

ABS Development of a Guide for Compressed Natural Gas Carriers

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ABSTRACT

Technical issues to be considered for all Compressed Natural Gas (CNG) projects are discussed. The principal concerns of all CNG developers and the administration is the development of safe and cost effective containment systems. CNG containment systems must optimize weight while maintaining sufficient strength to contain the CNG under the operating pressure.

Also considered are the necessary criteria to have CNG carriers suitable for their intended service in the shipping community and resolution of regulatory issues.

This paper outlines the steps to take for ABS Approval in Principle (AIP) and details the development of the CNG guide.

KEY WORDS: Approval in Principle (AIP), CNG Containment System, Compressed Natural Gas Carrier (CNG Carrier) Guide

INTRODUCTION

This paper identifies the principal safety considerations and the hazards that must be assessed when developing novel concepts for the carriage of Compressed Natural Gas (CNG) by sea. It will explain the approach that the American Bureau of Shipping (ABS) has taken in establishing the first classification standards for these new vessels, standards contained in two new ABS Guides that have been developed in close cooperation with industry. The paper also highlights both the differences and the commonalities associated with transporting gas in a compressed and in liquid form.

Designers of the various CNG concepts that have been developed have turned to ABS seeking Approval in Principle (AIP) for their designs. Approval in Principle is a process by which ABS issues a statement stating that the proposed concept design complies with the intent of the ABS Rules and/or appropriate codes, subject to a list of conditions that must be addressed in the final design stage. ABS considers parts of the design for which no previous experience exists to be "Novel Concepts" and has adapted well proven risk assessment methodology to assess these elements for appropriate levels of safety.

Based on experience gained in evaluating several novel CNG concepts over many years, in May of 2002, ABS issued a draft set of requirements in the form of *Guidance Notes for Building and Classing Ships Carrying Compressed Natural Gas*. This draft was developed to assist designers in obtaining ABS Approval in Principle and was distributed to industry for comment. In June of this year, ABS issued more fully

developed criteria for classing CNG carriers in the *Guide for Vessels Intended to Carry Compressed Natural Gases in Bulk*. This has also been distributed to industry for additional comment and will continue to be updated to reflect expanding knowledge and experience in this sector. The final draft guide has also been reviewed by industry and modified to reflect present knowledge. The CNG Guide (ABS 2005) is available on the ABS web site www.eagle.org. The criteria contained in the Guide are sufficient to allow ABS to class CNG carriers built in accordance with its requirements.

BACKGROUND

There are three means to move natural gas across a body of water: in a pipeline, on a ship or barge as a liquid (LNG), or as a compressed gas (CNG). When determining the best means of transportation for a specific project, it must be borne in mind that, while the project may be quantified in terms of bcf of gas per day or MMT of LNG per annum, what is being bought and sold is energy. The sale is always priced in terms of dollars per million BTU moved, regardless of the method selected for movement. A project can only be successful when the price of energy to the consumer over the long term is competitive with other available energy costs.

The most cost-effective means to transfer energy in the form of natural gas for relatively short distances across a body of water is through a pipeline. For most long-term projects, depending on the subsea topography, the subsea pipeline is the chosen method for distances up to about 500 miles. All the expense is up-front in terms of capital cost. There is little in the way of operating costs. However, even for short distances, if the sea bottom is very mountainous, as is the case of the deep water areas of the U.S. Gulf of Mexico, or if the gas supply is marginal with a projected short field life, the cost of installing a pipeline may be prohibitive.

For projects not suited for a subsea pipeline, the choice is between transporting the energy as either a liquid or as a compressed gas. The choice between employing a self-propelled ship as opposed to a barge will depend on the volume and distance for the specified trade route.

The concept of pressurizing and then squeezing as much natural gas as possible into a container for transport is not new. Several CNG concepts for storage and land transport were proposed as far back as the 1960's. One design concept, for a barge to operate in the South China Sea, was developed by Bechtel in the late 1980's and was sufficiently advanced to be submitted to ABS for Approval in Principle. However, the project never came to fruition. Interest in CNG has increased steadily over the last ten years. In this period, ABS has received several requests from designers to review their proposed design scenarios for the transportation of CNG by sea.

By converting natural gas to a liquid, LNG, there is a volumetric advantage of about 600 to 1. In the case of CNG, the volumetric advantage is directly proportional to the increase in pressure together with a reduction in temperature to at or below 0 degrees C. However, this still cannot match the tremendous volumetric advantage of liquefying the gas, so LNG will remain the chosen method of transport for both long and short term projects where the voyage distance is greater than about 2000 miles.

Proponents of CNG concepts suggest that energy companies consider the selection of CNG carriers to satisfy the transportation needs of niche projects where the trade is in the range of about 500 to 2000 miles.

The basic differences between CNG and LNG are highlighted in Figure 1. The most important differences are the temperature and pressure at which it is stored and carried.

ADVANTAGES OF CNG PROJECTS

The limitation in the volume of gas that can be transported in a single shipment has already been mentioned. There are a number of very distinct advantages of CNG when compared to LNG, which have created the very strong interest in CNG that exists today.

No need for liquefaction or re-gasification. Since there is no phase change with CNG, the cost of processing the natural gas to a point suitable for liquefaction and the very high energy-intensive process of making LNG are eliminated, as is the cost of pressurizing and vaporizing the liquid natural gas back to its original state. This cost of liquefaction and then regasification is between \$1.00 and \$1.50 per million BTU. With CNG, there is a cost of pressurizing the gas, but this process is much less expensive than liquefaction.

CNG vs LNG

- | | |
|--|---|
| • Pressurized Gas | • Cryogenic Liquid |
| • 90-280 Bars | • 0.25 Bar |
| • D / t ~ 25 to 50 | • D / t ~ 1000 |
| • -40 C to Ambient | • -160 C |
| • Fine grain normalized steel | • Aluminum, Stainless, Ni Steel |
| • V ₁ / V ₂ ~ 200- 300 / 1 | • V ₁ / V ₂ ~ 600 / 1 |

Figure 1. Summary of Differences between CNG and LNG

Offshore Loading and Discharge. Since the product being transported is not a cryogenic liquid, it can be discharged into a new or even an existing subsea gas transmission pipeline system through a mooring buoy or other type of simple offshore terminal arrangement. With concerns related to traffic, navigational issues and port security, offshore loading and discharge could be a considerable advantage in many projects as the vessel never has to enter a crowded terminal or port facility in a densely populated area.

Quality of the gas. Since the gas is not going to be converted to a liquid, the gas need not be cleaned to the same extent as is necessary for LNG pre-processing. All efforts are made, however, to dehydrate and remove sulfur from the gas so as to avoid corrosion when metallic containment systems are used. The gas quality must still meet the pipeline minimum specified requirements.

Material of containment system. The containment systems for most of the various CNG concepts being developed use fine grain normalized steel, such as API 5L pipeline quality steel, rather than the significantly more expensive high nickel steel, aluminum or stainless steel that is needed to carry cryogenic LNG. Three other designs are using nonmetallic containment systems.

System	Williams	EnerSea	TransCanada	Knutsen	Statoil etc.	IFP	TransOcean
Type of Containment System	Coiled Pipe	Cylindrical Pressure Vessel	Cylindrical Pressure Vessel	Cylindrical Pressure Vessel	Cylindrical Pressure Vessel	Cylindrical Pressure Vessel	Cylindrical Pressure Vessel
Pressure Vessel Orientation	Vertical Coil Axis	Vertical	Horizontal	Vertical	Horizontal	Vertical	Vertical
Material	Steel	Steel Pipeline	Composite Reinforced Steel Pipeline	Steel Pipeline	Steel Pipeline	Composite Reinforced Steel	Composite Glass or Carbon Fibre
P.V. Diameter	6.625"	36" To 42" or Larger	42"	42"	42" or 48"	2-3m	42"
P.V. Length	11 Miles	80ft To 120ft	80ft	18m or 38m	220m	14m to 24m	40ft
Pressure	280 BAR	90 to 130 BAR	200 BAR	250 BAR	250 BAR	130 BAR	240 BAR
Temperature	10 ^o c	-20 To -30 ^o c	Ambient	Ambient	Ambient	-30 ^o c	-40 ^o c

Figure 2. Principle Features of CNG Design Concept

Variable size. Since the individual cargo containers are small in size and the entire design is somewhat modular as compared to the normal arrangement of 4 or 5 very large tanks on an LNG carrier, there is great flexibility in the cargo carrying capacity of the ships.

Suitable for retrofit on existing vessels. Since the product is not being carried as a cryogenic fluid, the containment systems can be fitted in existing vessels.

CNG CONCEPT IN DEVELOPMENT

There are a number of CNG concepts in various stages of development. At the First International Marine CNG Standards Forum held in St. John's, NL, Canada 22 and 23 June 2004, there was an overview of the current CNG design concepts which included the following table showing the principal features of each. (See Figure 2.)

ABS has provided Approval in Principle (ABS 2003) to concepts developed by EnerSea, Trans Canada, Trans Ocean Gas, and Williams. Each has been provided with a list of specific requirements to complete in order to receive final approval for the design to be classed by ABS as Compressed Gas Carrier. Most have carried out safety studies and can demonstrate to prospective owners that the design can be profitable in moving gas to the consumer.

ABS APPROACH TO NOVAL CONCEPTS

ABS consistently follows the following methodology in the development and application of our rules and other applicable requirements for the evaluation of vessels of novel design. This is the approach that was followed in the evaluation of the CNG concepts that have been brought to ABS. The process consists of the following steps:

1. **Understand the Concept** through a series of meetings with the client. This may include discussions with the proposed shipyard, with designers and the owner and also a review of preliminary design documentation so that the key members of the ABS team become familiar with the important aspects of the novel concept.
2. **Identify "novel" areas of the proposed design.** These are the elements of the design that go beyond that which has previously been built or beyond that envisaged in the existing ABS Rules and other published requirements. In some cases, this may be just an extension of what has been done before, as compared to areas that are truly novel. For example, ABS is aware of several instances where compressed natural gas has been used for fuel on small self propelled vessels. However, there has not, as yet, been any direct experience in transporting bulk compressed natural gas by sea.
3. **Identify all hazards** that need to be considered in reviewing the design in order to establish that, as a minimum, the same overall level of safety contained in existing Rules or in other standards is achieved.
4. **Identify existing Rule requirements** that are most closely applicable to the identified hazards. It is usually easier to establish an acceptable level of risk on the basis of compliance with established criteria than starting with a clean sheet. In the case of CNG carriers, for example, it

was recognized that many of the same hazards identified were also present on LNG carriers, while other hazards, such as the sudden release of a high pressure flammable gas, are dealt with on offshore drilling and production units.

5. **Identify "Equivalent" areas of the design.** It is recognized that all Rules, standards and even the IMO Gas Code, provide a certain degree of flexibility if the designer can demonstrate that the proposed arrangement provides an equivalent level of safety.
6. **Identify area of the design for which no standards exist.** These are areas that are not covered by any known safety criteria such as other ABS requirements, national or international standards and even industry codes that have been effectively implemented in other industries in similar applications.
7. **Apply first principles.** Based on the foregoing, identify areas of the design that can only be justified by some form of engineering first principles approach.
8. **Provide the client with a consistent approach to the evaluation.** This will require agreement between ABS and the client as to:
 - a. Engineering assessments to be conducted for the AIP
 - b. Appropriate risk analyses to be employed and where they should be applied for the AIP and class
 - c. Appropriate data collection and testing to be carried out to assist in proving the technology for the AIP and class.

The above outlined approach has been formalized by ABS in a new publication, *ABS Guidance Notes for Novel Concepts* (ABS 2003). Figure 3 demonstrates graphically the evolution of a concept in terms of engineering and operation, risk assessment and ABS involvement in these phases.

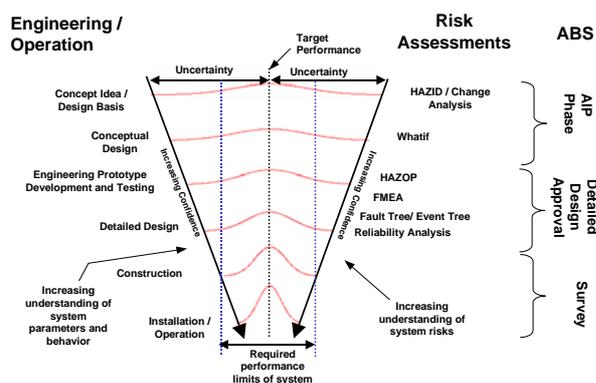


Figure 3. Evolution of a Concept.

The *ABS Guidance Notes for Novel Concepts* (ABS 2003) describe in detail the process for review, divided into three key stages. First the AIP stage describes when and what to submit, and outlines the review process and potential outcomes. The second stage involves moving forward with a project into detailed design, construction, installation and ultimately issuance of ABS class certificates. It is intended that the second stage builds on the AIP stage. The final stage is maintenance of class, that is, the ongoing evaluation to ensure the original assumptions regarding fitness for purpose and risk are met. The process that the client and ABS would

follow to achieve these milestones is outlined below in Figure 4

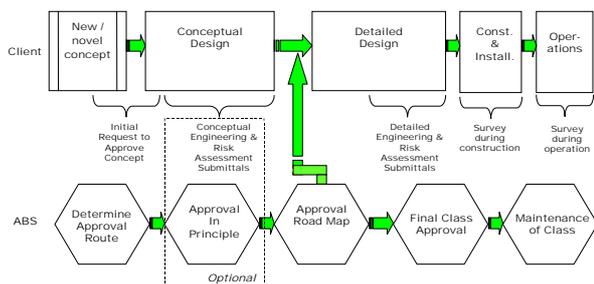


Figure 4. Milestones Outlines

TECHNICAL ISSUES

Some of the hazards applicable to LNG carriers such as methane vapor release, fire, explosion, toxicity, collision and grounding would also be applicable to CNG carriers. However, there are a number of additional hazards or possible increased risk from the same hazards due to the differences in carriage conditions. These could include the following:

Design of the containment systems. As will be discussed in detail below, designers have been forced to press the envelope of conventional pressure vessel design criteria in order to minimize the weight of the containment system. Fig 2 shows that there are a number of variations in containment system design both in the diameter of the containers and the material of construction. All of these present a major deviation from the cargo tanks on existing gas ship designs yet many of the same issues, such as static and dynamic loads, fatigue and brittle fracture must be considered.

Internal inspection of containment system. Because of the need to keep the diameter of the containers as small as possible, carrying out an internal inspection of the containment system is expected to provide a real challenge. Proposals for the use of intelligent ‘pigs’, as are used to inspect pipelines, and the use of acoustic emissions methods are being considered.

Suitable repair yard. Due to the weight of the containment system, the light ship weight of these CNG vessels is almost the same as the displacement, and the lightship draft in some cases is approaching 10M. It is difficult to find a repair facility in the world that can get a vessel that deep over the sill height and into the dry dock.

Overpressure in cargo hold. Containment system failure would result in the release of gas under a pressure that can be as high as 250 bars in some designs. If the leak is below deck, it could result in overpressure of the cargo hold and cause significant structural damage to the vessel. Consequentially, the size of a single bundle is limited to the maximum amount of high pressure gas that could be released into a cargo hold without causing an overpressure. Cargo hold over pressure protection is also being fitted.

Rapid dispersion of high pressure flammable gas. There is valid concern that if there is sudden release of high pressure

natural gas, the entire vessel could be quickly engulfed in a gas-dangerous atmosphere. This suggests a need for a gas dispersion analysis which may in turn lead to extending the conventional gas-dangerous zones on the ship and the need for the fitting of a total electrical ESD system as is used on offshore drilling rigs to protect against a blow-out.

Extinguishing a gas jet fire. It is recognized that the conventional means and equipment provided on gas carriers may not be fully effective in putting out a high pressure gas fire. Special arrangements more common on offshore projects will be considered.

Cold gas impingement. Although the gas being stored will not be at a cryogenic temperature and normal steel can be used for the containers, it is recognized that the gas escaping through a crack in the tank shell will be cooled by the Joules Thomson effect. Studies have shown the gas temperature could be cooled by more than 50 degrees C and the cold escaping gas could cause cold spot embrittlement on the adjacent sections of the containment system that have not been breached. This could lead to a cascade type failure.

ABS GUIDE

The ABS Rule requirements for *Vessels Intended to Carry Liquefied Gases in Bulk* are in full agreement with the IMO IGC Code but do not cover the carriage of Compressed Natural Gas (CNG) as compared to LNG. However, it is considered that these requirements are an excellent starting point for ABS as a Class Society seeking to establish requirements for the safe transport of CNG by sea. Also, IMO Guidelines for Formal Safety Assessment (FSA) for use in the IMO Rule-Making Process, MSC/Circ. 1023, MEPC/Circ., should be used to qualify designs that contain novel concepts.

Accordingly, in order to facilitate the concurrent review of a CNG design concept against the ABS requirements and what may be considered the applicable sections of the IMO Gas Code, ABS has elected to publish the 2005 Guide for CNG carriers in the same format as the IMO Code itself with the following chapters of the Gas Code added, modified or deleted and the Chapters of the ABS Guide renumbered accordingly:

- Chapter 2 Risk Assessment and Special Studies has been added to provide guidance on how to address the novel concepts of CNG and implement the IMO FSA
- Chapter 5 Cargo Containment has been completely revised to reflect the containment systems being considered by the industry
- Appendix to Chapter 5 has been included to indicate to the designer what is required to be evaluated when a limit state design is considered for the cargo containment system
- Chapter 7 has been completely revised to reflect the material definition required for the cargo containment system
- Chapter 14 on Personnel Protection has been deleted as this is under the purview of the flag state, not the class society
- Chapter 15 on Filling Limits has been deleted as we are dealing with a gaseous and not a liquid cargo
- Chapter 17 on Special Requirements has been deleted as we are dealing with only one cargo

- A new Chapter 17 is introduced to indicate what is to be examined when the vessel is in service
- Chapter 19 has been deleted as we are dealing with a gaseous and not a liquid cargo.

IMO Gas Code Type B or C Independent Tanks	½ Yield = 35 Ksi	1/3 Ultimate = 27.3 KSI
ASME B & PV Code Section VIII Div. 2	2/3 Yield = 46.6 Ksi	1/3 Ultimate = <u>27.3 KSI</u>
ANSI B 31.8 Code for Gas Pipelines	1/1.8 Yield = 38.88_Ksi	No Limit
ASME B & PV Code Section VIII Div. 2 (REWRITE)	2/3 Yield = 46.6 KSI	1/ 2.4 Ultimate = <u>34.2 Ksi</u>
ASME B & PV Code Section VIII Div. 3	2/3 Yield = 46.6 KSI	No Limit but a margin of <u>1.73 on plastic collapse</u> also requires plastic and limit state analysis

Figure 5. Allowable Hoop Stress, Assume Yield = 70 Ksi, Ultimate = 82 Ksi

In this effort ABS took care to apply or modify requirements contained in the IMO Gas Code and the *ABS Rules for Liquefied Gas Carriers* as appropriate to CNG Carriers. The following is an outline of how various portions of the CNG carrier are treated in accordance with the new ABS Guide:

- Chapter 2 of the Guide provides for the use of Risk Based Alternatives. Attention is directed to the *ABS Guidance Notes on Risk Assessment Applications for Marine and Offshore Oil and Gas Industries* (ABS 2000).
- Procedures for all cargo operations including cool-down, loading and unloading and gas freeing are required to be submitted for consideration of the overall design premises.
- The CNG vessels have retained the requirements of the IMO Gas Code for ship survival capability, location of cargo tanks and segregation of cargo areas.
- The hull scantlings are to be determined in accordance with the ABS requirements for oil carriers or container carriers with appropriate modifications as spelled out in the Guide
- Where the cargo is carried at low temperature, the Guide contains requirements for extension of the use of material of a grade suitable for low temperature. Hull structure is to be designed to the Steel Vessel Rules with material selected considering the actual temperature that may be found in service either from the cargo or ambient temperature where it will operate.
- For CNG carries with substantial gas processing equipment, attention is directed to the requirements of the *ABS Guide for Building and Classing Facilities on Offshore Installations*.
- Special requirements are included to address loads in way of supports for long cargo tanks (containers) mounted horizontally and also for those mounted vertically.
- The Guide requires the submission of a description of means to provide in-service inspection or provisions for alternative verification of the containment system.
- Provisions are included in the Guide for bow, stern and turret (internal and external) loading and unloading systems. In addition to providing requirements for the arrangements on the CNG carrier, reference is made to the *ABS Rules for Building and Classing Single Point Moorings*.
- Thermal protection is required to protect hull structure and critical components of the cargo tank support system against low temperature of cargo (if being stored at lower than ambient temperature) and direct impingement of gases on hull and support structure due to accidental release with cooling due to JT effects.
- The Guide contains extensive requirements for material manufacture processes and testing for the materials to be used in high pressure containers designed to higher allowable stresses than specifically permitted in the IMO Gas Code and the ABS Rules for LNG carriers.
- All portions of the cargo containment system with volume exceeding 20M³ are to be provided with two safety relief valves. In order to reduce the total number of safety valves, which are in themselves a potential source of gas leak, bottles or containers are normally grouped in bundles with connecting piping but no intervening means of isolation. The entire bundle would then be defined as a cargo tank and would only need to be provided with two safety valves.
- Cargo Holds are required to be provided with vacuum protection and overpressure protection. The overpressure protection is to be of a size based on the release of the largest single volume of gas possible as a result of failure of a cargo tank.
- The cargo holds are to be inerted with a suitable dry inert gas.
- For CNG carriers with cargo processing capabilities and turret systems for loading and unloading cargo, attention is directed to the *ABS Guide for Building and Classing Facilities on Offshore Installations* regarding fire fighting arrangements.

CONTAINMENT SYSTEM DESIGN

In a body of revolution such as a pipe or a sphere subjected to internal pressure, the membrane, or so called hoop stress in the container wall is directly proportionate to the pressure and the diameter and indirectly proportionate to the wall thickness. In order to limit the hoop stress to acceptable levels, taking into consideration the physical properties of the container wall material with an increase in design pressure, the thickness must be increased or the diameter must be reduced. That is why designs for CNG carriers with large 40M diameter spheres as are used on LNG carriers where the liquid is carried at a pressure only slightly above atmospheric, have not been proposed.

As can be noted from Figure 2, all the designs under consideration today have design pressures ranging from 90 bars up to 280 bars. It was determined during the preliminary discussion on the very first CNG concept that ABS was asked to consider, almost 20 years ago, that strict compliance with the allowable stress levels of the IMO Code for the cargo tanks would render the project commercially unfeasible. In addition, the weight of the containment system would cause the light ship weight to be such that the ship could not be dry docked anywhere in the world.

Accordingly, in every instance where a client has approached ABS, there has been a request to consider a pressure vessel criteria alternative to that provided with the use of the allowable stress levels in Chapter 4 of the IMO Gas Code and the ABS Rules for LNG carriers. In the consideration of such proposals, ABS has been cognizant of the following:

- The IMO Gas Code is not specifically applicable to vessels carrying natural gas as a pressurized gas rather than as a liquid.
- The factors of safety in the IMO Gas Code are intended to protect against accidental pressure surges. In the case of a gas container already at very high pressure, there is no incident that could cause more than a slight, 2 to 3 % pressure rise.
- While the proposed designs may not meet the IMO Gas Code for primary membrane stress, they have no problem complying with the normally referenced ASME, B& PV Code Section VIII, Div 2 criteria for primary and secondary stress and membrane plus bending stress and peak stress which can cause fatigue failure.
- Unlike the liquefied gas carrier, where the stress at any point in a cargo tank at any time is mostly dependant on the dynamic motion of the cargo and the deflection of the ship and the tank itself, the stress in a CNG container is almost 100% due to internal pressure and it remains almost constant between loading to discharge.

Accordingly, ABS is prepared to accept independent tanks (tanks designed in accordance with a recognized pressure vessel code) on the basis of alternative acceptable pressure vessel criteria. It should be noted that the use of higher allowable design stress in various design codes is permitted only on the basis of more rigorous design analysis, better control of material properties and fabrication, and additional analysis.

Figure 5 shows a comparison of the factors of safety on Yield and Ultimate Strength for the IMO Code and pressure vessel

and pipeline codes being proposed. In each case, the governing allowable stress is underlined in the table. It also points out that the rewrite of ASME Code Section VIII Div 2 (xxxx) will provide for an allowable stress approaching that permitted in pipeline applications and Section VIII Div 3 would permit the highest allowable hoop stress based on the provisions of a limit state analysis.

ABS is also prepared to consider the design on the basis of a Probabilistic Limit State Design Criteria as is provided for in Appendix 1 of the *ABS Guide for Vessels Intended to Carry Compressed Natural Gases in Bulk* (xxx).

In accordance with Appendix 1 to Chapter 5 of the ABS guide, probability of failure for an individual component in the containment system must be equal to or less than 1×10^{-6} for fatigue failure and 1×10^{-6} for burst failure. A higher probability of failure may be considered where it can be shown that the consequence of failure is somewhat less severe. The strength requirements for a CNG cargo container design will normally be satisfied if the following limit states are fulfilled: Bursting, Local buckling and collapse, Fracture, Fatigue, Out-of-roundness and Corrosion.

The target failure probability values selected by ABS are considered very rational based on a comparative study of failure statistics for pipes and pressure vessels in similar service in the process industry, offshore, the nuclear industry and in land transportation.

Figure 6 illustrates the concept of the probabilistic approach in the simplest case considering just design pressure.

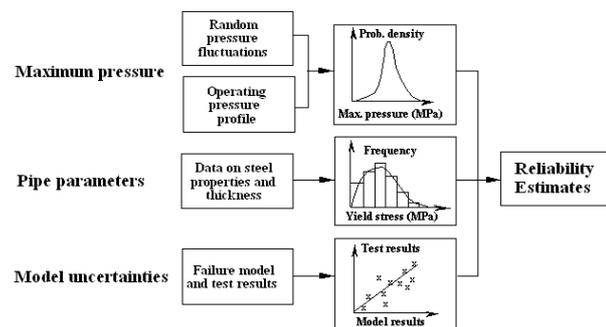


Figure 6. Reliability-Based Design Concept on Pressure

Figure 7 demonstrates that, with a better understanding as to the probabilistic distribution of load, just internal pressure in the simplest case and resistance which is dependant on how much is known about the actual material properties, construction tolerances, fabrication and absence of flaws, what appears to be a lower nominal safety margin can be accepted without reducing the overall level of safety.

REGULATORY ISSUES

ABS cannot speculate in regard to the requirements that would be applied to the proposed CNG carrier concept by a Flag Administration until such time as there is an IMO Resolution dealing with the applicable requirements for vessels intended to carry CNG in bulk. ABS can however offer the following insights based on knowledge of the marine industry and the typical approach followed by flag administrations and the workings of the IMO Organization.

- Since the IMO IGC Code became effective in 1975, it has been adopted and implemented by almost every maritime nation in the world and since that time virtually all of the LNG and LPG cargos that have been transported have been carried in vessels in full, or at least substantial, agreement with the Code.
- It would be reasonable to assume that any Administration signatory to the IGC Code, such as the United States, would seek to establish compliance with the Code, at least as a starting point.
- The LNG community is a relatively small community that meets in various forums such as SIGTTO (Society of Gas Tanker and Terminal Operators) and exchanges information readily. This community takes great pride in the fact that there has never been a major LNG incident at sea and this reputation will be rightfully protected. Owners and operators of gas carriers and terminals can influence their respective Flag States.
- Reliability-based engineering and other methodologies have had limited use heretofore to justify designs in the marine community, so many Administrations may not be prepared to consider designs that significantly differ from what has been done in the past on the basis of such studies. Administrations that are “Coastal States” for offshore activities may be more familiar with reliability-based engineering methods.
- Some Administrations may not be prepared to consider factors of safety for the containment system and piping systems other than those listed in 4.5.1.4 of the IGC Code.

It should be noted that the Flag Administration is required to notify other Administrations via Regulation 1.4 of the IGC Code that they have accepted such an equivalent, but they are not required to obtain the approval of the IMO organization as that can be a very time consuming process and would certainly slow innovative designs. IMO has provided Formal Safety Assessment guidelines as a means for changes to present codes where equivalence or new concepts are necessary for innovation.

CONCLUSIONS

The recent increase in the level of activity and enthusiasm regarding CNG, as demonstrated by the attendance of over 60 delegates from all over the world at the recent First International Marine CNG Standards Forum held in St. John’s NL, Canada in June of 2004, provides validation to ABS that the effort put forth in developing the Guide for CNG Carriers was time well spent. The proponents of this industry have demonstrated in various forums, such as this ISOPE conference, that there are real commercial prospects for the construction of the first of these novel vessels. ABS will continue to play a leading role in the advancement of this new sector, consistent with our mission, by providing the independent, unbiased type of classification services that have served the marine and offshore industry in the past.

Continued participation in such industry forums as the aforementioned meeting in St. John’s June of 2004 by flag Administrations will expedite the development of international standards for CNG carriers and may lead to a new IMO Code or extension of the IGC Code to include CNG.

The ABS Guide, issued as a draft in June of 2004, has had a review committee in November of 2004 to refine and improve the CNG Guide. The CNG Guide is now available on www.eagle.org. ABS will continue to work and meet with industry in this development and comments are not only welcome but they are requested.

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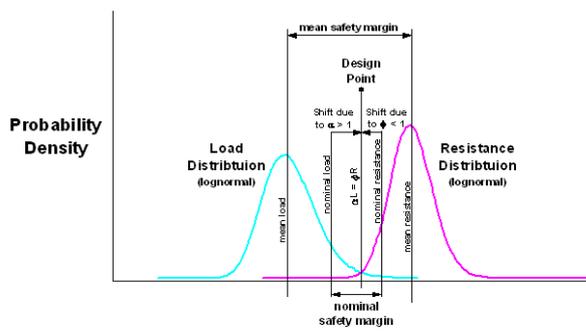


Figure 7. Load and Resistance Factor Distribution

ABS fully expects to implement the provisions of paragraph 1.4 of the IGC Code permitting equivalents, both as the Class Society and while acting on behalf of the Flag State, if it is called upon to do so. In such cases, it will be necessary to notify the Flag State Administration of the intent to take such action and seek its approval to do so. ABS can not act on behalf of the Flag State without its specific approval on such equivalents.

