



FLOATING OFFSHORE GAS UNITS

FEASIBILITY, SAFETY
AND PERFORMANCE

Move Forward with Confidence



**BUREAU
VERITAS**

FLEXIBLE SOLUTIONS FOR THE LNG INDUSTRY

GROWING DEMAND FOR NATURAL GAS IS LEADING PRODUCERS TO SEEK SAFE, FLEXIBLE SOLUTIONS FOR EXPLOITING OFFSHORE GAS. BUREAU VERITAS IS PROVIDING VITAL SUPPORT TO THE DEVELOPMENT AND OPERATION OF FLOATING OFFSHORE GAS UNITS.

Increasing demand for natural gas as a clean-energy alternative to traditional fossil fuels has resulted in unprecedented innovation in the global offshore LNG industry. In the last 10 years, producers have made rapid improvements in efficiency in the LNG value chain, first through the use of re-gasification vessels, then the development of Floating Storage and Regasification (FSRU) and Floating Liquefied Natural Gas (FLNG) units.

These innovations are transforming the LNG industry by enabling all upstream and midstream activities – production, transportation storage, offloading and re-gasification – to take place offshore. They bring a number of key advantages, including lower costs, faster time to market and greater flexibility. This flexibility enables gas players to respond more easily to changes in global gas demand, and serve the needs of fast-growing countries – an important advantage in today's rapidly-changing market.

MEET THE CHALLENGES OF FLNG AND FSRU DEVELOPMENT WITH A TRUSTED INDUSTRY PARTNER



in research and development, combined with our experience across a range of projects makes us a key partner in qualifying new technologies.

We draw on our 50 years experience in the LNG industry, onshore and offshore, and our 187 years promoting safety at sea. In this way, we use our technical expertise, advanced software and in-depth knowledge of regulations to maximize safety, performance and compliance of new floating offshore gas projects.

Bureau Veritas is a leader in classification and other services to support the feasibility of floating offshore gas projects. Over half the world's FSRUs, including the world's largest, are classed to Bureau Veritas rules. We also classed the first ever FLNG to reach completion, EXMAR's FLNG.

The services we offer are based on our technical skill, and real-life experience of the challenges faced by the industry when designing and building vessels. Our strength

→ KEY ADVANTAGES OF FLOATING OFFSHORE GAS UNITS

- **GET PRODUCTION UP AND RUNNING FASTER** by removing the time spent on permitting issues, laying pipeline to the coast and building onshore processing facilities.
- **REDUCE COSTS**
Construction or conversion costs for an FSRU can be as little as a fifth of the cost of an onshore import terminal. And while construction costs for FLNGs are currently high, the ability to move vessels at the end of a project to a new location, and start production immediately, cuts costs significantly in the long term.
- **GAIN FLEXIBILITY** by moving your facility as required and respond easily to global changes in gas demand.
- **IMPROVE SPEED TO MARKET**
Shipping directly to markets around the world cuts time to market by around 30-40%. Similarly, at the point of regasification, an FSRU conversion can be completed in just over a year, versus 5-7 years for an onshore terminal.
- **MINIMIZE ENVIRONMENTAL IMPACT** as a result of offshore location. Direct shipping also improves operational carbon footprint.
- **INCREASE FEASIBILITY**
Use smaller-sized FLNGs to exploit hard-to-reach or small gas fields in, for example, South-East Asia, and ensure untapped resources are left to a minimum.

WHY CHOOSE BUREAU VERITAS?

—
Protect your vessel, your crew and the environment

—
One of the oldest classification societies (established 1828)

—
The Bureau Veritas brand: a mark of reassurance

—
Industry-leading research, knowledge and technical expertise

—
In-depth knowledge of regulations

—
Extensive global network

—
Long-term partner to the LNG industry

—
Unrivalled experience: involved in the world's first two FLNG projects, and classification partner to more than half the world's FSRUs

FLNG: THE LATEST FRONTIER IN LNG INNOVATION

In an FLNG project, offshore gas reserves are exploited at the point of extraction, rather than being piped to onshore liquefaction plants. An FLNG can therefore be used to unlock "stranded" gas fields that are too small or remote to justify building a pipeline to land. Gas is pumped out of the seabed and transferred to a large structure permanently moored above the field, where it is treated, liquefied, stored and later transferred to LNG tankers for delivery to international markets.

Smaller FLNGs can also be combined with permanently moored floating storage units, or offload directly onto shuttle tankers.

FLNG is in its infancy, with the first two projects to complete in the next few years: Shell's Prelude, capable of producing 3.6 million tonnes of LNG each year off the coast of Australia when it begins operation in 2017, and EXMAR's smaller-sized FLNG, completed 2015.

Bureau Veritas has played an important role in both projects, via services ranging from classification, quality control, risk assessment and asset integrity, making us uniquely placed to support the industry in developing FLNG solutions.



SERVICES TO SUPPORT THE FEASIBILITY OF YOUR PROJECT

1/ REDUCE RISK

Bureau Veritas' mission is to help identify, prevent, manage and eliminate risks. While FSRUs and FLNGs present some safety advantages compared to both onshore LNG terminals and offshore oil platforms, a number of issues need to be taken into consideration when building and operating an offshore facility. These range from sea conditions, the type of liquefaction plant and cargo transfer, to marine environmental impact, risk of fire and explosion, security and evacuation and in-service maintenance. Bureau Veritas' services help you meet these challenges and achieve peace of mind.

→ MOORING ANALYSIS AVOID UNPLANNED SHUTDOWNS

Offshore operators need to understand the behavior of their mooring systems and floater, and have confidence in their reliability. Bureau Veritas provides full assessment of mooring design at the outset of a project, as well as providing support service once the facility is in operation, including training, mooring inspection and an Emergency Response Service.

→ NON-DESTRUCTIVE TESTING MAINTAIN CONFIDENCE IN SAFETY AND INTEGRITY

Non Destructive Testing (NDT) covers a wide range of analysis techniques used to evaluate the properties of a material, equipment or system without causing damage. Bureau Veritas is a highly recognized worldwide provider of NDT services for both vessels and LNG processing and storage equipment.

→ **INSPECTION**
REDUCE RISK FROM YOUR
INDUSTRIAL SUPPLY CHAIN

The quality and safety of components used in the construction and maintenance of offshore units, from raw materials through to pipes, valves and lifting equipment, are vital to the safety of the overall structure. We provide a range of inspection and verification services including shop inspection services at the place of manufacture; inspection upon delivery; and in-service inspections of on-board equipment.

→ **HSE AND RISK ASSESSMENT**
REDUCE OR ELIMINATE
OPERATIONAL RISK

LNG producers face numerous operational risks, ranging from employee and contractor safety to environmental risk, asset damage and interruptions to production. Bureau Veritas' safety engineering risk management and technical services, including HAZID and HAZOP, use advanced modeling tools to provide analysis of the potential impact of each hazard. We also help operators implement Process Safety Management (PSM), offering PSM technologies and expertise locally through our network of Technical Centers.

→ **SAFETY FEATURES**
AND TOPSIDE LAYOUT
OPTIMIZE SAFETY,
ACCESSIBILITY AND EFFICIENCY

A key challenge in designing floating offshore gas units is space: fitting all necessary modules, both hazardous and safe, in or above the same hull, and in a way that does not put the personnel, asset or operations at risk. Bureau Veritas builds on its background in offshore and onshore industrial engineering to offer topside layout assessment in compliance with recognized standards and supported by risk studies.

→ **HYDRODYNAMIC**
& HEADING ANALYSES
TAKE INTO ACCOUNT COMPLEX
MARINE ENVIRONMENTS

Floating units must be able to adapt to heavy wind, waves and current. Hydrodynamic analysis assesses the behavior of an FSRU or FLNG at sea, including its ability to withstand wave pressure, hull girder wave loads and accelerations, and the impact of green seas on the topside. Heading analysis, meanwhile, is used to assess the ability of a turret moored floating asset to weathervane depending on the direction of wind, waves and current. We use in-house ARIANE and HydroSTAR software to support our simulations and calculations.

→ **ASSESSMENT OF STRUCTURE**
AND FATIGUE ANALYSIS
EVALUATE AND PROVE
YOUR HULL STRENGTH

Floating units cannot easily be dry-docked, and structural repairs while units are in operation are difficult. Bureau Veritas helps you avoid unplanned shutdowns by offering a complete set of structural analyses to support hull assessment of vessels.

→ **SLOSHING ASSESSMENT**
SAFEGUARD AGAINST
CONTAINMENT SYSTEM
DAMAGES

Offshore floating units need to operate safely with tanks partly filled, but wave motion creates sloshing loads that may damage containment systems. We perform sloshing analyses according to methods defined in Bureau Veritas guidance notes and Rules (NR 467, NI 554, and NI 564) and supported by our advanced HydroStar and OpenFOAM software for CFD computations.

2/ IMPROVE PERFORMANCE

One of the advantages of floating offshore gas units is their long projected working life: once a gas field has been exploited, or demand reduces from a gas importer, the facility is simply moved to another location instead of being decommissioned. This presents its own challenges in terms of design and integrity management, as operators must anticipate future requirements and ensure long-term performance.

Bureau Veritas offers expert advice from the outset of a project, through design reviews and assessment at each stage (conceptual design, FEED and EPC).

The aim: to provide you with confidence that your asset design meets performance specifications, and complies with standards and guidelines that draw on best practice. We also offer specific assessments for noise and vibration from design stage, to optimize future working conditions and ensure compliance.



→ BOOST PERFORMANCE OVER THE LIFE OF YOUR ASSET

Once a unit is in operation, Bureau Veritas supports performance throughout the lifecycle. Asset Integrity Management is designed to ensure the offshore facility and its components continue to perform efficiently and safely throughout the asset's anticipated service life, and potentially beyond. It typically comprises regular inspections, data collection and management, risk and structural assessment and corrosion management.



3/ ENSURE COMPLIANCE

Bureau Veritas, a leading classification society, has risen to the challenge. In 2005, we introduced a specific guidance note (BV NR 542) for classification of offshore LNG terminals, covering production, liquefaction, storage and re-vaporisation, as well as structural and site notations. As well as classifying new FSRUs and FLNGs, we are able to classify conversion projects. As the industry is in its infancy, we have adopted a collaborative approach: for example, our work on EXMAR's FLNG involved using existing rules as a starting point, before developing additional relevant guidance notes to meet the needs of the project.

The LNG industry has evolved rapidly in the last 10 years, improving efficiency by moving offshore key segments of the value chain- treatment, liquefaction, storage and transfer to a transportation vessel. This has resulted in the need for new classification rules to provide owners and operators with confidence in the safety of their asset.



→ CONFIDENCE IN EQUIPMENT, INSTALLATIONS, PROCESSES AND NEW TECHNOLOGY

Through our certification programs, we also support operators in ensuring the compliance of on-board equipment, installations and processes. These include traceability of materials, review of workers' qualifications, witnessing of factory testing, installation and commissioning, and internationally recognized ISO certifications relating to the environment, systems and processes.

An important focus is qualifying new technologies. These are often introduced to improve safety and environmental performance or increase production efficiency, however as new entrants to the market, they do not benefit from recognized standards and rules. For example, offloading from LNG carriers to FSRUs is an important focus in new technology qualification as new side-by-side and tandem offloading systems are developed. We remove uncertainty for operators by assessing technology performance against defined objectives.

Finally, we provide Safety Case management and review services, to meet demands by regulators worldwide to justify ongoing operation of offshore units.

50 YEARS OF LNG INNOVATION

BUREAU VERITAS HAS BEEN INVOLVED IN EVERY MAJOR INNOVATION IN LNG SINCE THE BIRTH OF THE INDUSTRY, MAKING US WELL POSITIONED TO MEET THE CHALLENGES OF FSRU AND FLNG DEVELOPMENT.

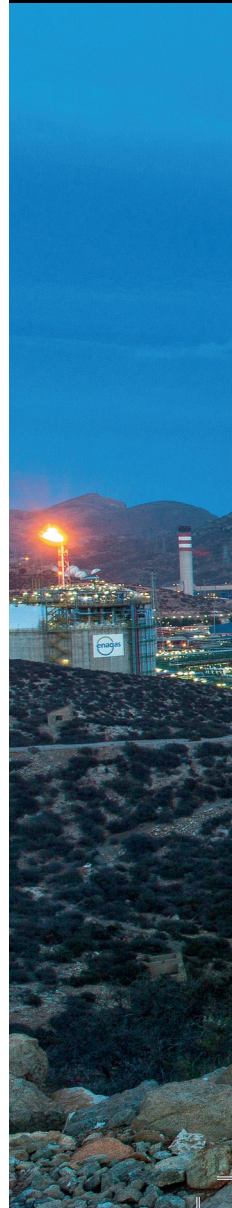
Bureau Veritas has been involved in every major innovation in LNG transportation and offshore LNG extraction and processing since the late 1950s.

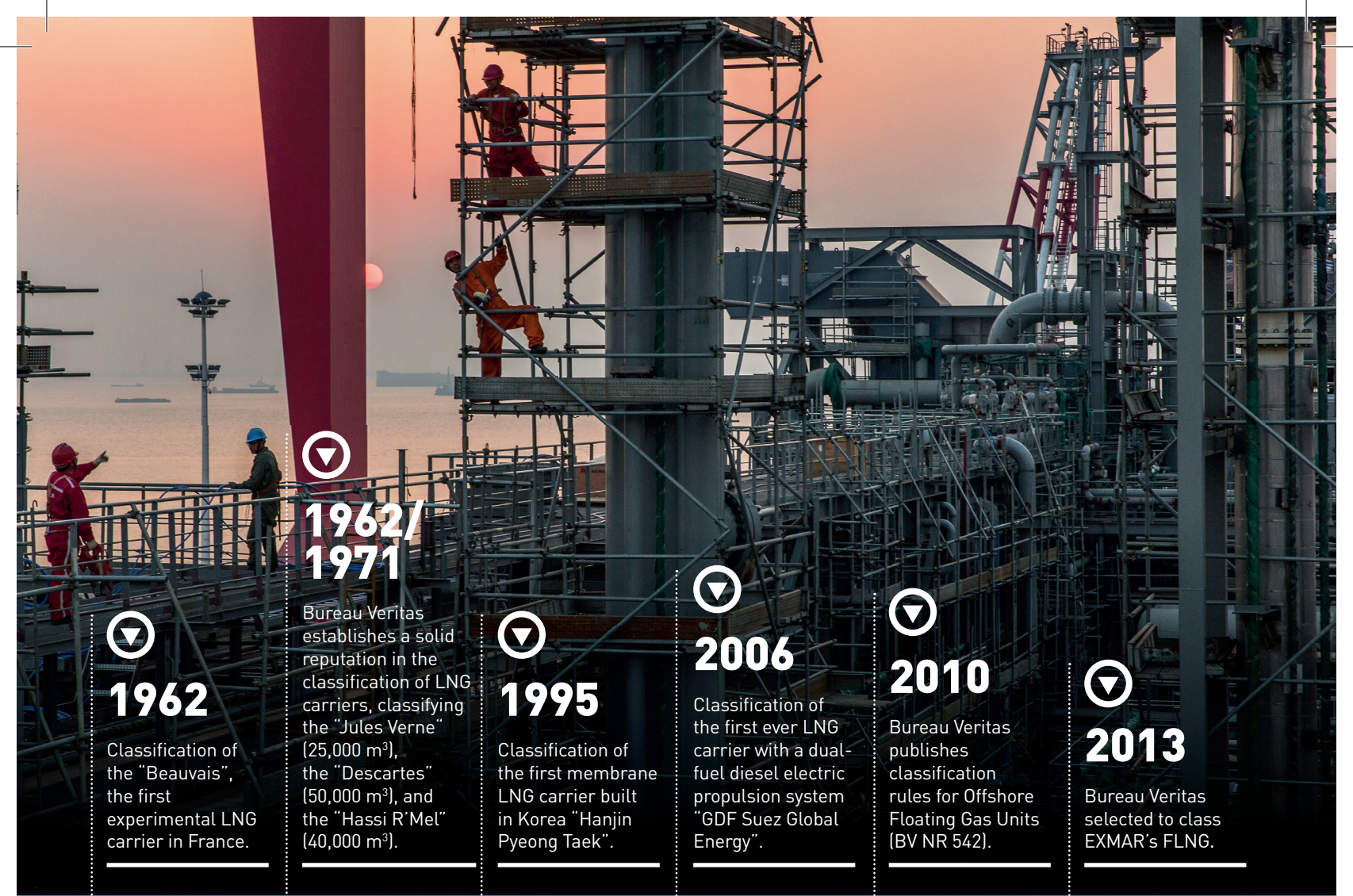
From the introduction of membrane type containment systems in the 1970s, to the development of re-gasification vessels, multipurpose gas carriers and floating storage units in the last decade, Bureau Veritas has been present every step of the way.

The result is unparalleled knowledge and experience of the LNG industry, which we share – and continue to develop – with our clients.



→ 200 + OFFSHORE
FLOATING UNITS USING
BUREAU VERITAS SERVICES





1962

Classification of the "Beauvais", the first experimental LNG carrier in France.



**1962/
1971**

Bureau Veritas establishes a solid reputation in the classification of LNG carriers, classifying the "Jules Verne" (25,000 m³), the "Descartes" (50,000 m³), and the "Hassi R'Mel" (40,000 m³).



1995

Classification of the first membrane LNG carrier built in Korea "Hanjin Pyeong Taek".



2006

Classification of the first ever LNG carrier with a dual-fuel diesel electric propulsion system "GDF Suez Global Energy".



2010

Bureau Veritas publishes classification rules for Offshore Floating Gas Units (BV NR 542).



2013

Bureau Veritas selected to class EXMAR's FLNG.



1962

Bureau Veritas publishes the first specific class Rules for LNG carriers.



1972

The first membrane LNG carrier is built to Bureau Veritas class. At 125,000 m³, the "Ben Franklin" is also the largest LNG carrier to date.



2005

Classification of the first two LNG re-gasification vessels, the "Excellence", and the "Excelsior".



2009

The first multipurpose gas carrier, the "Coral Methane", is built to Bureau Veritas class.



2010

Bureau Veritas selected to carry out hydrodynamics and structural analysis on Shell's Prelude FLNG.



2014

Bureau Veritas selected to class the world's largest FSRU, MOL's 263,000 m³ vessel built by DSME.



190 YEARS OF CONFIDENCE

**OUR WORLDWIDE NETWORK ENSURES WE
MEET YOUR NEEDS WHEREVER YOU OPERATE.**

A global leader in testing, inspection and certification, Bureau Veritas serves clients' needs around the world in quality, health, safety, environmental protection and social responsibility. For 190 years, our clients have looked to us to provide technical support, verify compliance, or obtain certification. Our mission is to help identify, prevent, manage and eliminate risks.

Our network of over 1,400 offices and laboratories meet our clients' needs, wherever they are in the world. We pride ourselves on our technical expertise, impartiality and detailed knowledge of international and local regulations.

We offer three principal services. Testing provides confidence that commodities are of the right quality, and conform to specifications. Inspections of facilities, equipment and products are designed to reduce risk and meet regulatory requirements. Finally, certification represents a third party stamp of approval that a product, service or system conforms to a specified standard.

We are a leading player in commodities testing, and long-term partner to the onshore oil and gas industries. This puts us in a unique position to serve the needs of the offshore industry, as we are one of the few major classification societies to have deep expertise throughout the oil and gas value chain.





LONGSTANDING PARTNER TO LNG AND OFFSHORE INDUSTRIES

Our testing, inspection and certification services cover both onshore and offshore, giving us an unrivalled understanding of the energy sector. We are involved in all sectors of the energy industry, from oil and gas through to nuclear and renewables, and at all stages, from extraction and processing to distribution. We are a leading classification society for offshore structures.

A KEY PLAYER IN OFFSHORE RESEARCH AND DEVELOPMENT

Alongside our own research, Bureau Veritas' Marine & Offshore business is involved in a number of European research programs, and several joint industrial projects with the oil and gas industries. This has led to the development of areas of expertise such as hydrodynamics, vibration and structural fatigue. We have also developed advanced calculation and simulation tools to analyze the behavior of offshore structures.

OVER 1,000 ACCREDITATIONS AND AUTHORIZATIONS

Our wide range of accreditations and authorizations across a range of industry sectors prove that we operate professionally and that our reports and certifications are recognized and respected. We also hold 145 delegations of authority on behalf of national maritime authorities.





**BUREAU
VERITAS**

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Bureau Veritas - Marine & Offshore

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