Our Mission

The mission of ABS is to serve the public interest as well as the needs of our clients by promoting the security of life, property and the natural environment primarily through the development and verification of standards for the design, construction and operational maintenance of marine-related facilities.

Quality & Environmental Policy

It is the policy of ABS to be responsive to the individual and collective needs of our clients as well as those of the public at large, to provide quality services in support of our mission, and to provide our services consistent with international standards developed to avoid, reduce or control pollution to the environment.

All of our client commitments, supporting actions, and services delivered must be recognized as expressions of Quality. We pledge to monitor our performance as an on-going activity and to strive for continuous improvement.

We commit to operate consistent with applicable environmental legislation and regulations and to provide a framework for establishing and reviewing environmental objectives and targets.
### Classification, Certification & Related Services for Gas Carriers

#### Introduction ......................................................................................................................... 3

#### The ABS Advantage ............................................................................................................ 4

#### A Multi-Level Approach to Service ..................................................................................... 8

#### Required Classification & Statutory Services ..................................................................... 9

- Design Analysis, Plan Review & Approval ............................................................................. 9
- Surveys During Construction .................................................................................................. 12
- Surveys After Delivery ........................................................................................................... 16
- Transfer of Class ...................................................................................................................... 18
- Major Conversion Services ..................................................................................................... 19
- Statutory Services ................................................................................................................... 20

#### Optional Class-Related Services & Notations ................................................................... 22

- Technical, Engineering & Rule-Related Services .................................................................... 22
- Hull & Machinery Maintenance Services .................................................................................. 33
- Integrated Management Systems Certification .......................................................................... 36
- ILO Maritime Labour Convention Services ............................................................................ 36
- Project Management Services .................................................................................................. 37
- Fleet Management Systems ......................................................................................................... 37
- Optional Notations ...................................................................................................................... 38
- Training Services ....................................................................................................................... 40
- Information Services ............................................................................................................... 40

#### Services Provided by Companies Affiliated with ABS ....................................................... 41

- Technical & Engineering Services .............................................................................................. 42
- Operational Services .................................................................................................................. 46
- Support Services ......................................................................................................................... 49
Setting Standards of Excellence
in the Classification & Certification of Gas Carriers
Classification, Certification & Related Services for Gas Carriers

ABS offers a comprehensive range of classification and related services to designers, builders, owners and operators of gas carriers. The principal elements of the ABS Gas Carrier program are summarized in this handbook. More complete details can be obtained from an account representative at the nearest ABS office.

Introduction

As one of the leading class societies, ABS is able to provide a wealth of practical and technical experience throughout a gas carrier project. For new construction, ABS engineers and surveyors work closely with an owner’s technical staff and the selected shipyard to verify conformance with the ABS Rules and applicable regulatory standards.

After delivery and for existing vessels, a network of nearly 3,000 ABS engineers, surveyors and operational support staff are located around the world to service the ABS-classed fleet and deliver efficient, practical and responsive assistance.

ABS’ experience covers liquefied natural gas (LNG) carriers of all sizes up to and including the largest LNG carriers of 270,000 m³ in addition to the new generation of floating LNG (FLNG) units. We currently class nearly a quarter of the existing LNG carrier fleet. In addition, ABS serves the liquefied petroleum gas (LPG) carrier market, classing both the traditional small ships and the recent generation of very large gas carriers (VLGCs). ABS has also been at the forefront of setting standards for both compressed natural gas (CNG) carriers and compressed liquid natural gas (CLNG) transportation systems and providing advice regarding the carriage of CO₂.
Gas Carrier Classification – the ABS Advantage

The ABS experience, technology and services outlined in the following pages demonstrate our commitment to being the preferred provider of classification services to the marine industry and, in particular, to the gas carrier sector.

Our Commitment

Our mission is to promote the security of life, property and the natural environment. We pursue this mission primarily through the development and verification of compliance with technical standards that encourage robust designs and the provision of solutions-oriented survey services. Vessels built and maintained to these standards may be accepted into and retained in class by ABS.

We are committed to providing superior technical and survey services that assist our clients in conforming to these standards, thereby encouraging safe, efficient operations.
Our Fleet

ABS is one of the largest classification societies in terms of gross tons and numbers of vessels in class. The ABS fleet profile covers all principal vessel types with tankers and bulk carriers dominating. However, ABS has gained a reputation for its pioneering technical work with gas transport that has supported innovation in the carriage of gas. ABS has more than 50 years of experience classing LPG and LNG carriers, including classing the first conversion of a cargo vessel to carry LPG, the first purpose-built LNG carrier and the first ice class LNG carrier. ABS maintains a strong orderbook of class contracts for new LNG carriers, the majority of these on order from the principal shipyards in Korea, Japan, and China. ABS works closely with the shipbuilders and the design offices around the world, providing technical assistance from the earliest stages of the design process.

The first LPG floating storage and offloading (FSO) and floating, production, storage and offloading (FPSO) units to enter service were also built to and are maintained to ABS class standards. Both of these units use the IHI Self-supporting, Prismatic-Shape, IMO Type-B tank system or SPB. ABS has experience with every current type of liquefied gas containment system. Most recently, ABS has worked closely with its industry partners on the development and approval of the new generation of floating LNG units (FLNG).

ABS has also worked alongside CNG developers to provide a comprehensive framework of reference material and acceptable methodologies for achieving class society approval of new CNG technology contained in the ABS Guidance Notes for Building and Classing Ships Carrying Compressed Natural Gas. All current designs for CNG and CLNG carriers have received approval-in-principle (AIP) from ABS.
New & Novel Gas Concepts

In addition to the traditional LNG and LPG fleets, industry looks to ABS to validate new and novel ship and gas containment, transport and terminal designs. ABS has provided its Approval in Principal or AIP to numerous concepts for the transport of natural gas. ABS guidance for building and classing offshore LNG terminals has facilitated industry development of both gravity-based and floating terminals contemplated for offshore installation. ABS has also provided class services for several floating LNG (FLNG) and floating storage and re-gasification unit (FSRU) concepts. The projects have ranged from the conversion of smaller, older LNG carriers to serve in a new role to technically novel concepts for newbuildings that can handle both LNG and LPG.

ABS’ evaluation of a floating gas project is based upon the application of prescriptive requirements, seakeeping studies, structural and fatigue analysis, assessment of the containment system and includes sloshing analyses and an evaluation of the station-keeping systems. As applicable, particularly for novel elements within a new floating LNG project, ABS reviews the topsides, the gas processing and liquefaction plants or the re-gasification modules and uses advanced risk analysis to verify compliance with accepted safety standards. A number of ABS publications are referred to for floating gas facilities including the ABS Guide for Building and Classing Offshore LNG Terminals as well as international standards such as the International Maritime Organization’s Gas Code as applicable.

Specialized analysis and technical studies may also be applied including: mooring analysis, containment system sloshing analysis, gas dispersion and heat radiation analysis, a cryogenic liquid spillage and structural protection study, vibration studies to analyze the impact of the topside processing facilities on the hull as well as other detailed process and marine systems studies.
Our Staff

Engineers and surveyors are located close to client operations around the world to support the ABS-classed fleet. ABS maintains engineering offices in Korea, Japan, China, Singapore, Greece, Italy, India, Brazil, the United Kingdom, the United States, Turkey and other centers to facilitate the design review of the gas carriers on order to ABS class.

Our experienced professionals provide technical support and assistance to clients from the initial design concept, through the design approval process, during construction and throughout the entire service life of the vessel.

ABS also offers a comprehensive LNG carrier training program that is used both within ABS and to assist clients around the world. A team of ABS surveyors have been specially trained and qualified in surveying gas carriers and have been located to major LNG trading ports and repair and inspection facilities around the world.

Our Gas Industry Leadership

ABS played a leading role among classification societies in contributing to the development of the IMO (then IMCO) Code for the construction and equipment of ships carrying liquified gases in bulk (the Gas Code). ABS was the first classification society invited to join the Society of International Gas Tanker and Terminal Operators (SIGTTO). ABS is also a member of the Center for Liquefied Natural Gas and the Centre for Marine CNG.

ABS’ Technology department has a dedicated staff addressing technical issues surrounding the transport of gas, from guidance on propulsion issues for LNG carriers to undertaking one of the most advanced studies in the field of computational fluid dynamics (CFD). ABS developed the industry’s first comprehensive guidance for CNG carriers, and ABS remains at the forefront of technical solutions for gas transport.

Our Fees

ABS services can be tailored to an owner’s fleet profile and operational and management requirements. These approaches include Master Service Agreements and Five Year Survey Fee packages as appropriate.
A Multi-Level Approach to Service

ABS service delivery consists of three categories, tailored to meet the specific needs of owners and operators of gas carriers.

Category I consists of the range of services associated with the issuance and maintenance of the classification and required statutory certificates. Owners may then choose to select from the range of additional products and services offered in Categories II and III.

Category II consists of several valuable, optional, class-related services provided by ABS including elements as diverse as training and advanced structural analysis to the fleet management software provided by ABS Nautical Systems. This category also includes additional notations that may be used by the owner to demonstrate that the vessel has been designed or is being operated in accordance with standards beyond those required under Category I for routine classification and statutory certification.

Category III consists of several additional optional products and services provided by companies affiliated with ABS including ABS Consulting and ABS Quality Evaluations.
Category I

Required Classification & Statutory Services

These services have been designed to assist an owner or shipbuilder to design, construct and deliver a gas carrier that conforms to the applicable ABS Rules as well as the IMO’s International Gas Code. These services have also been developed to assist an owner or operator to maintain the vessel to ABS class requirements throughout its operational life by conducting periodic and damage surveys.

When ABS is authorized to act as a Recognized Organization by the flag State, these services also include the applicable statutory inspections.

Category I services comprise six parts:
1. Design Analysis, Plan Review and Approval
2. Surveys During Construction
3. Surveys After Delivery
4. Transfer of Class
5. Major Conversion Services
6. Statutory Services

Design Analysis, Plan Review & Approval

Gas carriers are built to Part 5C of the ABS Rules for Building and Classing Steel Vessels, to the ABS Guide for Building and Classing Membrane Tank LNG Vessels (as applicable) and the ABS Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks as well as the IMO International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).

Gas carrier designs intended to be built to ABS class undergo various engineering reviews as well as structural analysis by ABS engineering staff. A suite of proprietary computer programs is used to evaluate the effects of static and dynamic loadings for LNG carriers, including:

- **Hull Structural Analysis**
  ABS reviews material selection, welding procedures, scantlings, overall strength, local strength and local stress concentrations, buckling and fatigue.

- **Machinery Systems**
  ABS focuses on piping and electrical systems considering the consequences of a loss in propulsion capability, maneuverability or electrical power.
• **Cargo Containment Systems**
ABS reviews and can perform its own independent tank calculations to verify the tanks are in accordance with the ABS Rules and IGC Code.

• **Cargo Handling Systems**
ABS examines a proposed system for compliance with ABS Rules and the IGC Code, including piping arrangement, piping system analysis, loading and unloading systems, venting and gas-freeing systems as well as procedures for cooling, loading and discharge.

• **Critical Machinery & Cargo System Components**
ABS reviews manufacturers’ engineering drawings for critical components against the applicable Rule requirements.

• **Sloshing & Partial Loading**
ABS reviews sloshing impacts due to partial filling with advanced proprietary sloshing simulation programs. High dynamic loads and impact sloshing pressure on the insulation system, tank structure and the pump tower are also assessed.

• **Structural Analysis**
ABS performs structural analysis of the various types of containment systems (membrane tanks, spherical tanks or independent prismatic Type B tanks). These offerings are discussed in Category II, Optional Class-Related Services and Notations. ABS requires an ABS SafeHull evaluation for LNG carriers with membrane containment systems.

**Plan Review**
ABS provides responsive professional technical services to the designers, builders and owners of gas carriers. These services are offered through a network of local engineering offices that have been strategically placed in the major shipowning and shipbuilding centers. Specially trained ABS engineering staff have been located in the principal gas carrier building nations of Japan, Korea and China.

Our engineering staff can work with the designer from the earliest conceptual stage of a gas carrier project, providing advice on the application of the ABS Rules and the relevant statutory regulations.
ABS Eagle Engineering Manager

ABS has implemented an advanced, secure, electronic engineering management system, ABS Eagle, that is used during the design and plan review process. Wherever possible, the shipyard and equipment manufacturers submit drawings in electronic format. Paper drawings are scanned into the system and the reviews are handled onscreen. For shipyards directly using the system, ABS Eagle Engineering Manager provides online, web-based interaction between the shipyard’s design team and the ABS engineers undertaking plan review of the structure and machinery.

Teams of ABS specialists in different engineering disciplines can work on the design review simultaneously. When requested by the shipyard, the number and identity of the reviewing engineers can be restricted and their actions are fully traceable as part of the system’s built-in security safeguards.

For each drawing or information package submitted, the status of comments can be viewed in real time by any of the involved parties, including the owner if so agreed in the contract between the owner and the shipbuilder. Compared to the traditional paper-based plan review process, the system offers faster overall review time and improves the lines of communication between ABS and the designers to quickly resolve questions or Rule interpretations.

ABS SafeHull

LNG carrier designs that adopt the membrane containment system are subject to evaluation using the ABS SafeHull Dynamic Loading Approach (DLA) that considers the three primary failure modes of fatigue, buckling and yielding. SafeHull transforms the complex process of the first principles approach to easy-to-use engineering calculations. The software’s finite element analysis (FEA) capability enables fatigue-sensitive areas to be identified and assessed at the design stage.

Of particular importance is the ability of SafeHull to allocate the steel within the structure in a more effective manner than is possible using prescriptive Rules. SafeHull identifies the high stress areas within a gas carrier allowing for the optimized distribution of the steel within the structure to properly account for these loads.
Surveys During Construction

Drawing from its global network of experienced surveyors, ABS will assign appropriate survey personnel to each newbuilding gas carrier project, wherever in the world construction is to be undertaken. These surveyors will verify that construction is in accordance with the Rules and approved plans. They will work closely with both the shipyard and the owner to assist in reconciling questions of interpretation.

The surveyors will also attend and/or audit steel mills, equipment manufacturers and foundries producing castings and equipment to verify that these are produced to the specifications contained in the applicable ABS Rules.

Construction Monitoring

The ABS SafeHull Construction Monitoring program is a requirement for gas carriers built to ABS Rules. The structural analyses serve to identify areas in the structure subject to higher stresses. When performing these calculations, assumptions are made about the construction standards such as fit-up, alignment and welding tolerances. In areas that are highly stressed, the as-built construction tolerances should be comparable with the tolerances assumed in the design calculations and should be free from defects that may cause stress raisers.
A construction monitoring plan for these high stress areas is prepared by the shipyard and submitted to ABS for approval prior to the start of fabrication. The plan is to include: structural drawings indicating the location of these areas as identified by the ABS review; construction standards and control procedures to be applied by the shipyard during construction; verification and recording procedures to be adopted by the shipyard at each stage of construction; and procedures for correcting defects.

During construction, ABS surveyors will verify that the construction carried out by the shipyard is in conformance with the agreed construction monitoring plan. The vessel will receive the ABS SafeHull Construction Monitoring SHCM notation to record compliance with this procedure.

**Coatings**

Vessels greater than 500 gross tons, contracted on and after 1 July 2008, must comply with the IMO Performance Standard for Protective Coatings (PSPC) requirements. The IMO PSPC requirements apply to the seawater ballast tanks of gas carriers.

ABS provides guidance to both shipowners and shipbuilders on the technical requirements of the PSPC and the role coatings play in the longevity of a vessel’s structure. Contained in the ABS Guidance Notes on the Inspection, Maintenance and Application of Marine Coating Systems, the information also takes into account the IACS Procedural Requirements (PR34) that specifically address the application of the IMO standards. Although the new standards place the responsibility for the proper application of the coatings on the shipyard, the ABS Guidance Notes clarify the issues and responsibilities for the appropriate parties.

Gas carriers built in conformance with the requirements contained in the ABS Guide for the Class Notation Coating Performance Standard (CPS) may be awarded the CPS notation.
Sea Trials
The ABS surveyor will attend the sea trials of the vessel to verify that the trials are carried out in accordance with the approved shipyard procedure and that relevant class and statutory criteria are met.

Gas Trials
An LNG carrier is required to perform gas trials before delivery. The ABS surveyor will attend the gas trials to verify that the trials are carried out in accordance with the approved shipyard procedure and that relevant class and statutory criteria are met.

The purpose of gas trials is to demonstrate the proper functioning and performance of the equipment associated with operations related to cargo handling and gas management systems, including instrumentation, monitoring control and alarm systems.

In general, the following operations are to be performed during gas trials:
- Filling the interbarrier spaces with nitrogen
- Inerting, aerating, warm-up and cool-down of cargo tanks and cargo lines
- Purging (gassing-up)
- Loading and unloading
- Cargo pump operation
- Emergency cargo transfer using emergency pumps
- Boil-off gas utilization (gas burning, reliquefaction and gas combustion)

First Loading & Unloading
ABS surveyors attend the first full loading and discharge to verify satisfactory operation of all cargo systems.
Class Notations

On delivery, a typical ABS class notation for a LNG carrier would be:

\[\text{A1, SH, SHCM, FL (30), CPS, AMS, ACCU, NIBS, TCM}\]

This defines that the:

- hull has been built under ABS survey for unrestricted ocean service (A1)
- ship complies with the ABS requirements for anchoring and mooring equipment (SH)
- hull has been evaluated using ABS SafeHull (SHCM)
- ship was subject to enhanced inspection during construction in conformance with the SafeHull Construction Monitoring procedure (SHCM)
- structure has been evaluated as having a 30 year fatigue life (FL (30))
- ship complies with the ABS Guide for the Class Notation Coating Performance Standard (CPS)
- ship’s machinery, boilers and systems have been constructed and installed in accordance with the requirements of the ABS Rules (AMS)
- ship has the means to control and monitor an unmanned propulsion-machinery space in an approved manner from the navigation bridge and from a centralized control and monitoring station installed in, or adjacent to, the propulsion machinery space (ACCU)
- ship has navigational integrated bridge system (NIBS)
- ship is subject to tail shaft condition monitoring (TCM)

Additional optional class notations may be recorded for the vessel. These are discussed in the Category II section.

On delivery, a typical ABS class notation for a LPG carrier would be:

\[\text{A1 Liquefied Petroleum Gas Carrier, SH, SHCM, AMS}\]

A notation prototype for a CNG carrier would be:

\[\text{A1 Compressed Natural Gas Carrier}\]

In addition, specific symbols will be used for gas units such as offshore LNG terminals or re-gasification facilities:

- F – Floating
- G – Gravity Base
- P – Gas Processing Facility
- L – Liquefaction Facility
- S – Storage Facility
- O – LNG Offloading
- R – Regasification Facility
- T – Terminal without Processing Equipment
Surveys After Delivery

Upon delivery and throughout its service life, an ABS-classed gas carrier is subject to the asset integrity management requirements of the ABS class survey regime. This imposes a requirement for the vessel to be subject to a series of periodic surveys – Annual, Intermediate, Special and Docking – on a rotating five year basis.

It also requires the owner to notify ABS when the vessel and/or its machinery suffers damage. An ABS surveyor will arrange to attend the vessel as promptly as possible and will verify that it remains in, or is returned to, a condition that is in conformance with the applicable Rules.

Prompt attendance by an ABS surveyor for the requisite periodic survey is made possible by the extensive, global network of strategically placed ABS survey offices.

ABS Eagle Survey Manager

To help the vessel’s owner, operator or manager plan for the required periodic surveys in an efficient, cost-effective and informed manner, ABS provides the operator with access to the advanced, web-based ABS Eagle Survey Manager program.

The ABS Eagle system has been in use for several years (formerly under the ABS SafeNet name) and has been subject to frequent enhancement and expansion. Positive user feedback gives us the confidence to consider the ABS Eagle Survey Manager system to be the most advanced, useful and easy-to-use system currently available to ship operators to monitor the classification status of their vessels.

The ABS Eagle Survey Manager efficiently manages the class and statutory data for an owner’s entire ABS-classed fleet in a web-based format. Shipowners have access to the data from multiple locations – in the office, on board a vessel or from remote sites such as a repair yard.

The ABS Eagle Survey Manager includes historical records of survey dates, locations and surveys carried out; a record of outstanding recommendations, both open and closed; and a system to integrate survey activities and review the status with the planned maintenance module.

Shipowners are able to select the interval to receive messages regarding upcoming and overdue surveys. Multicolored timelines of survey due dates significantly diminish the need to view individual listings of survey items such as hull, machinery and equipment.
ABS Eagle Survey Manager provides a wide range of informational and support services to the operator in real time from an office or on board the vessel. Services include:

- a fleet summary and complete status of class surveys for each ABS-classed vessel
- status of statutory surveys and certificates issued by ABS on behalf of the flag Administration
- timeline presentations of the class and statutory surveys completed in the previous three years, surveys in progress and surveys scheduled for the next five years including identification of grace periods
- principal particulars of each vessel
- vessel attendance history with links to related ABS reports
- an online certificate list and file containing copies of ABS-issued class and statutory certificates currently on board the vessel
- fleet level tools for budgeting within user-defined periods (such as drydockings)
- status indication of surveys completed, often before the surveyor leaves the ship
- automated on board issue of class and statutory certificates
- an owner administration module to enable the creation of an unlimited number of new users, and to select the vessel or fleets that each individual user will view
- tools for survey planning and survey guidance, including vessel-specific templates for the preparation of enhanced survey plans
- electronic booking of survey attendance and optional email progress notifications

**Port State Control**

ABS considers the Port State Control (PSC) record of vessels detained for class and/or Recognized Organization related deficiencies within the three principal PSC jurisdictions (Paris MOU, Tokyo MOU and the USCG) to be the best public accounting of the effectiveness of the ABS in-service surveys.

For many years ABS has consistently been placed among the elite tier of classification societies in each of these jurisdictions with, on average, more than 99.5 percent of ABS-classed ships subject to a port State inspection being found to be without class and/or Recognized Organization accountable detainable deficiencies.
Transfer of Class

While a gas carrier is most often classed with one society during construction and throughout its service life, some do change class either on delivery, on transfer of ownership or for other reasons. It is a relatively straightforward matter to transfer a vessel, in class with another IACS society, to ABS class while the ship is in service. Although the basic requirements are laid out by the IACS Transfer of Class Agreement (IACS PR1A), ABS has established streamlined procedures to assist an owner with the process, with minimum disruption to commercial and vessel operations. Owners can achieve significant operational and cost benefits by classing their fleet with ABS.

The owner can initiate the Transfer of Class process by contacting any ABS office. The process will then be handled by a dedicated project team who will review the ship’s status and history and coordinate the necessary requirements. The ABS project team members work closely with the owner during this process providing a single point of contact with the losing class society during the transfer.

For acceptance into ABS class, the owner of an existing ship classed by an IACS society will be asked to submit the following hull and machinery plans:

Main Plans
- General arrangement
- Hydrostatic curves
- Stability documents
- Hull structure in way of tanks (foundation, chock keys, if applicable)
- Capacity plan
- Loading guidance (if applicable)
- Cargo containment system

Hull Structure Plans
- Midship section
- Decks
- Transverse bulkheads
- Scantling plan
- Shell expansion
- Rudder and rudder stock

Machinery Plans
- Machinery arrangement
- Propeller
- Bilge and ballast piping diagram
- Cargo system operating manual
- Main engine, propulsion gears and clutch systems
- Steering gear systems, piping and arrangements
- Intermediate, thrust and screw shafts
- Wiring diagram
- Diagram of cargo piping system
- Diagram of fuel/gas piping system
- Cargo System Operating Manual
- Main boilers, superheaters and economizers (for steam turbine vessels)
A pre-inspection survey may also be necessary to confirm the overall condition of the ship. Typically, the requisite surveys to conduct a transfer of class are scheduled with current survey activities to minimize cost. As soon as the required surveys and plan reviews have been satisfactorily completed, ABS will issue an Interim Class Certificate to replace the existing classification arrangement.

ABS acts as a Recognized Organization for the major flag Administrations, issuing a range of internationally required statutory certificates on the flag Administration's behalf. When a vessel changes class to ABS from another IACS member, certain statutory certificates may remain valid. This varies depending on the flag Administration and circumstances. The ABS project team will work closely with the owner to verify that the statutory certificates are in order. Some surveys may be required depending on the validity of the certificates.

When changing class, a change in flag may also be requested and new statutory certificates may be required. The new flag Administration will determine which certificates are needed. The ABS project team will coordinate with the new flag Administration to facilitate the process for the owner. When the exact requirements of the new flag have been determined, ABS will conduct the necessary reviews and surveys.

**Major Conversion Services**

Recently ABS has seen some owners seeking to convert existing LNG carriers to an alternative configuration as either a floating storage and re-gasification unit (FSRU) or a floating storage and offloading (FSO) unit.

ABS is familiar with the technical challenges posed by such conversion projects and is able to offer shipowners and shipyards full support in facilitating the design reviews to verify continued conformance with applicable classification and statutory standards. ABS surveyors at the principal repair and conversion shipyards are also familiar with the processes and can verify that such conversions are carried out in conformance with the applicable Rules and standards.
Statutory Services

ABS is recognized by the leading international flag States and is authorized to act as a Recognized Organization on behalf of more than 120 governments. ABS carries out these responsibilities during the design stage, verifying that the design complies with the statutory requirements of the selected flag Administration, with respect to stability, load line, watertight subdivision, safety construction and safety equipment and with the applicable firefighting and lifesaving regulations as contained in the various international and national maritime codes and conventions.

These include the Safety of Life at Sea (SOLAS), Marine Pollution Prevention (MARPOL), IMO Gas Code, Tonnage, Load Line and Anti-Fouling System (AFS) Conventions and the ISM and ISPS Codes. In addition to the national or international tonnage certificates, ABS can issue Panama and Suez Canal tonnage certificates on behalf of those authorities. Once in service and when authorized by the flag State, ABS will conduct the applicable periodic statutory inspections and issue the relevant certificates.
**ISM Code Compliance**

As a Recognized Organization, ABS is authorized to act on behalf of flag States in performing audits and issuing certificates required by the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the International Safety Management – ISM Code). These include both the audits of the ship operator leading to the Document of Compliance (DOC) certificate and the audit of the ship which, when successfully completed, will result in the issuance of the Safety Management Certificate (SMC) to that ship. ABS maintains a global pool of fully qualified ISM auditors able to respond promptly to client needs.

**ISPS Code Compliance**

A large number of flag States have authorized ABS to act on their behalf as a Recognized Security Organization. In this capacity ABS can approve security plans, perform security audits of ships and issue International Ship Security Certificates (ISSC) on behalf of those flag States. The ABS *Guide for Ship Security (SEC) Notation* has been made available to assist operators in achieving compliance with the statutory security requirements of the International Ship and Port Facilities Security (ISPS) Code and in obtaining the ABS SEC notation. ABS maintains a global pool of qualified ISPS auditors able to respond promptly to client needs.

**US Coast Guard Assistance**

ABS also maintains a strong relationship with the US Coast Guard (USCG) under various, long-standing memoranda of understanding. These MOUs authorize ABS to act on behalf of the USCG on a number of issues and provide ABS with the experience and insight to offer specific assistance to owners trading to the United States who are seeking to demonstrate compliance with USCG requirements, particularly those related to environmental, safety and security issues. The USCG has also assigned a permanent Liaison Officer to ABS, located at the ABS headquarters in Houston, to facilitate communication between the two organizations.
Category II

Optional Class-Related Services & Notations

To assist owners of gas carriers or other types of gas transport concepts, ABS offers many optional services that range from detailed structural analyses to standards that address the habitability of the onboard living conditions, to enhanced safety, quality, environmental and health standards.

Category II services comprise eight parts:
1. Technical, Engineering and Rule-Related Services
2. Hull and Machinery Maintenance Services
3. Integrated Management Systems Certification
4. Project Management Services
5. Fleet Management Systems
6. Optional Notations
7. Training Services
8. Information Services

Technical, Engineering & Rule-Related Services

ABS personnel are available to provide a wide range of additional engineering-related services during the design evaluation and plan review phases of a gas carrier project. Depending on the size and type of gas carrier, these may range from a full ship analysis using the Dynamic Loading Approach (DLA) to the analysis of individual elements such as shaft alignment, vibration and sloshing.
Dynamic Loading & Spectral Fatigue Analysis

A detailed evaluation of a gas carrier's structure can be carried out using the Dynamic Loading Approach. This ABS-developed, first principles approach to the assessment of the hull structure has been applied to a large number of vessels over many years. Central to this methodology is the use of a program based on seakeeping theory for calculating the loads and response for a range of wave directions and loading conditions. The dynamic loads are then applied to a three-dimensional (3-D) finite element model of the complete vessel to assess the adequacy of the structure.

In addition, this procedure can also be used for the application of the Spectral Fatigue Analysis (SFA) method for the evaluation of structural fatigue. SFA is a rational analysis procedure for evaluating fatigue life related to local cracking of ship structures. The spectral-based method for evaluating fatigue strength due to the wave-induced responses is well established and has been extensively documented.

To streamline these procedures, ABS has integrated the proven analysis of both DLA and SFA into a single software program. Using a self-generated or user-supplied finite element model, the program can perform a thorough DLA and SFA analysis of a ship structure. Integration of 3-D seakeeping, short and long term statistical analysis, finite element analysis, strength evaluations and fatigue assessments are fully integrated within the program.

Gas carrier designs that successfully undergo an ABS DLA/SFA evaluation will be awarded optional notations denoting their evaluation by this methodology, including a notation indicating the vessel's designed fatigue life in North Atlantic conditions e.g. SFA(30).
Structural Analysis

Hull proportions and interaction between the containment system and the hull structure may suggest additional sophisticated technical analyses be undertaken. A suite of ABS proprietary computer programs, in addition to ABS SafeHull and DLA/SFA, is available to evaluate the effects of static and dynamic loadings. These programs include:

- ABS Shipmotion
- ABS ILOAD
- Vibration Analysis
- ABS Slosh: 2-D and 3-D sloshing analysis calculations to assess flow simulation and pressure
- Heat Transfer Analysis for independent or membrane tanks
- Buckling Analysis

Ice Operations & Cold Weather

ABS has conducted some of the industry’s leading research on the impact of ice loads on LNG containment systems. The comprehensive Guidance Notes on Ice Class provide operators a methodology for studying the impact of ice loads on LNG containment systems. The ABS Guide for Vessels Operating in Low Temperature Environments provides extensive practical advice for the operator sending vessels into Polar regions. ABS also works closely with the principal research institutes in Europe, Russia and North America on joint programs addressing harsh environment design and operational issues.

The principal elements in ice strengthening a LNG carrier design are: strengthening of the hull; the interaction of the hull structure with the containment system; minimum propulsion power requirements; and strength of the propeller.
Propulsion Advances

Advances in propulsion technology have expanded the offering of propulsion systems available for LNG carriers from the traditional steam turbine installation using boil off gas (BOG) to slow speed diesels; and dual fuel diesel electric (DFDE) engines to ME-GI dual fuel burning engines or gas turbines. ABS is prepared to assist owners selecting any propulsion type, and offers a Guide for Propulsion Systems for LNG Carriers which provides technical guidance for the various machinery arrangements.

ABS has been at the forefront of developing further guidelines for the equipment used in association with alternative propulsion systems, including re-liquefaction units and gas combustion units (thermal oxidizers).
Vibration Analysis

Shipboard vibration can affect the safety, functionality and habitability of a gas carrier. Excessive vibration may result in fatigue cracking of local structural members, malfunction of machinery and equipment or adversely affect crew performance.

ABS provides shipowners, designers and shipbuilders with guidance on concept design to help avoid excessive vibration. The critical areas addressed in the concept design are:

- Hull girder vertical vibration excited by a main diesel engine
- Main machinery/shafting system longitudinal vibration excited by the propeller
- Superstructure fore-and-aft vibration excited by either or both aforementioned initiators

At a client's request, or when found necessary, the guidance can include finite element-based vibration analysis procedures to predict the vibration response and evaluate the design in greater detail. This considers loading conditions, propeller and engine excitations and free and forced vibrations.

Stern vibration problems arise from unsteady cavities that attach to the surface of the propeller blades, creating an intense, fluctuating pressure impact on the ship's hull. In recent years, many innovative propulsion designs have been developed to address the vibration problems associated with propeller cavitation. ABS has developed a suite of advanced computer programs that use Computational Fluid Dynamics (CFD) to better assess propeller strength and analyze vibration. These include:

- A propeller cavitation analysis that also performs calculations of unsteady bearing forces, evaluating propeller performance, bearing forces and sheet cavitation
- A prediction of fluctuating pressure induced by the cavitating propeller
- A ship flow simulation of the interaction between the propeller and the hull

ABS also provides guidance on the vibration measurement procedure at sea trials and the acceptance criteria on vibration limits based on international standards and ABS experience. ABS has established a vibration measurement procedure to evaluate the effect of vibration on the superstructure, local structures, marine propulsion machinery and other equipment.
Vibration Effects on Membrane Systems

Propulsion advances, particularly the selection of diesel prime movers on vessels using the membrane containment system, may raise specific vibration issues. ABS has conducted one of the most detailed investigations into the effects of diesel engine vibration on membrane systems undertaken by industry. With an LNG carrier it is necessary to understand the interaction between the structural resonance that is excited by the diesel engine and the separate resonance that is created within the membrane containment system interacting with LNG. ABS has analytical tools and can provide guidance to address these effects.

Shaft Alignment

Proper shaft alignment can be an issue in the design of very large gas carriers as inadequate alignment can result in stern bearing failure, intermediate bearing failure or main engine bearing failure which could incapacitate the ship’s propulsion capability. Such failures may be attributable to factors including: inadequate alignment design tools; lack of hull deflection data; lack of sufficient experience-based knowledge; and production errors.

Until recently shaft alignment has been largely experienced-based engineering as adequate hull deflection data was not available. This made alignment conditions unpredictable for certain cargo loading conditions.

ABS has addressed these issues by developing specialist software and alignment optimization tools based on a multi-year research project conducted with the cooperation of several leading shipyards which collected and analyzed hull deflection data. The software can predict alignment behavior for different cargo loading conditions. ABS has the experience and equipment to provide full scale shaft alignment services including analysis, optimization, measurements, condition evaluation, troubleshooting and failure investigation.

Typically the tail shaft can be included under a condition monitoring system to minimize the frequency of withdrawal. This may lead to the award of the class notation TCM.
**Hull Condition Monitoring**

Some owners may elect to monitor the hull stress levels throughout the vessel's service life. A series of strain gauges, accelerometers, alarms and recording devices can provide an early warning system to avoid overstressing the hull structure, allowing the ship's officers to monitor how the ship is performing relative to its design limits and how the vessel responds to changes in heading and/or speed. This approach can provide a warning on slamming, green seas, excessive ship motions and hull girder stress. The system can be integrated with a voyage data recorder allowing for the collection of a wide variety of technical information.

The approaches covered by the ABS *Guide for Hull Condition Monitoring Systems* extend from simple one-motion monitoring systems to sophisticated voyage data recorders covering a multitude of hull, systems and machinery parameters. The reason for fitting hull monitoring systems is to acquire, display and/or record information and then use the information as a basis for making decisions that will improve operational efficiency and/or safety.

The overall hull condition monitoring process is one of: data measurement; data collection and conditioning; data processing and evaluation; and results presentation and storage. At the request of the owner or shipyard, a hull condition monitoring system which complies with the requirements of the ABS hull condition monitoring systems Guide will be given a notation HM1, HM2 or HM3, as appropriate, followed by the applicable qualifier such as Slam Warning, Green Seas Warning, Ship Motion, Hull Girder Stress, Local Load Monitoring, Fatigue Monitor, VDR or Enhanced VDR.
Maneuvering

To assist owners to quantify and document the maneuvering characteristics of a gas carrier, ABS has carried out extensive analyses of vessels entering ports using numerical simulation tools and full-scale trial data. ABS has the tools needed to assess the maneuverability of a wide variety of gas carrier sizes at the early design stage and to verify compliance with the relevant IMO criteria.

The ABS Guide for Vessel Maneuverability summarizes the procedures to be used in assessing a vessel’s maneuvering performance. Minimum requirements given in this Guide are consistent with IMO standards. An optional class notation, MAN, offered for compliant vessels, could be used as evidence of adherence to the IMO standards. ABS may assign another optional class notation, MAN-A to signify demonstration of maneuvering performance that exceeds the IMO standards.

Seakeeping & Motion Studies

Assessments of seakeeping and motions can be provided at several levels from strip theory to 3-D and non-linear methods depending upon the specific engineering need.
Position Keeping

LNG carriers designed or converted to act as floating terminals or for storage and offloading may be fitted with dynamic positioning systems. A dynamic positioning system is designed to maintain a vessel's position and heading within specified limits. The increasing classification requirements for Dynamic Positioning (DPS-0, DPS-1, DPS-2 and DPS-3) correspond to increasing levels of redundancy with DPS-2 and DPS-3 indicating that the vessel has sufficient duplication of machinery and systems to remain on location following a system failure. This allows for continued position keeping while any risk-related operations can be safely terminated.

The limits of the safe operating area and the limiting environmental conditions under which the vessel can remain on location are designated by the owner/designer. These parameters ultimately determine the required, installed, generator and thruster capacities. The design process involves the development of a Failure Modes and Effects Analysis (FMEA) to verify that applicable aspects of the final design are taken into consideration. This consists of a systematic process of establishing the effects of a failure of each component and system to verify that there is no ‘single point of failure’ which would deprive the unit of its dynamic positioning capability.

The final part of the classification process is the FMEA trials to determine that the assumptions and behaviors predicted by the FMEA are valid. The dynamic positioning system is subject to annual survey and testing in order to maintain its applicable DPS notation.
Human Factors Engineering

Ergonomic principles, criteria and design processes can be effectively integrated with engineering activities to improve human performance on board ships and contribute towards a reduction in the likelihood of accidents or incidents attributable to human error.

ABS has developed extensive guidance for shipowners and designers based on industry-specific and internationally-applicable ergonomic principles and criteria. The criteria address equipment, workstation and system design, including guidance for the ergonomic design of navigation bridges, as well as occupational health and safety concerns.

Design guidance accounts for personnel capabilities, limitations and needs so that the arrangement and orientation of the onboard work environment meets the needs of the crew members regardless of their cultural background and physical dissimilarities.

ABS criteria and notations also address the issue of crew habitability or the acceptability of conditions on board a ship in terms of vibration, noise, lighting, indoor climate and physical and spatial characteristics. They have been developed to support effective human performance, mental alertness and basic levels of comfort that promote the general well-being of the crew members and, as a consequence, the efficient and safe operation of the vessel.

Vessels that comply with the relevant criteria may be awarded the optional notations of Habitability HAB or Habitability Plus HAB+.
Environmental Services

ABS can provide assistance to designers and owners as they seek to understand and address the increasing number of environmental regulations and challenges. Advice and guidance is available on topics from ballast water management to cold ironing, controlling emissions, handling oily bilge water residues and complying with local and regional regulations that may differ from international standards.

The ABS Guide for Environmental Protection Notation for Vessels has been developed with the objective of promoting environmentally safe design, construction and operation of ABS-classed vessels and marine structures. The requirements relate to enhanced environmental standards for hull anti-fouling systems, ballast water management and the prevention of oil, sewage, garbage and air pollution.

ABS Eagle Rule Manager

To further simplify the application of the relevant ABS Rules and statutory regulations at the design stage, ABS has developed the advanced, web-based ABS Eagle Rule Manager. This application allows the designer and owner to easily and quickly identify and access relevant ABS Rules and statutory requirements for the vessel. The built-in search capability allows the owner, shipyard or designer to specify the scantling length, contract date, delivery date, class notations and other criteria which, in turn, highlights the relevant ABS Rule text and the IMO requirements for that specific project.

Advanced input parameters can be used to narrow the search criteria to the Rule requirements applicable to a specific system, component, structural element, item of equipment, notation or survey. Hyperlinks embedded within the text provide the user with immediate window access to other related sections of the Rules. The user can also generate check sheets that can be used to verify that applicable Rule requirements have been addressed during the design and construction phases of a project.
Hull & Machinery Maintenance Services

Gas carrier owners and operators tend to adopt maintenance procedures that promote the life cycle integrity of a vessel. To assist them, ABS offers a variety of programs that provide a framework for maintaining the structural and mechanical condition of a vessel.

Hull Inspection Program

Maintenance of the ship’s structure can be enhanced through the use of a ship-specific inspection manual created by ABS upon request for existing vessels and placed on board all newly constructed ABS classed vessels. It shows pictorially the critical areas in the structure identified in the plan approval process and the areas known to be susceptible to damage from both industry and historical experiences. The manual lays out a zonal scheme for categorization of six structural condition criteria and an inspection scheme to track deterioration in these areas.

Condition criteria tracked include cracking, coatings, corrosion, deformation, distortion and overall cleanliness. Inspections are to be carried out either by appropriately qualified ship’s staff or superintendents. The data is collected in software provided by ABS. It is stored in a way that categorizes the risk to the ship for the areas being inspected based on the severity of the deterioration. This information can then be readily used by the ship’s management to assess current condition as well as to view damage trends across a fleet of ships and provides an adjunct source of information for the ABS surveyor when attending the vessel for periodic surveys.

Satisfactory completion of a comprehensive training course approved by ABS is a requirement for operating this scheme in order to develop consistency. It can be tailored to suit the technical management needs of the client’s organization by adopting different levels of usage of the data:

- The data is collected in a spreadsheet application which automatically provides a traffic light management overview of the ship’s status
- Dashboard data can be made available to overview fleet performance
- Seamless integration of hull and machinery inspection and maintenance data can be further enhanced through the fleet management modules provided by ABS Nautical Systems

The ABS class survey requirements are unchanged by this service. The class notation HIMP may be awarded to vessels that apply and maintain the system to the satisfaction of ABS. New gas carriers built to ABS class are eligible for the free installation of the ABS hull inspection software and the ABS Nautical Systems Maintenance & Repair module on delivery of the vessel. This unique Newbuild Program includes the provision of a ship-specific model populated with inspection criteria. The Maintenance & Repair module is also provided prepopulated with the equipment and machinery information for the vessel as determined during the plan review process.
Hull Maintenance Program

The hull maintenance program provides a sophisticated, advanced management and information module that can be used to track the condition of the vessel's structure throughout its service life. Users can store gaugings, coating and anode information, damage incidents and repair data which can be presented in visual form through CAD drawings as well as through a library of digitized photographs.

The actual condition of any part of the structure can be assessed at anytime from the stored data and condition and then used to predict remaining fatigue life. A report on structural diminution for any part of the vessel can be generated automatically. Repair costs can be generated for user-specified scenarios. The benefits of the hull maintenance program include:

- Interlinks structural information with other data relating to the same vessel, such as Survey Status or Vessel Drawings once the basic definition of the vessel has been stored within the system
- Develops a compartmentalized model giving the user the ability to see compartment data and highlighting specific sections for more detailed review
- Links this compartmentalized description with a full CAD format of the vessel. Presents any portion of the hull structure in 2-D
- Stores multiple file types such as documents/reports, photos, sketches, video, etc., of structural members linked directly to each section for detailed visual and technical assessment
- Tracks multiple anomalous conditions such as damages, fractures, buckling, grooving and pitting
- Holds a life history of gauging information to facilitate analysis of past structural degradation and anticipated future degradation using built-in trending tools
- Compares actual condition data against “as-approved” or Rules scantlings for gauging evaluation as per prescribed renewal criteria
- Tracks coating application and condition through the lifetime of the vessel and stores the location and condition of anodes
- Generates coating material estimates, including cost, for user-defined scenarios
- Highlights areas of substantial corrosion using color codes and shows areas with user-defined degradation levels
- Generates steel weight, cost data and bill of materials for isolated repairs or different repair scenarios
Reliability-Centered Maintenance of Machinery

The application of reliability-centered maintenance (RCM) allows maintenance programs to be evaluated and applied in a rational manner that provides the most value to an owner/operator. RCM analysis allows an owner to optimize maintenance programs by first identifying functional failures within machinery systems that have the highest risk and then proactively determining the optimum maintenance tasks and strategies that mitigate such potential failures to an acceptable level. In this way, maintenance programs are created which focus on critical components and proper maintenance strategies.

By applying RCM principles, maintenance strategies are evaluated and applied in a rational and systematic manner. ABS can assist the owner in gaining approval for its own RCM program for maintenance of class or by further assisting in preparing and implementing an effective RCM program for the machinery on the vessel. The ABS Guide for Survey Based on Reliability-Centered Maintenance contains the RCM program requirements and the ABS Guidance Notes on Reliability-Centered Maintenance provide the maintenance theory and philosophy of RCM.

Machinery Condition Monitoring

Condition monitoring can promote cost-effective maintenance by reducing the number of breakdowns and extending operating periods beyond those of time-based programs. Maintenance is undertaken as a result of the knowledge of the condition of the equipment. This can result in better utilization of resources, the controlled replacement of wearing components and can reduce the incidence of unplanned breakdown maintenance. Many maintenance procedures include condition monitoring:

- Checking and recording of vibration levels
- Pressure
- Temperature
- Load current
- Running hours
- Lubricating oil analysis data
- Fuel consumption

Intelligent use of this equipment condition data can eliminate the need to open up machinery; save human resources and expenditures on spare parts; and reduce downtime and associated costs. By applying condition-based maintenance, credit can be given towards the requirements of the Continuous Survey of Machinery.
Integrated Management Systems Certification

In addition to facilitating the certification of a new gas carrier to the applicable classification and statutory regulatory requirements, ABS offers shipowners and operators additional services that allow them to demonstrate their adoption of specific health, safety, quality and environmental standards. Attaining certification to these optional ABS standards provides evidence that the vessel is being operated to the highest standards available to the industry. The ABS Guide for Marine Health, Safety, Quality and Environmental (HSQE) Management provides ship operators with an integrated management system model and for demonstrating operational excellence.

The requirements of the Guide have been largely derived from accepted management system principles reflected in the ISM Code, the latest ISO 9001 Quality Management Systems standards, ISO 14001 Environmental Management Systems standards and OHSAS 18001 Specification for Occupational Health and Safety Management Systems. Those standards have been marinized as deemed appropriate for greater relevance to the practical operation of marine facilities.

ILO Maritime Labour Convention Services

ABS has prepared extensive guidance for designers and owners of gas carriers on the application of the requirements contained in the ILO Maritime Labour Convention. This can be found in the ABS Guidance Notes on the ILO Maritime Labour Convention, 2006 and the ABS Guide for Compliance with the ILO Maritime Labour Convention, 2006 Title 3 Requirements. A cadre of trained ABS auditors is available worldwide to assist flag States in carrying out the MLC audits. Preparatory audits can be conducted to assist owners in identifying what steps are needed to prepare for certification.
**Project Management Services**

Professional project management, supported by unique software tools, may help to minimize the risk of unexpected delays, technical inaccuracies and cost overruns. If desired, a trained ABS project manager, experienced with gas carrier construction, can be assigned to a project with the client’s prior agreement at the commencement of the plan approval phase. In addition, ABS can assist with familiarization with the ship design and the details of the construction monitoring plan.

**Fleet Management Systems**

ABS Nautical Systems is a leading provider of fleet management software for the marine and offshore industries. Marketed as a suite of products called NS5, the software modules can function on a standalone basis or as a fully integrated management solution that addresses the principal elements of a fleet manager’s daily operational functions.

NS5 can efficiently handle tasks ranging from regulatory compliance to payroll, to stock control, planned maintenance and quality programs. Fully integrated, the modules eliminate the need for repetitive data entry, share information and allow the user to move rapidly from one module to another.

NS5 makes fleet management easier and more efficient, providing increased productivity and more effective cost control flow from the system's ability to link management, operations and onboard personnel into a seamless information stream. The integrated architecture makes adding modules simple. Each module is valuable on its own but a complete NS5 system provides the most powerful, single-source fleet management tool available.

NS5 is an easy-to-use Windows-based system with full replication capability. Available NS5 fleet management modules include:

- Maintenance and Repair
- Drydocking
- Purchasing and Inventory
- Quality and Compliance
- Crew Management
- Crew Payroll
- Hull Maintenance
- Incident Investigation
- Vessel Drawings
- Vetting Module

Full information on how the ABS Nautical Systems fleet management software can improve operating efficiency can be found at www.abs-ns.com
Optional Notations

Although the requirements for several of the ABS optional notations for gas carriers have been outlined in prior sections, they are summarized here together with additional notations not yet referenced. Conformance with the standards required for the award of the following optional notations allows an owner to demonstrate that a particular ship has been built or is being operated to internationally recognized standards that exceed those required solely for the issuance of the classification certificate.

Design and Construction

- **AT** – specified structural components incorporate additional plate thickness than the required scantlings. It will also include a designation and number to indicate the location and magnitude of the additional thickness e.g. AT(DK+0.5)

- **DPS-0, DPS-1, DPS-2 or DPS-3** – ship or gas concept unit is fitted with dynamic positioning equipment verified by ABS during construction. The numeral indicates the degree of redundancy of the system.

- **ES** – ship meets the requirements specified in the ABS Guide for Environmental Safety (ES)

- **Ice Class A0, Ice Class A1 or Ice Class 1A** – ship complies with the ABS Rules for ice strengthening of ships navigating in first-year or multi-year ice or complies with the Finnish-Swedish Rules for navigating in the Northern Baltic in winter, respectively

- **Ice Class A5, A4, A3, A2, A1, A0, B0, C0 or D0** – ship complies with the requirements in the ABS Guide for Building and Classing Vessels Intended to Operate in Polar Waters

- **R1, R1-S, R2 or R2-S** – these notations address redundancy arrangements for propulsion and steering systems

- **RES** – ship has been built in accordance with the procedure and criteria for calculating and evaluating the residual strength of hull structures contained in the ABS Guide for Assessing Hull-Girder Residual Strength

- **SFA(30)** – ship complies with the requirements of enhanced dynamic analysis for the fatigue life identified in parentheses in North Atlantic conditions

- **SH-DLA** – ship complies with criteria for calculating and evaluating the behavior of hull structures under dynamic loading conditions and built in accordance with plans approved on the basis of the results of such analysis, in addition to full compliance with the other requirements of the Rules
Operational Safety

- **ACCU** – ship has the means to control and monitor an unmanned propulsion-machinery space in an approved manner from the navigation bridge and from a centralized control and monitoring station installed in or adjacent to the propulsion machinery space
- **HAB or HAB+** – ship complies with the ABS Guide for Crew Habitability on Ships
- **HM1, HM2 or HM3** followed by the applicable qualifier such as Slam Warning, Green Seas Warning, Ship Motion, Hull Girder Stress, Local Load Monitoring, Fatigue Monitor, VDR, Enhanced VDR – the ship complies with the requirements of the ABS Guide for Hull Condition Monitoring Systems and will be given the appropriate notation
- **MAN or MAN-A** – ship complies with the ABS Guide for Vessel Maneuverability
- **NBL, NBLES or NIBS** – ship complies with the relevant section of the ABS Guide for Navigation Bridge Design and Equipment/Systems
- **PORT** – ship complies with the ABS Guide for Automatic or Remote Control and Monitoring Systems for Vessels in Port

Ship Management

- **HSQE, SHQ, SHE, HS, SQE, SQ, SE, S** – ship complies with the relevant criteria for health, safety, quality and/or environment management systems in the ABS Guide for Marine Health, Safety, Quality and Environmental (HSQE) Management
- **SEC** – Ship complies with the ABS Guide for Ship Security Notation

Maintenance

- **CSM** – the continuous survey regime for machinery is applied
- **HIMP** – ship complies with the ABS Guide for Hull Inspection and Maintenance Program
- **PMS** – a planned maintenance scheme for machinery is applied
- **RCM** followed by the applicable qualifiers such as (CARGO), (FIRE), (PROP) or (MACH) – ship complies with the ABS Guidance Notes on Reliability-Centered Maintenance as it applies to cargo handling, fire extinguishing, propulsion or both firefighting and propulsion, respectively
- **TCM** – ship complies with the requirements in the ABS Guide for Classification Notation Tail Shaft Condition Monitoring
- **UWILD** – ship meets the ABS requirements for underwater inspections in lieu of drydock
Training Services

ABS Academy offers specialized training courses addressing the design, construction and operational maintenance issues associated with LNG carriers. Customizable classes can be conducted at ABS Academy facilities or at client-specified locations around the world. Training topics include:

- Classification and Statutory Requirements
- Hull Inspections
- Marine Coatings
- Welding and Non-destructive Examination
- Risk Assessment
- Incident Investigation and Root Cause Analysis
- Shaft Alignment and Vibration
- Hull Structures, Engineering Systems and Rules Compliance
- Fatigue and Finite Element Assessment
- Inspection of Cargo Containment Systems
- SIGTTO Competency Standards for Seafarers
- LNG/LPG Carriers Design and New Construction

Training courses specifically relating to the classification and certification activities of ABS are provided by ABS. Courses that address maritime issues outside of classification and certification are provided by ABS Consulting, a subsidiary of the ABS Group of Companies and an affiliate of ABS.

Information Services

It is important for owners to stay informed of the constant flow of new regulatory and classification requirements. Through its participation in IMO as either a member of the IACS delegation or the US delegation, ABS is able to provide its owners with in-depth coverage and insight into these changes. Frequent regulatory updates are also posted to the ABS website and ABS owners receive a variety of informational newsletters and publications designed to assist their understanding of the issues. ABS Rules and current regulatory information can also be accessed on the ABS website at anytime.
Separate companies affiliated with ABS, specifically ABS Consulting and ABS Quality Evaluations, offer a broad range of class and certification-related services that have been designed to assist shipowners and operators to manage their projects and vessels more efficiently.

ABS Consulting's Maritime Services division can provide shipowners and operators with a range of technical support and representative services that are independent of the classification approval process. ABS Quality Evaluations is a leading international registrar providing shipowners with certification to ISO quality and environmental and OHSAS health standards. Category III services are comprised of the following:

**Technical and Engineering Services**
- Concept and Preliminary Design Development
- Outline Tender Specification and Evaluation of Bids
- Engineering Analyses and Plan Review
- Manuals and Studies
- Vessel Construction and Trial Attendance
- Guarantee Period Support
- Retrofitting and Modifications

**Operational Services**
- Life Cycle Hull Integrity Management
- Condition Assessment Program (CAP)
- Survey and Related Services
- Environmental Services
- Oil Testing

**Support Services**
- Project Management
- Rapid Response Damage Assessment
- Integrated Management Systems Certification
- Incident Investigation
- Risk Management and Reliability Services
Technical & Engineering Services

ABS Consulting Maritime Services offers a broad range of engineering and technical services for owners and operators of gas carriers. These services are applicable from the earliest stages of the conceptual design of a new gas carrier or gas concept project and continue throughout the life cycle of the vessel.

ABS Consulting engineers can verify design specification, drawings and calculations against project requirements and regulatory standards using advanced technology, analysis and modeling as appropriate. These services can be customized to meet the unique needs of each project, including the assignment of a qualified project manager to represent the shipowner.

The new vessel construction services offered by ABS Consulting include: concept development; preliminary design development; outline tender specifications; evaluation and selection of bids; detailed plan review; construction management; testing and trials; and guarantee period support.

Concept & Preliminary Design Development

From inception through the preliminary design phase, ABS Consulting staff can assist an owner in defining the technical specifications for the vessel, drawing up realistic project requirements and providing guidance on preliminary budget estimations. Concept development may include: industry trending and transportation studies; equipment definition; construction techniques; and statutory requirements.

During the evaluation phase, ABS Consulting can undertake an independent review of the design, taking into account both construction and subsequent operational factors that may include: suitability to owner’s needs; selection of propulsion plant; and operational requirements among others.
Outline Tender Specification & Evaluation of Bids

ABS Consulting staff can prepare the tender specification for a gas carrier newbuilding project, incorporating requirements identified by the owner. These may include factors such as: the main structural configuration; the containment system; the prime mover and principal machinery systems; materials and equipment; coating specifications; navigation systems; the identification of applicable certificates; and logistical support.

Once contract proposals have been received, the ABS Consulting team can assist the owner in reviewing the proposals to identify those considered most advantageous. This review is intended to reveal ambiguities, obvious omissions, incorrect requirements, future maintenance needs and potential issues associated with the deck, cargo handling and engineering operations and crew safety.

Engineering Analyses & Plan Review

ABS Consulting engineers are available to review the submitted drawings against specified industry, classification, regulatory or owner standards and requirements. If required, detailed technical analyses can be undertaken including dynamic load and spectral fatigue analysis, comprehensive vibration analysis, shaft alignment assessment, seakeeping and motion studies, maneuvering and mooring analyses, intact and damage stability analysis, failure mode and effects analysis, trim and stability calculations, human factors engineering assessment, environmental compliance assessments and a vessel specific analysis of the structural response when subject to very high loading rates.
Manuals & Studies

ABS Consulting's technical staff can prepare the various statutory and operational manuals required to be placed on board a gas carrier. These include the following:

Shipboard Oil Pollution Emergency Plan

Shipboard Oil Pollution Emergency Plan (SOPEP) manuals are prepared according to the provisions in MARPOL 73/78 Annex I Regulation 26/37, Annex II Regulation 16/17 and MEPC 54(32) as amended by MEPC 86(44), the relevant unified interpretations and according to flag Administration requirements. The manuals include guidelines, contact points and procedures in the case of an oil pollution incident.

Ballast Water Management Plan

Ballast Water Management Plans (BWMPs) apply to ships engaged in ballast operations according to IMO requirements as adopted by the applicable flag State. The ballast water manual is to be prepared according to the IMO Guidelines for Ballast Water Management and Development of Ballast Water Management Plans Resolution MEPC 127 (53), using ship specific drawings and information. The manual should provide standard operational guidance for the planning and management of the ship's ballast water and sediments and describe the relevant procedures to be followed, based on desired loading conditions, using the ship's approved loading program.

Garbage Management Plan

ABS Consulting personnel are available to prepare a Garbage Management Plan in accordance with MARPOL requirements.

Fire Control and Life Saving Plan

When required, ABS Consulting can upgrade a gas carrier's existing Fire Control and Life Saving Plan in accordance with IMO Resolutions A.952(23) and A.760(18).


Safety Training Manual

Preparation of the Safety Training Manual in accordance with SOLAS, Chapter III, Section V, Regulation 35 can be completed by the ABS Consulting Maritime Services team.

Tonnage Measurement

Tonnage Measurement according to the International Conference on Tonnage Measurement of Ships, 1969, or according to National Regulations, can be assigned by the staff at ABS Consulting.
Vessel Construction Services including Trial Attendance

When contracted, ABS Consulting surveyors will attend the vessel throughout the period of construction and trials providing comprehensive owner's representation services to verify that the vessel is constructed in accordance with the approved drawings, that the material and equipment conforms to specifications and provide other oversight as agreed with the owner. These may include inspection of fabrication procedures, machinery installation, non-destructive testing and evaluation, monitoring the installation of automation and control systems and progress monitoring.

Experienced ABS Consulting staff can confirm test requirements during builder's dock, sea, gas and acceptance trials. This may include verification of the adequacy of deck equipment, outfitting and navigational items, in addition to the propulsion machinery and auxiliary equipment. A report detailing any areas requiring rectification can be provided to the client on the completion of the trials.

Shipyard Guarantee Period Support

As required, ABS Consulting staff can be available to monitor the performance of the vessel for the entire shipyard guarantee period. This may involve monitoring the repair of all warranty items including machinery, coatings, deck and navigational equipment. Under normal circumstances the engineers assigned to the vessel during the guarantee period will already be familiar with the vessel and the contractual requirements from their exposure to the project during construction. Guarantee period oversight may include verification of warranty items, recommendations for operational enhancements, vessel performance, lube oil analysis, habitability (particularly noise and vibration) and coating performance.

Retrofitting & Modifications

ABS Consulting Maritime Services personnel have extensive experience advising owners and undertaking detailed engineering studies for major retrofit and modification projects. Representative projects include major conversion studies for LNG carriers to an alternative configuration such as a floating storage and re-gasification unit (FSRU).
Operational Services

ABS Consulting Maritime Services is available to provide worldwide technical support to the owner throughout the operational life of the gas carrier. ABS Consulting staff can be made available to conduct condition surveys and to assess the need for and approach to subsequent repairs including the preparation of repair specifications and inspection of any repair work undertaken.

ABS Consulting staff can also conduct through-life technical analyses of the vessel, in particular analyses of remaining fatigue life, using advanced dynamic-based evaluation programs that are proprietary to the ABS organization.

Condition Assessment Program for Gas Carriers

As a vessel ages, the manner in which the hull structure and principal machinery and equipment has been maintained is a critical element in determining the likelihood of accidents and failures. The ABS Consulting Condition Assessment Program (CAP) provides a charterer with a technical evaluation of the standard to which an older carrier has been maintained.

An ABS Consulting CAP survey may include:

- detailed survey, including gauging of the vessel’s structure
- sophisticated strength and fatigue engineering analysis
- extensive testing of the vessel’s machinery, equipment and cargo systems
- close-up visual inspection of cargo and ballast spaces to determine degree of structural deterioration

Survey & Related Services

ABS Consulting offers a wide range of survey services to the owners and operators of gas carriers. These can be conducted to industry-accepted or owner-specified standards and include:

- Pre-purchase condition surveys
- Damage surveys
- Draft and on/off hire surveys
- P&I condition surveys
- Material and equipment inspection

An owner considering purchasing a gas carrier can also contract with ABS Consulting to conduct a comprehensive record review of the vessel’s classification history.
Environmental Services

Failure to comply with the provisions of MARPOL and national legislation such as the US Clean Water Act can result in significant fines and possible criminal penalties. Increased vigilance by the United States Coast Guard (in addition to the European Union and many port State authorities) has led to several high profile prosecutions of shipping companies.

ABS Consulting offers a wide range of environmental management, auditing and training programs to assist an owner or operator to implement an effective Environmental Management Plan. These services encourage a shipowner to fully assess the company’s environmental risk profile and may include:

- **Environmental Management Plans:**
  ABS Consulting staff can assist in identifying potential waste streams, generating a GAP analysis of existing systems and assisting in the development of a corporate environmental management system.

- **Environmental Compliance Audits:**
  ABS Consulting staff can identify applicable regulations, develop compliance protocols, conduct external/internal audits and assist with the preparation of reports and documentation to confirm compliance.

- **Environmental Program Management:**
  ABS Consulting staff can assist with the implementation and management of a client's environmental management system (EMS) including planning, management support, document review and independent internal auditing. This may include assisting with the development and adoption of ISO 9000 Quality and ISO 14000 Environmental Management programs.

- **Economic, Technical and Risk Analysis:**
  ABS Consulting staff can conduct hazard assessments, evaluate options under consideration for environmental action and prepare regulatory analyses.
Oil Testing Services

ABS Consulting provides prompt, professional services to shipowners and operators for the analysis and management of their fuel and lube oil supplies. The comprehensive ABS Consulting Oil Test Program (OTP) can help the owner monitor deliveries, pre-test supplies, confirm quantities received and provide a detailed analysis of the fuel delivered to promote efficient operations and reduce the potential for disputes.

The ABS Consulting OTP encompasses the entire bunkering process, from pre-loading tests to machinery maintenance recommendations, with the particular service package being customizable to the individual client’s needs. It includes:

- Pre-loading tests to reduce incidences of de-bunkering
- Fuel line sampling to verify that the bunkers supplied meet the operator’s specifications
- Identification of fuel characteristics including density, viscosity, sulfur water, metals sediment, pentane insolubles, acidity, sediment particle count, ferrography, ignition quality and carbon residue fuel dilution
- Comparison with specified fuel standards and optional testing for specific criteria
- Verification of density for determination of delivered/invoiced quantity
- Determination of compatibility with other fuels
- Assessment of lube oil condition including additives
- Recommendations on condition maintenance and renewal of lube oils
- Machinery condition monitoring reports and performance trend analysis
- Fuel damage investigations
- Machinery damage surveys
- Preventative strategies for minimization of fuel-related problems
- Impartial independent measurement of bunker quantities

Each client will be placed in direct contact with an ABS Consulting appointed project coordinator who will be responsible for arranging the speedy dispatch of the fuel samples and efficient delivery of results. User-friendly forms have been created for the ship’s crew to simplify the collection and dispatch of the samples. Results are normally available electronically within 24 hours of receipt of the samples at the laboratory. A rapid alert service is initiated when the quality of the fuel does not meet the desired specifications.
Support Services

ABS Consulting Maritime Services takes a holistic approach to the development of products and services designed to assist shipowners and operators to manage their fleets more efficiently. These services range from a comprehensive curriculum of technical, safety, quality and environmental training courses, to detailed HAZID and HAZOP studies and the development of effective reliability-centered maintenance strategies. From design conception to the ship’s final voyage to the scrapyard, the global team of ABS Consulting professionals is available to provide or develop practical, effective support services that promote operational safety and efficiency.

Project Management Services

ABS Consulting can provide a gas carrier owner with tailored project management services that may promote efficiencies and help to minimize the risk of unexpected delays, technical inaccuracies and cost overruns. These services can be made available for new construction projects, for major modifications or repairs or to evaluate potential projects for their feasibility prior to being undertaken.

Rapid Response Damage Assessment

Proactive owners mitigate the potential risks associated with an incident by enrolling in a Rapid Response Damage Assessment (RRDA) program. ABS Consulting provides 24 hour, 365 days per year emergency support services to shipowners and operators with vessels enrolled in the program. There are currently more than 50 gas carriers enrolled in this program. Computer models of these vessels are held in the system and, upon notification of a casualty, detailed stability calculations can be made using the established HECSALV program. This information can be used to provide immediate guidance to the owner and master of the vessel and the salvor as needed, regarding appropriate responses including ballasting, cargo transfer and trans-shipment options.
Integrated Management Systems Certification

ABS Consulting can provide a gas carrier owner with the guidance needed to develop and implement management systems that conform to ISO 9001 quality standards, ISO 14001 environmental standards and the OSHAS 18001 Specification for Occupational Health and Safety Management Systems. The ABS Consulting staff can also assist a gas carrier owner to develop and implement management systems that can be audited by the flag State or its Recognized Organization for compliance with the ISM Code, the International Ship and Port Facility Security (ISPS) Code and the ILO Maritime Labour Convention.

ABS Consulting will review a gas carrier owner or operator's existing management systems and can prepare new manuals according to a client's request. The manuals and plans are prepared according to the applicable industry standards using ship-specific information.

ABS Consulting can also deliver guidance through concise in-house training courses to raise shore-based staff awareness concerning the organization's management system to maintain an increased level of safety and environmental awareness throughout the company. An ABS Consulting internal audit of the vessels in the client's fleet can help identify areas for improvement as well as prepare the crew for forthcoming external audits.

Incident Investigation

ABS Consulting can assist with training and the application of the analytical methodology needed for the effective investigation of incidents including near misses.
Risk Management & Reliability Services

ABS Consulting is one of the world’s leading providers of risk assessment, management and mitigation services. These services range from HAZID and HAZOP studies to detailed risk assessments associated with prevailing weather conditions, blast impact studies and process safety management. Services particularly tailored to the marine sector include the following:

Formal Safety Assessment of Marine Applications

ABS Consulting personnel can prepare a report for marine, safety or reliability related aspects of a shipowner’s operations in accordance with the IMO Guidelines on Formal Safety Assessment (FSA). The five-step FSA procedure incorporates customary techniques as well as novel safety and reliability methodologies in order to identify, measure and mitigate possible risks and their respective consequences.

Risk Assessment Manuals for Engineering Systems, Structures and Processes

ABS Consulting prepares risk assessment manuals on request to address the onboard engineering systems, including structures and processes required by the operator which can identify the following:

- The major hazards related to the installation, operation or maintenance of the item examined
- The risks related to the hazards identified and the severity of their respective consequences in more than one area, if applicable
- The immediate and future preventive risk reduction controls required
- An assessment of the financial aspect of the application of the controls proposed
- Guidance on the course of action required to minimize the risks
Reliability-Centered Maintenance Strategies
ABS Consulting can provide guidance for the identification of effective maintenance strategies for a specific piece of machinery, an engineering system or a complete engine room. The use of analytical reliability methodologies, combined with engineering and operational experience, can reveal actions required to minimize failures. These actions can reduce the overall vessel’s downtime due to engineering delays and increase the respective life expectancy and safety of the items examined.

Reliability-Centered Maintenance Plan for Marine Applications
ABS Consulting can prepare a reliability-centered maintenance plan for the identification of optimal maintenance intervals, with proactive engineering to help reduce overall expenses used for maintenance purposes.

HAZID and HAZOP Studies
With many years of experience in HAZID and HAZOP studies, ABS Consulting can facilitate an assessment of safety and reliability elements relating to the design or operation of a gas carrier. Systems, structures, processes or piping networks can be described and hazards can be identified.
Classification & Certification Services

For more information on the classification and statutory certification services provided by ABS, please contact the ABS office nearest you. A full listing of all ABS offices with contact information can be found on the ABS website at www.eagle.org

For further information on the products and services provided by ABS Nautical Services please contact the ABS Nautical Systems office nearest you. A full listing of the ABS NS offices can be found on the website at www.abs-ns.com

Related Services

General inquiries regarding products and services provided by ABS Consulting can be sent to info@absconsulting.com or please refer to the website to contact representatives at www.absconsulting.com
ABS WORLD HEADQUARTERS
ABS Plaza
16855 Northchase Drive • Houston, TX 77060 USA
Tel: 1-281-877-5800 • Fax: 1-281-877-5803
Email: abs-worldhq@eagle.org

ABS EUROPE DIVISION
ABS House
No. 1 Frying Pan Alley • London E1 7HR, UK
Tel: 44-20-7247-3255 • Fax: 44-20-7377-2453
Email: abs-eur@eagle.org

ABS PACIFIC DIVISION
438 Alexandra Road #10-00 • Alexandra Point
Singapore 119958 • Republic of Singapore
Tel: 65-6276-8700 • Fax: 65-6276-8711
Email: abs-pac@eagle.org

ABS AMERICAS DIVISION
ABS Plaza
16855 Northchase Drive • Houston, TX 77060 USA
Tel: 1-281-877-6000 • Fax: 1-281-877-6001
Email: abs-amer@eagle.org

Website
www.eagle.org