VSL's construction systems have been used throughout the world since 1956 and are technically proven, earning a well-deserved reputation for safety, quality, reliability and experience. This has led to VSL being recognised as an international leader in the field of specialist construction systems and engineering methods.

The VSL network, with profit centres established in over 35 countries, is working closely with partners and clients from the initial stage all the way through to the successful completion of the project utilising 'Swiss' quality partnered with local knowledge to offer the most efficient construction solutions.



Sines LNG, Portugal - 2002

VSL's services in LPG and LNG containment structures

- Post-tensioning
- Engineering
- Heavy lifting
- Formwork
- Repair and strengthening

For projects, both large and small, VSL's engineers and technicians have made it their goal to identify and resolve potential problems in order to ensure projects are carried out smoothly and efficiently.

VSL's project staff, working together with VSL's high-tech Research and Development department, aims to constantly refine, improve and expand the scope of VSL's systems and services.

With active members of technical committees, such as *fib* & PTI, and a global network of extensively trained engineers and specialists, VSL is able to stay ahead of the ever changing demands of the industry so as to provide the highest level of technical support to projects and clients.

VSL: guided by a strong QSE culture

VSL's leadership is based on a rigorous and committed quality culture. The QSE (Quality, Safety, Environment) policy represents a major focus for any service provided with the aim to continuously improve performance. In the VSL culture, the company's employees are vitally important and VSL is committed to maintain the highest level of client satisfaction and safety of its people.

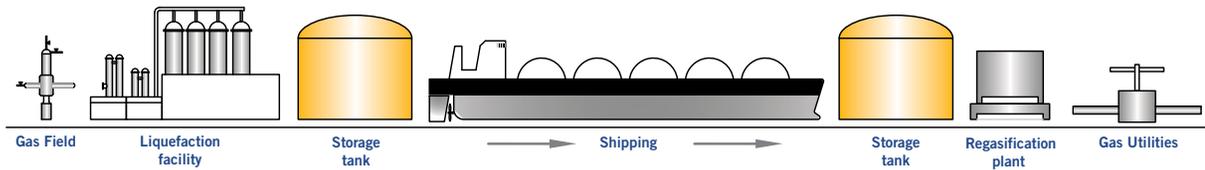
Changing the way we do business

For VSL, sustainable development (SD) means striking a balance in its development model between the economic profitability of its businesses and their social and environmental impact. That commitment is formalised into the VSL SD program which focuses on safety, use of fewer scarce materials and less energy and production of less pollution and waste.



LNG AND LPG APPLICATIONS

Double-walled tanks with post-tensioned concrete

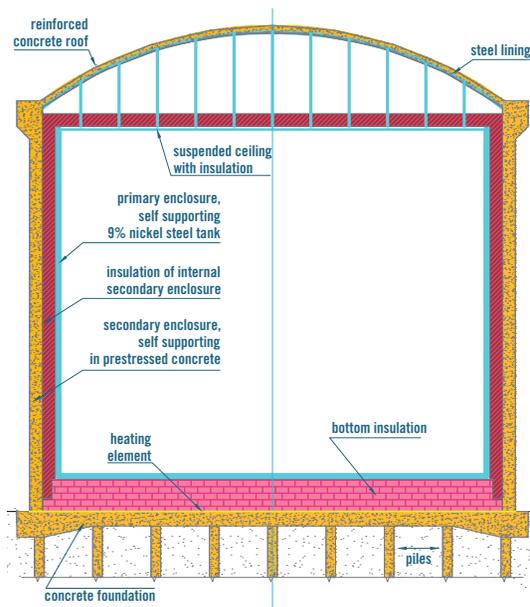


Processing liquified gas

Cost-effective and easy to maintain

Storage of the liquefied gas is provided by two elements:

- The primary or inner containment of the tank, to meet the extreme demands of cryogenic conditions (in the case of LNG), are typically constructed of high nickel content steel, aluminium, stainless steel or in some cases post-tensioned concrete and must be able to independently withstand the hydrostatic load of the liquid.
- The secondary or outer containment is most commonly constructed from post-tensioned concrete and is designed to withstand abnormal loads of external origin as well as retaining the liquid and vapours should there be a fracture of the primary containment.



The above ground tank is the most commonly used method for storage of LNG and LPG.



Markets worldwide need more energy

The world's energy consumption is projected to increase considerably over the next 30 years with fossil fuels continuing to cover the majority of the world's energy needs.

The global demand for gas will continue to grow and countries with a domestic surplus of natural gas may look to convert the gas into liquefied natural gas (LNG) or liquefied petroleum gas (LPG) which is subsequently contained in specially developed storage tanks and shipped to areas where natural gas is required.

LNG is composed primarily of methane (86% to 99%) which, when cooled to -165°C , condenses to a liquid at atmospheric pressure (liquefaction) reducing the volume by approximately 625 times. The resulting cryogenic liquid is odourless, non-corrosive and non-toxic.

LPG is composed mainly of propane and/or butane and liquefies at higher temperatures than LNG and is contained at temperatures below -50°C so as to condense it into a liquid reducing the volume by a factor of roughly 250 times. A powerful odorant of ethanethiol is added to the mixture so as to detect leaks of the gas.

Fujian LNG, China - 2006



VSL POST-TENSIONING AND ANCHORAGE

The most efficient structural solution for LNG and LPG

Extensive experience

VSL is recognised as an international leader in LNG and LPG tank construction.

Versatility

5 different types of anchorages to suit varying project requirements

Enhanced efficiency

Improved force distribution with VSL's PT PLUS® ducts

Compliant with international standards

Post-tensioning systems compliant with ETAG* 013 requirements and have been tested under cryogenic conditions

Full encapsulation

Greater tendon corrosion protection

Unique AF Anchorage

Allows vertical tendons without the requirement for a stressing gallery

*ETAG: European Technical Approval Guidelines

Stressing at the buttresses Vertical stressing



the leak tightness enabling the secondary containment to contain the liquefied gas in case of failure of the primary containment. It also leads to improved durability against corrosion of the structure.

VSL technology is based upon the principle of post-tensioning where the prestressing force is permanently introduced into the structure once the concrete has hardened via the stressing of high-strength prestressing tendons.

Thinner walls

Post-tensioned concrete is typically chosen for the secondary containment to allow a thinner wall than conventionally reinforced concrete. The reduced crack width achieved with post-tensioned concrete leads to an improvement in

Through the constant refinement of VSL's technology from over 50 years within the industry, VSL's Post-tensioning systems complies with the requirements of national and international standards as well as the specific needs of each individual project.



AF anchorages



L anchorages

SYSTEMS

Applications



GC Anchorage: This compact and easy to handle stressing anchorage with a cast iron bearing-plate and machined steel anchor-head has been successfully tested and confirmed for cryogenic applications. The GC Anchorage, VSL's new generation of anchorage, replaces the extensively used EC Anchorage.



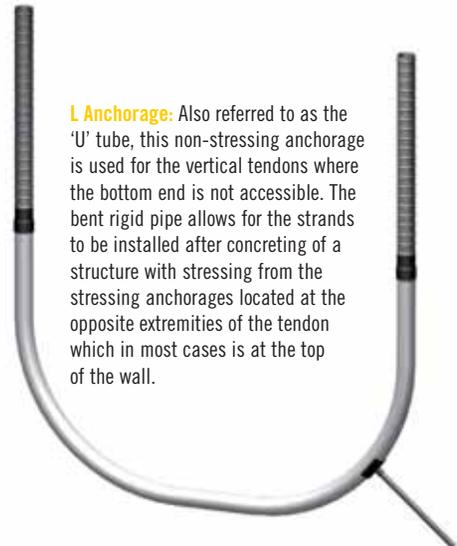
E Anchorage: This stressing anchorage comprises of a machined steel bearing-plate with a steel trumpet and a machined steel anchor-head. The E Anchorage was the first of VSL's anchorages to be confirmed for cryogenic applications.



CS Anchorage: Developed for increased fatigue and corrosion resistance, VSL's high performance stressing anchorage comprises of a cast iron bearing-plate and a machined steel anchor head. The anchorage can be supplied with full encapsulation if greater corrosion protection is required.



AF Anchorage: A unique VSL design for the lower non-stressing anchorage of the vertical tendons where access to the underside of the tank is not possible. It is made of cast iron and is another of VSL's new generation of anchorages. The strands, equipped with compression fittings, are installed one-by-one, the first-stage grouting of the anchorage (using VSL's high performance AF Anchorage grout with a compressive strength in excess of 100 MPa) is carried out, the tendon is stressed and finally the free length of the tendon is grouted.



L Anchorage: Also referred to as the 'U' tube, this non-stressing anchorage is used for the vertical tendons where the bottom end is not accessible. The bent rigid pipe allows for the strands to be installed after concreting of a structure with stressing anchorages located at the opposite extremities of the tendon which in most cases is at the top of the wall.



In addition to the standard steel spiral ducting, VSL offers the **PT-PLUS®** high resistance plastic duct with improved corrosion protection and also better force distribution along the tendon's length as a result of the reduced friction coefficient.

Please refer to the VSL Post-tensioning solutions brochure for further details.

VSL: COMMITTED TO QUALITY

Fit for cryogenic applications and enhanced durability

VSL's Research & Development department has tested anchorages under cryogenical conditions to ensure the material performs as required at extreme temperatures in the unlikely event of a failure of the primary containment. This has involved the full scale testing of various tendon assemblies at extreme temperature conditions to assess the potential failure modes.

VSL's E Anchorage, as well as the new generation GC Anchorage, have both been successfully tested and confirmed for cryogenic applications.



Grouting - the critical final step

Through many years of experience, VSL stresses the importance of high quality grouting to ensure the long term durability of a post-tensioned tendon. Under the trademark VSL-HPI® (High Performance Injection), VSL has developed a full process dedicated to improving the quality of grouting activities on site: the locally available grout constituents are checked for their compatibility and the grout mix is designed and optimised for stable, low bleed grouts so as to ensure the complete filling of the ducts in order to provide a fully alkaline environment for the steel materials.

Where there are potential fluctuations in local cement and/or grout admixtures quality, VSL has also developed the VSL-HPI® pre-bagged high-performance grout mix which satisfies all

standard tests for bleed, flow time, strength and volume change as well as the more stringent requirements of the inclined tube test, wick induced bleed test, mud balance test and stability of flow time, ensuring a consistently high standard of grout.



VSL Academy – World's first post-tensioning training center

To ensure the highest level of know-how and quality control in all countries, VSL has made a strategic decision to formalise and standardise the training of all its foreman, supervisors and site managers at a centralised facility.

The VSL Academy integrates VSL's world-wide technical knowledge so as to provide each trainee with proven expertise with regards to VSL's Post-tensioning systems. The expert trainers provide theoretical and practical sessions for all trainees. VSL Academy provides specific training spread over three stages, all in accordance with international recommendations for qualification and training of personnel in specialist post-tensioning companies.



The VSL Academy represents a major step in ensuring a consistent approach and a wider sharing of post-tensioning best practice.

Damietta LNG, Egypt - 2005



Fujian LNG, China - 2006



Hazira LNG Tank, India - 2003



LPG Project, Middle East - 2006



Pyong Taek LNG, Korea - 1996



Cartagena, Spain - 1998



Dabhol, India - 1999



Dragon LNG, UK - 2007



Huelva, Spain - 1989



CREATING SOLUTIONS TOGETHER

GROUND ENGINEERING



Ground anchors



VSoL® walls



D-walls & Piles



Ground improvement



Ground investigation

CONSTRUCTION



Bridges



Buildings



Slab on grade



Nuclear Containments



Offshore structures



LNG & LPG containments

REPAIR, STRENGTHENING & PRESERVATION



Heavy lifting



Structural diagnostics & Monitoring



Formwork & Equipment



Repair & Strengthening



Infrastructure Preservation



Infrastructure Protection

SYSTEMS & TECHNOLOGIES

- Post-tensioning strand systems
- Bars & post-tensioning bar systems
- Stay cable systems
- Damping systems (stays & buildings)
- Ductal® ultra-high performance concrete
- Bearings & Joints

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