



GUIDANCE NOTES ON

REVIEW AND APPROVAL OF NOVEL CONCEPTS

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**American Bureau of Shipping
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the State of New York 1862**

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Foreword

The mission of the American Bureau of Shipping (ABS) is to serve the public interest, as well as the needs of its clients, by promoting the security of life, property, and the natural environment. This is primarily accomplished through the development and verification of standards for the design, construction and operational maintenance of marine and offshore facilities. These standards or Rules are established from principles of naval architecture, marine engineering and other engineering principles that have been proven satisfactory by service experience and systematic analysis.

The marine and offshore industries frequently develop novel applications or processes that have no previous experience in the environment being proposed. These novel concepts have such little precedent and may be so different from existing designs that the guidance encompassed in the class Rules may not be directly applicable to them.

The guidelines presented herein offer ABS clients a methodology for requesting classification of a novel design. These Guidance Notes describe the process and responsibilities for ABS review of proposed novel concepts from the project concept stage through maintaining Classification on the novel concept. The process described in the document draws upon engineering, testing and risk assessments in order to determine if the concept provides acceptable levels of safety in line with current offshore and marine industry practice. The methodology relies heavily on risk assessment techniques as a way to better understand and anticipate structural and operational issues related to the novel concept.

These Guidance Notes are more suited to an application with a high degree of novelty. This document provides guidance, in the form of a checklist, to assist the client in identifying if a proposed design would be categorized as new or novel with regards to ABS classification. 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* in order to gain ABS approval.

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SECTION 1 Introduction

1 Purpose

This document provides guidance to ABS clients related to the ABS methodology for review and approval of new/novel concepts. The document describes the process and responsibilities for ABS review of proposed new/novel concepts from the project concept stage through maintaining Classification on the novel concept.

2 Background

A new or novel concept is defined as an application or process that has no previous experience in the environment being proposed. These Guidance Notes are intended to cover proposed applications that have not been proven in the marine or offshore industry and would therefore be considered novel for those environments. Marine and offshore installations which contain novel features of design 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 may still be classed or certified. This approval is on the basis that the Rules, Guides and existing industry standards insofar as applicable have been complied with, and that special consideration through appropriate risk assessment and engineering analyses has been given to the novel features through the application of this guideline.

In some instances, certain features of a particular system or structure may not meet the intent of the current Rule requirements. 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* in order to gain ABS approval.

3 The Evolution of a Concept

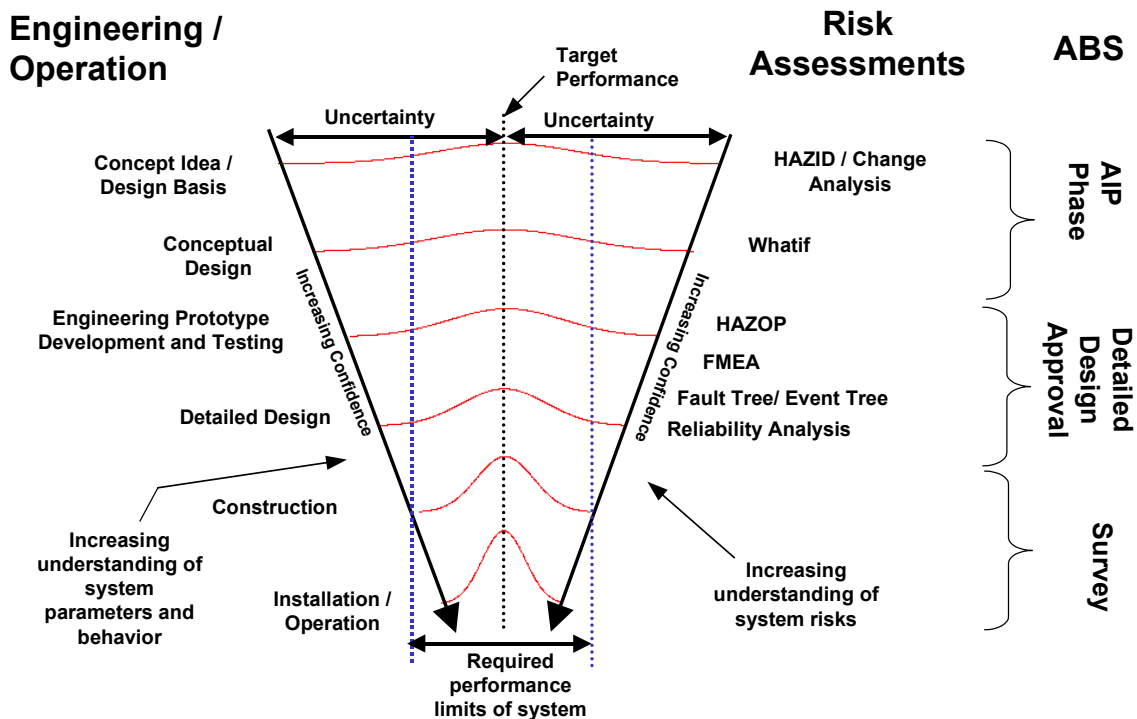
The document contained herein is structured to provide a general procedure for clients that guides them through the process of obtaining and maintaining class approval of new/novel concepts. The process described in the document draws upon engineering, testing and risk assessments in order to determine if the concept provides acceptable levels of safety in line with current offshore and marine industry practice. It also provides guidance, in the form of a checklist, to assist the client in identifying if a proposed design would be categorized as new or novel with regards to ABS classification. Guidance is also provided on the general level of evaluation and review conducted for different types of concepts. ABS recognizes that there are varying degrees of new concepts (e.g., level of uncertainties or similarities to existing applications), and hence not all proposed new concepts will require the same level of evaluation and review.

The document is organized around the general steps involved with developing initial concepts, through detailed design and ultimately to the implementation of the marine or offshore application. The primary milestones related to these steps for obtaining and maintaining class include:

- i) Approval in Principle (concept development phase)
- ii) Final Approval for Classification (detailed design/construction/commissioning phase)
- iii) Maintenance of Classification (implementation/operational phase)

Section 1, Figure 1 demonstrates graphically the evolution of a concept in terms of engineering and operation, risk assessment and ABS involvement in these phases. Clients who are just beginning to explore the possibilities of a new technology or concept often seek ABS input and expert opinion on its perception of the concept in terms of Class or ABS approval. Thus, clients will seek a preliminary approval from ABS on the novel feature or concept. This preliminary milestone in the ABS Class process is called Approval in Principle (AIP). The benefit of gaining AIP from a Class Society is that the client now has a document issued by a knowledgeable independent marine and offshore society attesting to the acceptability of the concept for classification. At the AIP stage, risk is assessed on a high level through qualitative techniques. Engineering within the AIP phase is to be progressed to the point of demonstrating that likely failure modes and consequences have been identified and at least considered in the concept design. The need for proof or model testing and data gathering will have been identified. Further need for refined risk assessment and engineering analysis will have been identified as well. Once granted AIP, the client will then most likely advance into the next phases of the project, involving the detailed design and also the advanced risk assessment and testing which may have been identified in the conceptual phase. This will aid the client and ABS in gaining certainty in their design as the level and accuracy of the risk assessment and engineering evaluation increases. This phase of the project would involve traditional Class participation in the form of design review and survey and would ultimately result in Class approval. Maintenance of Class would be performed in the traditional sense, involving periodic surveys to validate renewal of the Class Certificate. However, in this instance, the maintenance of Class for a novel concept may involve a modified and/or expanded survey scope or frequency as a condition of Class, until the concept has built up a satisfactory service experience.

FIGURE 1
Concept Evolution



4 Path to Class Approval

This document outlines the steps of the Class process for a novel concept that will aid the client in understanding of the process via the identification of a clear path to achieving both AIP and full ABS approval. This process involves ABS and the client working together to accomplish the following:

- i) Determine, as a first step, the approval route to achieve AIP. This will involve the client and ABS meeting to discuss the concept, its purpose, its novel features and where it deviates from traditional approaches, the proposed operating envelope and the potential impact of the concept on other systems or components. Agreement will be reached as to the best methods to assess risk in the AIP phase as well as the appropriate level of engineering analysis.
- ii) Meeting throughout the AIP phase as the concept is being evaluated to formulate an Approval Road Map that will lay out conditions to achieving full approval. This road map will form the basis for the conditions attached to the AIP issuance. The road map will define clearly the approach needed from a risk assessment and engineering analysis standpoint to justify those novel aspects not covered by existing Rules, codes and standards.
- iii) Participating in and evaluating the necessary risk assessments, analyses and tests necessary to satisfy the conditions outlined in the AIP Road Map to achieve a level of confidence that the design and the risk are acceptable.
- iv) Determining the necessary additional conditions assigned to 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.

In addition to the guidance as outlined in this document, it is important to stress the continuous, forthright and timely communications between the client and ABS throughout the concept approval process. This will ensure smooth evaluation, review and ultimately implementation of the new/novel concept, minimizing the potential for uncertainties while maximizing the client's efforts and efficient use of resources to gain approval of the concept.

5 Definitions

Approval is intended to mean 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) is a 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 stage.

Classification is a representation by ABS as to the structural and mechanical fitness for a particular use or service, in accordance with its Rules and standards. In the context of a novel concept, this would also mean that the conditions outlined within the approval road map identified during the AIP stage have been demonstrated to the satisfaction of ABS.

Consequence is the measure of the impact 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 are 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).

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 is 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 is the loss of the ability to perform the intended function

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

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

Final Concept Design Stage is the stage in the design evolution at which the feasibility of the technology from an engineering and risk perspective can be assessed.

Final Design Stage is the stage when all design issues have been addressed and all risk concerns mitigated to acceptable levels.

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

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

Maintenance of Classification is 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 are those applications where the majority of the general requirements for design, construction, installation and continued class of the concept will be derived from the *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 is 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/Novel Concept is a design or process that has no previous experience in the environment being proposed.

Offshore Applications are those 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 installations and the codes and standards utilized by the offshore industry.

Preliminary Conceptual Design Stage is the early stage of development of a new project/concept.

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

SECTION 2 Application

1 General

This document is applicable to all marine vessels and offshore facilities for which new/novel concepts are being proposed. New/novel concepts may be the entire concept of a vessel or facility, a system or subsystem or an individual component. New/novel concepts may be defined in several ways:

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

In order to help determine if a proposed design falls into the category of new/novel, the checklist in Section 2, Table 1 is provided. The objective of the checklist is to:

- i) Establish if the new design qualifies as a new/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 ensure there is a mutual understanding between the designers and ABS on how the design may deviate from existing applications, the degree of novelty present, the lack of suitable Rules, codes and standards to address that novelty and what plan of action will be required to address these deviations. In general, if a high degree of novelty is confirmed via the checklist, then 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 *ABS Guide for Risk Evaluations for the Classification of Marine-Related Facilities*. 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.

2 New/Novel Concept Checklist

Section 2, Table 1 is the novel concept checklist. The checklist is intended to help identify proposed new or 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 new or novel concept or application. The next set of questions address marine systems and structural features, covering possible new 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 or storage within marine or offshore applications. 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 facility 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 facility 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 facility could be impacted by the performance of this system.

TABLE 1
Novel Concept Checklist

No.	Checklist Questions	Yes/No/NA ⁽¹⁾
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 facility design basis (e.g., environmental constraints, operating parameters [temperatures, pressures], topside loads or interface with marine systems) 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?	
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)?	
	Do the proposed mooring control systems require active monitoring that is similar to existing mooring systems for the same type of applications and designed according to existing standards and recommended practices?	
	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?	

Section 2 Application

No.	Checklist Questions	Yes/No/NA ⁽¹⁾
	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 facility?	
	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 ensure adequate integrity and structural performance due to new features or application of new technology?	
Marine Systems		
MS1	Are the proposed ballast systems considered to be within the existing experience boundaries for the vessel or offshore facility?	
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 facility?	
	Is the electric power generation system considered to be within the current experience boundaries for the vessel or offshore facility?	
	Is the fuel system used for electric power generation considered to be within the current experience boundaries for the vessel or offshore facility?	
	Is the control system for power generation considered to be within the current experience boundaries for the vessel or offshore facility?	
	Are the power requirements for the vessel or offshore facility within current experience bounds?	
	Are the mechanical system arrangements (e.g., bilge, ballast) considered to be within the current experience boundaries for the vessel or offshore facility?	
	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 facility 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?	

Section 2 Application

No.	Checklist Questions	Yes/No/NA ⁽¹⁾
Process Systems		
P1	Are there any existing commercial applications of the proposed process systems that will be on the vessel or offshore facility?	
P2	Are there existing onshore applications of the proposed process systems that will be on the vessel or offshore facility?	
P3	Are there marine or offshore applications of the proposed process that will be on the vessel or offshore facility?	
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)?	
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 facility?	
SC2	Are there existing onshore applications of the proposed storage systems that will be on the vessel or offshore facility?	
SC3	Are there marine or offshore applications of the proposed storage systems that will be on the vessel or offshore facility?	
	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) as other existing applications?	
SC8	The handling (load/discharge) of the material being stored does <u>not</u> 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?	
Other Systems/Aspects		
AS1	There are <u>no</u> 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 <u>no</u> 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.	

Notes:

1 NA – Not Applicable

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 *ABS Guide for Risk Evaluations for the Classification of Marine-Related Facilities* 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 new or novel, precisely defining the new concept and identifying potential ramifications on the vessel or offshore facility classification approval. The process for evaluating the new or novel concept is described in Section 3 and detailed in Sections 4 and 5.

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 ensure no unforeseen issues related to the design with respect to classification review and approval are evident. If the concept is identified as new or novel, a plan of action, most likely covering an AIP phase, 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 new concept will depend on the degree to which the application of the new concept or technology deviates from existing applications as well as the potential impact of the failure of the application on the remainder of the facility.

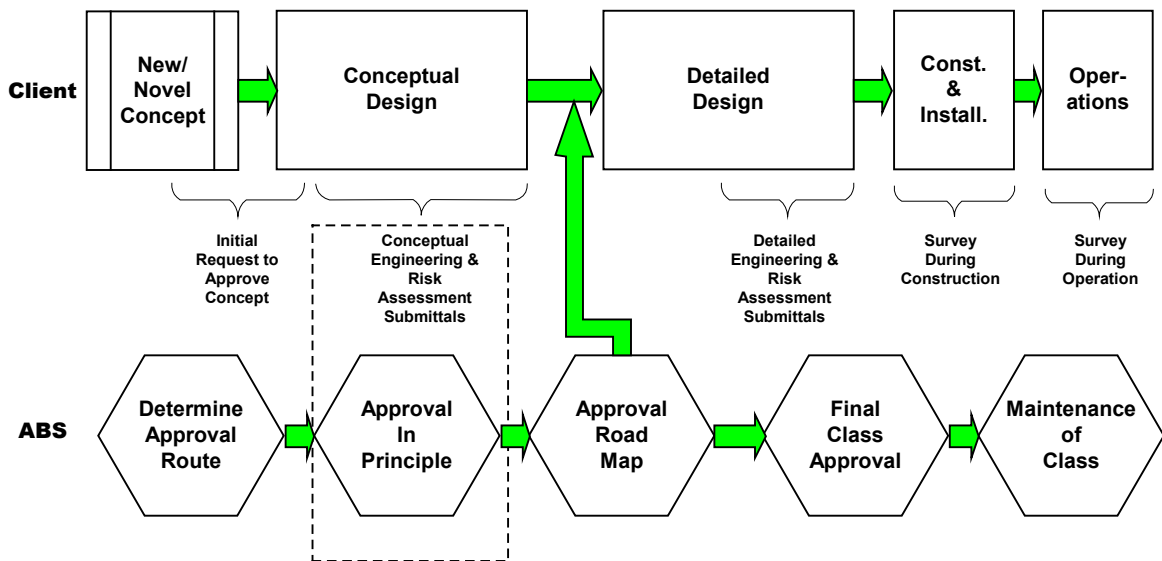
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SECTION 3 Novel Concept Approval Process

1 Overview

For the purposes of these Guidance Notes, the process for review of new or novel concepts is divided into three key stages. First, the AIP stage describes when and what to submit, the review process, and potential outcomes. The second stage, which involves moving forward with a project into detailed design, construction, installation and ultimately issuance of ABS class approval, is intended to build on the AIP stage. The final stage is maintenance of class that is the ongoing evaluation to ensure the original assumptions regarding risk are met. The process that the client and ABS would follow to achieve these milestones is outlined below in Section 3, Figure 1.

**FIGURE 1
Novel Concept Approval Process**



Once the client has reviewed this document and the associated checklist in Section 2, Table 1, and has determined that the proposed application has a degree of novelty necessitating the use of this guideline, a systematic approach to reaching each of the milestones identified in Section 3, Figure 1 shall be developed between the client and ABS. A brief description of these milestones follows:

1.1 Determine Approval Route

A meeting shall be conducted between the client and ABS that lays out the most appropriate plan for achieving AIP, if deemed necessary. At this meeting, ABS and the client will also determine if the *ABS Guide for Risk Evaluations for the Classification of Marine-Related Facilities* is more appropriate for the application in question. If the use of these Guidance Notes is chosen, this plan shall outline the necessary engineering and risk assessments to be conducted on the novel features, appropriate to the level of design evolution expected in the conceptual design stage. The plan as a minimum shall outline a preliminary overall Risk Assessment Plan to be followed throughout the project from concept through detailed design. It will also outline a preliminary Design Review Assessment plan, giving due consideration to the potential need to support the design analysis methodology with refined risk assessment techniques (e.g., frequency or consequence modeling/assessment), data collection, testing and inspection, if applicable. It is understood that as the results from various studies become known in the AIP phase, modification to the Risk Assessment, testing and Design Review plans may be necessary.

1.2 AIP (with Approval Road Map)

As a minimum, the 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 determining what is necessary to achieve AIP, consideration shall be 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 ensure 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 full class approval on the novel aspects. This Approval Road Map will cover all documentation required to be produced to achieve class approval and shall cover all engineering analyses, drawings and specifications, testing and test reports and risk assessments.

1.3 Final Class Approval

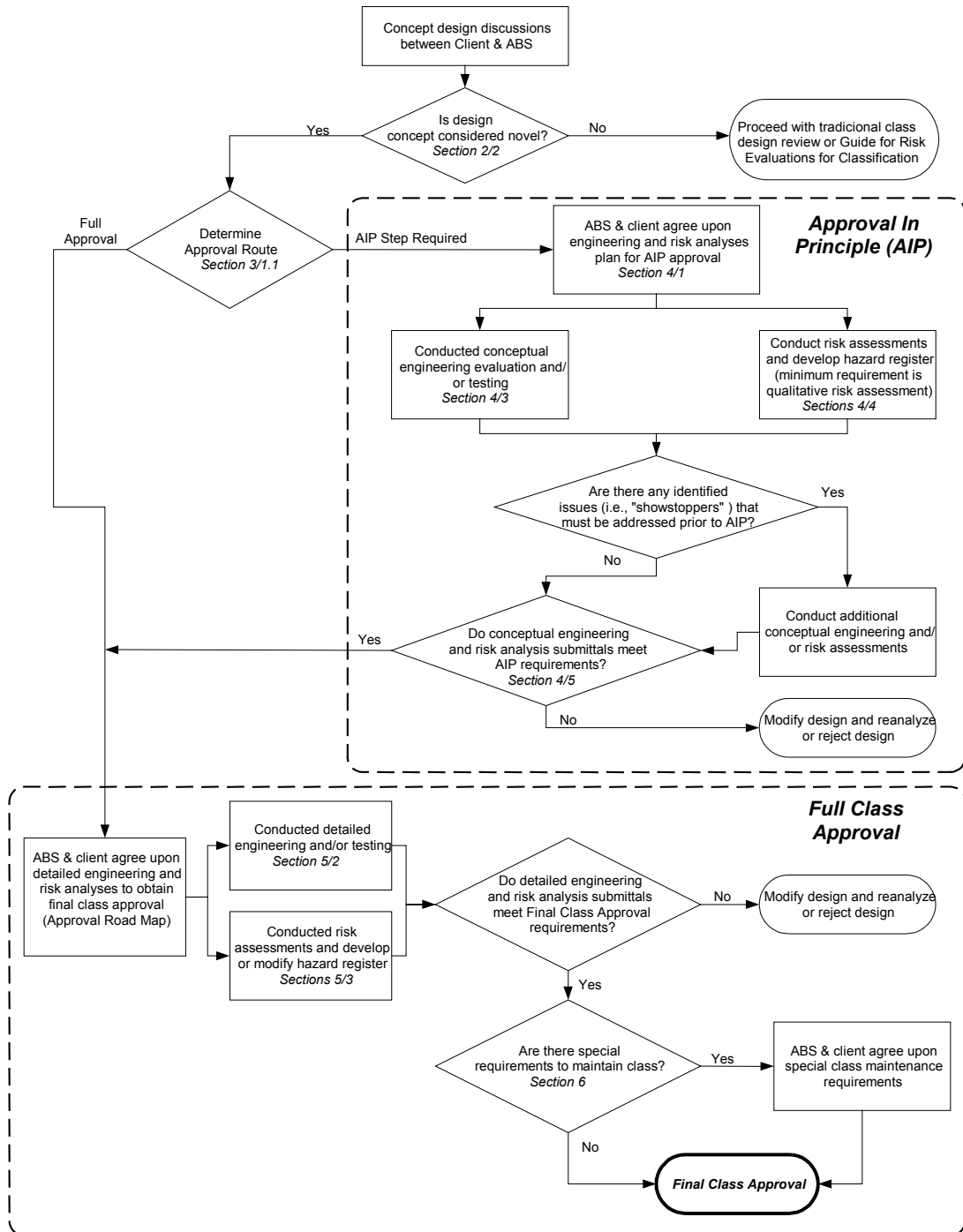
This phase will cover typical class approval submittals comprised of typical drawings, specifications, calculation packages and support documentation, along with submission of those items outlined in the Approval Road Map. Consideration shall also be given in this phase to ABS Surveyor attendance at model or proof testing, as may be required. Upon completion of this phase, the potential hazards and failure modes for the novel feature will have been assessed versus agreed-upon acceptance criteria to a level of confidence necessary to grant full class approval of the concept. In addition, the engineering 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.

1.4 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 dependant 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, these Annual Special Survey requirements may be relaxed.

Section 3, Figure 2 outlines the process flow for novel concept approval and Class following these Guidance Notes. The process essentially involves conducting certain engineering assessments, testing 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



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SECTION 4 Approval in Principle

1 Scope

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-fact that a proposed novel concept or 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 full Class approval. These submittals will generally cover the completion of drawings and project specifications, risk and engineering analysis reports and test results and reports, as applicable.

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

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

- i) *Risk Assessment Plan.* The risk assessment plan should be developed by the client for the concept identifying the appropriate type of assessment technique for the AIP phase and full approval phase. In this regard, the plan should address how the team envisions a holistic approach to risk assessment for all phases of the project with the understanding that as the team gains knowledge of the application and the concept level risk assessments are completed, modifications to this plan may be warranted. The plan should clearly propose risk acceptance criteria with a basis for the criteria. The requirement for generating a risk assessment plan is to ensure that those aspects of the novel application for which there exist no industry guidelines in terms of safety philosophy can, through the risk assessments, be demonstrated to both class and regulators as having acceptable risk levels. An example of a holistic risk assessment plan for a novel concept might involve performing a HAZID/HAZOP for the purposes of generating a hazard register in the AIP phase, and further studies as necessary in the detailed design phase [e.g., fire and explosion analyses, emergency system survivability analysis, smoke and gas ingress analysis, Escape, Evacuation and Rescue (EER) study, quantitative risk assessments (QRA)]. Further explanation on this aspect of the novel concept approach is given in Subsections 4/4 and 5/3.

- ii) *Design Assessment Plan.* The design assessment plan should address the proposed means of justification for all relevant features of the novel application, their associated failure modes and the means proposed to assess the engineering suitability. Similar to the risk assessment plan, the design assessment plan shall also outline acceptable results for the design analyses with the basis for the same. The plan should address required steps to be taken in the concept evaluation as well as in the full approval phase. This plan should be separated into two distinct sections for both phases:
- Those aspects for which there are suitable and appropriate codes and standards which can be applied.
 - Those aspects, which due to their novelty, may require a more rigorous approach to demonstrate feasibility of the concept.

The engineering and risk assessment submittals are to be compared with existing marine and offshore practice to demonstrate that the risk created by the novel concept is no more onerous than what currently exists in the marine and offshore industries. It should also be noted that in some instances, the risk mitigation methods may themselves be novel in their approach. However, these approaches must be demonstrated to the satisfaction of ABS that they still can be practically applied to the concept. It will also be necessary to identify areas where the proposed novel design is beyond that which has been built previously or beyond that envisaged in the existing ABS Rules and other published international code and standard requirements. All hazards created by the failure of the novel features are to be identified in order to assure appropriate mitigation measures are provided to have a comparable overall level of safety established in industry-published codes, standards and recommended practices or in ABS existing Rules and Guides.

2 Required Information to be Submitted

A new or novel concept for a marine vessel or offshore facility will typically affect a large portion (if not all) of the marine vessel or offshore facility. To ensure that the new or novel concept is fully addressed, and other aspects that are not new or novel are considered under existing Rules, the scope of the new or novel concept must first be defined. The requirements for defining the scope of the new or novel concept are:

- i) A description of the system or application, as well as the technical boundaries of the design and operations.
- ii) Identification of interfaces with the new or novel concept. This includes both systems or operations whose functionality or performance could be affected by the new or novel concept and systems and operations that could in turn affect the functionality or performance of the new or novel concept. These interfaces could be integral to the vessel or floating facility or external.

Once the scope of the new or novel concept as defined above has been identified, typically enough information will be available to start the AIP process. Design documents to be submitted include (as applicable) the documents stated in Paragraphs 4/2.1 and 4/2.2.

2.1 Novel Application Description

- i) Design basis documents that include the “operating envelope,” working environment, design life, etc.
- ii) Process or functional description
- iii) Preliminary documents identifying the load and resistance factors
- iv) Details of material specification to be utilized
- v) Preliminary General Arrangement/layout drawings

- vi)* Preliminary Process Flow Diagrams (PFDs), if applicable
- vii)* Preliminary Piping and Instrumentation Diagrams (P&IDs), if applicable
- viii)* Preliminary Electrical one line drawings, if applicable
- ix)* Preliminary Electrical Loads, if applicable
- x)* Preliminary Instrumentation details and accompanying logic diagrams, if applicable
- xi)* System Interface Requirements
- xii)* Preliminary structural drawings and configurations with suitable information showing primary scantlings and material dimensions, thicknesses, etc., if applicable
- xiii)* Preliminary mechanical design drawings, if applicable
- xiv)* Preliminary Safety system details (fire/gas detection and protection), emergency procedures
- xv)* Safety, health, and environmental aspects, if applicable
- xvi)* Preliminary Construction/manufacturing plan and project QA plan
- xvii)* Preliminary Inspection and test plan(s)

2.2 Support Information

- i)* List of reference codes and standards to be applied to the application and the technical justification for selection of those standards if not readily apparent.
- ii)* Outline for novel aspects not covered by the aforementioned codes and standards, the understood deviations from those codes and standards, and the proposed approach to be taken for establishing engineering justification on these features.
- iii)* Concept level engineering calculation dossiers demonstrating suitability of the novel features for the proposed service life and operational envelope via comparison with agreed upon acceptance criteria.
- iv)* Supporting test results and data sources used in the engineering analysis
- v)* Proposed welding, fabrication and NDE specifications

In addition, the information needed prior to conducting the Concept Level Risk Assessment (scope, risk analysis method to be used, subject matter experts and risk ranking methodology) shall also be submitted.

3 Concept Engineering Evaluation

The concept engineering evaluation shall be used to verify that the design is feasible with respect to intent and overall level of safety established in Rules, Guides and statutory requirements in all phases of operation (such as in-transit, installation, commissioning and operation for an offshore application) as far as practical within the concept phase. To demonstrate this feasibility, the client is to have identified where due to the degree of novelty, the proposed design deviated from existing code and standard practice. Sensitivity studies are also to have been carried out identifying the key design parameters driving the assessment. The client is then required to demonstrate that for each aspect of the concept, all relevant failure modes have been identified and justified through appropriate analyses when considering all applicable loading and environmental conditions. Loading and environmental conditions to be considered include, but are 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)* Chemical attack and associated material loss and cracking
- ix)* Accidental loads

Failure mechanisms and failure modes for each component shall be addressed and identified. This may be done prior to the concept level risk assessment and subsequently modified if new additional failure modes have been identified, or it may be done in conjunction with the concept level risk assessment with this objective in mind. The assessment must verify that the application does what it is intended to do, that its materials are suitable for the environments proposed, and that all critical components are demonstrated to be fit for their operating life.

Finally, most novel applications have aspects that are novel and aspects that are conventional. The concept evaluation shall consider not only the verification of the novel aspects, but also verify the effect of the novel aspect on the conventional aspects. This is done to ensure that the application of existing codes and standards to the non-novel features is still valid.

In general, the concept evaluation shall cover the following aspects as identified in the Design Assessment Plan:

- i)* Verification of Conventional Features
- ii)* Verification of Novel Features
- iii)* Verification of Operability
- iv)* Verification of Interface Issues
- v)* Verification of Inspectability and Maintainability

3.1 Verification of Conventional Features

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.

3.2 Verification of Novel Features

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. Typical approaches include the following:

- i)* A full reliability-based approach to demonstrate functionality and achieved margins of safety. The target acceptable probabilities of failure in this instance shall be associated with the risk assessments conducted in that acceptable targets are commensurate with the consequences of failure. It is important to stress that in this instance, the risk assessment used to set the acceptability criteria need not be fully quantitative, as in many instances a qualitative assessment of the failure consequence is fully acceptable in setting the failure acceptance criteria.
- ii)* A deterministic assessment is used, however key design parameter sensitivities can be treated in a semi-probabilistic approach, ensuring the design has adequate margin against failure given a potential large variance in the key design variables. In this instance as well, the risk assessment must be used to set the acceptable margins for the deterministic analysis given the failure consequence of that particular failure mode.

These approaches would be used when there are no existing codes or standards that cover the proposed application to an acceptable degree of certainty. Such a methodology would involve determination of applied loads and available resistance for the various identified failure modes defined in terms of probability functions, and the probability of failure is calculated for each failure mode. For such an analysis, the client and ABS would also need to agree on appropriate target probabilities of failure either during the AIP phase or prior to commencement of the full approval phase to be applied to each failure mode. Such a method may also require additional prototype/model/material testing to eventually be performed. When considering setting of target failure probabilities for novel concepts where no data presently exists, consideration shall be given to use of published information in existing codes for target values provided the client has also demonstrated consideration for the particular consequence of failure of both the component and overall system for each failure mode in question.

It is understood that to incorporate all relevant parameters into such methods can be time consuming and costly for a concept level evaluation. In this regard, when the analysis for concept approval is not robust enough to support detailed determination for all possible failure modes, the analyses in this phase shall as best as possible provide conservative estimations for loading and resistance aspects to prove feasibility. Then, refinements and more accurate determinations can be made in the detailed design phase.

3.3 Verification of Operability

A review is to be conducted to ensure the novel application can do what it is meant to do from a functional point of view with respect to Rules, Guides or statutory requirements. This aspect may be somewhat covered in the risk assessment. However, the concept must be reviewed to ensure that the operational aspects associated with placing the application in a marine or offshore environment are commensurate with typical operation practice for these facilities. Simply stated, is the concept practically applied?

3.4 Verification of Interface Issues

In addition, the novel application must not place undue burden on the surrounding systems and components. All necessary interfaces with other systems, both internal to the vessel or floating facility or external, must be fully understood and the determination made that the novel feature does not adversely affect those systems or components.

3.5 Verification of Inspectability and Maintainability

Lastly, the novel concept must be reviewed from the standpoint of inspectability and maintainability. The various components of the novel application must be reviewed to ensure 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.

4 Concept Level Risk Assessments

Risk assessments at the early or conceptual stages of a new or 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, testing 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 Full Class Approval process.

In general for the concept development phase, a design basis, preliminary engineering and possibly testing results as well as other information, as described in Subsection 4/3 for concept evaluation, will be available. At this stage of the concept development (i.e., level of design detail), a qualitative risk assessment technique is generally the most suited method. More refined assessments, such as quantitative risk assessments or reliability analysis, require considerably more details related to the engineering and/or testing and would tend to be more appropriately applied at later stages of the concept development. However, in some cases it may be necessary to conduct quantitative risk assessments during the conceptual design stage and Subsection 5/3 provides details on assessment techniques and submittal requirements.

4.1 Qualitative Risk Techniques

There are various qualitative risk techniques that can be applied, such as HAZID, What-if and HAZOP. However, the most appropriate technique depends on the available concept design information and type of system being proposed. General information on selecting the most appropriate risk techniques can be found in Chapter 3, Section 2 of the ABS *Guidance Notes on Risk Assessment Application for Marine and Offshore Oil and Gas Industries*. A description of these techniques and typical applications is presented in Section 4, Table 1.

TABLE 1
Qualitative Risk Techniques

<i>Risk Assessment Technique</i>	<i>Description</i>	<i>Typical Applicability</i>	<i>General Level of Effort</i>	<i>Level of Required Design Detail</i>	<i>Technique Limitations</i>
Change Analysis	Method which steps through a system logically for possible risk effects and proper risk management strategies in changing situations (e.g., when system layouts are changed, when operating practices, or when new or different activities will be performed).	Can be used for all types of systems, but generally for systems where changes in design or operation can be compared to existing system	Low to Moderate	Low to Moderate	Generally requires an alternative concept that can be easily defined in terms of discrete changes or deviations from an existing or proven application.
HAZID (HAZard Identification)	Method to rapidly identify hazards, assess potential consequences, and evaluate existing safeguards of the system. Method draws upon highly experience multi-discipline team using a structured brainstorming technique to assess applicability of potential hazards.	Used on all types of systems.	Low to Moderate	Low to Moderate	Typically high-level assessment with limited identification of initiation and intermediate events. Quality of assessment very dependent on subject matter experts who participate.
What-if	Method to identify hazards, hazardous situations or specific accident events by creatively brainstorming questions or concerns about initiating events that could result in undesired consequences. This method is often combined with checklists to add structure to the analysis.	Applicable to all types of systems and at various stages of design	Moderate to High	Moderate	Quality of assessment very dependent on subject matter experts who participate. Difficult to audit for thoroughness and for new or novel applications it would difficult to incorporate structured checklists.
HAZOP (HAZard and Operability Analysis)	A systematic method in which hazards and potential operating problems are identified using a series of guide words to investigate system or process deviations.	Typically used in the evaluation of process systems, especially fluid and thermal systems.	Moderate to High	High	Typically requires well-defined system or procedure, and if system is complex, process can be time consuming and resource intensive. Also quality of assessment dependent on subject matter experts.
FMEA (Failure Modes & Effects Analysis)	Systematic, tabular method of evaluating and documenting the causes and effects of known types of component failures. The technique considers how the failure modes of each system component can result in system performance problems and makes sure proper safeguards are in place.	Typically used to evaluate detailed mechanical or electric systems.	Moderate to High	High	Typically requires well-defined system and if system is complex process can take considerable amount of time. Quality of assessment dependent on analyst experience. Also tends to focus on single events or scenarios.

Conducting a qualitative risk assessment involves a team brainstorming session that provides a unique forum for designers, operational and safety personnel, as well as ABS representatives, to discuss the concept in a structured manner. ABS does not mandate that ABS personnel be part of the risk assessment team. However, benefits can be derived by the participation of an ABS representative that will be directly involved in reviewing the risk assessment to support the approval decision. Some of those benefits include:

- i)* As a participant, the ABS representative will be able to point out the issues that ABS considers to be relevant for the classification of the proposed design and thus should be discussed
- ii)* Participation will minimize the amount of questions and clarifications at the time of the ABS review of the risk evaluation because he/she will be familiar with the study and design.

4.2 Comparative Risk Assessment

Another method of evaluating risks of a new concept is to conduct a comparative risk assessment. The comparative risk assessment can be either qualitative or quantitative. A comparative risk assessment generally utilizes risk assessment techniques similar to those described in Section 4, Table 1, as well as those discussed later in Section 5, Table 1. However, rather than comparing the concept risk categorizations to a specific criteria, they are compared to risk categorizations of another similar system. More details on this method, some of the potential advantages of the method and the required submittals prior to and after the completion of the assessment are provided in Paragraph 5/3.3.

4.3 Concept Level Risk Assessment Submittal Requirements

Prior to conducting a qualitative risk evaluation, it is the responsibility of the organization proposing the new/novel concept to submit information on what method will be used, what subject matter experts will participate and what the scope of the assessment will cover. Additionally, a risk ranking methodology or risk matrix must be submitted and approved by ABS. An example risk matrix is provided in Appendix 1. The use of the organization's risk matrix may be acceptable provided it is in general compliance with ABS's safety, environmental and operability philosophies.

Irrespective of the method, documentation supporting the qualitative risk assessment of the concept must be submitted for review and at a minimum provide the following information.

- i)* Identified potential hazards related to the application of the concept and its potential impact on other systems
- ii)* Assessed potential risks associated to the new concept application.
- iii)* Initial hazard register that will be used by the organization to track identified issues through the resolution process and eventually to closure.
- iv)* Identified potential mitigation strategies or safeguards not currently in the design that could improve the safety, or operability of the concept (if applicable).
- v)* Identified potential inspectability/operability issues related to human factors and the complexity of the concept that might impact requirements the maintenance of class or operations (if applicable).
- vi)* Identified areas or issues related to the concept that may warrant further analysis, testing or risk evaluations prior to AIP or final classification approval (if applicable).

In addition to this information, any proposed changes to the original AIP evaluation plan, as described in Section 4, must be submitted based on the results of the risk evaluation. This could include additional engineering, testing or more detailed risk assessments (e.g., reliability analysis of critical components) as part of the conceptual or detailed design phase. Information on more detailed risk assessment techniques and the method and documentation requirements is presented in Subsection 5/3, "Detailed Risk Assessment". Typically, more detailed risk assessments conducted during the

conceptual stage are driven by potential high risk components or systems or high uncertainties related to the concept that must be addressed prior to receiving AIP. The detailed risk assessments typically must be drawn from more detailed engineering or possibly supported by testing. The purpose of more detailed risk assessments is to ensure there is general confidence that specific issues, which could be potential “showstoppers” with regards to safety or operability, have been addressed to the satisfaction of ABS. The issue may either be no longer considered a concern based on the results or the assessments have reduced design uncertainties to a level considered manageable such that it is considered satisfactory resolution can be achieved during the detailed design phase as outlined in the agreed upon approval road map.

5 Granting “Approval in Principle”

5.1 Conditions for Approval in Principle:

In order for ABS to grant Approval in Principle to the novel concept, the following conditions must be satisfied:

- i)* Both the Concept Engineering Evaluation and the concept-level Risk Assessment must not have identified any “showstoppers” (i.e. abnormal hazards or an excessively onerous failure mode) which the evaluation team has deemed as requiring reevaluation in the concept phase before the approval process is allowed to progress to the next phase.
- ii)* The concept must be deemed suitable for use within a marine or offshore environment without the need for excessive or onerous monitoring during operation or maintenance/inspection considered atypical for such applications.

5.2 Issuance of AIP Letter

Once the above conditions have been met, the ABS evaluation team will prepare a statement-of-fact letter attesting to the feasibility of the 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 phase. Attached to this letter shall be the aforementioned Approval Road Map outlining a list of submittals and conditions to be satisfied (as identified in the concept phase) in order to achieve full class approval.

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SECTION 5 Final Class Approval

1 Information Required for Engineering Evaluation

Detailed lists of required documents to be submitted in this phase are more appropriately detailed in applicable sections of the ABS Rules and Guides for systems similar to the novel application in question. Due to the general nature of these Guidance Notes, and for the sake of brevity, these lists are not repeated herein. The purpose of this Section is to cover required submissions in the full class approval phase for the novel features alone.

Typically, the submissions required in the full approval phase of the project include the following:

- i) Statement of relevant codes and standards applied and the deviations made to their application with respect to the novel features.
- ii) Completed and refined design calculations for the novel features taking into account the list of outstanding items identified in the AIP Approval Road Map, potentially including the following:
 - All relevant loading and the uncertainty in that loading
 - All relevant resistance factors and their uncertainties for materials of construction including, but not limited to yield, UTS, fracture toughness and CTOD values.
 - All associated resistance parameters, such as dimensional parameters or functional features
 - Failure data
- iii) Report on selection of appropriate acceptability criteria used to assess the design.
- iv) Final design basis document and project specifications for all key novel features
- v) Detailed drawings covering in detail all dimensional requirements, process and instrument details, safety features and ancillary systems for the novel features, as applicable.

In addition, risk assessment documents identified in Paragraph 5/3.1 shall also be submitted.

2 Review and Verification of Engineering Analyses for Full Approval

The requirement for full approval phase engineering analyses will be dependent on the proposed novel system and the agreed-upon approval road map, discussed in Subsection 4/1. As shown in Section 1, Figure 1, the objective of the engineering work in this phase of the project, such as detailed design and testing, is to increase the understanding and level of confidence in the novel feature by demonstrating adequate safety margins vs. failure for all relevant failure modes. The margins against failure must be demonstrated versus target limits identified during the AIP approval Road Map and which are commensurate with the risk level associated with the hazards posed by the failure mode in question. Further, the design must be shown to meet applicable operability, inspectability and safety requirements.

Generally as the design is further refined, so does the applicability of more detailed engineering analysis become appropriate. The design verifications performed and submitted in this phase will also include the following:

2.1 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 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 shall 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 shall explain the means for choosing appropriate safety margin or acceptable failure probabilities used to assess the design suitability. This explanation shall 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.

2.2 Calculation Dossier

Completed and refined design calculations for the novel features, taking into account the list of outstanding items identified in the AIP Approval Road Map. This submittal would in essence be a more accurate version of the concept calculations, but now would also include:

- i)* For load bearing applications, all relevant loading and the uncertainty in that loading. If it has been decided to not refine a preliminary loading input used during the concept evaluation in the detailed design phase, the justification as to the reasons for doing so must be submitted.
- ii)* For process and electrical systems, all associated potential system failure/breakdowns and their associated failure frequencies, as well as the consequence and impact on the system from each failure.
- iii)* Accurate understanding of the associated resistance factors and their uncertainties for materials of construction including yield, UTS, fracture toughness and CTOD values.
- iv)* Accurate understanding of associated resistance parameters, such as dimensional parameters or functional features as garnered from actual material tests, destructive and non-destructive prototype and model test results.
- v)* Verification of failure data through functional testing.

2.3 Confirmation of Interface Issues

Necessary interfaces with other systems shall be reinvestigated to ensure that no changes have occurred since the concept phase insofar as the novel feature's relation to other surrounding conventional design aspects and systems. This includes both the interfaces within the vessel or floating facility and external to it as applicable.

2.4 Confirmation of Inspectability and Maintainability

Inspectability and maintainability for surveyor access or access for survey related examinations shall be revisited to ensure that no substantial changes have been made to the system that could impact these issues.

3 Detailed Risk Assessment

The requirement for a detailed risk assessment will be dependent on the proposed novel system and the agreed upon approval road map, discussed in Subsection 4/1. At a minimum, a detailed qualitative risk assessment on the new concept will be required as part of the Full Class Approval process.

This section describes some of the available techniques that may be employed and their general applicability to particular systems or designs. As shown in Section 1, Figure 1, the objective of the risk assessments and the engineering work conducted in parallel, such as detailed design and testing, is to increase the understanding and level of confidence of the system, ensuring it meets applicable operability and safety requirements. Generally as the design is further refined, so does the applicability of more detailed risk assessments become appropriate.

3.1 Quantitative Risk Techniques

Detailed risk assessments may include both qualitative or quantitative risk techniques, and the most appropriate technique is dependent on the available concept design information and type of system being proposed. Possible detailed qualitative risk techniques, such as the HAZOP or FMEA are described in Subsection 4/2. These qualitative assessments would be recommended prior to initiating any quantitative risk analysis. This is to ensure the hazards related to the concept, have been identified and categorized (based on risk), such that the quantitative approach can be focused on the most critical aspects of the new concept. Some of the applicable quantitative techniques and typical applications are presented in Section 5, Table 1. General information on selecting the most appropriate risk techniques can be found in Chapter 3, Section 2 of *Guidance Notes on Risk Assessment Application for Marine and Offshore Oil and Gas Industries*.

TABLE 1
Quantitative Risk Techniques

<i>Risk Assessment Technique</i>	<i>Description</i>	<i>Typical Applicability</i>	<i>General Level of Effort</i>	<i>Level of Required Design Detail</i>	<i>Technique Limitations</i>
Fault Tree Analysis (FTA)	Technique that graphically models logical relationships between equipment failures, human errors and external events combined to cause specific undesirable events. Risk is determined numerically by providing initiating failure, error or event frequencies.	Generally most applicable for assessing electrical, mechanical, control and communication systems, in which the system or operation can be broken down into discrete components or events.	High	High (system or operation must be well defined in order to develop model)	Quality of numeric risk estimates directly related to quality and availability of initiating failure, error or event frequencies. In many cases, the results must be coupled with estimated consequences to evaluate over all risk. Results of analysis must be compared to allowable or target reliabilities drawing from other similar systems or developed independently for concept.
Event Tree Analysis (ETA)	Technique that uses decision trees to model possible outcomes of an event that can produce an undesired consequence. Similar to FTA, risk is determined numerically by providing initiating failure, error or event frequencies.	Generally most applicable for assessing system safeguards or response of particular systems or procedures once an event occurs. Useful in assessing mechanical and control systems, as well as modeling human responses.	High	High	Quality of numeric risk estimates directly related to quality and availability of component and system performance and reliability estimates. Results of analysis must be compared to allowable or target reliabilities drawing from other similar systems or developed independently for concept.

<i>Risk Assessment Technique</i>	<i>Description</i>	<i>Typical Applicability</i>	<i>General Level of Effort</i>	<i>Level of Required Design Detail</i>	<i>Technique Limitations</i>
Structural Reliability Analysis (component or system reliability)	Very useful means to evaluate reliability or failure probability of novel designs, provided statistical data is available or can be generated from testing or analysis. Structural reliability analysis is tied to structural analysis with input parameters (e.g., loads, material properties) regarded as random variables. It is also tied to limit-state design codes (e.g., AISC, LFRD)	Generally applicable to most structural (e.g., storage tank, connections, pressure vessel, mooring system), mechanical systems where structural analysis (e.g., FEM analyses are applicable). It can also be coupled with ETA and FTA.	High	High (generally requires design to be refined enough such that testing or detailed analysis can be conducted to generate required statistical data)	Generally dependent on statistical variations and correlation for a novel concept will come from testing or detailed analysis (e.g., finite element analysis). Results of analysis must be compared to allowable or target reliability drawing from other similar systems or developed independently. Also results are frequency based and must be coupled with estimated consequences in order to evaluate over all risk.

Prior to initiating a quantitative risk assessment to be used to assess the proposed novel concept, the following should be submitted to ABS for approval:

- i) Description of the system
- ii) Description of proposed quantitative method, scope of assessment and basis for assessment (e.g., based on results of qualitative assessments)
- iii) Objectives of quantitative risk assessment
- iv) Proposed risk acceptance criteria or target reliability. Specific requirements for the proposed risk criteria are described in Paragraph 5/3.2.

3.2 Selection of Target Reliability and Risk Acceptance Criteria

One of the difficulties of quantitative techniques in assessing novel concepts is being able to compare the results to risk acceptance criteria or reliability targets, which in many cases may not be readily available. In some cases, there may be available industry guidelines or design codes based on limit-state concepts that are similar enough to be used in defining a target reliability. However, prior to selecting a target reliability and initiating a reliability analysis, the following information should be submitted to ABS for approval.

When using an industry guideline target reliability of a component or system to compare with the novel concept, the following items are required:

- i) Guideline reference
- ii) The target reliability and detailed description of component or system similar to novel concept.
- iii) List of similarities and differences between the novel system and the target reliability component or system.
- iv) Reliability analysis assumptions

When using developed target reliability for the specific concept, the following is required:

- i) Target reliability
- ii) Documentation describing basis for target reliability (e.g., testing, experience with similar existing systems, governing limits such as safety or operational).

Selection of appropriate risk acceptance criteria for determining allowable FTA and ETA risk results can also be very difficult, particularly for a new or novel concept. In some cases, the organization proposing the concept may have defined company-wide risk acceptance criteria that must be met. In other cases, the organization will have to develop a risk acceptance criteria specific to the application of the new concept, in line with their functional, operational and safety philosophy. However, in all cases, the organization is required to submit to ABS, for review and approval, the risk acceptance criteria that will be used to categorize the risk results, prior to initiating a quantitative assessment. The submitted documentation will allow ABS to determine if the acceptance criteria meet or exceed their safety, environmental and operability criteria.

- i)* Risk acceptance criteria (e.g., individual, societal, environmental, business interruption, financial, aggregate).
- ii)* Basis for criteria selection (historical industry or occupational statistics [e.g., API, CCPS], governmental, country or regional statistics [e.g., HSE, US Department of Labor, EU], company statistics, jurisdictional requirements).
- iii)* Description of criticality for the application of the new concept in relation to overall vessel or installation performance and estimated fractional contribution to total risk (i.e., safety and environmental) that the new concept may contribute. Note that much of the available data used to develop risk acceptance criteria represents total risk. For example, occupational injury or fatality rates for fishermen represent the total occupational risk including all hazards such as falling objects, slips, trips and falls, environmental exposure, equipment failure, vessel structural failure, vessel loss of stability or capsizing, human error, collision, as well as many other potential causes. Hence, when justifying risk acceptance criteria for one particular system or application, it must be placed in the context of how much the application contributes to the total risk.

3.3 Comparative Risk Assessment

Another method of evaluating risks of a new concept is to conduct a comparative risk assessment. The comparative risk assessment can be either qualitative or quantitative. A comparative risk assessment generally utilizes risk assessment techniques similar to those described in Section 4, Table 1 and Section 5, Table 1, but rather than comparing the risk categorizations to a specific criteria, it is compared to risk categorizations of another similar system. This type of assessment can be a very efficient method of assessing relative risks between a novel concept and a similar proven system, provided the application and operations boundaries of the two systems are the same. One of the primary attributes of conducting a comparative risk assessment is not having to develop a risk acceptance criteria. Instead, the primary objective of the risk assessment is to show that the novel system provides similar or lower risks than the proven system. This type of assessment is very useful in identifying similarities and differences between a proven system and a new system, which can be very important in evaluating operating procedures and training requirements for the new system. If an organization wishes to use a comparative risk assessment to evaluate the relative risks associated with a novel concept, the following information should be submitted to ABS to determine if a comparison of the two systems is appropriate (this should be done prior to conducting the assessment):

- i)* Detailed description of novel and proven systems to be compared.
- ii)* Description of primary differences and similarities
- iii)* Description of testing, analysis and/or operating experience of proven system. This should include all known problems or failures of the proven system.
- iv)* Description of proposed qualitative or quantitative method used to compare systems
- v)* Definition of the risk assessment boundaries (i.e., scope of risk assessment)

3.4 Detailed Risk Assessment Submittal Requirements

Documentation supporting the detailed risk assessments must be submitted for review and at a minimum provide the information described in Paragraphs 5/3.1, 5/3.2 (if applicable) and 5/3.3 (if applicable), plus:

- i)* Risk assessment assumptions and data references.
- ii)* Description and demonstration of calibration of quantitative method. This is a very important step to ensure that consistent results are obtained using the method. The calibration step also increases the confidence of the quantitative risk analysis.
- iii)* Description of uncertainties and sensitivities of risk assessment.
- iv)* Risk assessment worksheets, fault trees, event trees and supporting calculations.
- v)* Conclusions, which summarize the results and clearly indicate the novel concept risks relative to the risk acceptance criteria, target reliability or the proven system being compared to.
- vi)* Identified areas or issues related to the concept that may warrant further analysis, testing or risk evaluations (if applicable).
- vii)* Identified potential mitigation strategies or safeguards not currently in the design that could improve the safety or operability of the concept (if applicable).
- viii)* Identified potential inspectability/operability/accessibility issues related to human factors and the complexity of the concept that might impact requirements the maintenance of class or operations (if applicable).



SECTION **6** **Input to Surveys and Maintenance of Class**

1 **Knowledge Gained**

Once class approval is obtained, and the application is proceeding into the construction phase, it must be ensured that the knowledge gained by the engineering and risk assessment teams is 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 ensure a high level of quality. 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 ensure 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 ensure that the application or system performs as intended

1.2 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. 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 ensure 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 ensure 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 7 **Government and Regulatory Involvement**

In some instances, there can be as many as three administrations required for acceptance of a novel concept. For ships and marine craft, 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 interim guidelines for these types of novel vessels is the Guidelines for Formal Safety Assessment (FSA) found in MSC/Circ.1023 dated 5 April 2002. The guideline is 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.

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APPENDIX 1 Sample Risk Matrix

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

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