ABS Approach to Classification using Risk Analyses

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Abstract

Risk analyses are finding a more prominent role in the assessment of marine systems as these systems become more complex and optimized. The value of risk analyses in the Classification process is becoming more and more evident. ABS has recently developed two Guides that provide sound practical approaches for performing risk evaluations to support the Classification of proposed designs. These two publications are the *Guide for Risk Evaluations for Classification of Marine-Related Facilities* and the *Guidance Notes for Review and Acceptance of Novel Concepts.*

These Guides describe methodologies for owners/operators requesting Classification of designs that offer 1) alternative means of compliance to current prescriptive requirements or 2) for proposed designs with such a high degree of novelty that no Class Rules address them. The necessity for treating novel design is increasing as greater demands are placed on marine systems, and the application of the latest technology often yields quite novel configurations, frequently using newer materials.

ABS risk-based approaches to Classification of proposed designs are applicable to retrofits and new designs of ships as well as fixed and floating offshore installations. These approaches are applied as an alternative to the straightforward application of the prescriptive Rules, and are pertinent in any situation where a design is being proposed on the premise that it provides an equivalent level of safety to that implicit in recognized ABS Class Rules.

This paper discusses the methodology outlined in these two Guides, provides advice for facilitating the processes described, and addresses lessons learned through the application of the Guides.

Keywords

Risk; maritime; ships; CNG; novel; Classification

Introduction

Organizations responsible for ensuring the structural and mechanical fitness of ships and other marine structures, such as the American Bureau of Shipping (ABS), face a particular challenge. As part of the process of ensuring the fitness of structural and mechanical systems, ABS establishes standards (known as Rules) and administers them, a process known broadly as Classification. The Rules have been developed primarily for the most common types of ship and offshore structures and systems, where there is generally a history of successful operation. The challenge relates to ensuring the fitness of novel systems for which there is limited or no experience. A related challenge is when alternative methods (to the Rules) are used to demonstrate fitness. Risk methods play a key role in responding to these challenges.

The section below provides background to the Classification process, the trends in engineering and the associated challenges that organizations such as ABS face. A description is then presented of risk methods, which are central to meeting the challenges briefly mentioned above. The role of risk approaches is summarized in the next section. The ABS approach to ensuring fitness of novel concepts is then described, accompanied by a case study. The paper concludes with a discussion of risk criteria.

The Role of Classification Societies

Classification Societies are independent organizations that promote the security of life, property and the natural environment through the development and verification of standards for the design, construction and operational maintenance of marine-related facilities. Ships and marine-related facilities that comply with the Classification Society Rules are said to be in “Class”. Classification is required by SOLAS, the most important international treaty concerning the safety of merchant vessels. Additionally, underwriters, ports, government bodies, financial institutions, cargo-owners, and other entities related with the marine industry often require it as a pre-requisite for doing business.

Traditional Classification Rules are prescriptive in nature and specify requirements, which the various systems that comprise the vessel or installation must satisfy. This type of approach has been successful in achieving a good common level of safety and without them; it would be difficult for a shipbuilder to quickly and confidently respond to a potential construction bid.

The objective of Class Rules has always been to reduce undesirable events that can harm humans, property or the environment. However, this objective is not explicit in the Rules, as they were developed without the benefit of risk technology. Additionally, is awkward to develop new Rules incorporating the rapid technological advances on the design and constructions of marine vessels and offshore structures. As a result, certain existing requirements within the Classification Rules may be excessive, not entirely comprehensive, or inconsistent.

Modern Trends in Engineering Systems

Most industries, the marine industry included, seek to make cost-effective improvements in their designs. This trend is apparent in the offshore and marine industry by requirements such as the exploration and production of oil in deeper waters, the use new, lighter and more cost-effective materials of construction for ships and platforms, and increases in the size and capacity of facilities and vessels.

A risk-based regulatory regime may be, in many instances, the best and only mechanism to offer greater guarantees that modern science and technology are being adequately applied in the fields that affect marine safety.

The application of risk approaches to engineering projects became more prevalent after a series of severe accidents in chemical plants and offshore production platforms in the late 1970’s. These devastating accidents resulted in legislation in many countries requiring all risks to be systematically analyzed, assessed and managed in order to protect public health and safety, and to limit the environmental and economic impacts of potential accidents.

The risk-based studies performed over the last 30 years have proved to be beneficial for all parties involved (industry, regulatory authorities, public, etc.) as they provide qualitative and quantitative measures that can support decision-making and enhance public understanding.

Risk can be used in all activities of the Classification business: a) Rule development, b) basis for Class assignment after assessment of a design and c) maintenance of Class after a survey of the facility in question. The focus of this paper will be using risk for Class assignment, in particular for novel concepts for which no Class Rules exist.

Risk in Novel Concepts

In the early phases of novel technology development, there are a) known hazards, b) hazards whose effects are not totally understood, and c) hazards that have not been recognized. Hazards that are unknown or not fully understood cannot be managed or mitigated appropriately, potentially resulting in major accidents. Risk-based methods provide a proactive approach to help identify unknown risks and use that information as a tool in decision-making.

There can be various degrees of novelty in a new concept. In the marine industry, the novel design may encompass the entire concept of a vessel or offshore facility, a system or subsystem, or apply only to an individual component. A novel structure may have novel failure mechanisms (e.g., potential failure modes that may have not been experienced before). The interactions of known factors (e.g., structural loads, environmental conditions, operational conditions, etc.) on novel designs may also be unknown, or if known, difficult to quantify.

History provides many examples of failure of novel systems. While the percentage of novel systems that fail is small, the consequences of failure can be disastrous in human life and cost. A proactive systematic approach is required to minimize the probability of failure of a novel design.

Some examples of failures of structures or mechanical systems that were novel at their time include:

- The Titanic – the well-known sinking of a ship in her maiden voyage, with the loss of 1,503 lives. Novel aspects of the ship included new material technology, new conditions/loads (fracture toughness, weldable steels, artic sea, design requirements). Little thought was given to how a ship, 852 feet in length, might turn in an emergency or avoid collision with an iceberg.
- The Tacoma Narrows Bridge – a long span suspension bridge built when most bridges to date were based on trusses, arches and cantilevers. Unfortunately, engineers did not fully understand the wind forces acting upon bridges. Neither did they understand the response of the suspension bridges to these poorly understood forces. Furthermore, the Tacoma Narrows Bridge was built with shallow plate girders instead of the more usual deep stiffening trusses. Note that the wind can pass through trusses. Plate girders, on the other hand, present an obstacle to the wind. The bridge collapsed within 4 months of commissioning as a result of complex dynamic interactions between motions of the deck and the wind. It boasted new design and new conditions (geography, wind, turbulence, vibrations).
- The Comet Passenger jet – new transport technology introducing new load cases (high altitude flight for turbojet engines requiring cabin pressurization). The planes suffered from metal fatigue, especially around rivet holes, due to the cyclic stresses caused by the pressurizing and depressurizing of the aircraft fuselage. This was an example of an improperly understood failure mode. Cracks in the Comets started at the corners of the square windows and led to explosive decompression at altitude. Modern jet aircrafts have rounded windows and doors.
- Alexander Kielland – was an offshore accommodation platform with a pentagon-type design. It lost one of its five main support columns after failure of a horizontal bracing member in severe weather. The resulting massive loss of buoyancy led to capsize within about 30 minutes, taking 123 lives.

How would a systematic risk identification and analysis have helped in all of these cases? Let us focus the Alexander Kielland for illustrative purposes.

Although material properties and welding played a significant part in the Alexander Kielland disaster, rig design was also a critical factor. Apart from the stability and buoyancy aspects that were inadequate, the design did not considerer attachments to highly stressed braces as important. After the Alexander Kielland, Norway adopted stability standards that included the requirement that floating offshore units should withstand loss of buoyancy from either the whole or a major part of one column, but without any requirement to return to the upright position. The objective in this case was to allow the crew time to evacuate the unit.

The net lesson from examination of these unfortunate accident cases is that consideration unwanted events, including its consequences, its failure modes and mechanisms is an integral part of successful design.

The prior examples illustrate structural failures, but the use of risk-based methods is not limited to structures, or to accidents arising from loading exceeding resistance. The risk-based methods described here relate to failures due errors in design, construction, or operation and have a wide area of application, including machinery and structural systems.

ABS Novel Concepts Approach to Classification

ABS has developed the *Guidance Notes on Review and Approval of Novel Concepts*, from now on referred to as the *Novel Concepts Guide*, which lays out a standard methodology for obtaining Classification of a novel design. The process draws upon engineering, testing and risk assessment to determine if the concept provides acceptable levels of safety in line with current offshore and marine industry practice.

In ABS terminology, risk-based approaches refer to qualitative or quantitative techniques that have the following phases:

- Definition of the system – defines the boundaries of the system, installation, ship, operation, etc. to be analyzed.
- Hazard identification – identifies what can possibly go wrong in the system, in most cases assuming that even established safeguards can fail. Examples of unwanted events are fire, explosion, sinking, loss of propulsion, oil spills, etc.
- Frequency and consequence analysis (qualitative or quantitative) – determines for all identified unwanted events, the magnitude of the consequence, and the likelihood of occurrence.
- Risk criteria – comparison of risk results against established guidelines to indicate whether the risks are acceptable.
- Risk reduction – if risks exceed the acceptance criteria, risk reduction measures are to be developed.

New/novel concepts may be the entire concept of a vessel or facility, a system or subsystem or an individual component. New/novel concepts may be defined in several ways:

- *Existing design/process/procedures in new or novel applications.* An example of this could be a proposed use of an onshore existing technology application, such as the use of a chemical process or storage medium on floating structures.
- *Existing design/process/procedures challenging the present boundaries/envelope of current offshore or marine applications.* An example of this could be a proposed use of an existing type of floating structure, typically only used for drilling and processing hydrocarbons that would also include hydrocarbon storage.
- *New or novel design/process/procedures in existing applications.* An example of this could be a new type of offshore floating structure that has not been used before.
- *New or novel design/process/procedures in new or novel application.* An example of this could be a proposed use of an onshore existing technology application, such as the use of a particular storage medium on a new type of floating structure, which contains an unproven or novel process system.

In order to help determine if a proposed design falls into the category of new/novel, a checklist is provided. The objective of the checklist is twofold:

- To establish if the new design qualifies as a new/novel concept and whether the use of the *Novel Concepts Guide* approach are appropriate for evaluating the concept and;

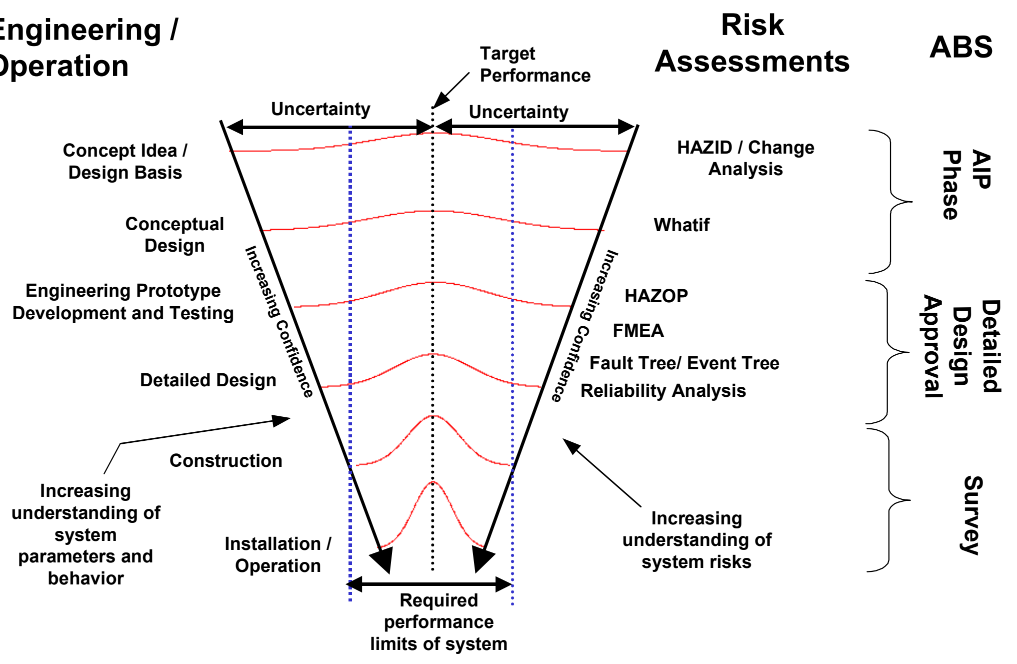
- To gain a general understanding of the variation from existing or proven marine or offshore applications, and thus the degree of novelty.

The checklist is intended as a trigger to indicate if the proposed design should be categorized as novel, thus requiring additional considerations and evaluation outside the standard Class approval process prescribed in the ABS Rules. The number of yes/no answers gained from the use of the checklist does not directly dictate what evaluations need to be performed in order to Class the design. Rather, the answers provide an indication that discussions with ABS should be initiated to ensure there is a mutual understanding between the designers and ABS on how the design may deviate from existing applications, the degree of novelty present, the lack of suitable Rules, codes and standards to address that novelty and what plan of action will be required to address these deviations. In general, if a high degree of novelty is confirmed via the checklist, then the *Novel Concept Guide* should be applied.

On the other hand, if the degree of novelty is limited in scope, such as an alternative to a Rule requirement (i.e. alternate pressure relief arrangement), then Class approval is best achieved through the application of the ABS *Guide for Risk Evaluations for the Classification of Marine-Related Facilities.* This latter *Risk Evaluations Guide* provides an approach to determining if the alternative to the Rule design provides and equivalent level of safety. It is understood that ABS and the client have to mutually agree to what constitutes a high degree of novelty and therefore the appropriate document to be used in the approval process.

Figure 1 illustrates graphically the evolution of a concept in terms of engineering and operation, risk assessment and ABS involvement in these phases. Clients who are just beginning to explore the possibilities of a new technology, or concept, often seek ABS input and expert opinion on the concept in terms of Class or ABS approval. Thus, clients will seek a preliminary approval from ABS on the novel feature or concept. This preliminary milestone in the ABS Class process is called Approval in Principle (AIP).

Figure 1 Concept Evolution



At the AIP stage the risk is assessed at a high level through qualitative techniques such as a What-if, Hazard Identification (HAZID), Hazard and Operability study (HAZOP), Failure Mode and Effects Analysis (FMEA), etc. The failure modes and consequences identified through one or more of these qualitative analyses are fed to engineering design to ensure they are considered in the concept design phase. The qualitative risk identification also identifies the need for proof or model testing and data gathering, as well as need for a more refined risk assessment and engineering analysis. These further studies do not necessarily need to be completed to grant an AIP.

Once the AIP is granted, the concept will advance into the next phases of the project, involving the detailed designed and advance studies and risk assessment identified in the AIP phase. This will aid the client and ABS in gaining certainty in their design as the level and accuracy of the risk assessment and engineering evaluation increases.

This phase of the project typically involves traditional Class participation in the form of design review and survey and would ultimately result in Class approval. Maintenance of Class would be performed in the traditional sense, involving periodic surveys to validate renewal of Class. However, the maintenance of Class for a novel concept may require a modified and/or expanded survey scope or frequency as a condition of Class, until the concept has built up a history of satisfactory service experience.

In order to achieve AIP, all relevant failure modes and hazards related to the concept are identified and addressed in an acceptable level of detail, to demonstrate to ABS that the concept is feasible for use in a marine or offshore application. This is accomplished through the preparation of appropriate engineering analyses and risk assessments at the Concept Phase so as to supply ABS with sufficient information to make this determination. Participation by ABS personnel in the various risk assessments is also strongly encouraged to facilitate the approval process.

As a first step in the AIP process, the client needs to develop the following two plans covering the risk assessment and engineering evaluation of the concept. It should be understood that the reason for conducting the risk assessment and design evaluation plans is to ensure that a body of evidence is built up to address approval of the novel features:

a) ***Risk Assessment Plan.*** The risk assessment plan should be developed identifying the appropriate type of assessment technique for the AIP phase and full approval phase. In this regard, the plan should address how the project team envisions a holistic approach to risk assessment for all phases of the project. Modifications to this plan may be warranted as the team gains knowledge of the application and the concept level risk assessments are completed. The plan should clearly propose risk acceptance criteria with a basis for the criteria.

   The requirement for generating a risk assessment plan is to ensure that those aspects of the novel application for which there exist no industry guidelines in terms of safety philosophy can, through the risk assessments, be demonstrated to both Class and regulators as having acceptable risk levels. An example of a holistic risk assessment plan for a novel concept might involve performing a HAZID/HAZOP for the purposes of generating a hazard register in the AIP phase, and further studies as necessary in the detailed design phase [e.g., fire and explosion analyses, emergency system survivability analysis, smoke and gas ingress analysis, Escape, Evacuation and Rescue (EER) study, quantitative risk assessments (QRA)].

b) ***Design Assessment Plan****.* The design assessment plan should address the proposed means of justification for all relevant features of the novel application, their associated failure modes and the means proposed to assess the engineering suitability. Similar to the risk assessment plan, the design assessment plan shall also outline acceptable results for the design analyses with the basis for the same. The plan should address required steps to be taken in the concept evaluation as well as in the full approval phase.

   This plan should be separated into two distinct sections for both phases:

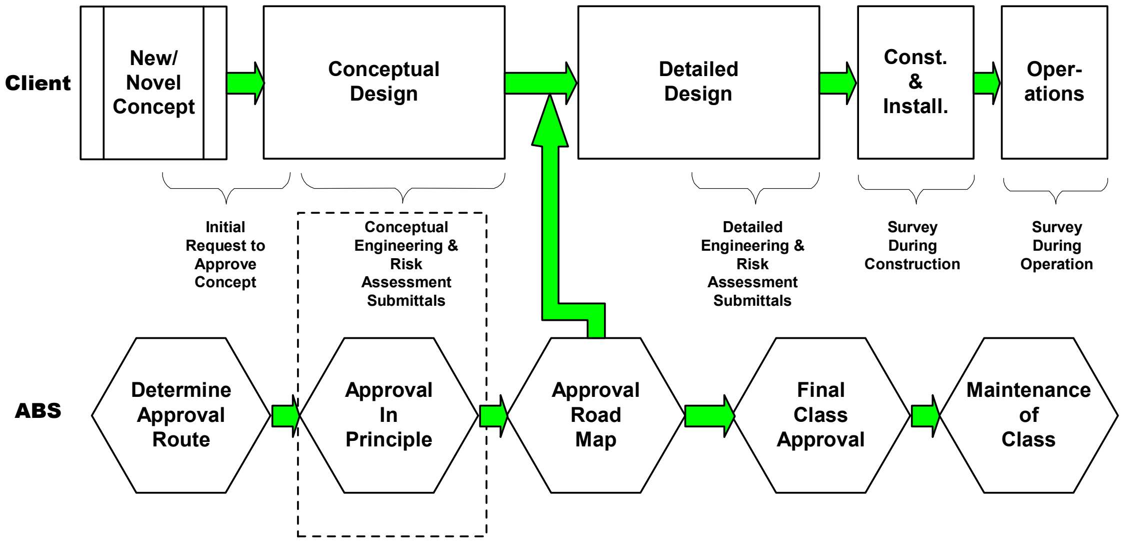
- Those aspects for which there are suitable and appropriate codes and standards, which can be applied.
- Those aspects, which due to their novelty, may require a more rigorous approach to demonstrate feasibility of the concept.

The engineering and risk assessment submittals are compared with existing marine and offshore practice to demonstrate that the risk created by the novel concept is no more onerous than what currently exists in the marine and offshore industries.

All hazards relevant to the novel features are to be identified in order to assure appropriate mitigation measures are provided to ensure a comparable overall level of safety established in industry-published codes, standards and recommended practices or in ABS existing Rules and Guides. In some instances, the risk mitigation methods might themselves be novel in their approach. However, these approaches must be demonstrated to the satisfaction of ABS that they still can be practically applied to the concept.

Figure 2 gives an overview of the process that the client and ABS would follow to achieve the approval milestones.

Figure 2 Novel Concepts Approval Process



Case Study: "AIP" Of a Compressed Natural Gas (CNG) Carrier Ship

The concept of transporting CNG by ship allows marketing of natural gas with minimal infrastructure in field or onshore. The concept was developed to monetize stranded gas opportunities. Stranded gas cannot be developed economically, either because the volumes are too small to justify LNG infrastructure for liquefaction, regasification and storage plants, or because it is too far offshore to justify pipelines.

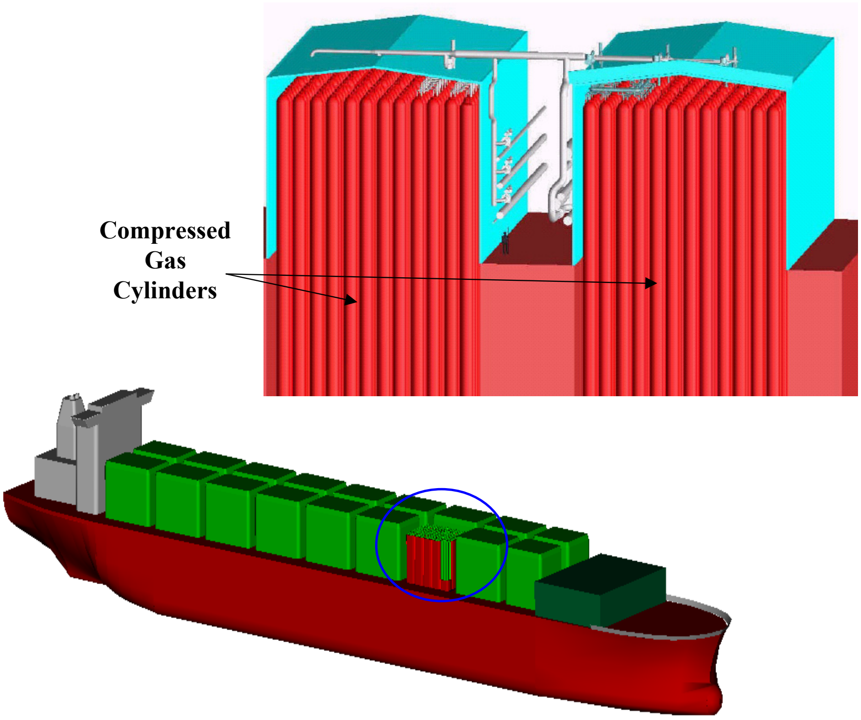
The CNG carrier system is an ocean-going gas delivery service. One concept (VOTRANS™ by EnerSea Transport LLC) is comprised of large diameter pipes contained within insulated structures integrated onto specially designed and constructed ships, as sketched in **Figure 3**. All loading and offloading facilities will be located offshore to provide safe and efficient operations and a quicker process for permit application and approval.

The concept has a high degree of novelty and capital expense to construct, thus the client wanted to have to have ABS "Approval in Principle" during concept design project phase.

No Classification Rules existed to date for CNG Carriers, thus, when ABS received the request for Approval in Principle, it followed the systematic approach indicated in the *Novel Concepts Guide.*

Figure 3 CNG Carrier System

Courtesy of EnerSea Transport LLC (www.Enersea.com)



Step 1: Is it a Novel Concept?

The first step is to determine if the proposed design is truly a novel concept, or only has limited novel features that can be addressed by traditional Class design review or risk-based Classification.

The *Novel Concepts Guide* provides a novel concept checklist, which was used to establish the level of novelty. A high degree of novelty was evident from the total of fifteen negative responses to questions such as

- Is the proposed type of marine or offshore application or facility currently being used in marine or offshore applications?
- Is the vessel or offshore facility design basis considered within current experience boundaries for this application?
- Are there applicable design guidance documents specific to the proposed marine or offshore applications?

Therefore, the use of the *Novel Concepts Guide* was considered appropriate.

Step 2: Is the Approval in Principle Required?

From the ABS perspective, the Approval in Principle is recommended but not always required. As indicated previously, the client specifically requested an AIP. The AIP was the prudent option for a design with such high degree of novelty and capital expense.

The Approval in Principle demonstrates the feasibility of the design during the Concept Design Project Phase, it confirms that there are no significant impediments to further development of the concept and gives the client a third-party confirmation on the concept feasibility to provide to regulators and business partners.

Step 3: Assessment Plans Development

This step entails development of both a Design Assessment Plan and a Risk Assessment Plan. For the development of the Design Assessment Plan, it is necessary to determine what is novel and how ABS will approve it. The development of the Risk Assessment Plan entails agreeing on the client plans to assess the risk created by novel features. Risk assessment techniques in the AIP phase must as a minimum identify the hazards created by novel features.

The CNG carrier is novel because of the vessel configuration, vessel layout and arrangement, process deck/system forward and gas process equipment on board, unique gas storage system, load/offload methods, and unproven materials of construction in this type of service. The CNG carrier Design Assessment Plan was developed to address all the issues associated with the proposed design, novel or standard or in-between.

The Risk Assessment Plan, on the other hand, was used to gain insight about the novel features, the standard features used in an "extended role", and the impact of all on the overall vessel. The requirements of the Risk Assessment Plan included the execution of a 1) global hazard identification evaluation, 2) a comparative risk assessment comparing the differences in risk between an LNG carrier and a CNG carrier, 3) a preliminary Pipe Tank Reliability Assessment to look for potential "showstoppers", and 4) development of target reliability for the novel structure.

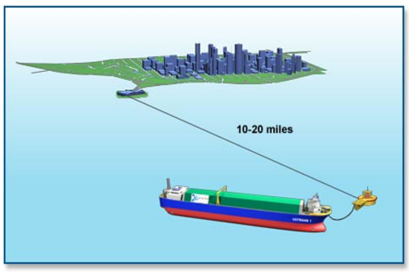
Step 4a: Risk Assessments

A qualitative risk assessment was conducted to identify the critical hazards associated with the CNG vessel that need to be addressed as the design progresses, and to assess the differences in risk between a typical LNG carrier based on well established technology and a CNG carrier. The risk assessment team comprised of independent experts representing all interested parties, and including technical experts in LNG, including LNG ship captains, naval architects, insurance technical risk experts, process engineers and Health, Safety and Environmental (HS&E) professionals.

Figure 4 Comparison of total risk on different phases between LNG and CNG

Courtesy of EnerSea Transport LLC (www.EnerSea.com)

LNG	CNG
Liquefaction	Compression and Refrigeration
Loading	Loading
Port Departure	Buoy Departure
Transit	Transit
Port Arrival	Buoy Arrival
Discharging	Discharging
Regasification	Decompression



In order to assess the risks associated with the new CNG concept, a comparable risk assessment was performed. The CNG concept was compared with well-established LNG technology. The risks were comparable, although distributed differently between the phases indicated in **Figure 4**. CNG and LNG have the same order of risk overall. CNG is found to have a slight risk management advantage since all risks are offshore, and the potential for affecting the public is virtually non-existent.

None of the identified risks evaluated using a pre-agreed Risk Matrix (Probability vs. Severity) were in the unacceptable range **(Figure 5)**.

Figure 5 Identified Risks Evaluated in a the Risk Matrix

	Severity of Incident (or Consequences)				
Probability	A	B	C	D	E
I	1	1	2	3	52 4
II	1	1	2	3	56 4
III	1	41 45 51 2	50 3	43 48 49 69 4	47 68 5
IV	61 71 2	42 67 3	55 63 4	62 70 5	54 57 58 59 60 5
V	44 46 3	53 64 65 4	4	66 5	5

Key elements of the CNG concept are the pressurized tanks. For this element target reliabilities were set by comparison with similar applications in other industries.

Step 4b: Engineering Evaluations

The Design Assessment Plan focused on novel aspects, including,

- Review of preliminary containment system design, paying attention to issues such as materials, strength/fatigue, fabrication, and inspection plan during berth fabrication and in-service.
- Review structural hull design aspects (layout, intact and damage stability, trim, loading strength review, and basic ship structural drawings).
- Basic electrical design aspects.
- Process design (gas load/offload, nitrogen system, vent and relief [gas dispersion and heat radiation calculations, fire protection]).

Step 5: AIP Approval and Road Map for Final Approval

As a result of the different work and analyses conducted during the AIP by the client and by ABS, all parties involved understood the concept to a level that enabled ABS to grant Approval in Principle, provided that the stipulated requirements are met during the final design phase.
These requirements are laid out in the ABS AIP letter issued to the client, and the plan forward clearly defined. The Full Class Approval Plan again includes both a Risk Assessment Plan and Engineering Evaluations Plan.

An output of the AIP phase was a list of risk analyses required as part of final approval process. These analyses addressed various elements of the design related to safety, such as

- Detailed Process System HAZOP Study.
- Advanced Gas Dynamics Study to determine behavior of gas release (unintended) on bottle in question and surrounding bottle and structures.
- Gas Dispersion Analysis to understand the consequences from controlled venting /flaring of gas from relief/vent system (flammability/radiant heat, etc.).
- Fire and Explosion (F&E) Analysis to address all F&E events and assists with layout design and identifying preventive measures.
- Smoke and Gas Ingress Analysis to assess potential for loss of life support in the safe refuge from smoke, toxics and thermal loads.
- Emergency System Survivability Analysis to assess vulnerability of critical safety systems to perform prior to impairment.
- Escape, Evacuation and Rescue (EER) studies to offer input to layout of egress routes and muster location.

The risk analysis studies are adequate to demonstrate whether the risk to persons and environment has been reduced to as low as practicable using demonstrable techniques suitable for submittal to

Class and regulatory authorities. Several engineering analyses studies were also required, such as

- Dynamic Loading Approach (DLA) and Spectral Fatigue Analysis (SFA) of hull.
- Prototype testing and benchmarking of pipe tank integrity monitoring methods.
- Final pipe tank design and reliability assessment considering all loads and the better understanding of resistance.

Step 6: Survey during Construction and / Maintenance of Class

This step addresses critical areas or special requirements that were highlighted in the prior evaluations regarding fabrication and maintenance. For Surveys during Construction of the CNG vessel, a Test Program during construction was designed that included a Prototype Test Plan and Operational Tests.

The Prototype Test Plan addressed materials, fabrication and testing. The Operational Test addressed process simulations and ship sea trials whose purpose are to verify that the vessel and components meet specified performance requirements.

The customized requirements for the Maintenance of Class of the CNG carrier include in-service monitoring utilizing Acoustic Emission Testing (AET) to confirm pipe tank integrity in lieu of traditional internal inspection and the permanent instrumentation (AE sensors) of multiple cargo containers. Also, key critical structural areas will be strain-gauged, as per International Gas Code (IGC) and to confirm calculations for pipe tank design.

Step 7: Final Class Approval

The technology company, EnerSea has entered into strategic partnerships with Kawasaki Kaisen Kaisha (“K” Line) and Hyundai Heavy Industries (HHI) to complete the vessel design and analysis of the CNG vessels to obtain necessary approvals and establish a firm basis for cost and schedule. The Approval in Principle allowed all parties to move forward with confidence and will assist in the final Class approval of the project.

Risk Criteria

The current ABS approach for risk-based Classification is to require clients to propose their own risk criteria. The criteria should be consistent with industry standards and norms and is a matter of negotiation.

ABS is in the process of developing its own criteria. The attributes that the risk criteria will have are as follows:

- Flexible – guidelines are given as a first step in decision making, but the specific circumstances, the engineering judgment, ABS’s values, and the social benefit of the project should be taken into consideration for the final decision.
- Broad – Criteria should fit all or most types of risk assessment methodologies: 1) quantitative risk analysis for a whole installation, 2) quantitative for a single scenario, and 3) qualitative for a single scenario. Qualitative risk criteria for the whole installation do not appear to be practical.
- Adaptable – Guidance on how to work with owner-operator own risk criteria.
- Calibrated – The risk criteria should be calibrated to be credible, using reality checks and consisted with industry standards of safety and risk acceptability.

The Rules applied by ABS are generally prescriptive, have evolved over many decades and are based on a history of successful performance. The Rules are modified in incremental fashion in response to increased knowledge and advancements in technology. In common with most prescriptive methods, safety levels in the Rules are not expressed in explicit terms. ABS is presently conducting research with the ultimate aim of integrating risk principles more explicitly in the Rules.

Conclusions

Risk approaches, coupled with engineering assessments, can be key in assisting Class to verify that a vessel or installation is designed and constructed to achieve the proper safety levels as well as provide for optimum performance. Risk techniques do not need to be complex and sophisticated to be a valuable tool for Classification. Simple, systematic, and well-documented approaches that include hazard identification, qualitative frequency and consequence analysis, comparison against established risk criteria, and risk reduction options have proven to be very effective tools.

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