LNG Tank Monitoring - Application Note

FIBER OPTIC LNG TANKS
INSTRUMENTATION & SAFETY MONITORING

Liquefied Natural Gas (LNG) is natural gas compressed at medium pressure but cooled at -169°C (-260°F) to maintain its liquid form for ease of storage and transportation. The volume of natural gas as liquid is 1/600th of its volume as gas.

The storage of LNG is mainly design in two ways: in specially-designed sea vessels or in large reservoirs (LNG Tanks). While the first method does require monitoring, Roctest has been involved mainly with LNG tank monitoring. The pipelines used inside the LNG terminal (for transportation, regasification, etc.) may also require monitoring.

The storage tanks

Many different designs of LNG tanks are used worldwide. One of the most common construction design consists of the following:

- A thick concrete base slab of approx. 90m in diameter
- A 40m high double wall tank (outer wall made of concrete, inner wall made of stainless steel/nickel composite)
- A suspended roof covered with a dome-shaped reinforced concrete roof.

To insulate the outer wall from the cryogenic temperature of the liquefied natural gas, several means of insulation are installed between the outer and inner walls (also called the annular space):

- A resilient blanket (in essence, a pile of curtains) beside the inner wall
- Perlite insulation (similar to powder) that entirely fills the annular space by vibration compaction
- The corner protection (steel curtain) along the outer wall up to a height of 10m.

The typical distance between each wall is less than 1m and the temperature inside the annular space ranges from -160°C (at the inner wall) to approx. -50°C near the outer wall. Between the storage tank and the slab base are multiple layers of concrete and insulation.

Dunkirk LNG Terminal
We are a leading expert in optical sensing, particularly fiber optic sensing to monitor LNG structures. We offer a wide variety of sensors using leading-edge technology and we can assist you in identifying the best products for your project and budget.

**BENEFITS OF OUR INTEGRATED HEALTH MONITORING SOLUTIONS AND LEAK DETECTION SYSTEMS FOR LNG TANKS**

1. **Integrated solutions** Deliver complete solutions, using a combination of fiber optic technologies and vibrating wire sensors.
2. **Quality assurance** Verify that new and existing structure performance meets design.
3. **Safety assessment of LNG tanks immediately following a major event** Monitor its condition after earthquakes, leakages or fires.
4. **Optimized security and maintenance** Provide Structural Health Monitoring data on the real condition of the LNG tanks.
5. **Remote access** Structural Health Monitoring on LNG tanks provides critical information such as temperature, movement or deformation due to thermal contraction/expansion of inaccessible locations inside the tank.
6. **Comply with regulations in many countries** Government agencies around the world require structural health monitoring to be part of the design of LNG Terminal projects.
7. **Easy to integrate with other monitoring systems** Our Structural Health Monitoring system works on almost any protocol such as Modbus, and can easily be hooked on any PLC used with other monitoring systems.
8. **Quick visualisation of points of interest** Our HMI-like software can easily be used by technical people without a structural engineering degree; critical data is shown in a fully graphical mode.
9. **Rugged equipment** Our sensors are designed for harsh environments such as extreme cold temperatures, heavy construction, rough manipulation, etc.

**INSTRUMENTATION AND SAFETY MONITORING IS PERFORMED WITH INSTRUMENTS THAT MEASURE:**

- Leaks in tank annular space
- Integrity of LNG tanks, hydrostatic test
- Underground LNG storage facilities deformation monitoring

**TECHNOLOGIES**

- Strain surface measurement: Fabry-Perot (FISO)
- Temperature distributed: DiTemp DTS Raman

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**Displacement sensor in tank annular space**

**Leakage and displacement in tank annular space**

**Leak detection of LNG tanks**
SLAB STRAIN MONITORING

During construction, monitoring temperature and strain in the concrete may accelerate construction time as these two parameters will give you critical information on different stages of concrete curing. It can also indicate if unexpected load is applied at specific locations in the concrete slab during construction of the remaining section of the reservoir. It is finally a very cost-effective quality control tool that will help the General Contractor for assessing quality throughout the whole construction period.

SETTLEMENT UNDER THE TANK

It is a proven method to monitor settlement of the concrete slab during construction, hydro-testing and normal operation, is the use of an inclinometer probe that is manually inserted inside a pre-installed inclinometer casing. While it is a manual method, it provides one of the most accurate results on the market for such measurement. Other monitoring methods are also available to automate this task.

HYDRO-TEST

The step before filling the tank with LNG is to perform Hydro-testing to monitor the behavior of the tank using water instead of LNG. For LNG tanks designed with double walls, monitoring the movements of the inner wall in comparison of the outer wall could be done in a cost-effective way by using specially designed sensors with a dial gauge that will only be used during the hydro-test.

TILTING OF THE TANK

Along with settlement at the slab level and movements within the annular space, another parameter that is usually monitored is the inclination of the concrete outer wall of the reservoir. Using electrical tiltmeters, it is easy to follow tilting movements via a remote station on a permanent basis, during construction and the normal operations of the LNG terminal.
ANNULAR SPACE MONITORING: VERTICAL MOVEMENTS

Once the hydro-tests are complete and the stability of the tank is confirmed, there are always risks that on the long term, differential movement (between the inner wall and the outer wall) within the tank occurred, mainly due to the weight of LNG inside the tank. Our unique solution, using intrinsically safe (IS) fiber optic sensors especially designed for this application, can monitor that type of movement and isolate it from other structural movements that may influence the result. This sensor can sustain cryogenic temperature (-169°C) on a permanent basis.

ANNULAR SPACE MONITORING: HORIZONTAL MOVEMENTS

It is expected that medium pressure and low temperature (approx. -169°C) inside the LNG tank cause differential movements between the outer and inner walls: the inner wall will « shrink » more or less uniformly and cause movements between the two walls. It is however almost impossible to quantify these differential movements without our horizontal monitoring system. As with the sensor for vertical movement, it is also isolating movement due to shrinkage of the inner wall from other structural movements such as settlement or rotational movement during that phenomenon.

ANNULAR SPACE MONITORING: ROTATIONAL MOVEMENTS

The third dimension of potential differential movement between the outer and inner wall is rotation: cold temperature and low pressure, causing « shrinkage » might also provoke rotational movement that may bring strain within the inner wall. This sensor can monitor the slightest movement, using intrinsically safe (IS) fiber optic technology designed in such a way that it also isolates movement due to shrinkages of the inner wall from other structural movements such as settlement and contraction of the inner wall.

TEMPERATURE MONITORING AND LEAK DETECTION

Temperature within the tank is a critical parameter that needs to be measured, using multiple Resistance Temperature Detectors (RTD) inside the tank in order to get some kind of temperature profile of the tank during operation. Our Intrinsically Safe Fiber Optic Distributed Temperature Sensor (DTS) can give an unparallel amount of information on temperature inside the tank with just a single fiber-optic cable installed at different levels along the perimeter of the tank. Leakage detection becomes, therefore, much more efficient as well as cost effective.
LNG PROJECTS REFERENCES

SURFACE LNG PROJECTS
- Zeebruge - Belgium
- Dunkerque LNG - France
- Damietta - Egypt
- Hariza - India
- Bonny Island - Nigeria
- LNG Storage - Qatar
- Huelva - Spain
- Huelva II - Spain
- Huelva III - Spain
- Huelva IV - Spain
- Cartagena - Spain
- Barcelona LNG - Spain
- Freeport LNG - USA
- Cameron LNG - USA
- Gulf LNG - USA
- Canaport LNG - Canada
- Arzew LNG - Algeria
- PTT LNG (phase 1 and 2) - Thailand
- S-LNG - Singapore
- Wheatstone LNG - Australia
- Dunkerque LNG - France

UNDERGROUND LNG PROJECTS
- Elgas - Austria
- Ningbo - China
- Pyongtech - Korea
- Taejon - Korea
- U1 - Korea
- U2 - Korea
- Sines - Portugal
Smartec is the leading developer, manufacturer and supplier of innovative sensing technologies based on vibrating wire and fiber optic sensors for geotechnical and structural instrumentation.

We are featuring a complete line of conventional sensor-based solutions ranging from the ultra-robust traditional vibrating wire technology to state-of-the-art fiber-optic technology used for the measurement and monitoring of geotechnical projects and structural health monitoring (SHM) of critical assets such as: dams, tunnels, mines, buildings, bridges, nuclear power plants and many other structures too numerous to list.

Smartec offers a wide range of pressuremeters, rock dilatometers, laboratory and in-situ testing equipment for soil and rock.

**Services**

- System Design
- Installation, Operation and Maintenance
- Data Management
- Data Analysis

**Other available Application Notes**

- FO Leak Detection for Dams and Dikes
- Dam & Dike Instrumentation and Safety Monitoring
- Tunnel Instrumentation & Structural Health Monitoring
- Bridge Instrumentation & Structural Health Monitoring
- Building Instrumentation & Structural Health Monitoring
- Historical Monument Instrumentation
- Geotechnical and Structural Monitoring
- Nuclear Power Plant Instrumentation
- FO Movement Detection in Tunnels
- FO Leak Detection for Chemical Plants
- FO Leak Detection for Pipelines
- Storage Facility Instrumentation
- LNG Pipelines Monitoring