GUIDANCE NOTES ON

REVIEW AND APPROVAL OF NOVEL CONCEPTS

APRIL 2017

American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

1701 City Plaza Drive
Spring, TX 77389 USA

Foreword

The marine and offshore industries regularly develop an asset such as a marine vessel or an offshore unit incorporating new technologies that have no service history in the proposed application or environment. An asset becomes a novel concept if the incorporation of any new technology(ies) appreciably alters its service scope, functional capability, and/or risk profile as it introduces proposed applications that have not been proven in the marine and offshore industry; and would therefore be considered novel. These new technologies may be so different from existing designs that the requirements contained in ABS Rules/Guides or industry standards may not be directly applicable to them. The ABS *Guidance Notes on Qualifying New Technologies* can be used to qualify these new technologies by confirming their ability to perform intended functions in accordance with defined performance requirements.

While individual new technologies can be qualified by following the ABS new technology qualification (NTQ) process, the classification of a novel concept that includes these new technology(ies) may have additional requirements to address the integration/interfacing with existing conventional technologies as well as the asset itself that may not be satisfied through the NTQ process by its own. The ABS *Guidance Notes on Review and Approval of Novel Concepts* offer ABS clients a methodology for requesting classification of a novel concept. These Guidance Notes describe the process and responsibilities for ABS review of proposed novel concepts from the project concept phase through maintenance of classification while in operations. The approval is on the basis that special consideration through appropriate engineering evaluations and risk assessments have been given to the novel features to determine if the concept provides acceptable levels of safety in line with current offshore and marine industry practice. The primary focus of novel concept classification is on safety even through the qualification of individual new technologies may have additional functional requirements as requested by the client (e.g., reliability).

As part of the Novel Concept Class Approval process, ABS grants an Approval In Principle (AIP) at an early conceptual design phase to assist the client in demonstrating project feasibility to its project partners and regulatory bodies. AIP confirms that the proposed novel concept that includes the new technology complies with the intent of the most applicable ABS Rules and Guides as well as required appropriate industry codes and standards, subject to a list of conditions. These conditions, herein referred to as an Approval Road Map, will typically define a list of submittals necessary to be completed in later phases of the project in order to obtain final class approval. The Approval Road Map will also outline the necessary qualification activities needed to be completed throughout the NTQ process. Once the required deliverables for the final class stage have been completed and all comments addressed, ABS will approve the novel concept design for Classification.

Typical clients that the Novel Concept Class Approval process is most applicable for include the end-users or system integrators (e.g., owner/operators, shipyards, etc.) who integrate new technologies qualified by the NTQ process with conventional technologies and/or the asset. While the NTQ process aids vendors in qualifying new technologies by setting a path for interactions between new technologies and conventional technologies, the Novel Concept Class Approval process takes this a step further by working with both vendors and end-users to fully implement these systems on an asset and achieve final class approval for this asset/novel concept.

These Guidance Notes become effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of these Guidance Notes is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org

Terms of Use

GUIDANCE NOTES ON

REVIEW AND APPROVAL OF NOVEL CONCEPTS

CONTENTS

SECTION 1 **Introduction 1**

1 Overview 1

3 Path to Class Approval 2

3.1 Milestone 1: Determine Approval Route 2

3.3 Milestone 2: Approval in Principle (with Approval Road Map) 3

3.5 Milestone 3: Final Class Approval 4

3.7 Milestone 4: Maintenance of Class 4

5 Definitions 6

7 Abbreviations 7

FIGURE 1 Novel Concept Class Approval Process 2

FIGURE 2 Process Flow for ABS Approval of Novel Concepts 5

SECTION 2 **Approval in Principle 9**

1 Introduction 9

3 Concept Engineering Evaluation 9

3.1 Verification of Feasibility of the Proposed New Technologies 10

3.3 Verification of Conventional Technologies 10

5 Concept Risk Assessment 11

5.1 Risk Assessment Plan 11

7 Approval Road Map 12

9 Summary of Submittals for Approval in Principle 12

9.1 Engineering Evaluation 12

9.3 Risk Assessment 12

11 Issuing Approval in Principle 12

11.1 Issuance of AIP Letter 12

SECTION 3 **Final Class Approval 13**

1 Introduction 13

3 Engineering Evaluation for Final Class Approval 13

3.1 Reconfirmation of Relevant Design Codes and Standards Applied 14

3.3 Calculation Dossier 14

3.5 Verification of Interface Issues 14

3.7 Verification of Inspectability and Maintainability 14

5 Detailed Risk Assessments for Final Class Approval 14
5.1 HAZID 15
5.3 Failure Modes and Effects Analysis (FMEA) 15
5.5 HAZOP 16
5.7 Quantitative Risk Assessment (QRA) 16
5.9 Emergency Systems Survivability Assessment (ESSA) 19
5.11 Escape, Evacuation, and Rescue Analysis (EERA) 19
5.13 Final Class Approval Stage Risk Assessment Plan 20
7 Management of Change 21
9 Summary of Submittals 21
9.1 Engineering Evaluation 21
9.3 Risk Assessment 21
11 Granting Final Class Approval 21

SECTION 4 Input to Surveys and Maintenance of Class 22
1 Knowledge Gained 22
1.1 Input to Survey during Construction 22
1.3 Input to Survey during In-Service Operation 23

SECTION 5 Government and Regulatory Involvement 24
1 General 24

APPENDIX 1 Sample Risk Matrix 25

APPENDIX 2 Novel Concept Checklist 26
1 General 26
3 Novel Concept Checklist 26

TABLE 1 Novel Concept Checklist 28

SECTION 1 Introduction

1 Overview

This document provides guidance to ABS clients regarding the ABS methodology for classification of novel concepts. An asset such as a marine vessel or an offshore unit becomes a novel concept if the incorporation of any new technology(ies) appreciably alters its service scope, functional capability, and/or risk profile. It is important to note that the term 'novel concept' refers to the entire concept of a vessel or facility that incorporates a new technology such as a system or subsystem or an individual component. In order to help determine if a proposed design falls into the "novel" category, Appendix 2 provides a novel concept checklist to gain a general understanding of the variation from existing or proven marine or offshore applications, and thus the degree of novelty. The guidelines presented herein are more suited to an application with a high degree of novelty. If a client is proposing an alternative to one or a small number of current Rule requirement(s), it may be more appropriate to follow the methodologies outlined within the ABS *Guide for Risk Evaluations for the Classification of Marine-Related Facilities (Risk Evaluation Guide)* in order to gain ABS approval.

The ABS *Guidance Notes on Review and Approval of Novel Concepts* is intended to work in conjunction with the ABS *Guidance Notes on Qualifying New Technologies (NTQ Guidance Notes).* As qualifying the individual new technologies by using the ABS new technology qualification (NTQ) process is a key step in obtaining class approval for the novel concept or asset, it is recommended to be familiar with Section 2 of the *NTQ Guidance Notes* in order to better understand the NTQ process. It is important to note that the primary focus of novel concept classification is on safety even through the qualification of individual new technologies may have additional functional requirements as requested by the client (e.g., reliability).

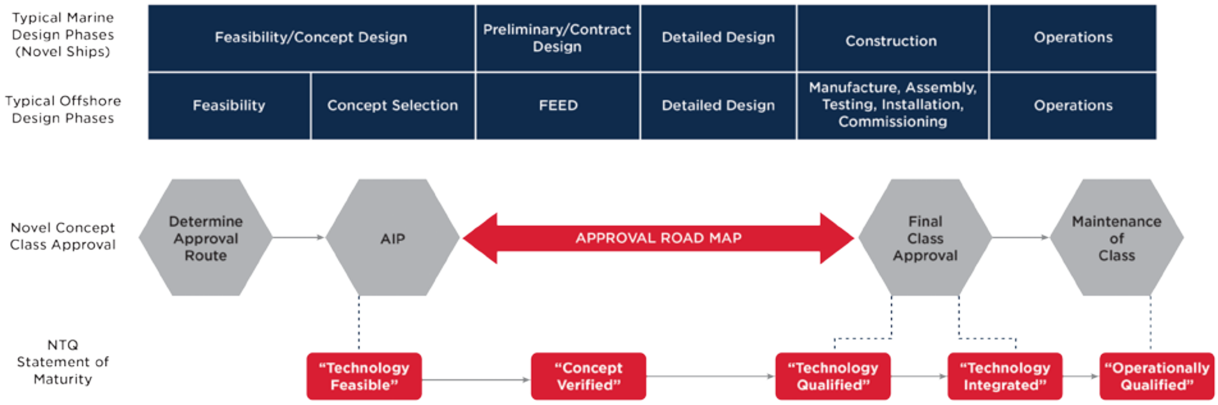
The Novel Concept Class Approval process is the process for obtaining class approval for an asset that incorporates new technologies. The process draws upon engineering evaluations and risk assessments in order to determine if the concept provides acceptable levels of safety in line with current offshore and marine industry practice. Once the engineering evaluations and the risk assessment have shown that the proposed novel concept is feasible, ABS will prepare a statement-of-compliance letter attesting to the feasibility of the novel concept and the approval in principle granted in so far as class and statutory issues are concerned, allowing the project to move into the next approval stage. Once the required deliverables for the final class stage have been completed and all comments addressed, ABS will approve the novel concept design for Classification.

The process can be applied simultaneously with the NTQ process or be applied after completion of specific NTQ qualification stages (e.g., Prototype Validation Stage, System Integration Stage). Typical clients that the Novel Concept Class Approval process is most applicable for include the end-users or system integrators (e.g., owner/operators, shipyards, etc.) who integrate new technologies qualified through the NTQ process with conventional technologies and/or the asset. While the NTQ process aids vendors in qualifying new technologies by setting a path for interactions between new technologies and conventional technologies, the Novel Concept Class Approval process takes this a step further by working with both vendors and end-users to fully implement these systems in order to achieve final class approval for the asset.

The overall class approval process for a novel concept is divided into four milestones. First milestone is to determine the most appropriate approval route to obtain class approval. Second is the Approval in Principle (AIP) stage which is an intermediary concept review that confirms feasibility, outlines when and what to submit, the subsequent review process, and potential outcomes. The third milestone builds on the AIP, with the project moving forward concept design phase into detailed design, construction, installation and ultimately issuance of ABS final class approval. The final milestone is maintenance of class via additional survey scope or frequency of attendance, condition monitoring, required maintenance and inspection techniques to maintain levels of monitoring assumed in the design phase which may have been necessary to achieve various design parameters, and finally as a means to verify assumptions and predictions made throughout the process.

The process that the client and ABS would follow to achieve these milestones is outlined below in Section 1, Figure 1. The figure also illustrates the alignment of the new technology qualification process with the evolution of a novel concept.

FIGURE 1
Novel Concept Class Approval Process



3 Path to Class Approval

Once an asset has been determined to be a novel concept based on a review of the checklist in Appendix 2 and discussions with ABS, then ABS and the client will agree upon a systematic approach to reaching each of the milestones identified in Section 1, Figure 1. A brief description of these milestones follows:

3.1 Milestone 1: Determine Approval Route

Once the client requests qualification of a novel concept using these Guidance Notes, a project kick-off meeting is scheduled. At this meeting, the client presents to ABS an overview of their asset, any known novel aspects along with their expectations and project timelines. ABS and the client will discuss to confirm if the methods presented in these Guidance Notes or the *Risk Evaluation Guide* or a traditional class design review is more appropriate for the application in question.

In order to make a preliminary determination regarding the most appropriate approval route, it is important to have an understanding of those aspects of the asset that are considered new or novel. An approach is to divide or decompose the asset (i.e. marine vessels and offshore units) into different systems (e.g., structure, process system, electrical system, mooring system, etc.) and review the design to identify what has changed from a conventional asset making this a novel concept. The novel concept checklist provided in Appendix 2 and the new technology definition could help in the review process. If this review has not been carried out prior to the kick-off meeting then it is recommended to perform this in a workshop setting with the end-user, system integrator and ABS participation. The review process will help identify at a high-level all conventional technologies and any deviations from typical Rules, Guides or other industry standards that qualify the reviewed systems as new technologies.

For identified new technologies, ABS will meet with respective vendors to perform a more detailed new technology screening process, determine the current maturity level of their new technology, designate an appropriate qualification stage and support the determination of qualification activities. The new technology qualification process follows the *NTQ Guidance Notes*.

In order for a novel concept to qualify for final class approval, these new technologies need to be qualified and technical risks related to integration/interfacing with conventional technologies and/or the asset addressed. Approval timelines will be dependent on the number of new technologies identified, the ability of these technologies to reach certain milestones, and when during the design life cycle phase the client approaches ABS.

It is understood that as more information becomes available and further discussions are held with new technology vendors in the AIP stage, modifications to the approval route may be necessary.

3.3 Milestone 2: Approval in Principle (with Approval Road Map)

The second milestone in the novel concept approval process is obtaining an Approval in Principle (AIP). The minimum goal of achieving AIP should be the identification of all hazards and failure modes applicable to the novel concept application along with suitable support information demonstrating that the control of these hazards and failure modes is proved to be feasible. In most cases, this is demonstrated by meeting the minimum submittal requirements outlined in the Feasibility Stage of the NTQ process. Novel concepts with new technologies granted a “Technology Feasible” Statement of Maturity are eligible for AIP.

The key considerations in order to achieve AIP include:

- Verification of Feasibility of the proposed New Technologies
- Verification of Conventional Technologies

Clients have an option to request an AIP at an early concept design phase or in later design phases. Depending on the design phase in which an AIP is requested, the amount of minimum submittal requirements may vary. In determining what is necessary to achieve AIP, consideration is given to performing analyses and studies that can be refined and improved upon as the design evolves. An example of this would be the use of preliminary material properties, dimensional variations or operating loads coupled with assumed probability distributions in an engineering analysis to prove the viability of the design at AIP, with a plan to refine these parameters and their associated uncertainties, as the design evolves and knowledge is gained. To make certain the client understands the information to be collected and the refined analyses to be performed in the detailed design phase, ABS will provide as a condition of the issuance of the AIP, an Approval Road Map outlining the necessary conditions the client must satisfy to achieve final class approval of the novel and conventional aspects. This Approval Road Map will cover all documentation required to be produced to achieve class approval.

The Approval Road Map typically contains the following information:

- The New Technology Qualification Plan (NTQP) that outlines all necessary system requirements related to safety as stated in the System Requirements and Description Document (SRDD), all necessary qualification activities (e.g., engineering evaluations and risk assessments) required to mature the new technology through the stage gate process, and all interfacing requirements with existing conventional technologies and the asset.
- All engineering evaluations and risk assessments for conventional technologies aboard the novel concept.
- All system-of-systems integration analysis plan for the novel concept.

Further information regarding the submittal requirements for AIP can be found in Section 2 of these Guidance Notes.

3.5 Milestone 3: Final Class Approval

This stage will cover typical class approval submittals comprised of typical drawings, specifications, calculation packages and support documentation, along with submission of those items outlined in the Approval Road Map. Novel concepts with new technologies that have completed up to and including the System Integration Stage of the NTQ process are eligible for final class approval. Upon completion of this stage, the potential hazards and failure modes for the integration of new technology with conventional technologies and the asset will have been assessed against agreed-upon acceptance criteria or defined performance requirements to a level of confidence necessary to grant final class approval of the novel concept. In addition, the engineering evaluations and risk assessments related to the novel features will have been conducted so as to be able to demonstrate a sound basis for class approval.

Further information regarding the submittal requirements for Final Class Approval can be found in Section 3 of these Guidance Notes.

3.7 Milestone 4: Maintenance of Class

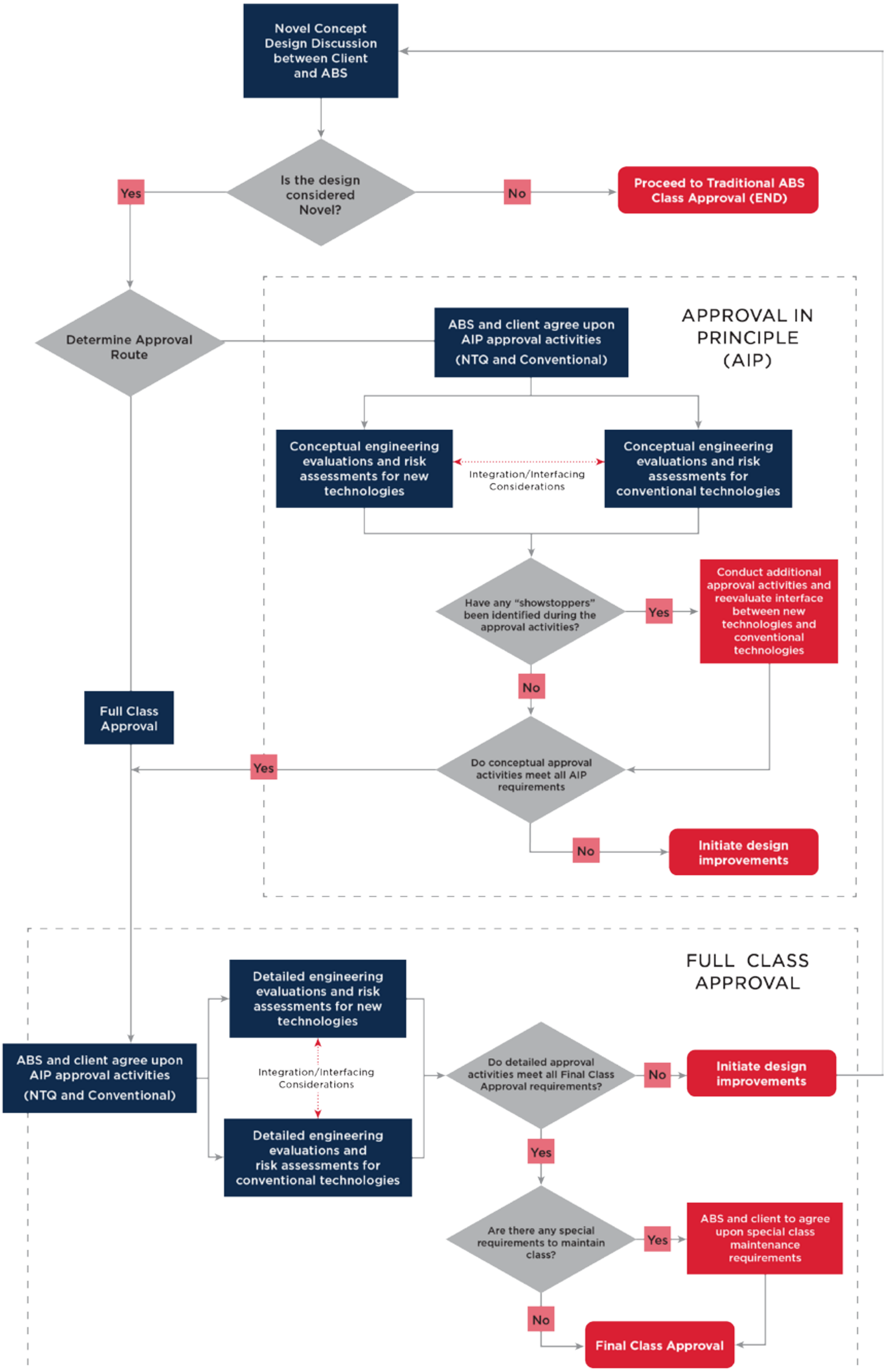
As a final condition of class approval, ABS will outline the necessary elements of in-service survey, inspection, monitoring and testing requirements required to gain confidence in the actual application, if any is deemed necessary. The need for special in-service requirements is dependent on any maintenance schedules, inspection scope/frequency, conditional failure probabilities, etc. assumed in the risk and design assessments for the novel aspects. Additionally, ABS Annual Special Surveys, comparable to a Special Survey, may be necessary as a condition of Class or to gather information necessary to refine its developing Rules for these applications.

As experience accumulates and confidence in the design is gained and that all technologies can obtain an "Operationally Qualified" Statement of Maturity based on the minimum requirements outlined in the Operational Stage of the NTQ process, these Annual Special Survey requirements may be relaxed.

Further information regarding the submittal requirements for Maintenance of Class can be found in Section 4 of these Guidance Notes.

Section 1, Figure 2 outlines the process flow for novel concept approval and Class following these Guidance Notes. The process essentially involves conducting certain engineering evaluations and risk assessments commensurate to the level of detail available in the particular project phase with the aim of achieving Class approval. In certain instances, this process will require the intermediate AIP milestone. In other instances, this step may be bypassed as shown on the flowchart.

FIGURE 2
Process Flow for ABS Approval of Novel Concepts



5 Definitions

As Low As Reasonably Practicable (ALARP). Refers to a level of risk that is neither negligibly low nor intolerably high, for which further investment of resources for risk reduction is not justifiable. Risk should be reduced to ALARP level considering the cost effectiveness of the risk control options.

Approval. Confirmation that the plans, reports or documents submitted to ABS have been reviewed for compliance with one or more of the required Rules, Guides, standards or other criteria acceptable to ABS.

Approval in Principle (AIP). The process by which ABS issues a statement that a proposed novel concept design complies with the intent of ABS Rules and/or appropriate codes although said design may not yet be fully evolved (i.e., concept appears to have technical feasibility from both safety [personnel and environment] and functional perspectives), subject to a list of conditions that must be addressed in the final design phase.

Consequence. The measure of the outcome of an event occurrence in terms of people affected, property damaged, outage time, dollars lost or any other chosen parameter usually expressed in terms of consequence per event or consequence amount per unit of time, typically per year.

Controls. The measures taken to prevent hazards from causing undesirable events. Controls can be physical (e.g., safety shutdowns, redundant controls, added conservatism in design), procedural (e.g., operating procedures, routine inspection requirements) and can also address human factors (employee selection, training, supervision).

Conventional Technologies. The technologies that can be qualified by existing Rules and standards.

Engineering Evaluations. Various engineering analysis tools and testing that may be used to support new technology qualification activities. Typical examples include but not limited to the following: Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), Functional and Performance Testing, Model Testing, System Integration Testing, etc.

Event. Event is an occurrence that has an associated outcome. There are typically a number of potential outcomes from any one initial event that may range in severity from trivial to catastrophic, depending on other conditions and add-on events.

Existing Application. A design or process that has been accepted previously by ABS or other Classification Society for which there is at least one complete 5-year survey cycle of proven experience in the proposed environment.

Failure. The loss of the ability to perform the intended function

Failure Mechanism. A physical or chemical process resulting in a form of damage which will ultimately lead to failure.

Failure Mode. The specific manner of failure that the failure mechanism produces.

F-N Curve. It provides a result of Likelihood or Frequency (F) of fatal events occurring causing a certain Number of Fatalities (N), within a given period of time.

Frequency. The occurrence of a potential event per unit of time, typically expressed as events per year.

Hazards. Conditions that exist which may potentially lead to an undesirable event.

Maintenance of Classification. The fulfillment of the requirements for surveys after construction. In the context of a novel concept, this would mean all requirements within the applicable ABS Rules, as well as any additional requirements outlined in the conditions of class for the concept.

Marine Applications. Applications where the majority of the general requirements for design, construction, installation and continued class of the concept will be derived from the ABS *Rules for Building and Classing Steel Vessels*, ABS related Guides for special vessel types, and the codes and standards utilized by the marine industry.

New Application. An overall process that has not been accepted previously by ABS or other Classification Societies or that there is none or limited (less than one complete 5-year survey cycle) proven experience in the proposed environment.

New Technology. Any design (material, component, equipment or system), process or procedure which does not have prior in-service experience, and/or any Classification Rules, Statutory Regulations or industry standards that are directly applicable. It is possible to categorize the type of "novelty" in one of four categories:

i) Existing design/process/procedures challenging the present boundaries/envelope of current offshore or marine applications

ii) Existing design/process/procedures in new or novel applications

iii) New or novel design/process/procedures in existing applications.

iv) New or novel design/process/procedures in new or novel applications

Novel Concept. A marine vessel or offshore unit that with the inclusion of new technologies, the service scope, functional capability, and/or risk profile is appreciably altered.

Offshore Applications. Applications where the majority of the general requirements for design, construction, installation, and continued class of the concept will be derived from applicable ABS Rules and Guides for offshore units and the codes and standards utilized by the offshore industry.

Reliability. The ability of an item to perform a required function under given conditions for a given time interval (ISO 14224).

Recognized And Generally Accepted Good Engineering Practice (RAGAGEP). Refers to the selection and application of appropriate engineering, operating, and maintenance knowledge when designing, operating and maintaining chemical facilities with the purpose of ensuring safety and preventing process safety incidents.

Risk. The product of the frequency with which an event is anticipated to occur and the consequence of the event's outcome.

Risk Assessment. The process by which the results of a risk analysis (i.e., risk estimates) are used to make decision, either through qualitative or quantitative risk assessments and to compare those outcomes to risk tolerance criteria.

System-of-Systems. The large-scale integration of many independent task-oriented systems to create a new and more complex system which offers more functionality and performance than simply the sum of the constituent systems. In the context of these Guidance Notes, this is often the novel concept or the asset itself.

7 Abbreviations

ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute Recommended Practice
CFD	Computational Fluid Dynamics
EESA	Emergency Systems Survivability Assessment
EERA	Escape, Evacuation, and Rescue Analysis
FEA	Finite Element Analysis
FMECA	Failure Mode Effects and Criticality Analysis
FTA	Fault Tree Analysis
HAZOP	Hazard and Operability
HAZID	Hazard Identification
NTQ	New Technology Qualification
NTQP	New Technology Qualification Plan
PFD	Process Flow Diagram
P&ID	Piping and Instrumentation Diagram

QRA	Quantitative Risk Assessment
RAGAGEP	Recognized And Generally Accepted Good Engineering Practice
SRDD	Systems Requirements and Description Document
SIT	Systems Integration Test

SECTION 2 Approval in Principle

1 Introduction

In some instances, an intermediate approval step, herein referred to as Approval In Principle (AIP), is required to be granted by ABS Class in order to assist the client in demonstrating project feasibility to its project partners and regulatory bodies outside of ABS. In many instances, clients will need to demonstrate to regulators and their partners that an outside independent technical body such as ABS has reviewed and verified the adequacy of the concept to an acceptable degree. AIP is meant to achieve this.

ABS Approval in Principle is a process by which ABS issues a statement-of-compliance that a proposed novel concept that contains new technology complies with the intent of the most applicable ABS Rules and Guides as well as required appropriate industry codes and standards, subject to a list of conditions. These conditions, herein referred to as an Approval Road Map, will typically define a list of submittals necessary to be completed in later phases of the project in order to obtain final Class approval. The Approval Road Map will generally cover submittals for the conventional technologies as well as the new technologies that need to be qualified in accordance with the New Technology Qualification Plan (NTQP). The NTQP outlines the necessary qualification activities needed to be completed throughout the NTQ process. The qualification activities include a combination of engineering evaluations and risk assessments.

The ability for a novel concept to achieve AIP is contingent upon the new technology to obtain a "Technology Feasible" Statement of Maturity letter, which will be awarded when the requirements for the Feasibility Stage in the *NTQ Guidance Notes* have been met.

It is important to note that the issuance of an AIP does not necessarily only happen at the concept design phase of the proposed project. An AIP can be issued throughout the design life cycle as seen in Section 1, Figure 1. For example a client can request an AIP from concept select through the detailed design phase or equivalent. The Approval Road Map will be developed based on the level of detail of the information available upon request for AIP. In all cases, all new technologies need to be qualified via the NTQ process in addition to the verification of conventional technologies in the actual application and operating environments.

3 Concept Engineering Evaluation

The objective of the engineering evaluation is to verify that the proposed concept is feasible with respect to intent and overall level of safety established in Rules, Guides and statutory requirements in all phases of operation as far as practical. For this purpose, a high-level design verification of the proposed novel concept is carried out.

A key element that needs to be verified is the qualification of new technologies. All goals, functional requirements, and performance requirements related to safety submitted as part of the SRDD in accordance with 2/3.3 of the *NTQ Guidance Notes* are reviewed along with any available high-level engineering design analysis. The primary focus of novel concept classification is on safety even through the qualification of individual new technologies may have additional functional requirements as requested by the client (e.g., performance, reliability, etc.). Functional and performance requirements as they pertain to the actual application and operational environment of the novel concept should be defined if known.

The client is required to demonstrate that for each aspect of the concept, all relevant failure modes have been identified and justified through appropriate analyses considering all applicable loading and environmental conditions. The loading and environmental conditions include, but not limited to, the following:

i) Pressure and temperature induced loads and fluctuations

ii) Static and dynamic loads

iii) Dynamic loads imposed due to vessel motions

iv) Loads imposed due to relative motion/deflection of the vessel

v) Loads imposed from cargo weight or process fluid flow dynamics

vi) Fatigue and fracture effects

vii) Wear and vibration effects

viii) Material degradation and associated loss from damage mechanisms

ix) Accidental loads (as applicable)

Additionally, most novel concepts have aspects that are novel and aspects that are conventional. The concept evaluation shall consider not only the verification of the new technologies, but also verify the effect of the novel aspects on the conventional aspects. This is done to confirm that the application of existing codes and standards to the conventional features is still valid.

In general, the concept engineering evaluation considers the following five key elements:

- Verification of Feasibility of the proposed New Technologies
- Verification of Conventional Technologies

3.1 Verification of Feasibility of the Proposed New Technologies

A review of the concept is to be conducted to determine the best method to proving the design. To accomplish this, one must first understand what aspects of the design go beyond current practice and why. Sensitivity studies shall be performed to understand key design parameters. This will enable the designer to determine the most appropriate method to assessment. It may be concluded that various novel aspects of the system require first principles-based approaches to assess their design suitability. The qualification of these new technologies is to follow the *NTQ Guidance Notes* which describes in detail the NTQ process and submittal requirements in order to mature the new technology from early conceptual phases through the implementation of new technologies onto ABS classed assets. All qualification activities, which revolve around determining the validity of the design through engineering evaluations and risk assessments are outlined in the New Technology Qualification Plan (NTQP). At a minimum, the engineering evaluation activities that are required at the "Feasibility Stage" of the *NTQ Guidance Notes* should be carried out to prove that the novel concept is feasible to achieve AIP.

The process to identify and qualify new technologies can be found in the *NTQ Guidance Notes*.

3.3 Verification of Conventional Technologies

A review of the conceptual design is to be conducted to determine what parts of the system or application can be covered through the application of pre-existing and codified Rules and standards. Wherever possible, prescriptive Rule or standard based justification shall be performed to validate various aspects of the novel application. However, it must be demonstrated that the codes and standards to be utilized are wholly applicable and that the degree of novelty is not invalidating one or several aspects of the code or standard which are implicit in their application. Lastly, these aspects shall provide for an acceptable safety margin in line with current marine and offshore practice and the applied code or standard. It is important to stress that codes and standard application should not be intermixed, and that doing so will in many instances result in an inconsistent approach. Conventional technologies are identified during the new technology screening process as described in Subsection 2/5 of the *NTQ Guidance Notes*.

5 Concept Risk Assessment

Risk assessments at the early or conceptual phases of a novel concept are part of the requirement to obtain approval in principle or part of an overall submittal package used in the detailed review for classification approval. In all cases, the requirement of specific risk assessments will be based on the degree of novelty of the application and the agreed upon engineering evaluations or risk evaluation regimen required to ultimately obtain classification approval. At a minimum, a qualitative risk assessment on the new concept will be required as part of AIP and/or Final Class Approval process that considers both new and conventional technologies, their interfaces with each other and the asset, in the actual application and operational conditions. The risk assessment should focus on documenting all foreseeable hazards, their causes, consequences, and potential risk control measures.

In general for the concept development phase, a design basis, preliminary engineering and possibly testing results as well as other information, as described in 2/5.1 for concept evaluation, will be available. At this phase of concept development (i.e., concept select), a qualitative risk assessment is generally the most suited method. More refined risk assessments, such as quantitative risk assessments or reliability analysis, require considerably more details related to the novel concept and would be more appropriately applied to later phases of design (i.e., detailed design phase). However, in some cases it may be necessary to conduct quantitative risk assessment during the conceptual design phase.

For the identified new technologies, the *NTQ Guidance Notes* provides options for risk assessment techniques for early concepts. The most appropriate risk assessment technique may be selected. If the NTQ process is followed simultaneously with the Novel Concept Class Approval process, then only one risk assessment between the two processes needs to be performed. In cases where the risk assessments from NTQ process has not considered the interactions with conventional technologies, the specific application, and/or the operating environment in regards to the novel concept, then a revalidation/update of the NTQ risk assessment may be needed.

In addition, a Hazard Register with an action tracking system should be developed to track all the risk activities during the Novel Concept Class Approval process.

5.1 Risk Assessment Plan

Before performing each risk assessment identified, the client should develop a risk assessment plan. ABS will accept and review any risk assessment plan submitted by the clients. The risk assessment plan should describe the following:

i) Description of the proposed design

ii) Description of direct design, highlighting primary differences and similarities (for comparative studies)

iii) Quantitative or Qualitative Risk assessment method(s) to be used and description if using a non-standard method

iv) Scope and objectives of the assessment

v) Subject matter experts/participants/risk analysts, including their background and area of expertise

vi) Proposed risk acceptance criteria or risk matrix

Further guidance on submitting a risk assessment plan can be found in the *Risk Evaluation Guide* and *NTQ Guidance Notes.*

The risk assessment plan should address all interactions between new technologies via the NTQ process, conventional technologies, and the asset to be classed. The plan should clearly propose risk acceptance criteria with a basis for the criteria. The requirement for generating a risk assessment plan should substantiate that those aspects of the novel concept for which there no industry guidelines exist in terms of safety philosophy can, through risk assessments, be demonstrated to both class and regulators as having acceptable risk levels. Additionally, the risk assessment plan should mirror the requirements for the appropriate flag administration and/or regulatory body under which the novel concept will operate. In some areas of operation, there are clear holistic risk requirements that need to be met in order for an asset to operate.

The Risk Assessment Plan will be different at the AIP stage and the final class stage because the design basis information and the risk assessment requirements are different at these two stages. For the AIP stage, only a qualitative concept risk assessment plan is needed while a more detailed qualitative or quantitative risk assessment plan is required at the final class stage. 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 stage, and further studies as necessary in the FEED or detailed design phase [e.g., fire and explosion analyses, Emergency System Survivability Analysis (ESSA), smoke and gas ingress analysis, Escape, Evacuation and Rescue Analysis (EERA), Quantitative Risk Assessment (QRA), etc.].

7 Approval Road Map

The Approval Road Map for the novel concept will include the activities that need to be completed throughout the design lifecycle of the novel concept in order to achieve the final class approval. These activities will revolve around the qualification of new technologies identified in the NTQ process and their interaction with both existing conventional technologies and the asset as a whole (system-of-systems). Qualification of all new technologies is one of the main drivers for maturation of the novel concept and essential to obtain final class approval in later stages. Each stage completed throughout the NTQ process can be used as a key milestone to update the Approval Road Map, subsequently reducing the amount of activities that needs to be completed throughout the Novel Concept Class Approval Process.

9 Summary of Submittals for Approval in Principle

The following is a list of typical submittals that is to be submitted to ABS for review in AIP stage:

9.1 Engineering Evaluation

i) Design basis, functional specification and/or technical specification of the new technology

ii) System and function architecture details such as functional flow block diagram

iii) Design details such as basic engineering drawings and engineering principles associated with further development

iv) Design analysis methodology and any available preliminary results

v) Details regarding physical and functional interface requirements (Mechanical, hydraulic, electronic, optical, software, human, etc.)

vi) Applicable design references, codes, standards and guidelines, and technical justification for any proposed deviations (may be identified independently or during the new technology screening process)

vii) Lessons learned, references and examples of comparable designs

9.3 Risk Assessment

i) Risk Assessment Plan for the risk assessment identified in the AIP stage and the NTQ plan (if applicable).

ii) The appropriate risk assessment report.

iii) Hazard Register complete with an action tracking system.

11 Issuing Approval in Principle

11.1 Issuance of AIP Letter

Once the engineering evaluations and the risk assessment have shown that the proposed novel concept is feasible and the evaluation team has deemed no reevaluation of the novel concept is required, ABS will prepare a statement-of-compliance letter attesting to the feasibility of the novel concept and the approval in principle granted in so far as class and statutory issues are concerned, allowing the project to move into the next approval stage. Attached to this letter shall be the aforementioned Approval Road Map outlining a list of submittals and conditions to be satisfied (as identified in respective entry phase) in order to achieve final class approval.

SECTION 3 Final Class Approval

1 Introduction

The Approval Road Map developed at the end of the AIP stage, sets the path for all activities that need to be completed in order to be granted Final Class Approval. Typically, the novel concept has progressed to a Detailed Design phase during this stage of the class approval process, where clients will be finalizing the design documents for final review (i.e. the detailed engineering and risk assessments). Clients are expected to have detailed design drawings, PFDs, PIDs, Heat and Material Balance, SIS/Emergency system design, process design, detailed structural layouts and construction plans, and developing operational procedures. At the end of this stage, the "System Integration" stage of the ABS new technology qualification (NTQ) process should be completed for the final class approval. Upon completion of this stage, all the hazards related to both the new technology and the conventional technologies have been assessed to satisfy the agreed-upon acceptance criteria.

If the NTQ process was pursued independent of the Novel Concept Class Approval process then it should be noted that many of the engineering evaluation and risk assessment activities may have already been performed during the NTQ process. In such cases, this stage should focus on engineering evaluation and risk assessment activities that have not been addressed during the NTQ process. The Approval Road Map will be updated accordingly to reflect the pending activities that need to be completed to obtain Final Class Approval.

3 Engineering Evaluation for Final Class Approval

The requirements for Final Class Approval engineering analyses will be dependent on the current qualification stage of the identified new technologies and the agreed-upon Approval Road Map. The objective of the engineering evaluations in this stage, such as detailed design and testing, is to increase the understanding and level of confidence in the novel feature(s) by demonstrating adequate safety margins versus failure for all relevant failure modes. The margins against failure must be demonstrated versus target limits identified during the NTQ process and the AIP Approval Road Map; and which are commensurate with the risk level associated with the hazards posed by the failure mode in question. The engineering evaluation for conventional technologies should also be completed by the end of this stage. Further, the design must be shown to meet applicable operability, inspectability and safety requirements.

The completion of "Prototype Validation" stage of the NTQ process is typically recommended for a new technology to be considered for the Final Class Approval stage. If the identified new technologies have not been awarded the corresponding "Technology Qualified" Statement of Maturity then all engineering evaluation activities that are required at the "Prototype Validation" stage and the less mature stages (if applicable) of the *NTQ Guidance Notes* should be carried out. These NTQ activities can be performed simultaneously with the Novel Concept Class Approval process. If new technologies have already matured beyond the "Prototype Validation" stage then the engineering evaluation in this stage will focus on the integration and interfacing of the new technologies with existing systems of an asset. At the end of the Final Class Approval stage, the "Technology Qualified" technology needs to be fully integrated into the actual operational environment and matured to "Technology Integrated" status. Only when this status is reached can class approval for a Novel Concept be issued.

The design verifications and validations performed and submitted in this stage will typically include the following:

3.1 Reconfirmation of Relevant Design Codes and Standards Applied

A finalized statement of the use of relevant codes and standards as applied to the novel concept clearly outlining the following:

i) Instances where the Rules, codes, and standards have been applied in full to the conventional technologies and without deviation to various aspects of the novel feature design and the justifications for doing so.

ii) Instances where it was necessary to apply deviations to the Rules, codes, and standards in their application with respect to the novel features. The deviation choices should be suitably substantiated via the information contained within the concept level risk assessments, sensitivity studies and concept level engineering analyses. For these instances, the document should explain the means for choosing appropriate safety margin or acceptable failure probabilities used to assess the design suitability. This explanation should also adequately address the relation the acceptance criteria has to the detailed risk assessments conducted in this phase of the project with a clear understanding of the relation to risk or at least consequence of failure, as a minimum.

3.3 Calculation Dossier

In this stage, all the engineering design, calculations, and testing up to the "Prototype Validation" stage should be performed and completed if not carried out during the NTQ process, taking into account the list of outstanding items identified in AIP stage. All functional and performance requirements of the integrated system related to safety as outlined in the system requirements and description document (SRDD) are validated through testing. In addition, all the engineering design related to the conventional technologies should also be completed and all design decisions that are outstanding are to be finalized.

3.5 Verification of Interface Issues

The novel application must not negatively impact the sounding systems and components. If the "System Integration" stage has not been completed for the identified new technologies, the interface analysis and the system integration testing should be performed to confirm the compatibility of the new technology to other surrounding conventional design aspects and systems. This includes both the interfaces within the vessel or offshore unit and external to it as applicable.

3.7 Verification of Inspectability and Maintainability

Lastly, the novel concept must be verified from the standpoint of inspectability and maintainability and what or how has this changed when considering integration of technologies (new and conventional). The various components of the novel application must be verified to make certain that they can be monitored, inspected and maintained in a manner consistent with existing practice for Surveyor access or access for survey related examinations, placing of inspection personnel in hazardous situations and finally without putting any new abnormal loading or condition on the concept during the preparation for inspection which could jeopardize its functionality. This step would not preclude the use of advanced inspection and monitoring techniques not typically performed for the type of application in question. However, use of these techniques would have to be proved to ABS to be feasible and reliable over the life of the concept.

5 Detailed Risk Assessments for Final Class Approval

The requirements for Final Class Approval risk assessments will also be dependent on the current qualification stage of the identified new technologies and the agreed-upon approval road map. If the identified new technologies have not been awarded the "Technology Qualified" letter, all risk assessment activities listed at the "Prototype Validation" stage and the less mature stages (if applicable) in the *NTQ Guidance Notes* should be completed as part of Final Class Approval stage. In this scenario, the NTQ and Novel Concept Class Approval processes are followed simultaneously. If the "Prototype Validation" stage has already been completed, the risk assessments should focus on the interface of the new technologies with existing systems and the whole offshore unit or marine vessel system.

Possible qualitative risk assessment techniques, such as HAZID, HAZOP and FMEA, are recommended if not done previously before initiating any quantitative risk assessments. The qualitative risk assessments are typically completed during the NTQ process. These qualitative risk analyses will help identify hazards related to the novel concept, categorize high risk items and inform the need for more detailed risk assessments to analyze critical aspects through the use of quantitative approaches such as Quantitative Risk Assessment (QRA), Emergency Systems Survivability Assessment (EESA), and Emergency Systems Survivability Assessment (EERA). In addition, applicable rules, codes and standards may have risk assessment requirements for conventional technologies. In such cases, risk assessment activities should also be performed for conventional technologies if they have not been addressed previously as part of AIP or NTQ process.

The following are typical risk studies that need to be considered if applicable for the final class approval process (beyond the risk assessment studies performed during the NTQ process):

i) HAZID

ii) Failure Modes and Effects Analysis (FMEA)

iii) Hazard and Operability Analysis (HAZOP)

iv) Quantitative Risk Assessment (QRA)

v) Emergency Systems Survivability Assessment (EESA)

vi) Escape, Evacuation, and Rescue Analysis (EERA)

vii) Any additional studies identified previously in the approval process

It should be noted that if the same kind of studies that cover relevant technical risks have already been performed during the NTQ process then such studies need not to be performed again in this stage. These risk studies performed during the NTQ process should be submitted to ABS for review to evaluate if the proposed design changes, interfacing or integrations with the asset have any influence on the risk items.

5.1 HAZID

An updated HAZID may be conducted based on the current state of the design during the final class stage. This analysis should focus on technical risks resulting from system integration and operations that have not been previously evaluated during the NTQ process. In addition, the HAZID should identify the hazards related to the whole offshore unit or marine vessel. The client should have close to finalized design information to adequately assess both normal operation and emergency operations.

During this HAZID, a review should be conducted of any previous HAZIDs completed during the AIP stage and the NTQ process, to determine if previously identified items have been affected or impacted by design changes.

5.3 Failure Modes and Effects Analysis (FMEA)

The client may conduct a FMEA which will identify potential design and process failures during installation, SIT, commissioning, operations and decommissioning that have not been previously evaluated during the NTQ process. The FMEA should meet, but not limited to the following objectives:

- Identify the equipment or subsystem, mode of operation and the equipment;
- Identify potential failure modes and their causes;
- Evaluate the effects on the system of each failure mode;
- Identify measures for eliminating or reducing the risks associated with each failure mode;
- Identify trials and testing (i.e., FMEA validation) necessary to prove the conclusions (where applicable);
- Outline provisions to provide information to the operators and maintainers so that they understand the capabilities and limitations of the system to achieve best performance.

If a preliminary FMEA was conducted during the AIP stage or the NTQ process, the items identified as part of that study should be reviewed during this FMEA and updated. Further guidance on FMEA techniques can be found in ABS *Guidance Notes on Failure Mode and Effects Analysis for Classification*.

5.5 HAZOP

The client may conduct a HAZOP to identify the hazards and the potential operating problems of the process systems that have not been previously evaluated during the NTQ process. This study should be based on any of the currently accepted methods used in industry and follow Recognized And Generally Accepted Good Engineering Practice (RAGAGEP). The HAZOP should be adequately documented and include at a minimum:

- Study description of method and risk matrix used.
- Study participants, durations, and drawings/design materials that were evaluated.
- Worksheets developed during review.
- Listing of all “high” risk identified items and preliminary recommended actions.

If a preliminary HAZOP was conducted during the AIP stage or the NTQ process, the items identified as part of that study should be reviewed during this HAZOP and updated.

5.7 Quantitative Risk Assessment (QRA)

As part of the final class approval stage, the client may have to conduct a Quantitative Risk Assessment (QRA) if such kinds of QRA studies have not been done during the NTQ process. The QRA should be based on a review of the detailed design and contain detailed calculations of events and frequencies which should be used to fully classify the risks of the novel concept. The models and methods used in the QRA should be quantitative and consistent with the detailed design. At this phase of the design few to no assumptions should be made concerning design details. If these types of assumptions are required they should be well documented and supported.

5.7.1 Hazard Categories

The QRA should cover all categories of hazards which relate to the risks of the novel concept being reviewed. These categories could include the following:

i) Dropped Object Risk Assessment

- Quantify the risks related to both on-board and over-board (where subsea systems exist) drops.
- Quantify the effects of dropped objects on critical safety systems and critical structural members.
- Address and quantify were necessary the potential for escalation (leading to loss of containment) from dropped objects.
- Address outstanding items identified in previously conducted studies to be addressed by the Dropped Object Study (items should be held in the hazard registry).

ii) Collision Risk Assessment

- Quantify the risks of collision into the novel concept (depending on the classification of the novel concept this may be a structure, vessel, or critical support system) from other vessels.
- Quantify the risks of collision of the novel concept into other vessels or structures.
- Risk of collision should review loss of power, control, guidance, mooring, and/or all other systems likely to lead to collision consequences.
- Where applicable this may include those risks due to the use of transportation systems (loading/unloading/transfer of equipment and supplies, loading/unloading/transfer of personnel by helicopter, boat, man lift, etc.)

iii) Cryogenic Spill Assessment

- Where applicable address the risk associated to the loss of containment of cryogenic systems to both health and safety of personnel and survivability of critical systems (as an example for vessels this would include reviewing integrity requirements of hull structures when exposed to cryogenic materials).
- Address the potential for loss of cryogenic containment to impact other non-cryogenic equipment which could lead to escalation of consequences.

iv) Structural Risk Assessment

- Quantify the risks associated with all identified critical structural elements of the novel concept. This should address the consequences to loading scenarios identified throughout the risk and design process.
- Address design loading cases in respect to risk and possible minimum (regulatory) standards.

v) Fire and Explosion Risk Assessment

- Quantify the risks of fire to and from the novel concept. Fire events should be based on RAGAGEP methods which should be clearly identified as part of the study documentation. Additionally events should include those identified throughout each hazard identification process.
- Quantify the risks of explosion to and from the novel concept. Explosion events should be based on RAGAGEP methods which should be clearly identified as part of the study documentation. Additionally events should include those identified throughout each hazard identification process.
- Address the potential for escalation of consequences from fire and explosion events.

vi) Gas Dispersion Risk Assessment

- Quantify the risks of gaseous dispersion for the novel concept. This should include review of flammable and toxic materials associated with the novel concept.
- Address endpoints/probits used for evaluation where applicable (toxic).
- Include potential events identified in previous study work (see hazard registry).
- Address potential risks associated with exhaust or vent stacks (this may include assessment of risks associated with flame out release from flare systems).

vii) Radiation and Thermal Impacts Assessment

- Quantify risks associated with radiation and thermal loading to and from the novel concept.
- Address impacts from flare systems (both normal operation and emergency loading/ blowdown conditions) and "hot" exhaust from equipment where appropriate.

viii) Gaseous Ingress Assessment

- Quantify risks associated with the ingress of hazardous materials (due to loss of containment, escalation) into protected spaces. Protected spaces may include but not limited to; protected electrical classification areas, personnel accommodations, and/or control rooms.

Note: This list is provided as guidance on the types of studies that should be conducted and is not intended to be all inclusive. Not all of the above studies will apply to the novel concept being reviewed. ABS and the client will discuss to determine which studies apply and the scope of each of these studies as it relates to the novel concept. Additional studies not included in this list may need to be included as part of the QRA. Additional components of each study discussed above may need to be included as minimum requirements.

5.7.2 Scope of Studies

Each of the above (where appropriate) and additionally identified studies that are conducted within the QRA should cover the following (at a minimum):

i) *Events.* A full series of hazardous events should be assessed based on the type of novel concept. In the case of process related novel concept, the study should include a review of flammable and toxic materials and the end consequences which could occur from each. These events should relate directly to individual process sections and characteristics; and should include a suite of varying leak sizes used as initiating events (A similar application should be used with the other study categories). Relevant events identified during the HAZID and/or the HAZOP should be included as part of this assessment. The hazardous events evaluated should encompass all applicable aspects of the novel concept.

ii) *Consequences.* Should be calculated for each event and should utilize detailed modes/ assessment (the choice of which methods is open to the client for final decision). All methods chosen may be required to provide justification for use. Each consequence evaluation method used should be adequately documented and referenced. It is recommended if available and where applicable that advanced computation methods be utilized, such as CFD and FEA.

- *End Points.* End point evaluation of consequences (failure modes, injury and fatality, damage assessments) should be documented and referenced where necessary. Endpoints should be consistent with the requirements of the selected Risk Criteria.

iii) *Frequency.* At this phase of the design, the client should have sufficient design details to conduct complete frequency calculations based on historical data sources (or develop frequencies where historical data does not exist or in not applicable). It is expected that in the case of novel concepts historical data will not typically exist. In these cases the client should thoroughly document all methods used to develop frequencies for these events.

iv) *Risk Presentation.* Risks should be presented as cumulative risk encompassing all categories appropriate to the novel concept. Additionally the client should develop a societal risk in the form of an F-N curve. This should be plotted against the selected risk criterion. And a detailed discussion should be included as to the findings of the QRA which includes the identification of risk drivers (those hazards which elevate the risk into the intolerable regions), and the current estimated state of risk the novel concept poses.

v) *Recommendations.* Discussion on mitigations and/or mitigation requirements based on the results of QRA which are required for current high risk items.

5.7.3 Documentation

The QRAs should be submitted documenting the following aspects as part of the final class approval stage (at minimum but not limited to):

i) Scope of Assessments and categories of risk reviewed.

ii) Overview of the current state of design at the time the assessment was conducted.

iii) Methods used in determining consequences:

- Dispersion, fire, explosion, toxic or material exposure, structural, environmental, etc.
- Probits – human effects (health and safety) and damage to equipment/structures.

iv) Details of the methods used in determination of frequencies. All historical data utilized should be referenced. It is recommended that individual equipment frequencies be included in the form of a Frequency Log.

v) All assumptions used provided in the form of an Assumption Log.

vi) Detailed discussion of risk results and requirement mitigations.

5.9 Emergency Systems Survivability Assessment (ESSA)

An Emergency Systems Survivability Assessment may need to be completed if deemed necessary as part of final class stage approval if it has not been done during the NTQ process. The analysis typically includes the following tasks:

i) Define requirements for survivability of the novel concept.

ii) Identify what systems of the novel concept are critical to survivability.

iii) Analyzed critical systems to determine if and to what level these systems will survive during a major accident event. Major accident events should be taken from the events analyzed during the QRA.

- Critical systems which are identified as "fail safe" under emergency conditions should not require further analysis. There are cases in which this may not hold "true". Thus all "fail safe" elements should be reviewed for effectiveness. Example: It is noted that under fire conditions spurious signals can be generated in electrical cabling so the fail state of the cable is not guaranteed. Optical Fibers however do not generate spurious signals.
- Critical systems which are not "fail safe", the vulnerability of their components against foreseen incidents is assessed. A system is vulnerable if it could fail in the major accident event under consideration. The client may utilize a check list to document the assessed vulnerability of the systems major components.
- Critical systems that are found to be vulnerable, are to be considered at risk and such risk should be mitigated. Where critical systems are deemed not vulnerable, further analysis for these systems is not required.

iv) Systems should be reviewed for redundancy, if a system's components are duplicated or if another independent system exists which fulfills the same function and remains serviceable, the client may use this justification for survivability.

The tasks described above should be documented and provided with discussion as to the overall survivability of these "critical systems" of the novel concept. Any items identified as requiring mitigation or management of risks, should be added to the Hazard Register.

5.11 Escape, Evacuation, and Rescue Analysis (EERA)

The client should conduct an Evacuation, Escape, and Rescue Analysis which assesses the provisions of the escape, evacuation and rescue of the novel concept if needed and has not been done during the NTQ process. The purpose of this assessment should confirm that suitable means of escape, evacuation and rescue have been incorporated in the design of the facility such that any ensuing risk to personnel is demonstrated to be ALARP or tolerable (relative to the client's selected risk criteria).

5.11.1 Objectives

The study should clearly show achievement of the following main objectives:

i) Identify escape and evacuation routes, systems, locations, and equipment which are utilized during an emergency.

ii) Identify the major accident events having the potential to impair escape routes and hinder evacuation systems. These events should be based on those analyzed in the QRA.

iii) Identification of EER goals and assess whether the EER facilities will satisfy the goals. Show that mitigation or management is implemented in order to satisfy goals which have not been met.

5.11.2 Information to be Documented

In the process of completing the above objective, the client should include the following when documenting and recording key information about the EER process:

i) The major accident events selected as representative and why these events have been selected.

ii) The hardware systems selected for use in such events and why they have been selected.

iii) The role and key features of the chosen systems which will form the input to the relevant performance standards.

iv) The number of personnel for whom the facilities should be designed.

v) The managerial arrangements for the control of EER events and the basis for the development of emergency procedures, drills and exercises.

vi) A goal analysis which tests a respective selection of EER scenarios against the goals and requirements, to confirm the adequacy of the arrangements or identify the need for improvement.

vii) An endurance time analysis which assesses the time needed to carry out all steps of the EER process.

5.11.3 Emergency Response

The client should show that in the event of a major incident the design of a facility is adequate such that any ensuing risk to personnel must be ALARP or tolerable. This is achieved by the provision of suitable means of escape, evacuation, and rescue in conjunction with implementation of emergency response procedures. Emergency response involves processes to safeguard the health and safety of the persons onboard an installation or nearby in the event of an unplanned incident that has potential to cause harm. The following key elements of emergency response may be included in the EERA review:

i) Incident detection

ii) Raising alarm

iii) Assessing the incident and activating the response

iv) Access to muster stations

v) Muster

vi) Egress from muster areas

vii) Evacuation

viii) Escape

ix) Recovery and rescue

x) Place of safety

Note: The above list is intended to provide example features of emergency response and is not intended to be limiting or all encompassing.

The tasks described above should be documented and provided with discussion as to the overall ability of personnel to escape, evacuate, and/or be rescued from the novel concept during an emergency. Any items identified as requiring mitigation or management of risks, should be added to the Hazard Register.

5.13 Final Class Approval Stage Risk Assessment Plan

ABS requires that a Risk Assessment Plan be development and submitted to ABS prior to conducting any detailed risk assessment. Contents that should be included in the risk assessment plan (e.g., scope of the risk assessment, selection of risk assessment techniques, and risk acceptable criteria, etc.) can be found in 2/5.1. Further guidance on developing a detailed risk assessment plan can be found in the *Risk Evaluation Guide*.

7 Management of Change

The characterization of the novel concept should be updated based on design changes resulting from progression of the design process and influences of risk mitigation to date. These changes should be addressed through a Management of Change (MOC) process. A document should be submitted that summarizes the changes made to the design throughout the NTQ process and the Novel Concept Class Approval process. Additional information regarding the design information; drawings, procedures, should be submitted as appropriate to properly describe the changes made during this final design phase.

The following reference provides more details on MOC processes:

- ABS *Guidance Notes on Management of Change for the Marine and Offshore Industries*

9 Summary of Submittals

The following qualification activities for the Final Class Approval should be submitted to ABS for review:

9.1 Engineering Evaluation

i) Statement of relevant codes and standards applied and the deviations made to their application with respect to the novel features and conventional technologies.

ii) Detailed design documents including detailed drawings, PFDs, PIDs, product specifications, detailed calculations, detailed structural layouts and construction plans, detailed operational procedures etc.

iii) All documents that describe requirements for system-of-systems functionality and interfaces (if not done during the NTQ process).

iv) Summary report outlining the changes made to the design throughout the NTQ and Novel Concept Class Approval processes.

v) System integration test plans, test data, and test results summarized in a report (if not done during the NTQ process).

vi) Plans for in-service survey, inspection, monitoring, sampling and testing (as applicable) during operations (if not done during the NTQ process).

Note: The engineering evaluation submittals should include both the engineering analyses and design activities from the NTQ process that are typically described in the NTQP and the engineering analyses and design for conventional technologies.

9.3 Risk Assessment

i) Risk Assessment Plan for the detailed risk assessment.

ii) Updated risk assessment reports from the AIP stage.

iii) Risk assessment reports for the risk studies conducted in the Final Class Approval stage.

iv) Other applicable technical safety studies.

v) Final Hazard Register with all action items closed out.

11 Granting Final Class Approval

Once the required deliverables for the final class stage have been completed and all comments addressed, ABS will approve the novel concept design for Classification. It should be noted that the requirements outlined in these Guidance Notes primarily addresses the novel aspects of the design. All other items related to conventional technologies covered by the applicable ABS Rules and Guides as outlined within the Approval Road Map will need to be complied with for Classification/Certification approval.

Approval is contingent on the ability to achieve a “Technology Integrated” letter of approval for the NTQ process.

SECTION 4 Input to Surveys and Maintenance of Class

1 Knowledge Gained

While the final class approval process is underway, and the application is proceeding into the construction phase, the knowledge gained by the engineering and risk assessment teams should be fed into the quality control process during construction and also in-service once the application is commissioned.

A key aspect of any novel concept is the fact that although it has theoretically been proven once approval is granted, it is still prudent to monitor prior assumptions and predictions through in-service field verification. Thus, the initial installation of a novel application is to some extent treated as a pilot application.

This Section will outline the necessary input that must be gathered and supplied to the ABS survey team assigned to the project. It is also strongly recommended that this aspect of the project be communicated to the project construction team and operations team via their participation in the risk assessment and design approval process. Likewise, the inclusion of a member of the ABS survey staff during key risk assessments and communication with the ABS survey team during the approval process is strongly encouraged.

1.1 Input to Survey during Construction

The novel feature may require that various tests or critical aspects of the design be scrutinized during construction to confirm a high level of quality. This is typically agreed between ABS and the client and outlined in an Inspection Test Plan (ITP). Among the areas which may require enhanced participation by the ABS Surveyor in close communication with the engineering/risk team are as follows:

1.1.1 Critical Areas

These are key design features or relatively high failure probability design aspects identified in the design review or risk assessment phase which would benefit from enhanced quality control at the construction site, closely supervised and verified by the surveyor in attendance.

1.1.2 Verification and Witness of Testing

In many instances, testing will be required to be carried out to gather data to feed the engineering analyses or to verify key assumptions made in the analysis work. Testing may also just be required simply to verify functionality and that the application or component used in the application performs as intended. Types of testing which may be required as a condition of accepting the novel application include, but are not limited to the following:

i) Material testing

ii) Destructive testing, such as burst tests, fatigue testing and other types of failure testing (can be on prototypes, small scale or full scale models)

iii) Nondestructive or other proof testing for components, sub-assemblies, and major assemblies. These tests may be required at several stages of fabrication to confirm that the process of manufacture and installation is not imparting intolerable defects into the application that were not considered in the analysis work. They may also include testing of prototypes.

iv) Functional testing covering FAT's and commissioning type test to confirm that the application or system performs as intended

1.3 Input to Survey during In-Service Operation

The class approval process for a novel concept will require ABS to outline the necessary elements of in-service survey, inspection, monitoring and testing requirements required to gain confidence in the actual application, if any is deemed necessary. The need for special in-service requirements is dependent upon the type of design justification and risk assessments performed as part of the class approval process. Any such requirements are to be included within the In-Service Inspection Plan (ISIP) and complied with for maintenance of class. For novel concepts, the following may result in the need for Annual Special Survey for in-service monitoring:

i) *Maintenance schedules* are to be enhanced in order to maintain a target failure probability assumed in the design phase. This requirement could be coupled with a full scale Reliability Centered Maintenance program developed in parallel to the design program.

ii) *Inspection scope/frequency* must be modified to cover monitoring of critical areas so as to confirm that critical design assumptions with respect to various failure modes are correct and also to reduce the probability of failure through enhanced inspection requirements. This requirement could be coupled with or part of a proposed Risk Based Inspection program.

iii) *Conditional failure probabilities* used in the design assessment require an enhanced level of maintenance or monitoring to confirm the application stays within prescribed safety margins.

iv) *Pilot Testing of Novel Features.* ABS may require information be gathered as necessary, to justify the concept or to refine its Rules for these applications. These enhanced requirements may or may not be required throughout the life of the application or they may be required on the initial assemblies while relaxing requirements to conventional prescriptive Class requirements for subsequently constructed assemblies of the same design.

SECTION 5 Government and Regulatory Involvement

1 General

In some instances, there can be as many as three administrations required for acceptance of a novel concept. For ships and marine vessels, these administrations will be the port states and the flag State that the vessel is to fly. This is known as the tripartite agreement.

Agreement by the aforementioned bodies precedes final agreement by IMO for formal use on any vessel. The present document covering guidelines for these types of novel vessels is the *Revised Guidelines for Formal Safety Assessment (FSA) For Use in the IMO Rule-Making Process* found in MSC-MEPC.2/Circ.12/Rev.1 dated 18 June 2015. The guidelines are a rational and systematic process for assessing risks relating to maritime safety. The process of building up a body of knowledge for a novel concept must generally follow this guideline to enable ABS to work within the final need to provide the required trading certificates necessary for operation of the vessel in the maritime community. The development of this documentation from the start of concept approval will enable the Administrations involved to evaluate the concept and clearly assess the results of the mitigation provided to minimize the defined risks from this concept operating within the marine community. The Flag State may also provide these studies to IMO for subsequent evaluation to enable the organization the ability to establish final regulations where necessary for the concept not presently found within the codified regulations of IMO.

The need is then presented for the client and ABS to assess and define the differences from present practice and codified regulations and to also understand the risks present and provide the necessary mitigation to reduce the consequences of the risks defined to comparable levels found in the maritime community.

It should be noted that to achieve these additional approvals, ABS and the client may be required to present the concept design along with the risk assessment and mitigation results to these administrations for acceptance, either under a tripartite agreements or for final regulations by IMO.

APPENDIX 1 Sample Risk Matrix

Likelihood						
Frequent Incident is likely to occur at this facility within the next 5 years.	4	L			High	Risk
Occasional Incident is likely to occur at this facility within the next 15 years.	3	I K E				
Seldom Incident has occurred at a similar facility and may reasonably occur at this facility within the next 30 years.	2	L I H		Medium	Risk	
Unlikely Given current practices and procedures, incident is not likely to occur at this facility.	1	O O D	Low	Risk		
			C O N S E Q U E N C E			
			1	2	3	4
			Incidental	Minor	Serious	Major

	1 Incidental	2 Minor	3 Serious	4 Major
Personnel	Minor or no injury, no lost time.	Single injury, not severe, possible lost time.	One or more severe injuries.	Fatality or permanently disabling injury.
Community	No injury, hazard or annoyance to the public.	Odor or noise complaint from the public.	One or more minor injuries.	One or more severe injuries.
Environmental	Environmentally recordable event with no Agency notification or permit violation.	Release which results in Agency notification or permit violation.	Significant release with serious offsite impact	Significant release with serious offsite impact and likely to cause immediate or long term health effects.
Facility	Minimal equipment damage at an estimated cost less than US$100K, negligible downtime.	Some equipment or structural damage at an estimated cost greater than US$100K, 1 to 10 days of downtime	Major damage to installation at an estimated cost than US$1 MM but less than US$10 MM, 10 to 90 days of downtime	Major or total destruction to installation estimated at a cost greater than US$10 MM; downtime in excess of 90 days.

* *Note:* The descriptions (including stated values) within the risk matrix are only provided for reference. It is acceptable for the client to use different descriptions or risk matrix when agreed with ABS.

APPENDIX 2 Novel Concept Checklist

1 General

This document is applicable to all marine vessels and offshore facilities for which novel concepts are being proposed. Novel concept refers to the entire concept of a vessel or a facility that incorporates a new technology with respect to the structural aspects, machinery systems, storage or process aspects to which the provisions of the current Rules, Guides and existing industry standards are not directly applicable. In order to help determine if a proposed design falls into the "novel" category, the checklist in Appendix 2, Table 1 is provided. The objective of the checklist is to:

i) Establish if the new design qualifies as a novel concept and whether the use of these Guidance Notes are appropriate for evaluating the concept and;

ii) Gain a general understanding of the variation from existing or proven marine or offshore applications, and thus the degree of novelty.

The checklist is meant to act as a trigger that would indicate that the proposed design might be categorized as novel, and thus potentially require additional considerations and evaluation outside the standard class approval process as 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 confirm 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 these Guidance Notes should be applied. As an alternative, it may be concluded upon completion of the checklist query that the degree of novelty is such that the approval route is best achieved through the application of the *Risk Evaluation Guide*. It is understood that ABS and the client will have to mutually agree as to what constitutes a high degree of novelty and therefore the appropriate document to be used in the approval process.

3 Novel Concept Checklist

Appendix 2, Table 1 is the novel concept checklist. The checklist is intended to help identify proposed novel concepts applied to marine and offshore systems. When evaluating whether or not an application is novel, all questions should be answered with "Yes", "No" or "NA" (Not Applicable).

The first set of checklist questions identifies potential general aspects of a proposed application that would indicate it is a novel concept or application. The next set of questions address marine systems and structural features, covering possible novel concepts related to moorings, structural configurations, material applications, ballasting systems, mechanical or electric systems.

The next category relates to novel processes (e.g., chemical or hydrocarbon processing/production), activities, storage within marine or offshore applications, or subsea systems. Novel processes may include new types of hydrocarbon production that have not been applied commercially before, or it may include the extension of a process that has never been applied on an offshore application. Novel activities may include the use of a vessel or offshore unit for purposes other than the original design purpose. Novel concepts may include a new type of mooring system for an offshore floating installation. Novel storage applications may include the application of new types of cargo tanks to transport highly volatile gases or liquids. In all of these examples, the proposed function of the vessel or offshore unit is affected by the application of the new technology, concept or activity. The last checklist category covers possible new or novel ancillary systems in which the function of the vessel or offshore unit could be impacted by the performance of this system.

The checklist questions are phrased such that if all of the answers that apply to the concept are "Yes" or "NA" then the probability is high that:

i) The general design application is not considered a novel concept;

ii) It does not include new unproven technology; or

iii) The new or novel applications utilize existing technology, and standard classification design review or the use of the guide for establishing equivalency as outlined in the *Risk Evaluation Guide* would generally be more appropriate for the proposed marine or offshore application.

However, it is important to note that prior to proceeding further with the design, the client should initiate communications with ABS to confirm that there are no potential application issues that may be related to the application's design.

If one or more of the answers are "No" in the checklist, then it is recommended that the designer, owner or operator contact ABS to discuss the proposed application. This will start the initial process of clarifying whether or not the design concept should be categorized as novel, precisely defining the novel concept and identifying potential ramifications on the vessel or offshore unit classification approval. The process for evaluating the novel concept is described in Section 1 and detailed in Sections 2 and 3.

It is important to note that any answer of "No" on the checklist also does not necessarily indicate the requirement for additional reviews or analyses. It does however, indicate that some discussion related to the design concept should be initiated with ABS early on in the approval process to confirm no unforeseen issues related to the design with respect to classification review and approval are evident. If the concept is identified as novel, a plan of action, most likely covering an AIP stage, will need to be discussed and agreed upon between ABS and the client. This plan would cover engineering, analysis, testing and/or risk evaluations required to justify acceptance of the novel features. The level of effort or additional evaluations of the novel concept will depend on the degree to which the application of the novel concept or new technology deviates from existing applications, the potential impact of the failure of the application on the remainder of the asset as well as the current qualification stage of the identified new technologies.

TABLE 1
Novel Concept Checklist

No.	Checklist Questions	Yes/No/NA*
General		
G1	Is the proposed type of marine or offshore application or facility currently being used in marine or offshore applications?	
	If Yes, what is estimated total operational years of experience of similar marine or offshore facilities?	
G2	Is the vessel or offshore unit design basis (e.g., environmental constraints, operating parameters [temperatures, pressures], topside loads or interface with marine systems, etc.) considered within current experience boundaries for this application?	
G3	Are there applicable design guidance documents (e.g., ABS, API, IMO, ASME) specific to the proposed marine or offshore application?	
G4	Are all the hazards induced by the proposed type of marine or offshore application or facility common without any new features?	
Stationkeeping Aspects		
SK1	Is the proposed mooring system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the proposed mooring line materials considered current industry practice for this application?	
	Is the proposed mooring system arrangement considered existing industry practice (e.g., no unique arrangement features such as lines crossing critical components or other mooring components in close proximity to critical components)?	
	Are there existing applications of the proposed mooring anchorage system (e.g., piles, anchors or other)?	
SK2	Is the proposed thruster system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the environmental and operating parameters for the thruster system within experience bounds for the vessel or floating facility?	
	Is the control system for the thruster system considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the potential consequences associated with failure of the thruster system considered to be similar to other thruster applications?	
Structural Aspects		
S2	Is the proposed hull or main structure design considered to be within the existing experience boundaries for the vessel or offshore unit?	
	Are there existing applications of the proposed structural configuration (e.g., unique shape, extreme size [scaled up of version existing application], arrangement [novel layout to enhance stability, motions, construction or speed] or atypical loading or load paths)?	
	Are there existing structural designs that utilize materials, connection details or construction tolerances for similar applications?	
	The proposed design will <u>not</u> require enhanced (i.e., in addition to what is typically required by class Rules) maintenance or structural monitoring procedures to confirm adequate integrity and structural performance due to new features or application of new technology?	
	Does the proposed hull or main structure design considered provide acceptable levels of reliability in line with current offshore and marine industry practice?	
Marine Systems		
MS1	Are the proposed ballast water management systems (BWMS) or ballast water management methods considered to be within the existing experience boundaries for the vessel or offshore unit?	
MS2	Are the proposed mechanical/electrical systems (e.g., bilge, power distribution, communication, navigational guidance) considered to be within the existing experience boundaries for the vessel or offshore unit?	
	Is the electric power generation system considered to be within the current experience boundaries for the vessel or offshore unit?	
	Is the fuel system used for electric power generation considered to be within the current experience boundaries for the vessel or offshore unit?	
	Is the control system for power generation considered to be within the current experience boundaries for the vessel or offshore unit?	

No.	Checklist Questions	Yes/No/NA*
MS2	Are the power requirements for the vessel or offshore unit within current experience bounds?	
	Are the mechanical system arrangements (e.g., bilge, ballast, etc.) considered to be within the current experience boundaries for the vessel or offshore unit?	
	Is the physical layout of the mechanical systems considered to be within current industry practices?	
MS3	Are there any new hazards in the design of the vessel or offshore unit that require active or passive prevention or mitigation systems not considered to be within current industry practice?	
	Are physical layouts of equipment and structures such that current industry practices for hazard detection (e.g., fire, gas, flooding) are clearly adequate?	
	Are physical layouts of equipment and structures such that current industry practices for egress and evacuation are clearly adequate?	
MS4	Is the proposed propulsion system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Is the fuel system considered to be within the current experience boundaries for the vessel or floating facility?	
	Is the physical layout of the propulsion system considered to be within current industry practices?	
	Is the control system for the propulsion system considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the operation requirements and potential consequences associated with failure of the propulsion system considered to be similar to other propulsion applications?	
MS5	Is the proposed steering system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Is the control system for steering considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the guidance and navigation systems considered to be within the current experience boundaries for the vessel or floating facility?	
Process Systems		
P1	Are there any existing commercial applications of the proposed process systems that will be on the vessel or offshore unit?	
P2	Are there existing onshore applications of the proposed process systems that will be on the vessel or offshore unit?	
P3	Are there marine or offshore applications of the proposed process that will be on the vessel or offshore unit?	
P4	Can the chemical process aspects, such as fluid/gas separation or distillation, be isolated from potential detrimental effects of the marine environment (e.g., ambient conditions, vessel motions, etc.)?	
P5	Are the potential consequences associated with this offshore application of the process facility considered to be the same as other similar onshore commercial applications?	
P6	Is the equipment layout similar to existing marine or offshore process facilities?	
P7	Is the equipment application or mechanical design similar to existing offshore process facilities?	
Storage/Cargo Transport Aspects		
SC1	Are there any existing commercial applications of the proposed storage systems similar to that which will be used on the vessel or offshore unit?	
SC2	Are there existing onshore applications of the proposed storage systems that will be on the vessel or offshore unit?	
SC3	Are there marine or offshore applications of the proposed storage systems that will be on the vessel or offshore unit?	
	Can the storage systems be isolated from the unique aspects of the marine environment (e.g., ambient/corrosive conditions, motions)?	
SC4	Are the potential consequences associated with this offshore application of the storage system or facility considered to be the same as other similar commercial applications?	
SC5	Is the storage equipment layout similar to existing marine or offshore facilities?	
SC6	Is the storage equipment application or design similar to existing offshore facilities?	
SC7	Does the material being stored or transported have similar handling requirements (e.g., monitoring and control of temperature or pressures, offload and unloading systems, operational constraints or compartmentalization requirements, etc.) as other existing applications?	

No.	Checklist Questions	Yes/No/NA*
SC8	The handling (load/discharge) of the material being stored does not require the use of any type of device (pump, compressor, connecting device such as a hose or product swivel) which has undergone extensive re-design to be able to handle these materials in a marine or offshore environment?	
Subsea Systems		
SS1	Is the proposed subsea system configuration considered existing industry practice without unique arrangement features?	
SS2	Are there existing applications of the proposed subsea system?	
SS3	Are the environmental and operating parameters (e.g., ice, earthquake, seabed subsidence, marine life, corrosive internal fluid, water depth, internal pressure and temperature, etc.) for the subsea system within experience bounds for the offshore application?	
SS4	Are the potential consequences associated with failure of the subsea system, subsystem, equipment and components considered to be similar to current subsea applications?	
SS5	Is the monitoring, communication, safety and control systems for the subsea system considered to be within the current experience boundaries for offshore application?	
SS6	Is the subsea process system considered to be within the current experience boundaries for offshore application?	
SS7	Are the proposed mechanical and electrical subsystems considered to be within the existing experience boundaries for subsea application?	
SS8	Are there existing structural designs (e.g., subsea equipment, foundation, pipeline, and riser) that utilize materials, connection details or construction tolerances for similar applications?	
Other Systems/Aspects		
AS1	There are no other new or novel applications that are not specifically covered under classification (e.g., new type of offloading system or new riser support system) in which the performance of that system could potentially impact, either directly or indirectly, vessel structural integrity, stability or safety of the classed components?	
AS2	There is no use of new material specifications or material usage which have not been demonstrated as adequate for their intended service and a marine and offshore environment.	
AS3	For all identified failure modes, there exists suitable data and experience relative to key material properties and characteristics needed to resist those failure modes in service.	

* *Note:* NA – Not Applicable