Rules For

Alternative Arrangements, Novel Concepts and New Technologies

Part 1D

January 2024

RULES FOR

ALTERNATIVE ARRANGEMENTS, NOVEL CONCEPTS AND NEW TECHNOLOGIES JANUARY 2024

PART 1D

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

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PART 1D

Foreword

The *Rules for Alternative Arrangements, Novel Concepts and New Technologies (Part 1D)*, is to be considered as being applicable to and comprising an integrated Part of any ABS Rules, Requirements, and Guides.

Due to the rapid adoption of new technology, Goal Based Standards have been incorporated into the ABS Rules. Goal Based Standards offer a path for class approval for alternative and novel concepts. Existing class requirements often prescribe a specific technological solution. Since Goal Based Standards do not dictate specific technical solutions, they are better suited to accommodate future technological developments.

This document outlines the procedure for the design and ABS acceptance of Alternative Arrangements, Novel Concepts and New Technologies. It focuses on the application of Goal Based Standards for classification. In addition, a consolidated list of Tier I Goals is provided.

The ABS incorporation of Goal Based Standards is based on IMO MSC.Circ.1394, *Generic Guidelines for Developing IMO Goal-Based Standards* and extensive experience with Novel Concepts, New Technology Qualifications, and risk-based methodologies.

This document also incorporates the previously standalone *Guidance on Review and Approval of Novel Concepts* and *Guidance on Qualifying New Technologies* which are found in Appendix 1 and 2 respectively .

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Alternative Arrangements, Novel Concepts and New Technologies

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CHAPTER 1
Introduction

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1 Objective

Goal Based Standards (GBS) provide a path to compliance with class requirements for alternative designs, novel concepts, and new technology.

Goal Based Standards also provide background information by identifying the intent of ABS requirements. The consolidated List of Tier I Goals provides an overview of high-level safety, environmental, and security objectives.

Alternatives, new technologies, and novel concepts may be accepted if Designers, Shipyards, Owners, Equipment Manufacturers, or others demonstrate compliance with the Tier I Goals and Tier II Functional Requirements during Tier III Verification of Conformity.

The objective of this document is to outline the process for applying Goal Based Standards.

3 Compliance

With the introduction of Goal Based Standards, there are two paths for compliance with the ABS Rules:

i) The prescriptive ABS requirements remain valid. A vessel is considered to comply with the Goals and Functional requirements within the scope of class when compliance with the applicable prescriptive requirements has been demonstrated.

ii) Alternative designs, new technology, and novel concepts may comply with the Goal Based Standards in accordance with the procedure outlined in Part 1D, Chapter 2.

The Goal Based Standards framework shows the relation between the different Tiers. It consists of five major components, namely Tier I to Tier V (see also 1D-1-1/Figure 1):

1) Tier I Goals

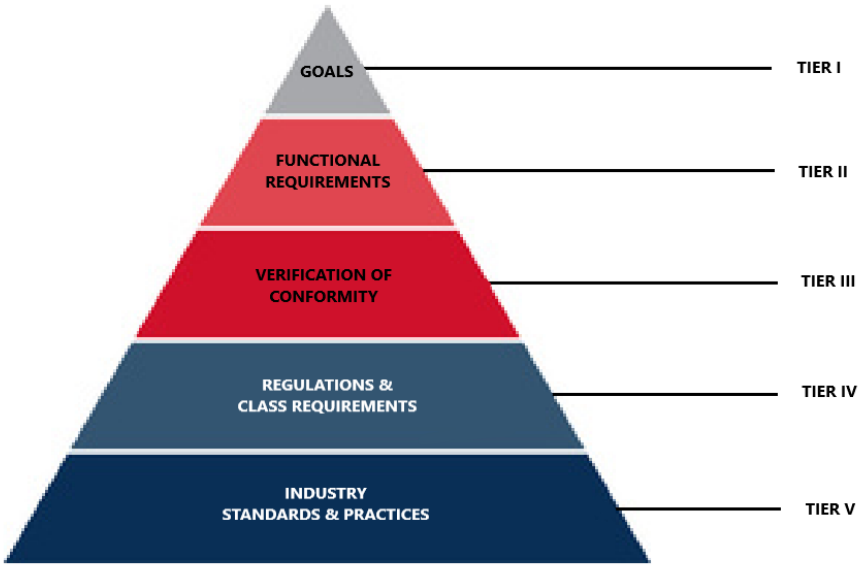
2) Tier II Functional Requirements

3) Tier III Verification of conformity

4) Tier IV Regulations and Class requirements

5) Tier V Industry standards and practices

FIGURE 1
Goal Based Standards Framework



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CHAPTER 1
Introduction

SECTION 2
Scope

1 Applicability

This document applies to alternative arrangements, novel concepts, or new technologies that are designed in accordance with a goal based approach. This document is to be used in association with the goals and functional requirements defined throughout the Rules.

Alternative arrangements, novel concepts, or new technologies that follow other recognized approaches may be accepted by ABS (i.e. IMO MSC.1/Circ.1212/Rev.1, *Guidelines on Alternative Design and Arrangement for SOLAS Chapters II-1 and III*). Aspects of this document may still apply.

Conventional designs, technologies, and arrangements are to comply with ABS prescriptive requirements and follow the conventional approval process.

3 International Conventions or Codes

When a goal-based approach is used as the basis for compliance with Administration and Coastal State requirements, the Administration is to be contacted, either directly or through ABS, to obtain an understanding as to the extent to which the Administration is prepared to consider alternatives to such requirements.

Refer to the detailed procedures contained in Part 1D, Chapter 2 and IMO MSC.1/Circ.1455 *Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments*. Refer to the consolidated List of Tier I Goals in Section 1D-3-1 which indicates whether a Goal is Class, Statutory, or Other.

5 Application of Goal Based Standards to Structures

Conventional vessels are to fully comply with the prescriptive requirements applicable to that vessel type. Vessels required to meet the Common Structural Rules (Part 5Aand 5B *of Rules for Building and Classing Marine Vessel Rules (Marine Vessel Rules)*) are to follow the procedures contained in IACS Procedure Volume 4 for interpretation of the requirements.

Commentary:

Examples of application of Goal Based Standards to Structures are:

i) Minimum thickness requirements may not be waived for conventional vessels. For example, 3-2-15/9.3 of *Marine Vessel Rules* requires a minimum thickness of 6 mm for the plating of hatchways closed by covers of steel fitted with gaskets.

ii) Finite element analysis may not be used to reduce the basic scantlings obtained from the direct application of the Rule criteria unless specific exceptions are identified in the Rules. For example, Part 5C, Chapter 5 of *Marine Vessel Rules* requires that a 400 m Containership in unrestricted service be evaluated using a full ship FEA (DLA or equivalent). However, the FEA may not be used to reduce the side shell plating requirements contained in 5C-5-4/11.1 of *Marine Vessel Rules*.

iii) Where the prescriptive requirements do not fully address the structural arrangement under consideration (i.e. grillage effect), Finite Element Analysis (FEA) may be used.

End of Commentary

7 Application of Goal Based Standards to Surveys

The Survey requirements for alternative arrangements and novel concepts are to be established during the verification of conformity step of the procedures as outlined in Part 1D, Chapter 2.

The GBS approach may be applied to evaluate alternative means to meet Survey Requirements by providing a method to allow the objective of the Rules to be met by some means other than the prescriptive requirements of the Rules and effectively evaluate the condition of the hull structure and/or machinery to demonstrate the satisfactory construction and subsequent maintenance of the vessel, and when necessary, recommend the work required to enable the vessel to be maintained in Class. Refer to Appendix 7-A1-12 of ABS *Rules for Survey After Constructions (Part 7)*.

9 Application to Portions of a Vessel

The GBS approach may be applied to alternative arrangements, novel concepts, or new technologies used for specific parts of the vessel.

All possible interfaces and known integrations are to be evaluated and are to consider the following to confirm the compatibility of the alternative to the other surrounding conventional design aspects and systems:

i) Personnel health and safety

ii) Asset protection

iii) Environmental protection

This evaluation and consideration are to include both the interfaces within the vessel or offshore unit and external to it, as applicable.

The integration/interfacing of alternatives with conventional technologies and/or the asset is not to introduce new hazards or undesirable events, unless the associated risks can be mitigated to an acceptable level. Guidelines on evaluating the impact of these alternatives on other systems can be found in Appendix 1, *Guidance on Review and Approval of Novel Concepts* and Appendix 2, *Guidance on Qualifying New Technologies.*

11 Application to Individual Equipment or Components

Individual equipment or components may be approved based on the overall system meeting the goals and functional requirements. However, individual equipment or components that do not comply with the prescriptive ABS Rules, Guides or other recognized standards will typically not be eligible for ABS Type Approval.

13 Application to IACS Unified Requirements

Alternatives may be considered for ABS Rules based on IACS Unified Requirements provided that the alternative meets the intent of these requirements and can provide an equivalent level of safety as a conventional design. As stated in 1D-1-2/1, conventional designs are to comply fully with the ABS Rules and IACS Unified Requirements.

15 <No Text>

17 Scope of Classification

The goal based approach may consider operational or procedural measures. The operation of the vessel is outside the scope of class. However, ABS may suspend class if the vessel is operated, loaded, or otherwise used in a manner for which it has not been approved and which affects or may affect classification or the structural integrity, quality, or fitness for a particular use or service.

Nothing contained in any certificate or report is to be deemed to relieve any designer, builder, Owner, manufacturer, seller, supplier, repairer, operator, insurer, or other entity or person of any duty to inspect or any other duty or warranty express or implied.

The Tier 1 Goals are often broader than the prescriptive Rules. However, a goal based approach is not to be considered to extend the scope of class beyond what is covered in the prescriptive Rules.

19 Recognized Industry Standards

Where the ABS Rules require compliance with “recognized standards” and the standard has a proven record in marine and offshore applications, the standard may be accepted without going through the equivalency process outlined in Section 1D-2-2.

When there are no specific standards in the Rules applicable to the proposed alternative, it may be evaluated based on recognized industry standards. It is the responsibility of the submitter to justify the suitability of industry standards and practices. The evaluation is to consider use in a marine environment (i.e. dynamic loads due to vessel motions, vibration, exposure to corrosive saltwater environment, etc.)

Where ABS Rules do not address a specific design, arrangement, or equipment, IACS (International Association of Classification Societies) Member's Rules may be considered so long as the proposed alternative is not less effective than permitted by the ABS Rules. Individual Rule cites should not be applied without consideration of the overall requirements applicable to equipment, systems, or designs.

Industry Standards may also be accepted for equipment, components and systems which have specific requirements in the Rules. Refer to 4-1-1/1.7 of *Marine Vessel Rules*.

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Definitions

1 Definitions

Goal Based Standards "are high-level standards and procedures that are to be met through regulations, Rules and standards for ships. GBS are comprised of at least one goal, functional requirement(s) associated with that goal, and verification of conformity that rules/regulations meet the functional requirements including goals." (IMO MSC.1 Circ.1394)

Tier I Goals "are high-level objectives to be met. A goal should address the issue(s) of concern and reflect the required level of safety." (IMO MSC.1 Circ.1394)

Tier II Functional Requirements "provide the criteria to be complied with in order to meet the goals." (IMO MSC.1 Circ.1394)

Tier III Verification of Conformity "provides the instruments necessary for demonstrating and verifying that the associated rules and regulations for ships conform to the goals and functional requirements." (IMO MSC.1 Circ.1394)

Alternative Designs/arrangements. Designs or arrangements that are not addressed by existing Rules, regulations and standards but may meet the intent of these requirements. These designs/arrangements do not incorporate new technologies or novel concepts.

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

Conventional Designs. Designs for which ABS has detailed prescriptive requirements. Known applications of proven technologies. The terms "Conventional Design" and "Conventional Vessel" may be used interchangeably throughout this document.

Equivalent Level of Safety. An alternative design or system, based upon engineering analysis, which achieves a level of safety equal to or greater than that required by existing Rules or regulations.

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

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

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

Major Hazard. Hazard with potentially unacceptable risk if not eliminated, controlled, and/or managed. Chapters 4 and 5 of ABS's *Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries* provide a list of major hazards.

New Technology. Any design (material, component, equipment or system) or process which does not have prior in-service experience, and/or any Classification Rules, Statutory Regulations or industry standards that are directly applicable. Use of a technology that has not been accepted previously or with limited (less than one complete 5-year survey cycle) or no proven experience in the proposed environment. Previous acceptance can be by either ABS or other classification societies. A shorter period may be accepted if the technology is installed on multiple vessels and subject to an equivalent Survey.

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

Prescriptive Requirements. Detailed criteria that specify how the requirements are to be met.

Proven Technology. Technology with proven experience (at least one complete 5-year Survey cycle) in the proposed environment

Recognized Standard. Published national or international standards acceptable to ABS. Examples include but are not limited to the American Society of Mechanical Engineers (ASME), American Society of Testing and Materials (ASTM), Department of Transportation (DOT), Japanese Industrial Standard (JIS), German Design Standard (DIN), British Standard Code of Practice (BSI), International Standard Organization (ISO), American Petroleum Institute (API), which are recognized by ABS as being acceptable standards for a specific purpose or service. Each standard is to be used independently and in a consistent manner.

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

Risk Assessment. The process by which the results of a qualitative or quantitative risk analysis are used to make decisions, comparing those outcomes with risk tolerance criteria.

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

Refer to additional definitions in 1D-A1-1/5 and 1D-A2-1/11.

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CHAPTER 2

Application of Goal Based Standards for Classification

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CHAPTER 2

Application of Goal Based Standards for Classification

SECTION 1

Path to Class Approval

1 Overview

This chapter applies to alternative arrangements, novel concepts, or new technologies that are designed in accordance with a goal based approach. This document is to be used in association with the goals and functional requirements defined throughout the Rules.

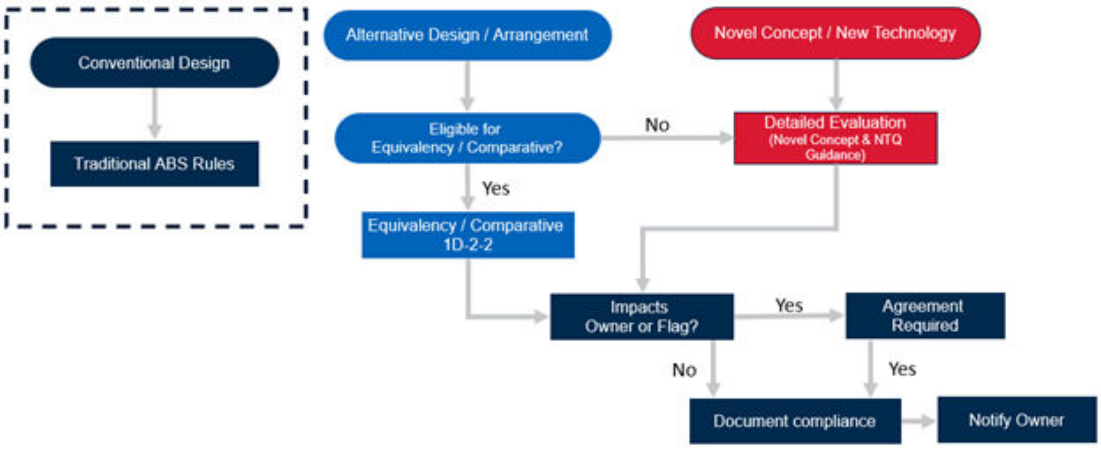
This document outlines two approaches to applying Goal Based Standards for class approval:

1) The Equivalency Approach is to be used for alternative arrangements that can be shown to be equivalent to existing requirements. Refer to Section 1D-2-2. This approach requires fewer steps than the Detailed Evaluation approach. It may be applied when the specific conditions outlined in 1D-2-2/3 are met.

2) The Detailed Evaluation approach is a more involved process. Refer to Section 1D-2-3. This approach is to be applied to novel concepts, new technologies, and other alternative arrangements that do not qualify for the equivalency approach.

Refer to 1D-2-1/Figure 1 for an overview of the procedure for applying Goal Based Standards.

FIGURE 1
Procedure for Applying Goal Based Standards



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CHAPTER 2

Application of Goal Based Standards for Classification

SECTION 2

Equivalency Approach

1 Overview

Alternative arrangements that are not addressed by existing Rules, regulations and standards but provide an equivalent level of safety may be evaluated in accordance with this section. For a design to be considered equivalent, it is to provide compliance with the overall criteria for safety and suitability for intended service established in the applicable ABS Rules, Requirements and Guides. This is known as an equivalency demonstration.

3 Applicability

The Equivalency Approach may be applied when all the following conditions are met:

i) The alternative is a new arrangement of a proven technology

ii) The component or system has only limited impact* on other systems

iii) The number of affected Rules and/or regulations is limited

iv) The component or system is not considered high risk

Note:

** "limited impact" components may impact one system other than the system it is installed in, so long as the impact is easily identified and mitigated.*

To confirm eligibility of an alternative for the Equivalency Approach, a hazard identification study should be performed to identify all potential hazards and mitigating measures to be applied. In some instances, more detailed risk assessments covering either likelihood or consequence estimation, or both, may be required.

If operational or procedural measures are used in place of design measures to mitigate risks, the Detailed Evaluation approach is to be used.

Examples of high-risk items include electrical equipment in hazardous areas, turbochargers, and rudders.

5 Procedure

The Equivalency Approach procedure is as follows:

1) Propose design and high-level justification

2) Identify affected systems, components, and operational procedures

3) Identify applicable hazards via a hazard identification study

a) Identify new hazards introduced by the proposed design

b) Identify applicable class and statutory requirements

c) Identify the Tier I Goals and Tier II Functional Requirements that address the hazards

4) Confirm the alternative is eligible for the Equivalency Approach (1D-2-2/3)

5) Review for equivalency (1D-2-2/7)

6) Establish requirements for verification of conformity to the identified Tier I goals and Tier II functional requirements (1D-2-2/9)

7) Stakeholder engagement (Section 1D-2-4)

8) Documentation of compliance (Section 1D-2-5)

9) Survey after construction (1D-2-2/11)

7 Evaluation of Equivalency

The alternative design is to be evaluated based on the identified metrics. Three major attributes that are to be considered when determining equivalency:

i) The safety performance of the proposed design (e.g., the hazards and potential undesirable events addressed by the design) is found to be acceptable, as compared to a design that complies with the prescriptive Rules

ii) Confirmation that no new unacceptable hazards are introduced by the proposed design

iii) Goals and applicable functional requirements are met

Because the equivalency approach applies to designs that impact limited requirements and systems, the process for evaluating alternatives can be simplified:

1) Identify a comparable design to the one being proposed. Typically, one which is already in class and has significant successful operating experience.

2) Establish the key differences between the alternative and the conventional design.

3) Identify the undesirable events that can arise from the differences.

4) Assess the impact of differences on major risk factors for all identified scenarios.

5) Compare the safety level between the alternative and the conventional design to determine if the alternative is acceptable for classification and required safety level addressed in the goals and functional requirements are met.

6) If inconclusive, the Detailed Evaluation Approach invoking more detailed risk analyses as provided in Section 1D-2-3 is to be followed.

9 Verification of Conformity

Once equivalency has been established, the acceptance criteria for verifying conformity to the safety, environmental and security requirements are to be defined and agreed by all stakeholders. During construction, these may include:

- Design approval
- Verification of manufacturing quality
- Testing program

- Factory acceptance testing
- Onboard testing and system comissioning
- Sea trials

The verification process should be transparent and result in a consistent outcome irrespective of the evaluator. (IMO MSC.1 Circ.1394)

Survey after construction requirements are also to be established during the initial Evaluation of Equivalency.

11 Survey After Construction

Requirements are to be established to confirm that the alternative arrangement has been properly maintained while in service. Survey After Construction requirements may include the following, as appropriate:

- Inspection
- Monitoring
- Testing
- Review of maintenance records

The scope and intervals of these activities are to be defined, and typically correspond to Annual, Intermediate and Special Surveys.

Requirements that differ from the standard Survey After Construction requirements will be captured in the vessels records and verified by the attending Surveyor.

13 Submission of Documents

The following documents are to be provided for alternative arrangements that follow the equivalency approach:

i) *General description of alternative and/or equivalency; (IMO Circ. 1455)*

ii) *Functional description of alternative and/or equivalency*

iii) *Identification of interfaces between alternative and/or equivalency and other systems/operations*

iv) Detailed drawings of the alternative

v) *List of* regulations, Rules, *codes and standards applied, risk assessment plans, or … design basis documents, if necessary.*

vi) Comparative study of the risk impact

vii) Confirmation of compliance with goals and applicable functional requirements

viii) Other applicable documentation as required for the specific arrangement

ix) Documentation for verification of conformity covering design, testing, commissioning and trials and survey after construction

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CHAPTER 2

Application of Goal Based Standards for Classification

SECTION 3

Detailed Evaluation Approach

1 Overview

The marine and offshore industries regularly develop marine vessels or offshore units that incorporate new technologies that have no service history in the proposed application or environment. An asset becomes a novel concept if the incorporation of any new technology(ies) appreciably alters its service scope, functional capability, and/or risk profile as it introduces proposed applications that have not been proven in the marine and offshore industry; and would therefore be considered novel. These new technologies may be so different from existing designs that the requirements contained in ABS Rules or industry standards may not be directly applicable.

The application of Goal Based Standards and risk evaluations provides a practical and effective means to demonstrate that the proposed designs appropriately manage the risk, and thus provide an equivalent level of safety. The evaluation process described in this section and referenced documents provides ABS clients with a formal method for proposing designs to ABS for assessment and approval.

3 Applicability

Alternative arrangements, novel concepts, and new technologies that are not eligible for the Equivalency Approach (as described in 1D-2-2/3) are to be evaluated in accordance with this section and applicable references.

5 Procedure

The following documents provide an acceptable procedure for the evaluation of Alternative Arrangements, Novel Concepts, or New Technologies:

i) ABS *Guidance on Review and Approval of Novel Concepts,* provided in Appendix 1

ii) ABS *Guidance on Qualifying New Technologies,* provided in Appendix 2

iii) IMO *Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments, IMO MSC.1/Circ.1455*

These procedures draw upon engineering evaluations and/or risk assessments to determine if the design provides acceptable levels of safety in line with current offshore and marine industry practice.

Commentary:

Other guidelines that may also be used:

i) *Guidelines on Alternative Design and Arrangements for Fire Safety* (MSC/Circ.1002)

ii) *Revised Interim Guidelines for the Approval of Alternative Methods of Design and Construction of Oil Tankers Under Regulation 13F(5) of Annex I of MARPOL 73/78* (MEPC.110(49))

iii) *Guidelines on Alternative Design and Arrangements for SOLAS Chapters II-1 and III* (MSC.1/Circ.1212)

End of Commentary

The goals and functional requirements throughout the Rules identify hazards and describe the expected performance components and systems are expected to achieve. These Goal Based Standards are to be addressed during the Detailed Evaluation.

The selected approach is to cover the following minimum steps:

1) Propose design and high-level justification

2) Identify affected systems, components, and operational procedures

3) Identify applicable risks and hazards via a basic risk assessment

- *a)* Identify new hazards introduced by the proposed design
- *b)* Identify applicable class and statutory requirements
- *c)* Identify Tier I Goals and Tier II Functional Requirements

4) Initial stakeholder engagement*

5) Establish acceptance criteria

6) Review for acceptance

7) Establish requirements for Verification of Conformity (1D-2-2/9)

8) Stakeholder engagement (Section 1D-2-4)

9) Documentation of compliance (Section 1D-2-5)

10) Survey after construction (1D-2-2/11)

Other approaches may be used if found acceptable to ABS.

Note:

*It is recommended to engage Administrations early on in the process, so issues relevant for approval can be identified promptly. However, this process may differ across the various Administrations.

7 Reliability and Availability Assessment

When new technologies are applied in systems that support Tier I Goals that require reliability, redundancy, or availability (i.e. PROP 2, PROP 5, POW 4, or POW 5), these aspects are to be addressed. To demonstrate compliance with reliability goals related to safety, assessments are to be submitted to ABS for review. Although quantitative assessment is preferred, qualitative analysis is acceptable if there is insufficient historical data for quantitative assessment.

Commentary:

Refer to ABS Guidance Notes on Reliability-Centered Maintenance for information related to equipment failure, maintenance strategies, risk considerations, conducting and documenting a Reliability-Centered Maintenance (RCM) analysis and sustaining a RCM program. Vessels that fulfill redundancy requirements without considering the contribution of the new technology will not require a reliability assessment.

End of Commentary

9 Submission of Documents

The submission of documents is outlined in the individual procedural documents identified in 1D-2-3/5 (i.e. IMO Circ. 1455).

SECTION 4
Stakeholder Involvement

1 Stakeholders

Depending on the proposed alternative and applicable regulations, several stakeholders may be involved:

- Flag Administration
- Shipyard
- Designers
- Equipment Manufacturers
- Owner
- Crew
- ABS Surveyors
- ABS Engineers
- Port Authorities/Port States or Coastal States

3 Government / Regulatory Involvement

Where the alternative arrangement, novel concept, or new technology deviates from the requirements of the Administration or other responsible regulatory agencies (i.e. Coastal states), the arrangement is to be approved by the Administration.

Stakeholders should consider all safety objectives when applying Goal Based Standards. For example, the ABS Rules may not address seafarer training and certification. However, crew training may need to be specially considered for certain novel concepts.

When a vessel changes flag, acceptance from the new Administration is to be obtained for alternatives that impact statutory requirements.

5 Owner Involvement *(2024)*

The shipowner is to be notified when GBS will be applied to alternative arrangements, novel concepts, and new technologies.

For the purposes of this requirement, the shipowner is considered to be the party that will operate the vessel. Where the operator is not identified, the shipowner may be the party that signs the contract with the shipyard to take delivery of the vessel.

Commentary:

Shipowner can specify in the ABS Request for Class Agreement that alternative approaches are not permitted without their permission. In addition, the stakeholders may stop the GBS process if they consider the identified risks/hazards to be unacceptable and/or the proposed risk mitigating measures impractical to be applied.

End of Commentary

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CHAPTER 2

Application of Goal Based Standards for Classification

SECTION 5

Documentation of Compliance

1 Overview

When an alternative arrangement, new technology or novel concept is approved, proper documentation is required. In this scenario, the standard class requirements are replaced by the criteria established by the process outlined in this Chapter.

Documentation is to remain readily accessible to stakeholders throughout the life of the vessel. Interested parties may include the owner, crew, designers, shipyards, Administration, Port States, ABS Engineers, ABS Surveyors, and others. Where the alternative arrangement impacts Survey After Construction, the applicable requirements are to be captured within the ABS reporting systems. When a modification is proposed, the impact on the alternative arrangement and original assumptions are to be evaluated.

3 ABS Record *(2024)*

Vessels with alternative arrangements, new technology or novel concepts approved in accordance with this Part are to have the following comment entered in the ABS *Record*:

"Certain innovative arrangements or features accepted based on the ABS *Rules for Alternative Arrangements, Novel Concepts, and New Technologies*"

5 Documentation

The documents identified in 1D-2-2/13 and 1D-2-3/9 are to be submitted and retained by ABS.

7 Modification of Vessels incorporating Alternative Arrangements

Modifications made to vessels with alternatives approved are to be in accordance with this section.

For modifications proposed to a system, machinery, equipment or hull structure that were previously approved using Goal Based Standards, the following documentation is to be provided, as applicable:

i) Drawings and specifications of the update, including applicable safety studies and reports

ii) Scope and description of the update, including the critical design assumptions and critical design features and interfaces with other systems, equipment or operations

iii) Relevant documentation previously submitted and approved is to be submitted or retrieved by ABS i.e. general arrangement and detailed plans, technical safety studies, close-out reports, list of affected rules/regulations)

iv) Summary of the result of the engineering analysis and basis for demonstrating equivalency

v) Test, inspection and maintenance requirements

9 Documentation for other Stakeholders

Where statutory requirements are impacted, Administration approval is to be obtained and archived.

ABS requirements for survey during and after construction are to be documented in the ABS systems.

The above documentation and final ABS and Administration approval will be documented in the ABS systems to enable easy access in response to requests from Port State Control, Owners, and other stakeholders.

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CHAPTER 3

Goals and Functional Requirements

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CHAPTER 3
Goals and Functional Requirements

SECTION 1
Tier I Goals

1 Tier I Goals

This section provides a consolidated list of Tier 1 Goals. The January 2024 list of Tier I Goals was developed based on the *Marine Vessel Rules* and may not fully address other vessel types or topics. This list also contains items that are not included within the scope of class. It is important for stakeholders to consider all safety objectives when applying Goal Based Standards. However, the scope of ABS class remains relevant for those items specifically addressed by the Tier IV requirements contained in the Rules and Guides applicable to a specific vessel. This list has been developed to generally represent a vessel subject to the *Marine Vessel Rules*. The extent of requirements within the scope of class depends on several factors including the type and size of vessel, cargoes carried, number of passengers, operational profile and the optional notations requested. The Tier I Goals list is applicable to all marine vessels and offshore units, herein referred to as vessels.

When "**Class**" is shown in the 5th column of the table, it means that this Goal is generally covered by mandatory requirements within the ABS Rules. When "**Statutory**" is indicated, this Goal is covered by IMO or ILO requirements for a typical trading cargo vessel. When "**Other**" is shown, the Goal is outside the scope of Class and International requirements but may be covered by other regulatory bodies.

Goals that are indicated with "**SG**" are Special Service Goal that may only be applicable to certain vessel type/offshore unit/facility.

ABS Goal Based Standards					
Tier 0	***Promote the security of life and property, and preserve the natural environment.***				
TOPIC	**Number**		**Goal**	**Class / Statutory / Other**	**Reference**
STABILITY - Shall be designed, constructed, operated, and maintained to…					
STAB	1		have adequate watertight integrity and restoring energy to prevent capsize in an intact condition.	**Class / Statutory**	**SOLAS II-1**
STAB	2		have adequate subdivision and stability to provide survivability to damage or accidental conditions.	**Class / Statutory**	**SOLAS II-1**
STAB	3		have adequate freeboard to prevent excessive water on deck.	**Class / Statutory**	**Load Line**

STAB	4		detect accumulated liquids.	**Class / Statutory**	**SOLAS II-1**
STAB	5		be able to remove accumulated liquids to mitigate the effects of flooding.	**Class / Statutory**	**SOLAS II-1**
STAB	6		provide means to control the overall vessel weight and distribution to maintain adequate trim and stability.	**Class / Statutory**	**SOLAS II-1**
STRU 1, 2, POW 1, 2, MGMT 2, 3, 4, & AUTO 2 in particular contribute to the overall stability goals.					
STRUCTURE - Shall be designed, constructed, operated, and maintained to…					
STRU	1		in the intact condition, have sufficient structural strength to withstand the environmental conditions, loading conditions, and operational loads anticipated during the design life.	**Class**	
STRU	2		withstand structural failure associated with accidental conditions.	**Class / Other**	
STRU	3		provide protection to persons onboard, the environment and required safety services.	**Class**	
STRU	3	1	maintain mechanical properties during extreme temperatures.	**Class / Statutory**	**SOLAS II-1**
SAFE 1, MGMT 3, 4, 5.1 & AUTO 2 in particular contribute to the overall structural goals.					
MATERIALS - are to be suitable for the intended application in accordance with the following goals and support the Tier 1 Goals listed elsewhere in the Rules.					
MAT	1		The selected materials' physical, mechanical and chemical properties are to meet the design requirements appropriate for the application, operating conditions and environment.	**Class / Other**	
MAT	2		The manufacturing process is to be capable of producing products to meet the specified quality and property requirements.	**Class / Other**	
MAT	3		The fabrication and welding process is to be capable of producing products that meet the specified quality and property requirements.	**Class / Other**	
Refer to Part 2-A1-2 to identify the applicable material properties					
PROPULSION, MANEUVERING, STATION KEEPING - Shall be designed, constructed, operated, and maintained to…					
PROP	1		provide sufficient thrust/power to move or maneuver the vessel when required.	**Class / Statutory**	**SOLAS II-1**
PROP	2		provide redundancy and/or reliability to maintain propulsion.	**Class / Statutory**	**SOLAS II-1**

PROP	3		provide *sufficient power for going astern...to secure proper control and bring the ship to rest in all normal circumstances. (SOLAS II-1 Reg 28)*	**Class / Statutory**	**SOLAS II-1**
PROP	4		provide means to maneuver the vessel.	**Class / Statutory**	**SOLAS II-1**
PROP	5		provide redundancy and/or reliability to maintain maneuverability.	**Class / Statutory**	**SOLAS II-1**
PROP	6		*be provided with* means *to enable the safe conduct of all towing, mooring* and anchoring *operations. (SOLAS II-1 Reg 3-8.2)*	**Class / Statutory**	**SOLAS II-1**
PROP	7		be provided with means to reduce the risk of *impending or imminent slowdown or shutdown. (SOLAS II-1 Reg 31-6.1 or SOLAS II-1 Reg 31-2.10)*	**Class / Statutory**	**SOLAS II-1**
PROPULSION - Special Service Goals*					
PROP	SG9		*maintain the* vessel/*unit on station in* the open waters. *(MODU Code 4.12.1)*	**Class / Statutory***	**IMO MODU Code**
PROP	SG11		enable vessel to return to port upon a fire or flooding casualty.	**Class / Statutory**	**SOLAS II-1**
* Vessels or units in offshore service may be required to provide station keeping capability in place of or in addition to other Goals in this section.					
STAB 4, 5, POW 1, 2, 3, 4, ENV 1.1, COMM 2, 2.1, SAFE 1, 2, 3, MGMT1, 2, 2.1, 3, 4, 4.1, 4.2, 5, AUTO 1, 2, 3, 5, 6 in particular contribute to the overall propulsion, maneuvering and station-keeping goals.					
POWER GENERATION & DISTRIBUTION - Shall be designed, constructed, operated, and maintained to…					
POW	1		provide safe and reliable storage and supply of fuel/energy/power.	**Class / Statutory**	**SOLAS II-1**
POW	2		provide power to enable the machinery/ equipment/electrical installation to perform its required functions necessary for the safe operation of the vessel.	**Class / Statutory**	**SOLAS II-1**
POW	3		enable *all electrical services necessary for maintaining the vessel in normal operational and habitable conditions* to be available *without recourse to the emergency source of power. (SOLAS II-1 Reg 3-7 and SOLAS II-1 Reg 40-1.1)*	**Class / Statutory**	**SOLAS II-1**
POW	4		enable all electrical services required for safety to be available during emergency condition. *(SOLAS II-1 Reg 40-1.2)*	**Class / Statutory**	**SOLAS II-1, III, IV**
POW	5		enable supply/power for essential services to be restored after malfunction.	**Class / Statutory**	**SOLAS II-1**
POW	6		have fail-safe features that prevent progressive failure in the event of failure of any single component.	**Class / Statutory**	**SOLAS II-2**

STAB 4, 5, COMM 2, SAFE 1, 1.1, 2.1, 5, MGMT 2, 2.1, 3, 4, 4.1, 4.2, 5, AUTO 1, 2, 3, 5 in particular contribute to the overall power generation and distribution goals.					
FIRE SAFETY - Shall be designed, constructed, operated, and maintained to…					
FIR	1		*prevent the occurrence of fire and explosion. (SOLAS II-2/Reg 2.1.1)*	**Class / Statutory**	**SOLAS II-2**
FIR	2		*reduce the risk to life caused by fire. (SOLAS II-2/Reg 2.1.2)*	**Class / Statutory**	**SOLAS II-2**
FIR	3		*reduce the risk of damage caused by fire to the ship, its cargo and the environment. (SOLAS II-2/Reg 2.1.3)*	**Class / Statutory**	**SOLAS II-2**
FIR	4		detect, *contain, control and suppress or swiftly extinguish a fire in the compartment of origin. (SOLAS II-2/Reg 2.1.4)*	**Class / Statutory**	**SOLAS II-2**
STAB 4, 5, STRU 3, 3.1, POW 2, 3, 4, COMM 2, SAFE 1.1, 2.1, 5, MGMT 2, 2.1, 3, 4, 4.1, 4.2, 5, AUTO 1, 2, 3, 5 in particular contribute to the overall fire safety goals.					
EER - ESCAPE, EVACUATION, RESCUE - Shall be designed, constructed, operated, and maintained to…					
EER	1		*provide means of escape so that persons on board can safely and swiftly escape to* a protected place of refuge, muster station, or embarkation station. *(SOLAS II-2/Reg 13.1)*	**Class / Statutory**	**SOLAS II-2**
EER	1	1	provide means to transfer an injured person to a safe place.	**Statutory**	**SOLAS III**
EER	2		provide evacuation and lifesaving of all persons during and after an emergency situation.	**Statutory**	**SOLAS III**
EER	2	1	provide equipment in a state of readiness *for immediate use. (SOLAS III Reg 20-2)*	**Statutory**	**SOLAS III**
EER	2	2	*provide means* for a safe abandonment of the vessel for all *persons. (SOLAS II-2 Reg 13.1)*	**Statutory**	**SOLAS II-2/SOLAS III**
EER	2	3	provide means for the safety and survivability of all persons after abandonment for the time until expected rescue.	**Statutory**	**SOLAS III**
EER	2	4	provide all persons with means to facilitate survival in the water until rescued into a survival craft or rescue unit.	**Statutory**	**SOLAS III**
EER	2	5	provide each survival craft active and passive means of detection by other survival and rescue craft.	**Statutory**	**SOLAS III**
EER	2	6	provide active and passive means for detection of persons in the water by survival units and by rescue craft.	**Statutory**	**SOLAS III**

EER	3		provide for the search, rescue and retrieval of persons in the water.	**Statutory**	**SOLAS III**
EER	3	1	provide rescue and survival craft in a state of continuous readiness for embarkation, launching and recovery.	**Statutory**	**SOLAS III**
EER	4		provide muster list and emergency instructions for identification and accounting of all persons onboard during emergency.	**Statutory**	**SOLAS III**
POW, FIR 2, COMM 1, 1.2, 2, 2.1, NAV 1.3, 1.4, SAFE 1, 2, MGMT 2, 2.1, 3, 4, 4.1, 4.2, 5, AUTO 1, 3 in particular contribute to the overall goal of providing Escape, Evacuation, and Rescue.					
PROTECTION OF ENVIRONMENT - Shall be designed, constructed, operated, and maintained to…					
ENV	1		prevent and minimize oil pollution due to vessel operation and accidents.	**Class / Statutory**	**MARPOL Annex I**
ENV	1	1	minimize pollution from lubricants and additives likely to come in contact with the marine environment.	**Other**	
ENV	2		minimize pollution by noxious liquid substances carried in bulk due to vessel operation and accidents.	**Statutory**	**MARPOL Annex II**
ENV	3		minimize pollution by harmful substance carried in packaged form.	**Statutory**	**MARPOL Annex III**
ENV	4		prevent sewage pollution and discharge it appropriately.	**Statutory**	**MARPOL Annex IV**
ENV	5		prevent garbage pollution and discharge it appropriately.	**Statutory**	**MARPOL Annex V**
ENV	6		prevent and minimize air pollution.	**Statutory**	**MARPOL Annex VI, EEDI, EEXI, CII**
ENV	7		minimize the negative impact of vessel decommissioning.	**Other**	**Hong Kong Convention, EU SRR**
ENV	7	1	be of materials for environmentally acceptable recycling without compromising the safety and operational efficiency of the ship.	**Other**	**Hong Kong Convention, EU SRR**
ENV	7	2	have an inventory to provide ship-specific information on the actual hazardous materials present on board, in order to protect health and safety and to prevent environmental pollution at ship recycling facilities.	**Other**	**Hong Kong Convention, EU SRR**
ENV	7	3	minimize the negative impacts due to ship recycling so as to achieve safe disposal or recycling of all ship components, including hazardous materials.	**Other**	**Hong Kong Convention, EU SRR**

ENV	8		have provisions in place to control/ minimize the introduction of unwanted aquatic organisms and pathogens into the marine environment from ships' ballast waters and sediment discharges.	**Statutory**	**Ballast Water Management Convention**
ENV	9		*reduce or eliminate adverse effects on the marine environment and human health caused by anti-fouling systems. (AFS Convention Article 1-1)*	**Statutory**	**AFS Convention**
ENV	10		have provisions in place for the safe handling, storage, and disposal of radioactive waste.	**Statutory**	**INF Code**
ENV	11		minimize noise pollution.	**Other**	
ENV	11	1	minimize the adverse effect of underwater radiated noise from vessels on marine mammals.	**Other**	
ENV	11	2	minimize external airborne noise to surrounding onshore environment.	**Other**	
ENV	12		have provisions to cover the financial liability arising from potential environmental pollution and contamination.	**Statutory**	**MARPOL**
ENV	13		provide means to monitor and record environmental discharges.	**Statutory**	**MARPOL**
COMM 1.3, MGMT 3, 4 in particular contribute to the overall goal of providing environmental protection.					
COMMUNICATIONS - Shall be designed, constructed, operated, and maintained to…					
COMM	1		provide *means of external communications* with shore, ships and aircraft.	**Statutory**	**SOLAS II-2, III, IV, V**
COMM	1	1	enable communication with personnel in other ships or onshore to manage marine traffic and safety of navigation.	**Statutory**	**SOLAS IV, V**
COMM	1	2	enable communication with search and rescue teams to aid in escape, evacuation and rescue activities.	**Statutory**	**SOLAS III, IV**
COMM	1	3	enable personnel to inform without delay of any incident that may cause pollution of the marine environment.	**Statutory**	**SOLAS III, MARPOL**
COMM	1	4	have means to transmit and receive distress signals.	**Statutory**	**SOLAS IV**
COMM	2		provided with means for internal communications.	**Class / Statutory**	**SOLAS II-2**
COMM	2	1	enable essential safety services of the communication installations to be maintained and be available at all times.	**Class / Statutory**	**SOLAS IV**

COMM	2	2	provide reliable communication equipment so as to minimize risk of malfunction.	**Statutory**	**SOLAS IV**
POW, FIR 2, SAFE 1.1, 2.1, 5, MGMT 2, 2.1, 3, 4, 4.1, 5, AUTO 1, 3 in particular contribute to the overall goal of providing communications.					
NAVIGATION - Shall be designed, constructed, operated, and maintained to…					
NAV	1		be navigated independently and safely while at sea, minimizing the risk of collision, grounding, floundering and adverse impact to the marine environment.	**Statutory**	**SOLAS V, COLREGS**
NAV	1	1	identify and avoid potential hazardous navigational situations.	**Statutory**	**SOLAS V, COLREGS**
NAV	1	2	assess environmental, meteorological data/forecasts/warnings.	**Statutory**	**SOLAS V, COLREGS**
NAV	1	3	enable the vessel to provide aid to other ships, offshore units or person in distress.	**Statutory**	**SOLAS V**
NAV	1	4	have means to indicate its location at all times.	**Statutory**	**SOLAS V, COLREGS**
NAV	2		*facilitate the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship.*	**Statutory**	**SOLAS V**
NAV	3		*promote effective and safe bridge resource management.*	**Statutory**	**SOLAS V**
NAV	4		*enable the bridge team and the pilot to have convenient and continuous access to essential information.*	**Statutory**	**SOLAS V**
NAV	5		maintain the availability of essential navigational functions at all times in the event of single failure.	**Statutory**	**SOLAS V**
NAV	6		record the voyage data to assist in casualty investigations.	**Statutory**	**SOLAS V**
POW, SAFE 1, 2, 3, MGMT 2, 2.1, 3, 4, 4.1, 5, AUTO 1, 3 in particular contribute to the overall goal of providing navigation.					
SECURITY - Shall be designed, constructed, operated, and maintained to…					
SEC	1		have suitable (physical) security arrangements and plans to reduce the internal and external security risks that vessels may face on voyages.	**Statutory**	**SOLAS XI-2, ISPS Code**
SEC	2		take preventive measures to avoid security incidents.	**Statutory**	**SOLAS XI-2, ISPS Code**
SEC	3		enable the exchange of security-related information.	**Statutory**	**SOLAS XI-2, ISPS Code**

SEC	4		*provide means for raising the alarm in reaction to security threats or security incidents.*	**Statutory**	**SOLAS XI-2, ISPS Code**
SEC	5		achieve safe and secure shipping which is operationally resilient to cyber risks.	**Class / Other**	
SEC	5	1	Identify: Develop an organizational understanding to manage cybersecurity risk to onboard systems, people, assets, data, and capabilities.	**Class / Other**	
SEC	5	2	Protect: Develop and implement appropriate safeguards to protect the vessel against cyber incidents and maximize continuity of shipping operations.	**Class / Other**	
SEC	5	3	Detect: Develop and implement appropriate measures to detect and identify the occurrence of a cyber incident onboard.	**Class / Other**	
SEC	5	4	Respond: Develop and implement appropriate measures and activities to take action regarding a detected cyber incident onboard.	**Class / Other**	
SEC	5	5	Recover: Develop and implement appropriate measures and activities to restore any capabilities or services necessary for shipping operations that were impaired due to a cyber incident.	**Class / Other**	
POW, MGMT 2, 2.1, 3, 4, 4.1, 4.2, AUTO 1, 2, 5, 6 in particular are coupled to the overall security goals.					
CARGO - Shall be designed, constructed, operated, and maintained to…					
CARGO	1		enable all cargoes be stored and secured in such a way that the ship and persons onboard and the environment are not put at risk.	**Class / Statutory**	**SOLAS VI, VII**
CARGO	3		be equipped to handle and transfer cargo safely.	**Class / Statutory**	**SOLAS II-1, VII**
CARGO	5		enable monitoring of the cargo and vessel storage, securing, or containment systems	**Class / Statutory**	**SOLAS VI, VII**
CARGO	7		protect cargo from contamination.	**Class / Statutory**	**IBC Code, IGC Code**
CARGO - Special Service Goals - Carriage of solid cargo in bulk					
CARGO	SG7		have measures to mitigate risk to vessel's stability due to cargo shift or cargo liquefaction.	**Statutory**	**IMSBC Code**
CARGO - Special Service Goals - Carriage of liquid or gaseous cargo					

CARGO	SG 9		provide *safe containment of* liquid/ gaseous *carg..... having regard to the nature of the cargo carried. (IGC Code Chapter 4)*	**Class / Statutory**	**IGC Code, IGF Code**
CARGO - Special Service Goals - Use of cargo as a fuel					
CARGO	SG 11		enable safe and reliable use of cargo as fuel and distribution of cargo fuel to the consumers.	**Class / Statutory**	**IGC Code, IGF Code**
STAB, STRU, POW, FIR, ENV, SAFE 1, 2, 4, MGMT, AUTO in particular are coupled to the overall Cargo goals.					
SAFETY OF PERSONNEL - Shall be designed, constructed, operated, and maintained to…					
SAFE	1		promote the occupational health and safety of personnel onboard.	**Class / Statutory**	**SOLAS II-1, ISM Code, ILO MLC**
SAFE	1	1	minimize danger to persons on board, the vessel, and surrounding equipment/ installations from hazards associated with machinery and systems.	**Class / Statutory**	**SOLAS II-1**
SAFE	1	2	provide means to minimize the risk of strikes against objects/equipment, slips, trips, and falls within the vessel and overboard.	**Class / Statutory**	**SOLAS II-1**
SAFE	2		provide suitable and readily available illumination.	**Class / Statutory**	**SOLAS II-1**
SAFE	3		*prevent the occurrence of potentially hazardous noise levels. (IMO Resolution MSC.337(91)-1.1.1)*	**Statutory**	**SOLAS II-1, ILO MLC**
SAFE	4		provide for health protection and prompt access to medical care onboard vessel and ashore.	**Statutory**	**ILO MLC**
SAFE	4	1	provide arrangements to limit *the spread of infectious diseases* and*.....facilitate the treatment of the occupants. (MLC Guideline B3.1.8)*	**Statutory**	**ILO MLC**
SAFE	5		eliminate *unreasonable radiation or other nuclear hazards, at sea or in port, to the crew, passengers or public, or to the waterways or food or water resources. (SOLAS VIII/Reg 6)*	**Statutory**	**SOLAS VIII**
STAB, STRU, POW, FIR, EER, COMM 1.2, 2, 2.1, ENV 7.1, 7.2, 10, 11, HAB 1, 1.1, 1.7 MGMT 2, 2.1, 3, 4, 4.1, 4.2, OTH in particular contribute to the overall goal of providing safety to personnel.					
SAFETY MANAGEMENT - Shall implement a safety and environmental management system to….					
MGMT	1		*provide for safe practices in ship operation and a safe working environment. (ISM Code 1.2.2.1)*	**Statutory**	**IMO ISM Code**
MGMT	1	1	identify *risks to its ships, personnel and the environment and establish appropriate safeguards. (ISM Code 1.2.2.2)*	**Statutory**	**IMO ISM Code**

MGMT	1	2	*continuously improve safety management skills of personnel ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection. (ISM Code 1.2.2.3)*	**Statutory**	**IMO ISM Code**
MGMT	1	3	investigate and analyze *non-conformities, accidents and hazardous situations* that *are reported to the company including the implementation of corrective action* and *measures to prevent recurrence. (ISM Code 9.1 and 9.2)*	**Statutory**	**IMO ISM Code**
MGMT	2		have qualified, trained and certified seafarers/crew to maintain safe operations on board the vessel.	**Statutory**	**IMO ISM Code**
MGMT	2	1	have crew with *the necessary knowledge and skills to handle emergency cases. (SOLAS II-2/Reg 15.1)*	**Statutory**	**SOLAS II-1, II-2, III, STCW**
MGMT	3		*establish procedures, plans and instructions for operations concerning the safety of the personnel, vessel, and protection of the environment. (ISM Code 7)*	**Class / Statutory**	**IMO ISM Code**
MGMT	4		*establish procedures, plans and instructions for* emergency situations *concerning the safety of the personnel, vessel, and protection of the environment. (ISM Code 7)*	**Statutory**	**IMO ISM Code**
MGMT	4	1	provide all crew and passengers with information and instructions of the actions to be taken in an emergency.	**Statutory**	**SOLAS III, ISM Code**
MGMT	4	2	conduct *drills and exercises to prepare for emergency actions. (ISM Code 8.2)*	**Statutory**	**SOLAS III, ISM Code, ISPS Code**
MGMT	4	3	provide adequate resources and shore-based support to enable the crew onboard to perform their duties or carry out their functions.	**Statutory / Other**	**SOLAS III, ISM Code**
MGMT	5		maintain and inspect the vessel, machinery, electrical, safety systems and standby arrangements to be ready for immediate use and perform intended functions during emergencies.	**Statutory**	**IMO ISM Code**
MGMT	5	1	facilitate safe access, ease of inspection, survey, and maintenance of the vessel, machinery and electrical systems.	**Class / Statutory / Other**	**IMO ISM Code**
MGMT	6		have *procedures to control all documents and data which are relevant to the safety management system. (ISM Code 11.1)*	**Statutory**	**IMO ISM Code**

MGMT	7		periodically *verify whether safety and pollution-prevention activities comply with the safety management system. (ISM Code 12.1)*	**Statutory**	**IMO ISM Code**
AUTOMATION (CONTROL, MONITORING and SAFETY SYSTEMS) - Shall be designed, constructed, operated, and maintained to…					
AUTO	1		perform its functions as intended and in a safe manner.	**Class / Statutory**	**SOLAS II-1**
AUTO	2		indicate the system operational status and alert operators of any essential machinery/systems that deviate from its defined design/operating conditions or intended performance.	**Class / Statutory**	**SOLAS II-1**
AUTO	3		have an alternative means to enable safe operation in the event of an emergency or failure of remote control.	**Class / Statutory**	**SOLAS II-1**
AUTO	4		provide the equivalent degree of safety and operability from a remote location as those provided by local controls.	**Class / Statutory**	**SOLAS II-1**
AUTO	5		be provided with a safety system that automatically leads machinery being controlled to a fail-safe state in response to a fault which may endanger the safety of persons on board, machinery/ equipment or environment.	**Class / Statutory**	**SOLAS II-1**
AUTO	6		independently perform different functions, such that a single failure in one system will not render the others inoperative.	**Class / Statutory**	**SOLAS II-1**
AUTO	7		enable rational human machine interface without unintended errors due to the layout or arrangement of machinery/ equipment.	**Other**	-
HABITABILITY - Shall be designed, constructed, operated, and maintained to…					
HAB	1		provide a suitable working and living environment for personnel onboard *consistent with promoting the seafarers'* (occupational) *health and well-being. (MLC Regulation 3.1.1)*	**Statutory**	**ILO MLC**
HAB	1	1	effectively control the indoor environmental parameters in all conditions of weather and climate.	**Statutory**	**ILO MLC**
HAB	1	2	*provide adequate berth arrangements for* all persons on board. *(MLC Guideline B3.1.5)*	**Statutory**	**ILO MLC**

HAB	1	3	provide properly equipped mess rooms sufficient to accommodate the greatest number of seafarers likely to use them at any one time.	**Statutory**	**ILO MLC**
HAB	1	4	*have convenient access on the ship to sanitary facilities meeting minimum standards of health and hygiene and reasonable standards of comfort. (MLC Standard A3.1.11.a)*	**Statutory**	**ILO MLC**
HAB	1	5	provide recreational facilities and services.	**Statutory**	**ILO MLC**
HAB	1	6	provide *food and drinking water of appropriate quality, nutritional value and quantity that adequately covers the requirements of the ship and takes into account the differing cultural and religious backgrounds. (MLC Regulation 3.2.1)*	**Statutory**	**ILO MLC**
HAB	1	7	have provisions to reduce discomfort caused by vibration.	**Statutory**	**ILO MLC**
STAB, STRU, POW1, 2, 3, 4, SAFE, MGMT, AUTO 7 in particular contribute to the overall goal of providing habitability and comfort to personnel.					
OTHER SYSTEMS - Shall be designed, constructed, operated, and maintained to…					
OTH	1		provide safe means of embarkation and disembarkation to persons on board, material, equipment or stores.	**Statutory**	**SOLAS II-1**
OTH	1	1	be provided with pilot transfer arrangements to enable safe embarkation and disembarkation for pilots.	**Statutory**	**SOLAS V**
OTHER SYSTEMS - Special Service Goals - Vessels fitted with Helicopter Facilities are to…					
OTH	SG5		enable safe helicopter operations.	**Class / Statutory**	**SOLAS II-2**
OTH	SG7		provide means, clear of obstacles to enable safe transfer of personnel or stores.	**Class / Statutory**	**SOLAS II-2**
OTHER SYSTEMS - Special Service Goals - Vessels that support Diving or ROVs are to…					
OTH	SG9		provide means of deployment, recovery, and communication with any divers or ROVs.	**Other**	
OTH	SG11		provide stationkeeping sufficient for a safe underwater environment and preserve the natural environment.	**Other**	
OTH	SG13		provide essential and other services required for safe diving or decompression operations.	**Other**	

OTH	SG15		enable safe evacuation of divers under pressure *in the event of* an emergency. *(IMO Diving System Code 3.1)*	**Statutory**	**IMO Diving System Code**
OTH	SG17		enable communication with personnel and divers to control and monitor emergency situations	**Other**	
OTHER SYSTEMS - Special Service Goals - Fire Fighting Vessels are to…					
OTH	SG19		provide capability to fight fires on other assets.	**Class**	
OTHER SYSTEMS - Special Service Goals - Safety Standby Rescue Vessels are to….					
OTH	SG21		provide evacuation, rescue, reception and care of recovered or rescued persons.	**Class**	
OTHER SYSTEMS - Special Service Goals - Lifting Appliances are to be designed, constructed, operated, and maintained to...					
OTH	SG23		provide means for the safe lifting, handling or transfer of cargo or personnel.	**Class**	
OTH	SG25		prevent failures or accidents, which would cause harm to personnel or damage to ships, offshore facilities, subsea or shore-based structures, as well as the environment.	**Class**	

PART 1D

APPENDIX 1

Guidance on Review and Approval of Novel Concepts

CONTENTS

PART 1D

APPENDIX 1

Guidance on Review and Approval of Novel Concepts

SECTION 1

Introduction

1 Overview

This Appendix provides guidance to ABS clients regarding the ABS methodology for classification of novel concepts. Assets such as marine vessels and offshore units become novel concepts if the incorporation of any new technology(ies) appreciably alters its service scope, functional capability, and/or risk profile. It is important to note that the term 'novel concept' refers to the entire concept of a vessel or facility that incorporates a new technology such as a system or subsystem or an individual component. To help determine if a proposed design falls into the "novel" category, Appendix 2 provides a novel concept checklist to give a general understanding of the variation from existing or proven marine or offshore applications, and thus the degree of novelty. The guidelines presented herein are more suited to an application with a high degree of novelty. If a client proposes an alternative to one or a small number of current Rule requirement(s), it may be more appropriate to follow the methodologies outlined in the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries* in order to gain ABS approval.

This Appendix, *Guidance on Review and Approval of Novel Concepts* is intended to be used in conjunction with Appendix 2, *Guidance on Qualifying New Technologies (NTQ Guidance)*. As qualifying the individual new technologies by using the ABS new technology qualification (NTQ) process is a key step in obtaining class approval for the novel concept or asset, it is recommended to be familiar with Section 2 of the *NTQ Guidance* to better understand the NTQ process. It is important to note that the primary focus of novel concept classification is on safety even though the qualification of individual new technologies may have additional functional requirements as requested by the client (e.g., reliability). Consideration should also be given for environmental protection, asset protection, and security. Throughout this document the term "safety" may be used in place of the full list for brevity.

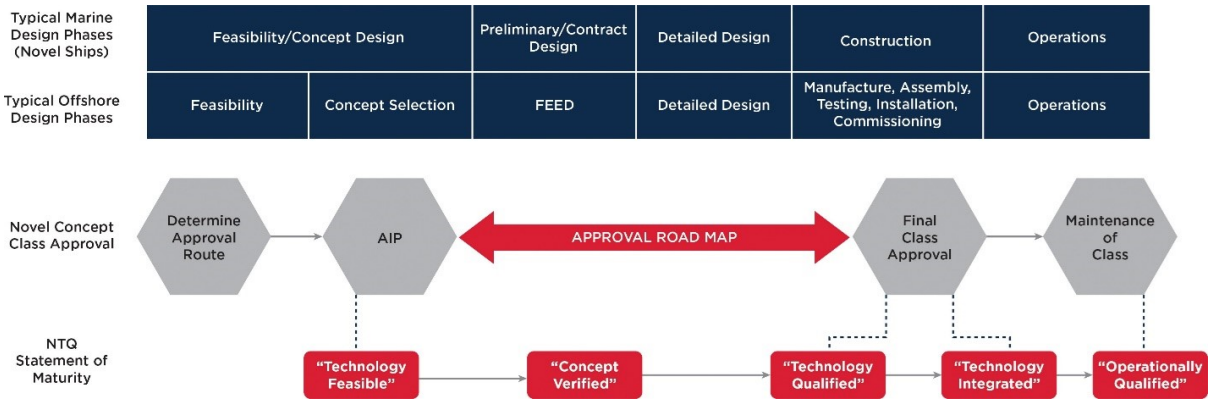
The Novel Concept Class Approval process is the route for obtaining class approval for an asset that incorporates new technologies. The process draws upon goal based standards, engineering evaluations, and risk assessments to determine if the concept provides acceptable levels of safety in line with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

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

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

The process that the client and ABS would follow to achieve these milestones is outlined below in 1D-A1-1/Figure 1. The figure also illustrates the alignment of the new technology qualification process with the evolution of a novel concept.

FIGURE 1
Novel Concept Class Approval Process



3 Path to Class Approval

Once an asset has been determined to be a novel concept based on a review of the checklist in Appendix 2 and discussions with ABS, ABS and the client will agree upon a systematic approach to reaching each of the milestones identified in 1D-A1-1/Figure1. A brief description of these milestones follows:

3.1 Milestone 1: Determine Approval Route

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

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

For identified new technologies, ABS will meet with respective vendors to perform a more detailed new technology screening process, determine the current maturity level of their new technology, designate an appropriate qualification stage, and support the determination of qualification activities. The new technology qualification process follows the *NTQ Guidance,* provided in Appendix 2.

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

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

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

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

The key considerations in order to achieve AIP include:

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

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

The Approval Road Map typically contains the following information:

- The New Technology Qualification Plan (NTQP) outlining all necessary system requirements related to safety as stated in the System Requirements and Description Document (SRDD), all necessary

qualification activities (e.g., engineering evaluations and risk assessments) required to mature the new technology through the stage gate process, and all interfacing requirements with existing conventional technologies and the asset.

- All engineering evaluations and risk assessments for conventional technologies aboard the novel concept.
- All system-of-systems integration analysis plans for the novel concept.

3.5 Milestone 3: Final Class Approval

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

Further information regarding the submittal requirements for Final Class Approval can be found in Section 3 of this Appendix.

3.7 Milestone 4: Maintenance of Class

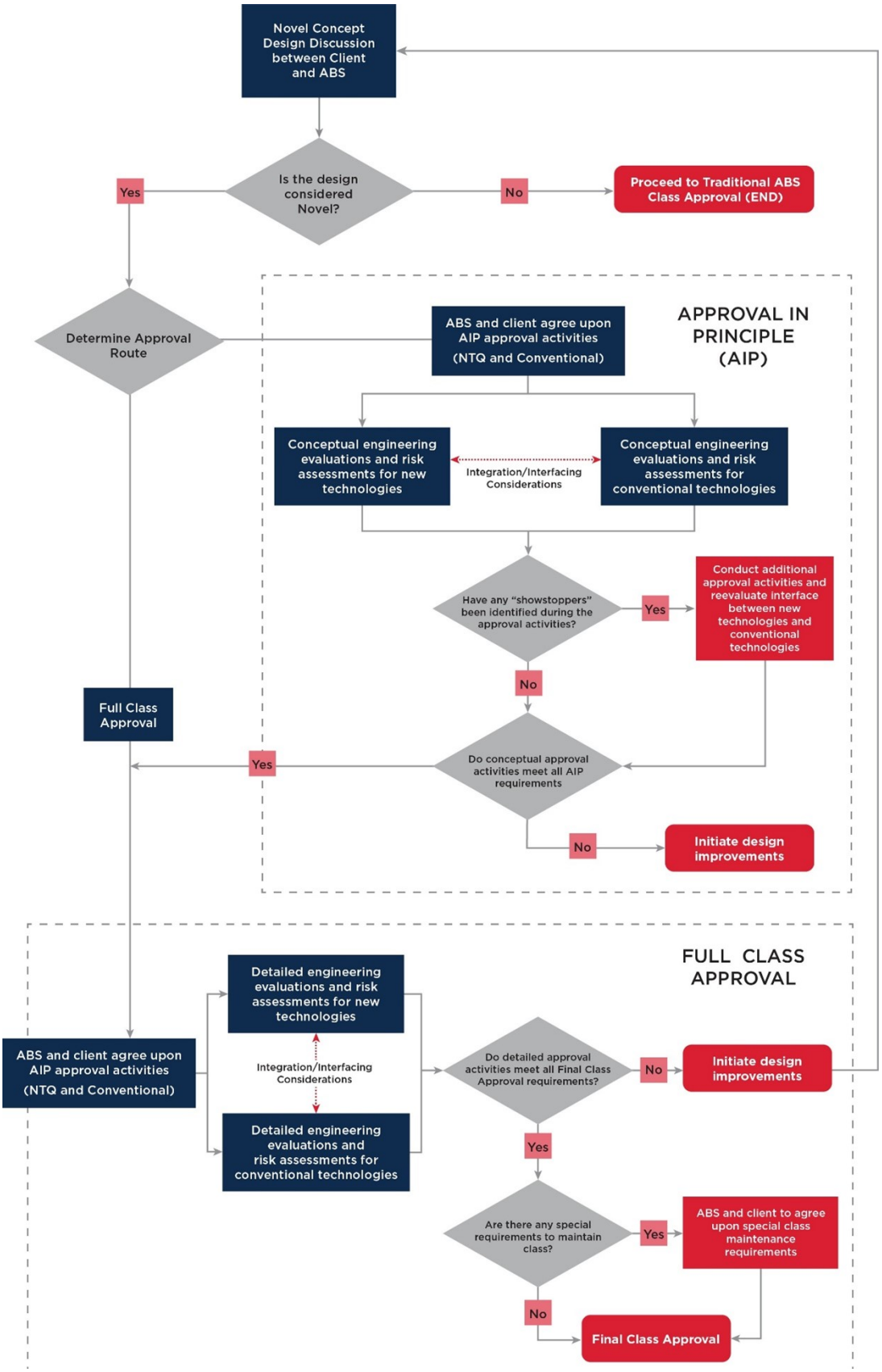
As a final condition of class approval, ABS will outline the necessary elements of in-service survey, inspection, monitoring, and testing requirements required to gain confidence in the actual application, if any is deemed necessary. The need for special in-service requirements is dependent on any maintenance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

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

Further information regarding the submittal requirements for Maintenance of Class can be found in Section 4 of this Appendix.

1D-A1-1/Figure 2 outlines the process flow for novel concept approval and Class following this Guidance. The process involves conducting certain engineering evaluations and risk assessments commensurate to the level of detail available in the particular project phase with the aim of achieving Class approval. In certain instances, this process will require the intermediate AIP milestone. In other instances, this step may be by passed as shown on the flowchart.

FIGURE 2
Process Flow for ABS Approval of Novel Concepts



5 Definitions

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

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

Approval in Principle (AIP). The process by which ABS issues a statement confirming a proposed 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 should be addressed in the fin al design phase.

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

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

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

Engineering Evaluations. Various engineering analysis tools and testing that may be used to support new technology qualification activities. Examples include Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), Functional and Performance Testing, Model Testing, and System Integration Testing.

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

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

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

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

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

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

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

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

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

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

New Application. An overall process that has not been accepted previously by ABS or other Classification Societies or with no or limited (less than one complete 5-year survey cycle) proven experience in the proposed environment.

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

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

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

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

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

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

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

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

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

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

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

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

7 Abbreviations

ALARP: As Low As Reasonably Practicable

API: American Petroleum Institute Recommended Practice

CFD: Computational Fluid Dynamics

EERA: Escape, Evacuation, and Rescue Analysis

ESSA: Emergency Systems Survivability Assessment

FEA: Finite Element Analysis

FMECA: Failure Mode Effects and Criticality Analysis

FTA: Fault Tree Analysis

HAZOP: Hazard and Operability

HAZID: Hazard Identification

NTQ: New Technology Qualification

NTQP: New Technology Qualification Plan

PFD: Process Flow Diagram

P & ID: Piping and Instrumentation Diagram

QRA: Quantitative Risk Assessment

RAGAGEP: Recognized And Generally Accepted Good Engineering Practice

SRDD: Systems Requirements and Description Document

SIT: Systems Integration Test

PART 1D

APPENDIX 1

Guidance on Review and Approval of Novel Concepts

SECTION 2

Approval in Principle

1 Introduction

In some instances, an intermediate approval step, herein referred to as Approval In Principle (AIP), will be granted by ABS 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. The AIP is meant to achieve this.

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

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

It is important to note that the issuance of an AIP does not necessarily only happen at the concept design phase of the proposed project. An AIP can be issued throughout the design life cycle as seen in 1D-A1-1/ Figure 1. For example, a client can request an AIP from concept select through the detailed design phase or equivalent. The Approval Road Map will be developed based on the level of detail of the information available upon request for AIP. In all cases, new technologies need to be qualified via the NTQ process in addition to the verification of conventional technologies in the actual application and operating environments.

3 Concept Engineering Evaluation

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

A key element that needs to be verified is the qualification of new technologies. All goals, functional requirements, and performance requirements related to safety submitted as part of the SRDD in accordance with 1D-A2-2/3.3 are reviewed along with any available high-level engineering design analysis. The primary focus of novel concept classification is on safety even through the qualification of individual new technologies may have additional functional requirements as requested by the client (e.g., performance, reliability, etc.). Functional and performance requirements as they pertain to the actual application and operational environment of the novel concept should be defined, if known.

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

i) Pressure and temperature induced loads and fluctuations

ii) Static and dynamic loads

iii) Dynamic loads imposed due to vessel motions

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

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

vi) Fatigue and fracture effects

vii) Wear and vibration effects

viii) Material degradation and associated loss from damage mechanisms

ix) Accidental loads (as applicable)

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

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

- Verification of Feasibility of the Proposed New Technologies
- Verification of Conventional Technologies
- Verification of Operability
- Verification of Interface Issues
- Verification of Inspectability and Maintainability

All goals and functional requirements of the affected conventional features are to be considered.

3.1 Verification of Feasibility of the Proposed New Technologies

A review of the concept is to be conducted to determine the best method to proving the design. To accomplish this, one should first understand what aspects of the design go beyond current practice and why. Sensitivity studies is to be performed to understand key design parameters. This will enable the designer to determine the most appropriate method of assessment. It may be concluded that various novel aspects of the system require first principles-based approaches to assess their design suitability. The qualification of these new technologies is to follow the *NTQ Guidance* (see Appendix 2) which describes in detail the NTQ process and submittal requirements to mature the new technology from early conceptual phases through the implementation of new technologies onto ABS classed assets. All qualification activities, which revolve around determing the validity of the design through engineering evaluations and risk assessments, are outlined in the New Technology Qualification Plan (NTQP). At a minimum, the

engineering evaluation activities that are required at the "Feasibility Stage" of *NTQ Guidance* (see Appendix 2) should be carried out to prove that the novel concept is feasible and able to achieve AIP.

The process to identify and qualify new technologies can be found in in the *NTQ Guidance*, provided in Appendix 2.

3.3 Verification of Conventional Technologies

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

5 Concept Risk Assessment

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

In general, for the concept development phase, a design basis, preliminary engineering and possibly testing results as well as other information, as described in 1D-A2-2/5.1 for concept evaluation, will be available. At this phase of concept development (i.e., concept select), a qualitative risk assessment is generally the most suitable method. More refined risk assessments, such as quantitative risk assessments or reliability analysis, require considerably more details related to the novel concept and would be more appropriately applied to later phases of design (i.e., detailed design phase). However, in some cases it may be necessary to conduct quantitative risk assessment during the conceptual design phase.

For the identified new technologies, *NTQ Guidance* (see Appendix 2) provides options for risk assessment techniques for early concepts. The most appropriate risk assessment technique may be selected. If the NTQ process is followed simultaneously with the Novel Concept Class Approval process, then only one risk assessment between the two processes needs to be performed. In cases where the risk assessments from NTQ process has not considered the interactions with conventional technologies, the specific application, and/or the operating environment in regards to the novel concept, then a revalidation/update of the NTQ risk assessment may be needed.

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

5.1 Risk Assessment Plan

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

i) Description of the proposed design.

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

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

iv) Scope and objectives of the assessment.

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

vi) Proposed risk acceptance criteria or risk matrix.

Further guidance on submitting a risk assessment plan can be found in the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries* and the ABS *NTQ Guidance* (see Appendix 2).

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

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

7 Approval Road Map

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

9 Summary of Submittals for Approval in Principle

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

9.1 Engineering Evaluation

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

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

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

iv) Design analysis methodology and any available preliminary results.

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

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

vii) Lessons learned, references and examples of comparable designs.

9.3 Risk Assessment

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

ii) The appropriate risk assessment report.

iii) Hazard Register complete with an action tracking system.

11 Issuance of AIP Letter

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

PART 1D

APPENDIX 1

Guidance on Review and Approval of Novel Concepts

SECTION 3

Final Class Approval

1 Introduction

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

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

3 Engineering Evaluation for Final Class Approval

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

The completion of "Prototype Validation" stage of the NTQ process is typically recommended for a new technology to be considered for the Final Class Approval stage. If the identified new technologies have not been awarded the corresponding "Technology Qualified" Statement of Maturity, then all engineering evaluation activities that are required at the "Prototype Validation" stage and the less mature stages (if applicable) in Part 1D, Appendix 2 should be carried out. These NTQ activities can be performed

simultaneously with the Novel Concept Class Approval process. If new technologies have already matured beyond the "Prototype Validation" stage, then the engineering evaluation in this stage will focus on the integration and interfacing of the new technologies with existing systems of an asset. At the end of the Final Class Approval stage, the "Technology Qualified" technology needs to be fully integrated into the actual operational environment and matured to "Technology Integrated" status. Only when this status is reached can class approval for a Novel Concept be issued.

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

3.1 Reconfirmation of Relevant Design Codes and Standards Applied

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

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

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

3.3 Calculation Dossier

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

3.5 Verification of Interface Issues

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

3.7 Verification of Inspectability and Maintainability

Lastly, the novel concept should be verified from the standpoint of inspectability and maintainability and what or how has this changed when considering integration of technologies, both new and conventional. The various components of the novel application should be verified to make certain that they can be monitored, inspected and maintained in a manner consistent with existing practice for Surveyor access or access for survey related examinations, placing of inspection personnel in hazardous situations, and finally without putting any new abnormal loading or condition on the concept during the preparation for inspection which could jeopardize its functionality. This step may include 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 accepted by ABS as being feasible and reliable over the life of the concept.

5 Detailed Risk Assessments for Final Class Approval

The requirements for Final Class Approval risk assessments will also be dependent on the current qualification stage of the identified new technologies and the agreed-upon approval road map. If the identified new technologies have not been awarded the "Technology Qualified" letter, all risk assessment activities listed at the "Prototype Validation" stage and the less mature stages (if applicable) in Part 1D, Appendix 2 should be completed as part of Final Class Approval stage. In this scenario, the NTQ and Novel Concept Class Approval processes are followed simultaneously. If the "Prototype Validation" stage has already been completed, the risk assessments should focus on the interface of the new technologies with existing systems and the whole offshore unit or marine vessel system.

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

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

i) Hazard Identification (HAZID)

ii) Failure Modes and Effects Analysis (FMEA)

iii) Hazard and Operability Analysis (HAZOP)

iv) Quantitative Risk Assessment (QRA)

v) Emergency Systems Survivability Assessment (ESSA)

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

vii) Any additional studies identified previously in the approval process

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

5.1 Hazard Identification (HAZID)

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

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

Applicable goals and functional requirements should be considered.

5.3 Failure Modes and Effects Analysis (FMEA)

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

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

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

5.5 HAZOP

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

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

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

5.7 Quantitative Risk Assessment (QRA)

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

5.7.1 Hazard Categories

The QRA should coverall categories of hazards which relate to the risks of the novel concept being reviewed. Applicable functional requirements should be considered. In additional, hazard categories could include the following:

i) Dropped Object Risk Assessment

- Quantify the risks related to both on-board and over-board (where subsea systems exist) drops.

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

ii) Collision Risk Assessment

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

iii) Cryogenic Spill Assessment

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

iv) Structural Risk Assessment

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

v) Fire and Explosion Risk Assessment

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

vi) Gas Dispersion Risk Assessment

- Quantify the risks of gaseous dispersion for the novel concept. This should include review of flammable and toxic materials associated with the novel concept.
- Address endpoints/probits used for evaluation where applicable.
- Include potential events identified in previous study work (see hazard registry).

- Address potential risks associated with exhaust or vent stacks (this may include assessment of risks associated with flame out release from flare systems).

vii) Radiation and Thermal Impacts Assessment

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

viii) Gaseous Ingress Assessment

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

Note:

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

5.7.2 Scope of Studies

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

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

ii) Consequences. These should be calculated for each event and should utilize detailed modes/assessment (the choice of methodology may be determined by the client). Justification may be required for all methods chosen. Each consequence evaluation method used should be adequately documented and referenced. It is recommended, if available and where applicable, that advanced computation methods be utilized, such as CFD and FEA.

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

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

iv) *Risk Presentation.* Risks should be presented as cumulative risk encompassing all categories appropriate to the novel concept. Additionally, the client should develop a societal risk in the form of an F-N curve. This should be plotted against the selected risk criterion. And a detailed discussion should be included as to the findings of the QRA,

including the identification of risk drivers (those hazards which elevate the risk to intolerable levels), and the current estimated state of risk the novel concept poses.

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

5.7.3 Documentation

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

i) Scope of Assessments and categories of risk reviewed

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

iii) Methods used in determining consequences

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

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

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

vi) Detailed discussion of risk results and requirement mitigations

5.9 Emergency Systems Survivability Assessment (ESSA)

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

i) Definition of requirements for survivability of the novel concept.

ii) Identification of systems of the novel concept that are critical to survivability.

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

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

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

The tasks described above should be documented and discussed as possibly requiring mitigation, or management of risks should be added to the Hazard Register.

5.11 Escape, Evacuation, and Rescue Analysis (EERA)

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

5.11.1 Objectives

The study should clearly show achievement of the applicable Goals, Functional Requirements, and the following main objectives:

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

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

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

5.11.2 Information to be Documented

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

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

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

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

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

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

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

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

5.11.3 Emergency Response

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

i) Incident detection

ii) Raising alarm

iii) Assessing the incident and activating the response

iv) Access to muster stations

v) Muster

vi) Egress from muster areas

vii) Evacuation

viii) Escape

ix) Recovery and rescue

x) Place of safety

Note:

The above list provides example features of emergency response. It is not intended to be limiting or all encompassing.

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

5.13 Final Class Approval Stage Risk Assessment Plan

ABS requires that a Risk Assessment Plan be development and submitted to ABS prior to conducting any detailed risk assessment. Contents that should be included in the risk assessment plan (including scope of the risk assessment, selection of risk assessment techniques, and risk acceptable criteria) can be found in 1D-A1-2/5.1. Further guidance on developing a detailed risk assessment plan can be found in the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries.*

7 Management of Change

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

The ABS *Guidance Notes on Management of Change for the Marine and Offshore Industries* provides more details on the MOC processes.

9 Summary of Submittals

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

9.1 Engineering Evaluation

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

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

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

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

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

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

vii) List of subsystems/components that make up the system in the scope of approval, along with the details of the suppliers responsible for submitting drawings to ABS.

Note:

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

9.3 Risk Assessment

i) Risk Assessment Plan for the detailed risk assessment.

ii) Updated risk assessment reports from the AIP stage.

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

iv) Other applicable technical safety studies.

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

11 Granting Final Class Approval

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

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

1 Knowledge Gained

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

A key aspect of any novel concept is 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 has to 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, it is strongly encouraged to include an ABS surveyor during key risk assessments and communicate with the ABS survey team during the approval process.

1.1 Input to Survey during Construction

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

1.1.1 Critical Areas

These are key design features or relatively high failure probability design aspects identified in the design review or risk assessment phase which would benefit from enhanced quality control at the construction site, and 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 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:

i) Material testing

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

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

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

1.3 Input to Survey during In-Service Operation

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

i) *Maintenance schedules* are to be enhanced 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* has to be modified to cover monitoring of critical areas to confirm that critical design assumptions with respect to various failure modes are correct and also to reduce the probability of failure through enhanced inspection requirements. This requirement could be coupled with or be part of a proposed Risk Based Inspection program.

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

iv) *Pilot Testing of Novel Features*. ABS may require information to 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.

PART 1D

APPENDIX **1**

Guidance on Review and Approval of Novel Concepts

SECTION **5**

Government and Regulatory Involvement

1 General

In some instances, there can be as many as three administrations involved in the acceptance of a novel concept. For marine vessels and offshore units, these administrations include the coastal states, port states and the Flag State that the vessel is to fly. This is known as the tripartite agreement.

Agreement by the aforementioned bodies precedes final agreement by IMO for formal use on any vessel. The present document covering guidelines for these types of novel vessels is the *Revised Guidelines for Formal Safety Assessment (FSA) For Use in the IMO Rule-Making Process* found in MSC-MEPC.2/Circ.12/Rev.1 dated 18 June 2015. The guidelines are a rational and systematic process for assessing risks relating to maritime safety. The process of building up a body of knowledge for a novel concept should 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. 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 Administration 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 to comparable levels.

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.

PART 1D

APPENDIX **1**

Guidance on Review and Approval of Novel Concepts

SECTION **6**

Sample Risk Matrix

1 Sample Risk Matrix

	CONSEQUENCE			
	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.

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

PART 1D

APPENDIX 1

Guidance on Review and Approval of Novel Concepts

SECTION 7

Novel Concept Checklist

1 General

This document is applicable to all marine vessels and offshore facilities for which novel concepts are being proposed. "Novel concept" refers to the entire concept of a vessel or a facility incorporating a new technology with respect to the structural aspects, machinery systems, storage or process aspects to which the provisions of the current Rules, Guides and existing industry standards are not directly applicable. Refer to the checklist in 1D-A2-3/Table 1 for guidance in determining if a proposed design falls into the "novel" category. The objective of the checklist is to:

i) Establish if the new design qualifies as a novel concept and whether the use of this Guidance is appropriate for evaluating the concept, and

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

The checklist is intended to act as a trigger that indicates that the proposed design should 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 obtained from the checklist does not directly dictate what evaluations need to be performed in order to Class the design. Rather, the answers provide an indication that discussions with ABS should be initiated to confirm there is a mutual understanding between the designers and ABS on how the design may deviate from existing applications, the degree of novelty present, the lack of suitable Rules, codes and standards to address that novelty, and the plan of action required to address these deviations. In general, if a high degree of novelty is confirmed via the checklist, then this Guidance 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 *Risk Assessment Guidance Notes*. ABS and the client will come to mutual agreement as to what constitutes a high degree of novelty and therefore the appropriate document to be used in the approval process.

3 Novel Concept Checklist

The novel concept checklist is provided in 1D-A2-3/Table 1. The checklist is intended to help identify proposed novel concepts applied to marine and offshore systems. When evaluating whether or not an application is novel, all questions should be answered with "Yes", "No" or "NA" (Not Applicable).

The first set of checklist questions identifies general aspects of a proposed application that would indicate it is a novel concept or application. The next set of questions address marine systems and structural

features, covering possible novel concepts related to moorings, structural configurations, material applications, ballasting systems, and mechanical or electric systems.

The next category relates to novel processes (e.g., chemical or hydrocarbon processing/production), activities, storage within marine or offshore applications, and subsea systems. Novel processes may include new methods of hydrocarbon production not previously applied commercially before or the extension of a preexisting process that has not been applied on an offshore application previously. Novel activities may include the use of a vessel or offshore unit for purposes other than the original design purpose. Novel concepts may include a new type of mooring system for an offshore floating installation. Novel storage applications may include the application of new types of cargo tanks to transport highly volatile gases or liquids. In all of these examples, the proposed function of the vessel or offshore unit is affected by the application of the new technology, concept or activity. The last checklist category covers possible new or novel ancillary systems in which the function of the vessel or offshore unit could be impacted by the introduction of this system.

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

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

ii) It does not constitute a 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 *Risk Assessment Guidance Notes* would generally be more appropriate for the proposed application.

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 begin the initial process of clarifying whether or not the design concept should be categorized as novel, precisely defining the novel concept and identifying potential ramifications on the vessel or offshore unit classification approval. The process for evaluating the novel concept is described in 1 and detailed in 2 and 3.

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

TABLE 1
Novel Concept Checklist

No.	*Checklist Questions*	*Yes/No/NA**
General		
G1	Is the proposed type of marine or offshore application or facility currently being used in marine or offshore applications?	
	If Yes, what is estimated total operational years of experience of similar marine or offshore facilities?	
G2	Is the vessel or offshore unit design basis (e.g., environmental constraints, operating parameters [temperatures, pressures], topside loads or interface with marine systems, etc.) considered within current experience boundaries for this application?	
G3	Are there applicable design guidance documents (e.g., ABS, API, IMO, ASME) specific to the proposed marine or offshore application?	
G4	Are all the hazards induced by the proposed type of marine or offshore application or facility common without any new features?	
Stationkeeping Aspects		
SK1	Is the proposed mooring system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the proposed mooring line materials considered current industry practice for this application?	
	Is the proposed mooring system arrangement considered existing industry practice (e.g., no unique arrangement features such as lines crossing critical components or other mooring components in close proximity to critical components)?	
	Are there existing applications of the proposed mooring anchorage system (e.g., piles, anchors or other)?	
SK2	Is the proposed thruster system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the environmental and operating parameters for the thruster system within experience bounds for the vessel or floating facility?	
	Is the control system for the thruster system considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the potential consequences associated with failure of the thruster system considered to be similar to other thruster applications?	
Structural Aspects		

No.	*Checklist Questions*	*Yes/No/NA**
S2	Is the proposed hull or main structure design considered to be within the existing experience boundaries for the vessel or offshore unit?	
	Are there existing applications of the proposed structural configuration (e.g., unique shape, extreme size [scaled up of version existing application], arrangement [novel layout to enhance stability, motions, construction or speed] or atypical loading or load paths)?	
	Are there existing structural designs that utilize materials, connection details or construction tolerances for similar applications?	
	The proposed design will not require enhanced (i.e., in addition to what is typically required by class Rules) maintenance or structural monitoring procedures to confirm adequate integrity and structural performance due to new features or application of new technology?	
	Does the proposed hull or main structure design considered provide acceptable levels of reliability in line with current offshore and marine industry practice?	
Marine Systems		
MS1	Are the proposed ballast water management systems (BWMS) or ballast water management methods considered to be within the existing experience boundaries for the vessel or offshore unit?	
MS2	Are the proposed mechanical/electrical systems (e.g., bilge, power distribution, communication, navigational guidance) considered to be within the existing experience boundaries for the vessel or offshore unit?	
	Is the electric power generation system considered to be within the current experience boundaries for the vessel or offshore unit?	
	Is the fuel system used for electric power generation considered to be within the current experience boundaries for the vessel or offshore unit?	
	Is the control system for power generation considered to be within the current experience boundaries for the vessel or offshore unit?	
	Are the power requirements for the vessel or offshore unit within current experience bounds?	
	Are the mechanical system arrangements (e.g., bilge, ballast, etc.) considered to be within the current experience boundaries for the vessel or offshore unit?	
	Is the physical layout of the mechanical systems considered to be within current industry practices?	
MS3	Are there any new hazards in the design of the vessel or offshore unit that require active or passive prevention or mitigation systems not considered to be within current industry practice?	
	Are physical layouts of equipment and structures such that current industry practices for hazard detection (e.g., fire, gas, flooding) are clearly adequate?	
	Are physical layouts of equipment and structures such that current industry practices for egress and evacuation are clearly adequate?	

No.	*Checklist Questions*	*Yes/No/NA**
MS4	Is the proposed propulsion system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Is the fuel system considered to be within the current experience boundaries for the vessel or floating facility?	
	Is the physical layout of the propulsion system considered to be within current industry practices?	
	Is the control system for the propulsion system considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the operation requirements and potential consequences associated with failure of the propulsion system considered to be similar to other propulsion applications?	
MS5	Is the proposed steering system design considered to be within the current experience boundaries for the vessel or floating facility?	
	Is the control system for steering considered to be within the current experience boundaries for the vessel or floating facility?	
	Are the guidance and navigation systems considered to be within the current experience boundaries for the vessel or floating facility?	
Process Systems		
P1	Are there any existing commercial applications of the proposed process systems that will be on the vessel or offshore unit?	
P2	Are there existing onshore applications of the proposed process systems that will be on the vessel or offshore unit?	
P3	Are there marine or offshore applications of the proposed process that will be on the vessel or offshore unit?	
P4	Can the chemical process aspects, such as fluid/gas separation or distillation, be isolated from potential detrimental effects of the marine environment (e.g., ambient conditions, vessel motions, etc.)?	
P5	Are the potential consequences associated with this offshore application of the process facility considered to be the same as other similar onshore commercial applications?	
P6	Is the equipment layout similar to existing marine or offshore process facilities?	
P7	Is the equipment application or mechanical design similar to existing offshore process facilities?	
Storage/Cargo Transport Aspects		
SC1	Are there any existing commercial applications of the proposed storage systems similar to that which will be used on the vessel or offshore unit?	
SC2	Are there existing onshore applications of the proposed storage systems that will be on the vessel or offshore unit?	
SC3	Are there marine or offshore applications of the proposed storage systems that will be on the vessel or offshore unit?	
	Can the storage systems be isolated from the unique aspects of the marine environment (e.g., ambient/corrosive conditions, motions)?	

No.	*Checklist Questions*	*Yes/No/NA**
SC4	Are the potential consequences associated with this offshore application of the storage system or facility considered to be the same as other similar commercial applications?	
SC5	Is the storage equipment layout similar to existing marine or offshore facilities?	
SC6	Is the storage equipment application or design similar to existing offshore facilities?	
SC7	Does the material being stored or transported have similar handling requirements (e.g., monitoring and control of temperature or pressures, offload and unloading systems, operational constraints or compartmentalization requirements, etc.) as other existing applications?	
SC8	The handling (load/discharge) of the material being stored does not require the use of any type of device (pump, compressor, connecting device such as a hose or product swivel) which has undergone extensive re-design to be able to handle these materials in a marine or offshore environment?	
Subsea Systems		
SS1	Is the proposed subsea system configuration considered existing industry practice without unique arrangement features?	
SS2	Are there existing applications of the proposed subsea system?	
SS3	Are the environmental and operating parameters (e.g., ice, earthquake, seabed subsidence, marine life, corrosive internal fluid, water depth, internal pressure and temperature, etc.) for the subsea system within experience bounds for the offshore application?	
SS4	Are the potential consequences associated with failure of the subsea system, subsystem, equipment, and components considered to be similar to current subsea applications?	
SS5	Is the monitoring, communication, safety and control systems for the subsea system considered to be within the current experience boundaries for offshore application?	
SS6	Is the subsea process system considered to be within the current experience boundaries for offshore application?	
SS7	Are the proposed mechanical and electrical subsystems considered to be within the existing experience boundaries for subsea application?	
SS8	Are there existing structural designs (e.g., subsea equipment, foundation, pipeline, and riser) that utilize materials, connection details or construction tolerances for similar applications?	
Other Systems/Aspects		
AS1	There are no other new or novel applications that are not specifically covered under classification (e.g., new type of offloading system or new riser support system) in which the performance of that system could potentially impact, either directly or indirectly, vessel structural integrity, stability or safety of the classed components?	
AS2	There is no use of new material specifications or material usage which have not been demonstrated as adequate for their intended service and a marine and offshore environment.	
AS3	For all identified failure modes, there exists suitable data and experience relative to key material properties and characteristics needed to resist those failure modes in service.	

Note: * NA – Not Applicable

PART 1D

APPENDIX **2**

Guidance on Qualifying New Technologies

CONTENTS

PART 1D

APPENDIX 2
Guidance on Qualifying New Technologies

SECTION 1
Introduction

1 Overview

This Appendix describes the ABS approach for qualification of new technologies to confirm their ability to perform their intended functions in accordance with defined performance requirements. It also provides details of the required submittals, the ABS review process, and the key interaction points with ABS during the new technology development.

This document provides a systems engineering approach to qualification that allows for systematic and consistent evaluation of a new technology as it matures from a concept through confirmation of operational integrity in its intended application. The approach is divided into a multi-stage process that is aligned with the typical product development phases of a new technology. The qualification activities within each stage employ risk assessments and engineering evaluations that build upon each other to determine if the new technology provides acceptable levels of safety in line with current offshore and marine industry practice. The qualification efforts by all stakeholders including the vendor, system integrator and end-user at each stage are recognized and captured within a new technology qualification plan (NTQP). Completion of qualification activities as identified within each stage of the NTQP will result in a Statement of Maturity being issued by ABS attesting to the maturity level of the new technology.

The process is also compatible with approaches based on technology readiness levels (TRLs), (e.g. API RP 17N/Q, ISO 16290/NASA, and US DoD); and can be tailored to projects that require the use of multiple pathways to qualification. The comparison of ABS Qualification Stages with industry TRLs can be found in Section 9 of this Appendix.

It is to be noted that when applying this Guidance for certification or classification purposes in conjunction with Novel Concept Class Approval process, the primary driver for classification acceptance is safety, even though there may be additional functional requirements (e.g., reliability) defined by the client.

3 Background

The marine and offshore industries regularly develop new technologies that have no service history in the proposed application or environment. Often, governing industry codes and regulations do not develop at the same pace. These new technologies have little or no precedent and may be so different from existing designs that the requirements contained in class Rules may not be directly applicable.

Marine vessels and offshore units which contain new technological features or designs that are not currently governed by Rules, Guides and existing industry standards may still be qualified and/or approved by ABS through the process described in this Guidance. This qualification 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 assessments and engineering evaluations has been given to the new features through the application of this Appendix.

This document is structured to provide a general procedure for vendors/system integrators/end- users to guide them through the process of obtaining Statements of Maturity attesting to the maturity level of new technologies. The process can be applied to technologies seeking qualification independent of Class approval or installation on ABS classed assets.

The integration of the new technology qualification process and the Novel Concept Class Approval process provides end users of the qualified technologies assurance that the transition from new technology qualification to Class approval will be seamless. It provides regulatory agencies with the confidence that hazards associated with the introduction of the new technology have been systematically identified and mitigated.

5 Application

This Appendix is in general applicable to all new technologies for offshore units and marine vessels that do not follow typical Rules, Guides, or industry codes or standards. This document provides guidance to parties seeking recognition for the maturity level of a proposed new technology.

A new technology for the purpose of this Guidance is defined as any design (material, component, equipment or system), process or procedure which does not have prior in-service experience, and/or any classification rules, statutory regulations or industry standards that are directly applicable. It is possible to categorize the type of "novelty" in one of four categories:

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

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

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

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

An asset such as a marine vessel or an offshore unit becomes a novel concept if the incorporation of any new technology(ies) appreciably alters its service scope, functional capability, and/or risk profile. Novel concepts are typically presented to ABS for review and class approval following the process in *Guidance on Review and Approval of Novel Concepts (Novel Concept Guidance),* found in Appendix 1.

The New Technology Qualification (NTQ) process could be applicable in the following cases:

i) To qualify new technology that may need to be classed or certified at a later date

ii) To simultaneously qualify new technology identified while seeking class approval for a novel concept

iii) To qualify a new technology independent of the need to be classed or certified

If the proposed new technology is intended for incorporation on an asset to be classed by ABS, it is recommended that the new technology progress up to and include the System Integration Stage of the New Technology Qualification (NTQ) process. In other cases, the level of maturity to which the new technology may be qualified depends on the client's request. New technology qualification could be requested from ABS at any level of indenture as desired such as component, sub-system or system level.

The process is designed to accommodate cases where multiple vendors, system integrators, and/or end-users need to work together to qualify a combination of new technologies. In such cases, it is important for the teams to work together to integrate technologies as early as possible in order to optimize the process.

Even though this Guidance is primarily intended for the qualification of new technologies, the approach could also be applied to qualify existing technologies.

7 New Technology Qualification Process

The NTQ process confirms the ability of a new technology to perform its intended functions in accordance with defined performance requirements. The process starts with a comprehensive description of the technology to be qualified, followed by a screening of the technology to reveal the new or novel features that the qualification should focus on.

The process is divided into five sequential stages that progressively qualify the technology from feasible to operational stages as requested. The five qualification stages are:

i) Feasibility Stage

ii) Concept Verification Stage

iii) Prototype Validation Stage

iv) System Integration Stage

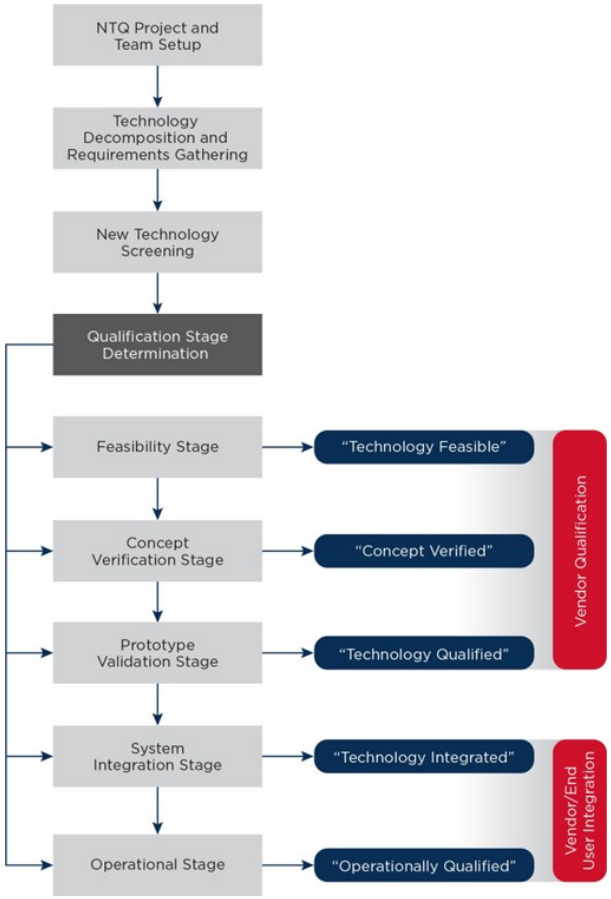
v) Operational Stage

Qualification activities outlined in the New Technology Qualification Plan (NTQP), are to be performed within each stage and should be defined at the end of the previous stage as agreed upon between the client and ABS. The qualification activities are based on the information available depending on the maturity level and based on the findings and knowledge gained in the previous stages completed. Typically, there are two main sets of activities within each stage: engineering evaluations and risk assessments.

Upon completion of each of the five stages, a Statement of Maturity will be issued to the vendor(s) and the technology can progress to the next stage of maturity. It is envisioned that some vendors may have developed technologies to a level beyond the Feasibility Stage prior to contacting ABS for this qualification service. In such cases, ABS will perform an assessment of the current stage of technology development and endorse the technology with the applicable Statement of Maturity based on this assessment. The technology qualification can then proceed starting at that stage and continuing to the subsequent stages. Additionally, the new technology qualification process can be stopped at any stage and restart later at an agreed upon time.

Section 1, Figure 1 provides a basic overview of the process along with the Statements of Maturity issued. Further guidance on each topic and deliverables that are to be submitted to ABS for review can be found in later Sections.

FIGURE 1
New Technology Qualification Process



9 ABS Type Approval Program

New technologies that have completed the Prototype Validation Stage of the NTQ process or have been "Technology Qualified", and can be consistently manufactured to the same design and specification may be "Type Approved" under the ABS Type Approval Program. During the Prototype Validation Stage, if all the engineering evaluations have been completed, a Product Design Assessment (PDA) can be issued prior to further consideration for ABS Type Approval. The ABS Type Approval Program is a voluntary option for the demonstration of compliance of a system or product with the defined performance requirements as derived from Rules, Guides, or other recognized standards. It may be applied at the request of the vendor or manufacturer. The suitability of the ABS Type Approval Program for the proposed new technology will be determined on a case-by-case basis.

Specific requirements and details regarding the ABS Type Approval Program can be found in 1A-1-4/7.7 and Appendix 1A-1-A3 of the ABS *Rules for Conditions of Classification (Part 1A)*.

11 Definitions

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

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

Availability. Ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided (ISO 14224).

Boundary. Interface between an item and its surroundings (ISO 14224).

Client. The vendor, OEM, manufacturer, asset owner/operator of the new technology or novel concept, representing any party or parties that have a stake or interest in the design or third party groups working under or for these entities.

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

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

Critical Assumption. An assumption that if found not true will change the conclusions of the study that used such assumption.

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

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

Failure Causes. Circumstances associated with design, manufacture, installation, use and maintenance that have led to a failure (ISO 14224).

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

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

Functional Specification. Document that describes the features, characteristics, process conditions, boundaries and exclusions defining the performance and use requirements of the product, process or service (ISO 13880).

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

Global Effects. Total effect an identified failure has on the operation, function or status of the installation or vessel and end effects on safety and the environment.

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

Indenture Level. The level of subdivision of an item from the point of view of maintenance action (ISO 14224).

Item. Any part, component, device, subsystem, functional unit, equipment or system that can be individually considered (ISO 14224).

Local Effects. Impacts that an identified failure mode has on the operation or function of the item under consideration or adjacent systems.

Maintainability. Ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources (ISO 14224).

Manufacturing Assessment (MA). An inspection of the product during manufacture, an assessment of the quality control system and manufacturing processes that should be satisfactorily completed if the manufacturer wants a product to be labeled "Type Approved" under the ABS Type Approval Program.

Manufacturing Plan. Document setting out the specific manufacturing practices, technical resources and sequences of activities relevant to the production of a particular product including any specified acceptance criteria at each stage (ISO 13880).

Product Design Assessment (PDA). Technical evaluation of a product for potential use on ABS-classed assets. The process involves ABS Engineers verifying product compliance with manufacturers' specifications, applicable ABS Rules and national or international standards.

Quality Assurance and Quality Control. Typical quality plans and related processes for controlling quality during production.

Qualification. The process of confirming, by examination and provision of evidence, that equipment meets specified requirements for the intended use (API RP 17N).

Qualification Activities. Usually in the form of risk assessments, engineering evaluations, and testing that is required to be performed in order to mature the new technology to the next stage.

Qualification Plan. A document containing the qualification activities listed to mature the new technology to the next qualification stage. This is submitted as a New Technology Qualification Plan (NTQP) report.

Redundancy. Existence of more than one means for performing a required function of an item (ISO 14224).

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

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

Risk Profile. Description of any set of risks (ISO 31000).

Technical Specification. Document that defines technical requirements to be fulfilled by the product, process or service in order to comply with the functional specification (ISO 13880).

Type Approval. A voluntary ABS Program for product certification that is used to demonstrate a product manufacturer's conformance to the Rules or other recognized standards. The Product Design Assessment (PDA) and Manufacturing Assessment (MA) together result in a Type Approval or a "Type Approved" product.

Validation. The process of evaluating a production unit (or full scale prototype) to determine whether it meets the expectations of the customer and other stakeholders as shown through performance of a test, analysis, inspection, or demonstration.

Verification. The process of evaluating a system to determine whether the product of a given development stage satisfy the approved requirements and can be performed at different stages in the product life cycle by test, analysis, demonstration, or inspection.

13 Abbreviations

ALARP: As Low As Reasonably Practicable

API: American Petroleum Institute Recommended Practice

CFD: Computational Fluid Dynamics

FEA: Finite Element Analysis

FMECA: Failure Mode Effects and Criticality Analysis

FTA: Fault Tree Analysis

HAZOP: Hazard and Operability

HAZID: Hazard Identification

HFE: Human Factors Engineering

ITP: Inspection Test Plan

MA: Manufacturing Assessment

MTBF: Mean Time Between Failure

NTQ: New Technology Qualification

NTQP: New Technology Qualification Plan

PDA: Product Design Assessment

PFD: Process Flow Diagram

P&ID: Piping and Instrumentation Diagram

PPE: Personal Protective Equipment

RAM: Reliability, Availability and Maintainability

RBD: Reliability Block Diagram

SRDD: Systems Requirements and Description Document

SIT: Systems Integration Test

US DoD: United States Department of Defense

QA: Quality Assurance

QC: Quality Control

PART 1D

APPENDIX 2

Guidance on Qualifying New Technologies

SECTION 2

Getting Started

1 New Technology Qualification Project and Team Setup

Once the client (vendor/system integrator/end-user) requests qualification of a technology using this Guidance, a project-kick-off meeting is scheduled. At this meeting, the client presents to ABS a brief overview of their proposed technology along with their expectations, any ongoing qualification activities (if initiated) and project timelines. ABS will advise the client if new technology qualification is the most appropriate path for proceeding and recommend next steps.

The kick-off meeting is followed by the establishment of a new technology qualification team. An important factor for a successful technology qualification is the composition of the qualification team. The qualification process involves the interaction of two teams: the vendor or client team (design team) and the ABS-designated review team.

For each NTQ project, depending on the complexity of the proposed new technology, ABS may establish a special multidisciplinary review team comprised of ABS staff members. The composition of the team will depend on the technical areas involved in the project as well as the physical location of the client's engineering and testing facilities. This will help the client benefit from technical review and comment from our subject matter experts throughout the qualification process. One of the members will be the designated NTQ project lead to act at as the client's main point of contact throughout the NTQ process. All ABS team members will be covered under the confidentiality/non-disclosure agreement that is typically signed between ABS and clients for this type of qualification services.

It is encouraged whenever possible to include ABS, system integrators and end users of the new technology early in the qualification process. This will facilitate the identification and alignment of requirements early in the design process avoiding costly design modifications later. If applicable, input from regulatory agencies (including Administration) will also help align the qualification activities with requirements or other expectations.

3 New Technology Decomposition and Requirements Gathering

3.1 Introduction

The NTQ process follows a systems engineering approach to qualifying new technology. This approach focuses on the following elements:

- Defining goals of the new technology
- Identifying the functional requirements to meet the goals

- Identifying the performance and safety requirements for the functional requirements
- Performing qualification activities to verify and validate the performance requirements

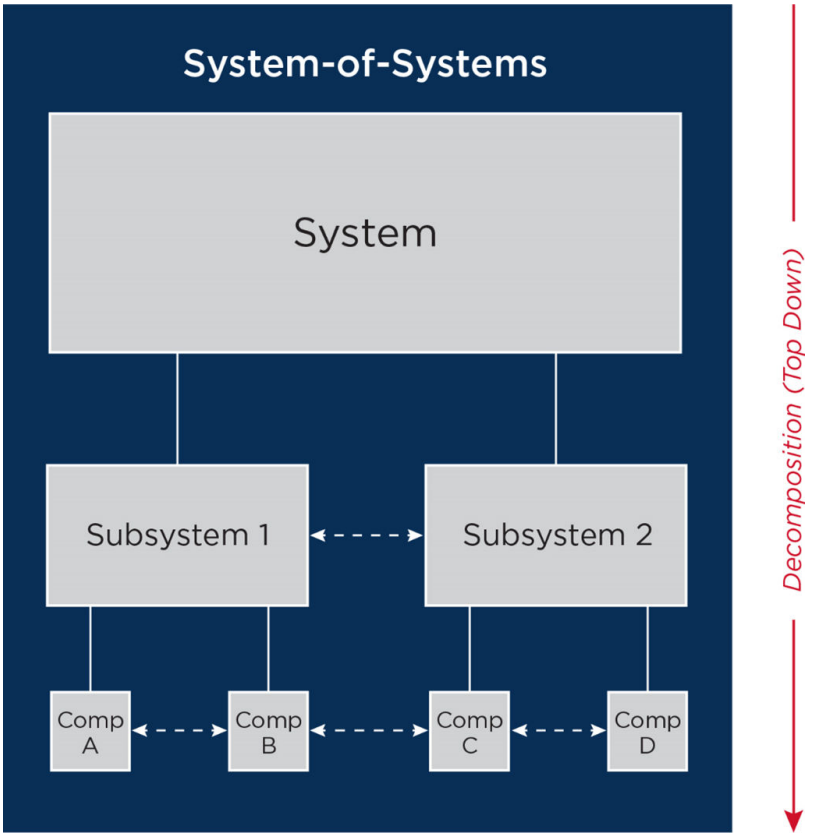
The qualification process starts with a top-down system decomposition, wherein the system is divided into subsystems, which are further broken down into components. This decomposition process is used to achieve the following:

- Mapping functional requirements of the system to item(s)(e.g., subsystems or components) identifying ownership of a specific functional requirement
- Mapping functional requirements to specific performance requirements
- Confirming that all defined functional requirements can be addressed by configurable items
- Identifying new technology items prior to determining if qualification is needed and what interactions between items need to be considered

Depending on the type of item for which the client is seeking qualification, the NTQ process can be tailored. This is applied by considering the different categories of new technology as defined in Section 1D-A2-5 and understanding what exactly has changed to focus qualification efforts.

The maximum maturity level of the system is based on the individual qualification of each item(s). For example, the overall maturity level of the system is equal or lower than that of the subsystems, which are equal or lower than that of the individual components. The decomposition, system hierarchy and interactions between all items are depicted in 1D-A2-2/Figure 1.

FIGURE 1
New Technology System Hierarchy



The item for which new technology qualification is desired could be at any level of indenture within the system hierarchy. System-of-Systems (SoS) refers to the larger system in which integration of the new technology could occur. This SoS could be another system or an asset such as a marine vessel or an offshore unit. The asset becomes a novel concept if the incorporation of any new technology(ies) appreciably alters its service scope, functional capability, and/or risk profile.

3.3 New Technology System Requirements and Description Document

Properly defining a new technology is a critical aspect of NTQ. For this purpose, a System Requirements and Description Document (SRDD) should be developed for the new technology and maintained throughout the NTQ process. This document defines and sets the baseline requirements for the new technology and may be derived from functional and technical specifications. The requirements will be defined for each level within the system hierarchy as applicable. As the design matures through development and more knowledge is gained through qualification, these requirements may be subject to change. The SRDD will need to be updated accordingly.

3.3.1 Defining System Requirements

3.3.1(a) Goals.

The goals defined for the new technology are to address the issue of concern(s) and identify the required level of safety, high-level scope, objectives, or requirements that the new technology needs to meet. Goals may be derived from client's needs, mission, measures of effectiveness, environmental or application constraints, program/policy decisions and/or requirements derived from tailored specifications or standards.

3.3.1(b) Functional Requirements.

Functional requirements define each function that the system is required to perform and the hazard that is to be addressed. The functional requirements should be mapped to specific items that will perform the function and the hazard(s) the function is to mitigate. It typically includes a description of the function to be performed, the environment within which the function should be performed, the conditions under which the system should start the function and the conditions under which the system should terminate the function.

3.3.1(c) Performance Requirements.

The performance requirements define how well each functional requirement should be accomplished, and the set of performance metrics including identification of critical performance parameters. The performance requirements can be defined qualitatively at early design stages and progressively more quantitatively during subsequent stages of technology maturation. In case where performance requirements are not defined because of the novelty of the technology, the requirements should be extrapolated from existing Rules, Guides, and/or other industry standards. Any relevant requirements from regulatory agencies or Administration should be also considered. The performance criteria is the acceptance criteria against which the results of each qualification activity is evaluated.

The requirements should be defined according to NATO AVT-092 "Qualification by Analysis" and/or ISO 13879 "Petroleum and natural gas industries – Content and drafting of a functional specification". The aspects to consider for inclusion when defining functional requirements and related performance requirements may vary depending on the new technology to be qualified.

3.3.1(d) Design Conditions.

The system design conditions describe all applicable loading requirements under the environmental and operating conditions. This should include, but not be limited to, the natural environment (e.g., temperature and chemical exposure), the induced environment (e.g., vibration and noise), electromagnetic signal environment, and threats. Typical loading and design conditions to be considered include, but are not limited:

- Pressure and temperature induced loads and fluctuations
- Static and dynamic loads
- Fatigue and fracture effects
- Wear and vibration effects
- Material degradation and associated loss from damage mechanisms
- Accidental loads (as applicable)

3.3.1(e) System Interface Requirements.

The system interface requirements define all internal and external physical and functional interfaces (e.g., mechanical, electrical, etc.) relevant to the new technology. Interfaces among system elements should also include interfaces with the human element. The system interface definition confirms that various elements of the system can functionally and physically interact with each other and with all external systems they connect to or communicate with. A graphic description of the interfaces can be used when appropriate for clarity.

3.3.1(f) Human System Integration Requirements.

Human factors play an important role for the system to work safely and effectively in achieving the required functions and goals and should be considered throughout the design life of the new technology. Human factors requirements (ergonomics) define the characteristics of human system interaction in terms of usability, safety, human reliability, performance, effectiveness, efficiency, maintainability, and health. It is important that human factors be considered during early design stages.

Human Factors Engineering (HFE) is a specialized engineering discipline that integrates human behavioral and physical capabilities and limitations with conventional engineering disciplines to produce a human-system interaction that maximizes both, allowing both the human and system to work together to achieve functional and performance requirements.

The focus of HFE is the design of the human-system interface. This includes interfaces between personnel and the hardware, software, and physical environments associated with systems. It also involves the interfaces between personnel, individual tasks, and the overall work system (e.g., its structure, management, policies, and procedures). A good starting point is defining usability requirements which identify user needs and expectations. Usability requirements define the appropriate allocation of functions between users and the technology as well as the measurable effectiveness, efficiency, and satisfaction criteria in specific contexts of use.

During the design process, specific areas, stations, or equipment arrangements that would require concentrated human engineering attention should be defined. Any special requirements, such as constraints on allocation of functions to personnel and communications and personnel/equipment interactions, should be specified. Successful application of HFE depends on a proper process of conducting the appropriate activities in the various stages of the development life cycle of the system.

Further guidance on Human Factors Engineering can be found in the following references:

- ABS *Guide for Ergonomic Notations*
- ABS *Guidance Notes on the Implementation of Human Factors Engineering into the Design of Offshore Installations*
- ABS *Guidance Notes on the Application of Ergonomics to Marine Systems*
- ABS *Guidance Notes on Ergonomic Design of Navigation Bridges*

- *Standard Human Engineering Program Requirements for Ships and Marine Systems, Equipment and Facilities, Standard F-1337-22. American Society of Testing and Materials (ASTM) (2022)*
- *Common Requirements, Architectural Components & Equipment (C-CR-002). Norwegian Oil Industry Association and the Federation of Norwegian Engineering Industries (NORSOK). (2015)*
- *Working Environment (S-002). Norwegian Oil Industry Association and the Federation of Norwegian Engineering Industries (NORSOK). (2018)*

3.3.1(g) Maintainability.

Specify the quantitative maintainability requirements that apply to maintenance in the planned maintenance and support environment. Examples are as follows (taken from ISO 29148):

- Time (e.g., mean and maximum downtime, reaction time, turnaround time, mean and maximum times to repair, mean time between maintenance actions)
- Rate (e.g., maintenance staff hours per specific maintenance action, operational ready rate, maintenance time per operating hour, frequency of preventative maintenance)
- Maintenance complexity (e.g., number of people and skill levels, variety of support equipment, removing/replacing/repairing components)
- Maintenance action indices (e.g., maintenance costs per operating hour, staff hours per overhaul)
- Accessibility to components within systems and to parts within components

3.3.1(h) Reliability.

Reliability describes the ability of a system or component to function under stated conditions for a specified period of time. Reliability requirements determine the robustness, consequences of, and redundancy of the system. Reliability requirements are best stated as quantitative probability statements that are measurable by test or analysis, such as the mean time between failures(MTBF) and the maximum acceptable probability of the failure during a given time period.

3.3.1(i) Safety and Environment.

Safety and environmental requirements applicable to eliminating or minimizing hazards related to people, environment, and asset.

3.3.1(j) System Life Cycle Sustainment.

The system life cycle sustainment requirements include activities relating to sustaining the quality or integrity of the system. Typical requirements include, but are not limited to, support, sparing, sourcing and supply, provisioning, technical documentation, and personnel support training for all modes of operation (e.g., installation, hook-up, commissioning, and decommissioning) throughout the life cycle of the system. These requirements should be updated as needed to sustain performance.

3.3.1(k) Data Management and System Security.

For data-intensive systems, the management of information should be defined. The information management requirements should define the information the system receives, stores, generates and exports as well as the backup of the information.

System security requirements define both the surrounding environment (i.e., location) of the system and the operational security requirements. For example, to protect the system from accidental or malicious access, use, or destruction, some protection methods (e.g., access limitations, use of passwords, or the restriction of communications between some areas of the system) can be used. For control systems that govern multiple critical aspects of the

assets, insights should be provided for operations, maintenance and support of cyber-enabled systems, to improve security in those systems.

The ABS CyberSafety™ program addresses cyber-enabled systems protection in an extended set of engineering processes that emphasizes human and systems safety. For further guidance on this program, refer to the following documents:

- ABS *Guidance Notes on Application of Cybersecurity Principles to Marine and Offshore Operations – ABS CyberSafety™ Volume 1*
- ABS *Guide for Cybersecurity Implementation for the Marine and Offshore Operations – ABS CyberSafety™ Volume 2*
- ABS *Guidance Notes on Data Integrity for Marine and Offshore Operations – ABS CyberSafety™ Volume 3*
- ABS *Guide for Software Systems Verification – ABS CyberSafety™ Volume 4*
- ABS *Guidance Notes on Software Provider Conformity Program – ABS CyberSafety™ Volume 5*

3.3.2 System Description

The SRDD is also to include a detailed technology description. This involves additional documentation that could help provide evidence or demonstrate the ability of the technology to meet defined system requirements. The description of the technology typically includes the following:

i) List of subsystems/components that make up the system in the scope of approval along with the details of the suppliers responsible for submitting drawings to ABS.

ii) Comparison with existing similar technologies

iii) Lessons learned from similar technologies

iv) Possible applicable standards, codes, or industry practices

v) Relevant engineering documents as applicable:

- Piping and Instrumentation Diagrams (P&IDs)
- Heat and material balances
- Block diagrams
- Design schematics
- General arrangements
- Material specifications including material properties
- Design analysis methodology and related reports
- Installation analysis
- Test reports

vi) Control and safety system details

vii) Operational, maintenance, and inspection strategies

viii) New or unproven manufacturing, assembly, transit, storage, installation, hook-up, testing, commissioning, and decommissioning details

ix) Quality, health, safety, and environmental philosophies

The SRDD is to be submitted for ABS review. The SRDD is not intended to be a single consolidated document but rather a design review package that compiles the relevant documents into a single source.

It is recognized that the requirements definition and the supporting description documentation is developed throughout the NTQ process. The submittal only needs to include the information available based on the design maturity of the new technology.

5 New Technology Screening

Once the technology has been described, a systematic screening process is needed to identify the new or novel elements, characteristics, or environment for which qualification is needed. The decomposed system should be reviewed to identify which of those items are considered new technology, as defined in Subsection 1/5, and which ones are not. The level of effort involved in qualification increases from categories *i)* through *iv)*. Items that are not considered new technology may follow the conventional ABS certification process.

For new technology items, it is useful to identify whether similar technology exists and whether relevant Rules, Guides, and/or standards apply wholly or partially for this technology. Identifying the new technology items provides a basis for reducing the qualification scope to only those items that need to be addressed through the NTQ process. The vendors could perform the screening process independently or in a workshop setting with ABS, which will help support and guide the process. 1D-A2-2/Table 1 provides a sample that can be used for a systematic screening.

TABLE 1
Systematic Screening Table

Item	*Description*	*Similar Technology Exists?*	*Relevant Rules, Guides, or Industry Standards for This or Similar Technology?*	*New Technology (Yes/No)*	*New Technology Category (i, ii, iii, iv)*	*Notes*
1		Technology 1, Technology 2…	Standard 1 (partially) Standard 2 (No)…	*Yes*	i	
2		No	Standard 1 (partially) Standard 2 (partially)…	*Yes*	*iii*	
3		This technology exists	N/A	*No*	N/A	

Columns:

Description: Description of elements of the new technology item(s)(e.g., subsystems)

Similar Technology Exists?: Identify whether similar technologies exist, for example, technologies in other industries (e.g., onshore, aerospace, etc.). If existing technology exists, list them in this column.

Relevant Standards for This or Similar Technology: List of any standards applicable to the new technology with short explanation about applicability.

New Technology (Yes/No): Decide which technologies are new and which are not.

New Technology Category: As defined in Subsection 1/5:

i) Existing technology challenging current boundary/envelope

ii) Existing technology in new applications

iii) New technology in existing applications

iv) New technology in existing applications

Note:

Other information or justification relevant to the screening process (e.g.,conditions for applicability of standards, recommendations for qualification, etc.).

The systematic screening results and supporting information is to be submitted for ABS review.

7 New Technology Stage Determination

Based on the results from the new technology screening process and review of the SRDD, ABS and the client will agree on a maturity level determination. An appropriate qualification stage will be assigned to proceed with qualification activities. Guidance for determining the technology maturity level and qualification stage can be found in Section 9 of this Appendix.

A more mature design may result in the ability to start at a later qualification stage, thus minimizing the level of effort and time it takes to complete the qualification of the new technology. Once credit has been given to the design maturity and the appropriate qualification stage is determined, the client can proceed through the qualification process outlined in the following Sections:

- Feasibility Stage (Section 3)
- Concept Verification Stage (Section 4)
- Prototype Validation Stage (Section 5)
- System Integration Stage (Section 6)
- Operational Stage (Section 7)

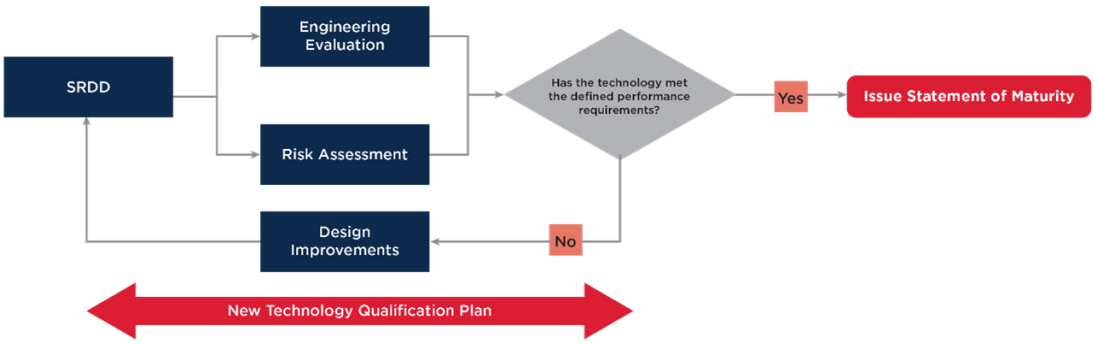
9 New Technology Qualification Plan and Activities

The New Technology Qualification Plan (NTQP) defines a road map for progressing the new technology through the appropriate qualification stages. The objective of the NTQP is to provide a summary of qualification activities that need to be performed at each stage to demonstrate the ability of the new technology to meet the requirements specified in the SRDD.

The initial NTQP should be developed based on the findings in the screening process described in Subsection 2/5. The NTQP for each subsequent stage is to be updated based on the findings from the previous stage activities and discussions between the client and ABS. An NTQP template is provided in Section 1D-A2-11.

Qualification within each stage is comprised of a set of iterative activities that include engineering evaluations and risk assessments to verify new technology design. Results of these activities could lead to design improvements or modifications to the requirements specified in the SRDD. All design improvements and/or modifications should be documented in the NTQP with necessary technical justification. 1D-A2-9/Figure 2 summarizes the iterative NTQP activities.

FIGURE 2
New Technology Qualification Stage Iterative Process



9.1 Risk Assessment Requirements

As stated in Subsection 2/9, a risk assessment is to be prepared and submitted to ABS for review.

For a new technology requesting qualification through the NTQ process, a risk assessment is to be performed/updated at each stage as applicable. The risk assessment within the NTQ process will vary from qualitative to quantitative depending on the maturity level and information available at that stage. The primary objective of the risk assessment is to identify technical risks and uncertainties associated with the proposed design and document all foreseeable hazards, their causes, consequences, and potential risk control measures considering the new technology in its proposed application and operating environment. All possible interfaces, and known integrations are to be evaluated as part of this assessment.

All risk assessments performed should consider the following areas:

i) Personnel safety

ii) Asset protection

iii) Environmental protection

It is recommended that the risk assessment be carried out by a multidisciplinary team that includes the design team (vendor) and the end-user. ABS' participation in the risk assessment is also recommended. 3/1.5 of the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries* provides an overview of how to assemble an appropriate risk assessment team.

Prior to performing the risk assessment, a risk assessment plan should be prepared and submitted to ABS for review. The risk assessment plan should include the following information:

i) Scope of the Assessment

- ***a)*** Description of the proposed new technology including physical and operational boundaries
- ***b)*** Intended service application of the new technology

ii) Assessment Team

- ***a)*** Subject matter experts/participants/risk analysts, including their background and areas of expertise

iii) Assessment Preparation

- ***a)*** All available new technology information (e.g., design basis, drawings, procedures, etc.),
- ***b)*** Proposed risk assessment method (e.g., FMECA)

c) Proposed risk assessment criteria for evaluation (e.g., risk matrix)

After the risk assessment has been completed, a report including the following information should be submitted to ABS for review:

i) Scope

a) Description of the proposed new technology including physical and operational boundaries

b) Intended service application of the new technology

ii) Risk Assumptions and Data References

iii) Supporting Engineering Documents

a) Technical drawings

iv) Risk Assessment Worksheets (Hazard Register) that

a) Identifies hazards associated with the new technology in its current boundary conditions (application and operating environment),

b) Identifies scenarios associated with each identified hazard,

c) Identifies scenarios associated with each identified hazard,

d) Identifies consequences of the hazardous scenario,

e) Identifies existing risk control measures for each hazardous scenario,

f) Estimates the likelihood (frequency) and the severity of the consequence,

g) Evaluates the risk of the hazardous scenario by measuring it against the acceptable risk criteria agreed upon by the analysis team,

h) Identifies and evaluates the need for any recommendations to lower the risk to acceptable levels (design improvements through risk control measures)

v) Conclusions and Recommendations

a) Action items and/or recommendations

Further guidance on developing risk assessment plans can be found in Section 3 of the ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*.

It is recognized that each new technology may be unique in terms of design, operating environment, and application, therefore it is difficult to provide precise guidance on which risk assessment techniques should be used in a given situation. Therefore, the selection of risk assessment methodology should be considered on a case-by-case basis and discussed with ABS prior to performing a risk assessment. Some typical recommended risk assessment techniques and their common uses can be found in 1D-A2-2/Table 2.

TABLE 2
Recommended Risk Assessment Techniques

Type of Study	*Description*	*Common Uses*
HAZID	A method to rapidly identify hazards, assess potential consequences, and evaluate existing safeguards of the system. Methods draw upon a highly experienced multi-disciplinary team using a structured brainstorming technique to assess applicability of potential hazards.	• Used for all types of systems and processes.
FHA	A functional hazard assessment (FHA) is used t o identify and assess the functional failures of a system or subsystem.	• Used for all types of systems and processes.
FMEA (Failure Mode and Effects Analysis)	An FMEA is a reasoning approach best suited to reviews of mechanical and electrical hardware systems. The FMEA technique(1) considers ho w the failure modes of each system component can result in system performance problems and (2) makes sure the proper safeguards are in place. A quantitative version of FMEA is known as failure modes, effects and criticality analysis (FMECA).	• A design FMEA/FMECA can be used for reviews of mechanical and electrical systems (e.g., fire suppression systems, vessel steering and propulsion systems) to identify design related failures. • A process FMEA is often used to identify failures while performing steps within a given process or procedure (e.g., manufacturing, assembly).
Hazard and Operability (HAZOP) analysis	The HAZOP analysis technique uses special guide words for (1) suggesting departures from design intents for sections of systems and (2) making sure that the proper safeguards are in place to help prevent system performance problems.	• Used for finding safety hazards and operability problems in continuous process systems, especially fluid and thermal systems. It can also be used to review procedures and other sequential or batch operations.

Further guidance on risk assessments techniques can be found in the following references:

- ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Oil and Gas Industries*
- ABS *Guidance Notes on Failure Mode and Effects Analysis (FMEA) for Classification*
- *Petroleum and Natural Gas Industries – Offshore Production Facilities – Guidelines on Tools and Techniques for Hazard Identification and Risk Assessment, ISO 17776*
- *Risk Management – Risk Assessment Techniques, ISO 31010*
- *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment, SAE ARP 4761*

9.3 Engineering Evaluation

Engineering evaluations are used to verify and validate that the new technology is capable of performing acceptably with respect to intent and overall safety according to the requirements of each stage. This is achieved gradually for each qualification stage through specific qualification activities as the technology matures and can be found in the NTQP. The types of activities for engineering evaluation are:

i) *Review Engineering Design Requirements*. As the technology matures, and more detailed design information becomes available, the functional and performance requirements are reviewed/ updated as needed.

ii) *Technical Analyses and Simulations*. Engineering design analyses and simulations are used to verify the technology at the earlier qualification stages

iii) *Validation Testing*. Functional, model testing, and prototype testing are used to verify that the new technology satisfies all the specified functional and performance requirements.

iv) *Interface Analyses*. Interface analyses of the technology with existing systems are required and system integration testing is needed in order to fully understand all interactions between the new technology and surrounding systems, including people and the environment.

v) *Verification of Operability*. Operational testing and the collection of test data are required to verify the new technology satisfy the operational requirements.

vi) *Verification of Inspectability and Maintainability*. The various components of the new technology should be reviewed to confirm that they can be monitored, inspected and maintained in a manner consistent with existing practice.

vii) *Quality Assurance and Quality Control (QA/QC) Program*. Establish and maintain an effective quality control procedure(s) and quality acceptance criteria at each stage in accordance with recognized industry standard.

9.5 Design Improvements

Based on the results of the engineering evaluation and risk assessment activities, design improvements may be necessary to enhance reliability and safety of the design. The opportunities to improve safety could be through changes or modifications that make the design inherently safer or implementation of appropriate risk control measures. Example design changes include, material changes, reconfiguration, redundancy, and loading requirements.

Any design improvements that are identified and determined necessary as part of further refinement of the new technology is to be re-evaluated against the functional and performance requirements outlined in the SRDD. The updated qualification activities should aim to meet these new requirements. Design improvements should be tracked in the NTQP.

The following sections should be considered when improving the design of any new technology.

9.5.1 Hierarchy of Risk Control Measures

Inherently safe design is an innate and inseparable element.In other words, the risk control measures in place are “built in”, not “added on”. Identification of measures to control risks identified throughout the qualification process can be summarized in the following list:

i) *Elimination or Substitution*. Elimination of the design element, or the hazard associated with it should always be the first consideration. Careful evaluation may indicate that the functional requirements may be accomplished by another design element.

ii) *Engineering*. Engineering controls are mechanical or physical features added to the equipment, systems, subsystems, and/or components in order to remove or control the hazard, either by initial design specifications or by applying methods of substitution, minimization, isolation, or ventilation.

iii) *Administrative*. Administrative controls rely more actively on human action and behavior. Examples of administrative controls include written operating procedures, maintenance and inspection strategies, checklists, safety meetings, alarms, signs, training of personnel.

iv) *Personal Protective Equipment*. Personal protective equipment (PPE) creates a barrier between the person wearing the PPE and the hazard associated with the job. PPE such as

hearing protection, protective clothing, safety glasses, respirators, gloves, welding aprons, and hardhats are methods of controlling hazards.

In general, inherently safe design is more of a philosophical way of thinking rather than a specific set of tools or methods. For example, a hazard might be considered "safe" because it has specific risk reducing measures in place.

The goals of inherently safe design can be summarized by the following:

- Fewer and smaller hazards
- Fewer causes that initiate hazardous events
- Reduced severity and consequences (e.g. fatalities, lost time incidents, asset damage, etc.)
- More effective management of residual risk

The inherently safe design approach to achieve goals of safer design should consider elimination or substitution to significantly reduce hazards. The following questions should be asked when considering the design of new technologies with hazardous potential:

1) Can the hazard be eliminated by design improvements?

2) If not, then can the magnitude of the hazard be reduced?

3) Do the alternative designs identified in question 1 and 2 increase the magnitude of other hazards or present new hazards?

4) What other risk control measures (engineering or administrative) are required to manage hazards that remain?

An inherently safe design approach to design improvements is recommended in order to eliminate design elements that are limiting the new technology from meeting defined functional and performance criteria. This philosophy should shift focus on improving design by implementing elimination, substitution, or engineering risk control measures.

9.5.2 Management of Change

Design improvements are expected during the course of technology design and development and are integral to the process, especially during the early design phases. These improvements can potentially have an impact on risk, and on previously performed qualification activities during the NTQ process. For this reason, it is important that clients establish an appropriate Management of Change (MoC) program. It is recommended that a MoC program be developed to confirm that design improvements are reviewed in a responsible manner by appropriate personnel.

A MoC program is a combination of policies and procedures used to evaluate the potential impacts of a proposed design improvement so that it does not result in unacceptable risks. Developing an effective MoC strategy requires establishing, documenting, and successfully implementing formal policies to evaluate and manage both temporary and permanent modifications including equipment, materials, procedures and conditions.

The techniques used to evaluate the improvement, the people available for review, the time frames for reviewing and implementing the improvement will differ between the design phases. During the early phases, there may be many design improvements, but there will be fewer records to update than if the improvement occurs at a later stage. Tools such as software simulations and preliminary risk analysis can prove extremely valuable when determining design improvements at early stages and are less labor intensive than in later stages.

An effective MoC program requires preparation beyond defining and documenting a policy to outline the system. The following factors are important to successful implementation of a MoC program:

i) Clear roles and responsibilities

ii) Appropriate organizational preparation

iii) A written MoC program manual that includes MoC forms

iv) Pilot roll-out before the full-scale deployment, training of affected personnel, and

v) Close attention when integrating MoC with existing programs.

The following references provide more details on Management of Change processes:

- ABS *Guidance Notes on Management of Change for the Marine and Offshore Industries*
- *API RP 750, Management of Process Hazards, American Petroleum Institute, Washington, DC, 1990*
- *API RP 75, Recommended Practice for Development of a Safety and Environmental Management*
- *Program for Offshore Operations and Facilities, American Petroleum Institute, Washington, DC, 2004*
- *Guidelines for Management of Change for Process Safety, Center for Chemical Process Safety CCPS, 2008*

PART 1D

APPENDIX 2
Guidance on Qualifying New Technologies

SECTION 3
Feasibility Stage

1 Introduction

A new technology considered for qualification in the Feasibility stage is at an early concept maturity level, where basic research and development activities to identify engineering principles are complete; and a concept has been formulated along with its functional requirements. A high-level design analysis is performed to verify the concept in the intended application and that the overall proposed level of safety is comparable to those established in Rules, Guides, other recognized industry standards and recommended practices.

In cases where multiple concepts are submitted for ABS review, the overall objective is to work with ABS to identify a concept that proves most feasible for the application with respect to safety and reliability.

3 Qualification Activities

3.1 Engineering Evaluation

The engineering evaluation at the Feasibility Stage involves a high-level design verification of the proposed concept. All goals, functional requirements, and performance requirements submitted as part of the SRDD in 1D-A2-3/3.3 are reviewed along with any available high-level engineering design analysis to verify that the proposed concept is feasible.

3.3 Risk Assessment

A high-level risk assessment should be carried out during this stage to identify any preliminary technical risks and uncertainties associated with the proposed concept. The risk assessment should focus on documenting all foreseeable hazards, their causes, consequences, and potential risk control measures considering the new technology in its proposed application and operating environment. Additionally, all possible interfaces and known integrations should be considered. This risk assessment should set the basis for any subsequent qualitative/quantitative assessments that may need to be performed to completely understand the new technology's risk profile. Subsequent assessments may be in the form of additional engineering evaluation or risk assessments.

The results of the risk assessment should be documented and tracked in a hazard register for assessment and implementation in future qualification stages. The primary function of the hazard register should be to demonstrate that hazards and appropriate risk control measures have been identified. Recommendations for additional risk assessments and engineering evaluations are to be documented and submitted as part of the NTQP.

An appropriate risk assessment technique should be selected for this high-level risk assessment and submitted to ABS for review in the form of a risk assessment plan as discussed in 1D-A2-2/9.1. The engineering evaluation documents that support the risk assessment should be available and at an appropriate level of maturity before the risk assessment is performed. The following high-level risk assessment techniques are recommended as options for identifying preliminary technical risks:

i) HAZID identifying possible hazards, events, and outcomes related to the impact on personnel, asset, environmental, and reputation

ii) Functional FMEA identifying possible failure modes, effects (local and global), causes, and preliminary safeguards including all interfaces (i.e. system to system, system to subsystem, etc.)

iii) Functional Hazard Analysis (FHA) identifying system/sub-system functions and hazards associated with those functional failures

A risk assessment report including the hazard register should be prepared. The risk assessment report and the NTQP should be submitted to ABS for review.

There may be specific cases where the information available at this maturity level is limited and a risk assessment technique may not be possible. This scenario will be treated on a case-by-case basis, and ABS will recommend an alternative approach as needed to meet the new technology Feasibility Stage requirement.

5 Summary of Submittals

The following qualification activities along with future activities for the Concept Verification Stage should be highlighted in the NTQP and submitted to ABS for review:

5.1 Engineering Evaluation

i) SRDD

- Design basis, functional specification and/or technical specification of the new technology
- System and function architecture details such as functional flow block diagram
- Design details such as basic engineering drawings and engineering principles associated with further development
- Design analysis methodology and any available preliminary results
- Details regarding physical and functional interface requirements (mechanical, hydraulic, electronic, optical, software, human, etc.)
- Applicable design references, codes, standards and guidelines, and technical justification for any proposed deviations (may be identified independently or during the new technology screening process)
- Lessons learned, references and examples of comparable designs

5.3 Risk Assessment

i) Risk assessment plan in accordance with 1D-A2-2/9.1

ii) The appropriate risk assessment report identified in 1D-A2-3/3.3

iii) Hazard Register complete with an action tracking system

7 Feasibility Stage Completion: Technology Feasible

Once the above deliverables have been submitted to ABS for review and all specified performance requirements have been verified, then a Statement of Maturity will be issued stating that the technology is feasible. The technology is now ready to proceed to the Concept Verification Stage.

SECTION 4
Concept Verification Stage

1 Introduction

The second stage of the NTQ process is the Concept Verification Stage. The new technology is verified as performing its functions in accordance with defined performance requirements. This is accomplished by performing more detailed engineering studies and physical (or virtual) model testing. Reliability testing of select items may be performed. The operating conditions and the relevant environment are further refined. The functional and performance requirements outlined in the SRDD are re-evaluated, verified, and updated (as needed). The interfaces between configurations are verified against functional and performance requirements.

In addition, the production strategy is developed in the form of a preliminary manufacturing plan. A design risk assessment is carried out to identify technical risks related to design failures. Risk assessments from the Feasibility Stage are reviewed and updated (as needed) based on the design development in this stage.

3 Qualification Plan Activities

3.1 Engineering Evaluation

3.1.1 Engineering Design Review

At the Concept Verification Stage, the concept is confirmed and the engineering design is performed to verify that the functionality and performance of the new technology can be satisfied. The subsystem and component level requirements following the systems engineering approach should be defined if not specified at the Feasibility Stage. The objective is to define complete and consistent requirements an item should have and confirm that the design correctly and completely captures each specification in the system requirements.

The performance requirements should state how the technology will perform its function and how the system requirements will be met. The performance requirements are to be established and should be detailed enough that the technology can be evaluated against the expected performance criteria. In addition, the requirements for the integration of subsystems and components into system prototypes should be defined. The overall configuration of the system should be provided, and a preliminary interface analysis should be performed to verify the interfaces between configurations.

Design constraints should be identified and incorporated into the system requirements and design documentation. At this stage, the system requirements should be stated in quantitative measures

that can be verified by subsequent numerical or analytical models and model tests. The overall system requirements defined at the Feasibility Stage should be reviewed to confirm continued relevance. Any change should be reviewed and documented with technical justification.

A preliminary manufacturing plan should be developed and should include the manufacturing methods and processes, the facilities, the production schedule, and the quality assurance requirements. The materials used in the system should be determined and reviewed during the qualification process. The technology design documentation is to be submitted for ABS review.

3.1.2 Functional and Model Testing

Tests are an essential part of the NTQ process and they can demonstrate the performance of the new technology. The types of tests required depend on the novelty of technology itself and pre-existing experience with similar concepts.

Functional and model tests are used to verify the functionality of the system and its ability to meet the defined functional requirements. Testing is to be performed in the technologies anticipated environment and operating conditions. The objectives of the functional testing are to verify that the system meets the performance and reliability requirements, as well as to verify the results obtained from the analytical models. The functional testing should consider and address the critical failure modes identified during the risk assessments.

For the new materials or those that can have a significant effect on the performance of the system, destructive or non-destructive testing should be used to identify the relevant failure modes and mechanisms and to explore the critical parameters and their effects. The same raw materials or components stated in the material specification for the actual product should be used in the tests. For materials that will degrade over time, materials degradation testing should be performed. Accelerated testing methods may be used to test the lifetime performance of the materials in a shorter time. Additionally, reliability testing for select items may be required.

Before performing any testing, a test plan should be developed and submitted to ABS. The test plan should document the test setup and strategy that will be used to verify that a product meets its design specifications and other requirements. The specific test plans should include the assumptions and constraints, input data, test procedures, expected test results, the parameters to be measured, instrumentation system specifications, and the acceptance criteria for evaluating results. For certain tests, it may be required for an ABS Surveyor to witness the testing activities to verify that it meets performance requirements and confirm the presence of an effective quality control program. Further guidance on function and model testing can be found in references [10], [11], [12] and [13] listed in 1D-A2-8.

3.3 Risk Assessment

The objective of the risk assessment in this stage is to identify technical risks associated with the new technology design to the lowest level of indenture as practicable. The updated concept level design engineering documentation from the Feasibility Stage and the additional engineering documents developed in this stage serve as input to the risk assessment. This design risk assessment should take into account:

- Any design modifications from the Feasibility Stage
- Updated functional and performance requirements
- Updated configurations
- Possible interfaces and integrations
- All potential failure modes, failure causes and failure mechanisms in all expected operational modes and life cycle stages
- The effectiveness of existing risk control measures and the need for any additional or more reliable measures

- Closing out any action items (qualification activities) as agreed in the Feasibility Stage

Based on the findings of this risk assessment, additional qualification activities in the form of risk assessments or engineering evaluation may be required to further assist in identifying and assessing the full potential ranges of failure causes, failure mechanisms, consequences and any related uncertainties. These additional studies may be coarse, detailed, or a combination depending on the objective of the study. The results of the risk assessment should be documented and tracked in a hazard register for assessment and implementation in future qualification stages. The resulting qualification activities should be documented within the NTQP. A risk assessment report including the hazard register should be prepared. The risk assessment report and the NTQP should be submitted to ABS for review.

A risk assessment methodology that is appropriate for reviewing the new technology design should be sele cted and submitted as part of the risk assessment plan to ABS. Potential design related failure events in all anticipated operational modes should be evaluated. Typically, for hardware or mechanical systems, a Failure Mode Effects and Criticality Analysis (FMECA) is recommended. The FMECA performed can help evaluate failure modes and corresponding failure causes, failure mechanisms, and the local and global effects of failure. It also includes a criticality analysis which is used to estimate the probability of failure and the severity of the associated consequence. The probability can be qualitative if lacking historical quantifiable data, but quantitative probabilities are preferred. The method of assigning criticality should be included within the risk assessment plan and agreed by ABS prior to the study. Results from the FMECA should be relayed back to the design process of the new technology to facilitate any design improvements or FMEA verification activities. Further guidance on FMECA and related verification activities can be found in the ABS *Guidance Notes on Failure Mode and Effects Analysis for Classification*.

The following risk assessments verifying all technical risks are to be performed and submitted to ABS for review.

i) Design risk assessment (e.g., FMECA) as described above.

ii) Update Feasibility Stage risk assessments as needed based on updated design documentation.

iii) Perform any additional risk assessments identified while verifying the design and/or updating previous risk assessments.

If reliability, availability and maintainability (RAM) targets are defined as part of the functional requirements then a preliminary system RAM analysis should be carried out in this stage. System modeling techniques such as reliability block diagrams (RBD), fault tree analysis (FTA), Markov state diagrams or other established methods should be used to demonstrate the ability of the system to meet the defined performance requirements. The FMECA serves as input to the system reliability models along with the other engineering documentation developed at this stage. A RAM analysis should be prepared and submitted for ABS review. The data sources used, their applicability and any related assumptions should be documented within this report.

5 Summary of Submittals

The following qualification activities along with future activities to be addressed in the Prototype Validation Stage should be highlighted in the NTQP and submitted to ABS for review:

5.1 Engineering Evaluation

i) SRDD

a) Documents that describe the concept verification design requirements

b) Design documents that include but not limited to the configuration, drawings, PFD/P&ID, and analytical models

c) Functional and model test plans, test data (as requested), and test results

ii) Preliminary manufacturing plan

i) Updated risk assessments from the Feasibility Stage (as applicable)

ii) Updated Hazard Register with updated action items closed out

iii) Preliminary design risk assessment (e.g., FMECA) report

iv) Preliminary system RAM analysis report (as applicable)

7 Concept Verification Stage Completion: Concept Verified

Once the above have been submitted to ABS for review and all specified performance requirements have been verified, a Statement of Maturity will be issued stating that the concept has been verified. The technology is now ready to proceed to the Prototype Validation Stage.

PART 1D

APPENDIX **2**

Guidance on Qualifying New Technologies

SECTION **5**

Prototype Validation Stage

1 Introduction

The third stage of the NTQ process is the Prototype Validation Stage. New technology that has matured to this stage has previously completed conceptual functional, performance, and reliability testing in nonspecific environments. The main objective in this stage is to validate with a prototype what was verified in the Concept Verification Stage.

During this stage, the technology is further developed to the point where a prototype or full scale production unit can be manufactured. All engineering studies and design risk assessments are completed and the design is refined to the detailed design. Engineering documents such as detailed drawings, product specifications, manufacturing plan and qualification test procedures are all fully developed. A preliminary system-of-systems interface analyses may be performed and system integration testing plan developed. Process risk assessments may be carried out (as needed) to evaluate relevant procedures and further refine them.

A prototype or full scale production unit is manufactured and all necessary qualification testing is carried out to validate the design. After completing this stage, the new technology has demonstrated that it can perform within the established performance requirements in a simulated or actual environment for an extended period of time.

3 Qualification Plan Activities

3.1 Engineering Evaluation

3.1.1 Engineering Design Review

At the Prototype Validation Stage, the engineering design is to confirm that the overall system, down to the lowest component level, has satisfied all system requirements. The performance requirements a technology should meet should be finalized and measurable. In addition, the requirements for system integration, installation, commissioning, operation, maintainability, and decommissioning should be established.

At this point the system has reached the necessary level of maturity to start fabricating, integrating, and testing. Changes in the requirements defined for any items during the previous stages should be reviewed and documented with technical justification.

At this stage, all design analyses and configuration definitions are completed and all design decisions that are outstanding are to be finalized. It is noted that there may be a need to revisit certain analytical and other relevant studies based on results of the prototype test. Detailed drawings including all dimensional requirements, process and instrument details, safety features and ancillary systems are completed as applicable. For load bearing components, all relevant loading and the uncertainty in that loading are analyzed. For process and electrical systems, all associated potential system failure/breakdowns and their associated failure frequencies (if applicable), as well as the consequence and impact on the system from each failure are identified.

In addition, all information (e.g., drawing and data) required for the production of the system are to be finalized. The actual performance of the new technology should be evaluated during prototype testing and compared against existing designs if available. The aforementioned design engineering documents are to be submitted to ABS for review. A preliminary system-of-systems interface analyses and system integration testing plan may be developed at this stage and submitted to ABS for review before the System Integration Stage.

3.1.2 Prototype Testing

Prototype testing is intended to prove that the interactions between the systems/subsystems/components under relevant loading and environmental operating conditions can perform reliably as intended. Prototype tests can identify potential failure modes and mechanisms as well as the critical parameters, especially when operational experience in relevant environments is limited or unknown.

Prototype testing can be used to verify the analytical models and the assumptions made during the engineering design process. A test plan which details test techniques, test limits, expected test data, quality assurance requirements should be developed and submitted to ABS for review before prototype testing. Calibration of measuring devices is to be current with manufacturer's quality management system. Calibrations should be traceable to a recognized national standard (e.g., NIST, ANSI, etc.).

For certain new technologies, it may be very difficult to perform prototype testing in the actual environment. In this case, virtual prototype testing in a simulated environment can be performed. However, the virtual prototype testing should be reviewed by ABS to assess that the simulated environments are commensurate with expected operational practices. Analysis tools, such as finite element analysis(FEA) and computation fluid dynamics (CFD), and other methods used should be qualified for application. The prototype testing documents should include inputs, assumptions, boundary conditions, the computational models and appropriately conditioned/reported test results. Prototype test results should be documented and analyzed to determine whether the prototype satisfies specified functional and performance requirements in its actual environment. A prototype test report is to be submitted to ABS for review. Further guidance on prototype testing can be found in references [10], [12], [13] and [14] listed in Section 1D-A2-8.

3.1.3 Manufacturing

A manufacturing plan should be finalized that includes the manufacturing methods and processes, the facilities, the production schedule, and quality assurance requirements. Quality assurance of the manufacturing process should confirm that the product meets the required specifications. The manufacturing plan should be submitted to ABS for review. Further guidance on developing a manufacturing plan can be found in references [15], [16] and [34] listed in Section 1D-A2-8.

3.1.4 ABS Survey

Survey during the manufacturing process and prototype testing may be required. The vendor should submit an Inspection Test Plan (ITP) to ABS for review. The ITP should define witness points and hold points as agreed between the vendor and ABS. The ABS Surveyor should witness the manufacturing process and prototype testing to verify that proper manufacturing and prototype testing processes are followed, and they meet the quality assurance requirements.

3.3 Risk Assessment

The main objective of the risk assessments performed in the Prototype Validation Stage is to validate the final design of the new technology. The design risk assessment (e.g., hardware design FMECA) from the Concept Verification Stage should be reviewed and updated to evaluate changes to the design and/or other aspects of the new technology description. Changes made to one part of the design or new technology design requirements could have the potential to introduce new technical risks to other previously evaluated parts. The results of other qualification activities in this stage may also serve as input to the updated design risk assessment. Follow-on qualification activities determined from the results of the updated design risk assessment should be included within the NTQP.

For certain new technologies with high consequence severity levels upon failure, if not already addressed by other risk assessments, ABS may recommend that an additional process risk assessment (e.g., process FMECA or HAZOP) is performed. The objective of this risk assessment is to evaluate the potential failures that could occur during specific steps as listed within the procedures. This process risk assessment typically evaluates procedures related to manufacturing (as defined within the final manufacturing plan), testing (prototype and systems integration), installation/integration, commissioning, operations and decommissioning. A risk assessment technique that is appropriate for reviewing these procedures should be selected and submitted as part of the risk assessment plan to ABS for review. Typically, a process FMECA or HAZOP study is recommended. It is recognized that the scope of this risk assessment depends on the availability of relevant procedures. All interfaces should also be considered when performing this assessment. The recommendations from the study should be used by the engineering design team and the operations team to determine any design improvements or procedural changes necessary before finalizing the design and manufacturing.

Based on the findings of the final design risk assessment and process risk assessment (if applicable), a re-evaluation of all previous risk assessments should be considered. All previous risk assessments should be reviewed against any newly identified failure modes or hazards. Changes made to the design due to findings in these risk assessments should also be checked against the final functional and performance requirements.

Finally, all identified technical risks from the Prototype Validation Stage and risk assessments from previous stages should be appropriately managed through any necessary design improvements. All corresponding action items should be closed in order for the new technology to complete this stage of the NTQ process.

The following final design level risk assessments verifying all technical risks are to be performed and submitted to ABS for review:

i) Final design risk assessment (e.g., design FMECA)

ii) Final process risk assessment (e.g., process FMECA or HAZOP) if applicable

iii) Update all previous risk assessments as needed based on updated final design level documentation

iv) Final hazard register based on the final design with all actions items closed out

If applicable, the preliminary RAM analysis should be re-evaluated and finalized. The final RAM analysis report should be submitted for ABS review.

5 Summary of Submittals

The following qualification activities along with future activities for the System Integration Stage should be highlighted in the NTQP and submitted to ABS for review:

5.1 Engineering Evaluation

i) SRDD

- Review engineering documents that describe the component requirements and the interaction between components, subsystems, and the overall system if applicable.

- Detailed design documents including detailed drawings, product specifications, process and instrument details, detailed calculations, etc.
- Prototype test plans, test data (as requested), and test results summarized in a report.
- Additional qualification testing, data, and results identified in the design risk assessment (e.g., FMECA).

ii) Inspection Test Plan (ITP)

iii) Detailed manufacturing plan.

5.3 Risk Assessment

i) The final updated risk assessment reports from the Concept Verification Stage (as applicable).

ii) The final design risk assessment (e.g., FMECA) report.

iii) The process risk assessment (e.g., process FMECA) report (as applicable).

iv) The final system RAM analysis report (as applicable).

v) Final hazard register with all action items closed out

7 Prototype Stage Completion: Technology Qualified

Once the above deliverables have been submitted to ABS for review and all specified performance requirements have been verified, a Statement of Maturity will be issued stating that the technology has been qualified. The technology is now ready to proceed to the System Integration Stage.

9 ABS Type Approval Program

Upon completion of the Prototype Validation Stage of the NTQ process, the new technologies that are consistently manufactured to the same design and specification may be Type Approved under the ABS Type Approval Program to limit repeated evaluation of identical designs. During the Prototype Validation Stage, if all the engineering evaluations have been completed, a PDA can be issued prior to further consideration for ABS Type Approval.

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SECTION 6

Systems Integration Stage

1 Introduction

The fourth stage of the NTQ process is the Systems Integration Stage. In this stage, discussions between the vendor and end-user are held to understand the compatibility of the technology with final operating system and operating environment. An interface analysis is performed to confirm the compatibility of the item. The technical risks during operations that have not been addressed during previous risk assessments are evaluated and relevant reports updated. All necessary risk control measures are implemented.

The "Technology Qualified" item is then integrated (by installation) with the final intended operating system. All functional and performance requirements of the integrated system as outlined in the SRDD are validated through testing before (or during) commissioning. Plans for in-service survey, inspection, monitoring, sampling and testing (as applicable) are determined.

3 Qualification Plan Activities

3.1 Engineering Evaluation

3.1.1 System Interface and Integration Requirement

At this stage the overall technology goals and requirements may remain unchanged. However, specific requirements for system-of-systems functionality and interfaces should be finalized. In addition, the detailed operational performance parameters should be defined and operational procedures should be developed. System interface and integration requirements are to be submitted to ABS for review.

3.1.2 Interface Analysis

It should be analyzed that the addition or incorporation of the new technology does not negatively affect the integrity of the surrounding systems and components. All necessary functional and physical interfaces (e.g., mechanical, electrical, environment, data, human, etc.) and other systems should be reviewed and verified that the new technology does not adversely affect those systems. At this stage, the interfaces should be specified in quantitative limiting values, such as interface loads, forcing functions, and dynamic conditions. The use of tables, figures, or drawings is recommended as appropriate. The vendor/end-user should provide detailed interface control methods or other engineering solutions so that the new technology is compatible with the integrated systems. The complete interface analysis and necessary engineering solutions are to be submitted to ABS for review.

3.1.3 System Integration Testing (SIT)

The operational prototype is built and integrated into the final system. Full interface and function test programs are performed in the intended (or closely simulated) environment. The impact of the new technology on the performance and integrity of other systems as well as the impact of other systems on the new technology itself should be addressed. An initial operational test and evaluation should be performed to assess the operational effectiveness and suitability in the intended environment. The operational test should demonstrate that the operational aspects associated with placing the application in a marine or offshore environment are commensurate with typical operational practice for these facilities. Changes to the technology design or operational procedures may be necessary to address any issues encountered during operational testing. A test plan which details test techniques, test limits, expected test data, quality assurance requirements should be developed and submitted to ABS for review before the system integration testing. All test procedures and test results are to be summarized in a report and submitted to ABS for review.

3.1.4 ABS Survey

Survey during the system integration testing may be required as agreed upon in the system integration test plan. ABS Surveyor will witness the system integration testing to verify that proper testing processes are followed and it meets the quality assurance requirements based on the witness points as agreed between the vendor/end-user and ABS.

An In-Service Inspection Plan (ISIP) to address in-service survey, inspection, monitoring, sampling and testing (as applicable) during operations should be submitted for ABS review.

3.3 Risk Assessment

The main objective of the risk assessments performed in the System Integration Stage is to evaluate any technical risks resulting from system integration and operations that have not been previously evaluated as part of the design risk assessment, process risk assessments or other risk assessments in the previous stages. The end-user should manage any additional/residual risks identified through appropriate risk control measures.

An appropriate risk assessment technique should be selected and submitted as part of the risk assessment plan to ABS for review. The use of a process FMECA, HAZOP or HAZID are recommended. The scope of this risk assessment typically includes installation, SIT, commissioning, operations and decommissioning. The assessment should consider all interfaces between the validated prototype and the connected system (system-of-systems). Follow on qualification activities may be determined from the results of the risk assessment such as engineering evaluation, testing, design improvements or procedure changes. These activities should be addressed within the NTQP. All risk control measures should be implemented and any outstanding action items from the risk assessment closed before proceeding with system integration testing and commissioning.

The need for updates to any previously submitted risk assessments or RAM analysis should be evaluated and addressed as appropriate. Updated risk assessment reports including hazard registers, RAM analysis (if applicable) and the NTQP should be submitted for ABS review.

5 Summary of Submittals

The following qualification activities along with future activities for the Operational Stage should be highlighted in the NTQP and submitted to ABS for review:

5.1 Engineering Evaluation

i) SRDD

- All documents that describe detailed operational procedures and performance parameters.
- System integration test plans, test data, and test results summarized in a report.

- Plans for in-service survey, inspection, monitoring, sampling and testing (as applicable) during operations or ISIP.
- All documents that describe requirements for system-of-systems functionality and interfaces.

5.3 Risk Assessment

i) Updated risk assessment reports from the previous stages (as applicable)

ii) Other applicable technical safety studies (e.g., RAM).

7 System Integration Stage Completion: Technology Integrated

Once the above deliverables have been submitted to ABS for review and all specified performance requirements have been verified, then a Statement of Maturity will be issued stating that the technology is integrated. The technology is now ready to proceed to the Operational Stage.

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Operational Stage

1 Introduction

The last stage of the new technology qualification process is the Operational Stage. New technology categorized as "Operationally Qualified" denotes that it has been integrated into the final system and has been operating successfully in service in the relevant operational environment.

Once the technology has been qualified at the Prototype Stage, it should be confirmed that the knowledge gained by the engineering and risk assessment tests and studies is fed into the operational stage, in order to monitor prior assumptions and predictions through in-service field verification. In other words, the first implementation of any new technology should be treated as a first-time application to some extent. This Section will outline the necessary activities that should be completed and the information to be supplied to ABS during this stage. It is recommended that the qualification process involves members with operational background in this stage of the project. These members should become familiar with the results of all the previous qualification stages if they had not participated from the start of the qualification process.

At this stage, the operational objectives, operating environment, and the performance requirements established during design are reviewed and applied to define goals for in-service operation. Following successful operation and performance achievement of the goals in the actual operational environment, the technology can be granted a Statement of Maturity.

The activities of the Operational Stage are as follows:

i) Implementation of in-service survey, inspection, monitoring, sampling and testing plans

ii) Collection and analysis of reliability, availability, maintainability (RAM analysis) and other operational performance data as needed

iii) Comparison of operational data above with previously specified performance requirements, goals and criteria

iv) Performance of root cause analyses for any observed failure and using feedback to introduce modifications for improvement

v) Comparison of observed parameters with any critical assumptions made during the previous qualification stages and updating calculations as necessary

It is to be noted that when applying this Appendix for classification or certification purposes, the primary driver for classification acceptance will be safety even though there may be additional functional

requirements (e.g., reliability, ability to perform as per operational design specification) defined by the client.

3 Qualifications Plan Activities

The need and extent of special in-service qualification requirements are dependent upon the justifications and risk assessment results during the design and qualification process. System requirements have been started to be defined in the Feasibility Stage of qualification, and they have been updated in later stages as the design evolved. Such requirements have to be translated into specific and quantifiable performance requirements to be attained during operations. Additionally, any critical assumptions made in the risk assessment and engineering evaluations during the four previous qualification stages should be monitored to confirm that operational experience does not disprove them. Taking all the above into consideration, the vendor and/or end-user together with ABS should outline the necessary elements of in-service survey, inspection, monitoring, sampling and testing needed to gain confidence in the real world application of the new technology.

These special requirements can be integrated in the end-user's Asset Integrity Management program. Advanced inspection and maintenance approaches like Reliability Centered Maintenance (RCM) and Risk Based Inspection (RBI) are appropriate strategies to follow since they are based on reliability and risk goals. Data collection and management are very important activities to consider for the in-service qualification stage.

The amount of operational history that is sufficient to verify performance requirements during operations depends on several factors, including actual equipment run time, failure rate and exposure time to failure. Therefore, the time to reach the "Operationally Qualified" status for the proposed new technology will be determined on a case-by-case basis.

All records related to the inspection, monitoring, sampling and testing of the new technology as established by the agreed-upon operational qualification plan or ISIP should be kept and made available for review upon request by ABS at any time. These records will be reviewed periodically to establish the scope and content of the required surveys that should be carried out by ABS.

The following references contain additional guidance for in-service monitoring, sampling, testing and inspection plans:

- ABS *Guidance Notes on Equipment Condition Monitoring Techniques*
- ABS *Guidance Notes on Reliability-Centered Maintenance*
- ABS *Guide for Surveys Using Risk-Based Inspection for the Offshore Industry*
- ABS *Guidance Notes on the Investigation of Marine Incidents*
- ABS *Guide for Hull Condition Monitoring Systems*
- ABS *Guide for Hull Inspection and Maintenance Program*
- ABS *Guide for Building and Classing Subsea Pipeline Systems*
- API RP 17N Recommended Practice Subsea Production System Reliability, Technical and Integrity Management

5 Summary of Submittals

The output of this stage is a report reviewing the operational data collected and demonstration that the specified performance requirements and criteria have been met.

The following items are typical submittals that ABS would expect to receive annually to conduct an Operational Stage audit:

- Summary report of results of the inspection, monitoring, sampling and qualification testing activities
- Failure data analysis of critical components
- Non-conformance reports and corrective actions taken

Note:

In case of a non-conformance report for a critical component, ABS should be notified as soon as practical.

7 Operational Stage Completion: Operationally Qualified

Once the operational experience of the new technology has proven to be successful (i.e., according to the expected performance, for a satisfactory amount of time in the actual operating environment, and meeting criteria acceptable by ABS), then a Statement of Maturity stating the operational qualification of the technology will be issued.

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11) Military Handbook 781A (MIL-HDBK-781A), *Handbook for reliability test methods, plans, and environments for engineering, development qualification, and production,* 2015.

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17) ABS *Guidance Notes on Reliability-Centered Maintenance*. Houston, TX.

18) ABS *Guide for Surveys Using Risk-Based Inspection for the Offshore Industry*. Houston, TX.

19) ABS *Guidance Notes on the Investigation of Marine Incidents*. Houston, TX.

20) ABS *Guide for Hull Condition Monitoring Systems*. Houston, TX.

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23) ABS *Guide for Ergonomic Notations*. Houston, TX.

24) ABS *Guidance Notes on the Implementation of Human Factors Engineering into the Design of Offshore Installations*. Houston, TX.

25) ABS *Rule for Crew Habitability on MOUs*. Houston, TX.

26) ABS *Guide for Crew Habitability on Offshore Installations*. Houston, TX.

27) ABS *Guidance Notes on the Application of Ergonomics to Marine Systems*. Houston, TX.

28) ABS *Guidance Notes on Ergonomic Design of Navigation Bridges*. Houston, TX.

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31) Industry Association and the Federation of Norwegian Engineering Industries (NORSOK). *Working environment (S-002)*, 2004.

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35) ABS *Guidance on Review and Approval of Novel Concepts*. Houston, TX, provided in Appendix 1 of this document.

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SECTION **9**

Comparison of ABS Qualification Stages with Industry TRLs

1 Introduction

Technology Readiness Levels (TRLs) are a method of estimating the maturity level of new technology. There are a wide variety of scales in industry based on the ISO 16290 standard. This standard uses a numerical scale one through nine, with nine representing the most mature. The American Petroleum Institute (API) uses a scale ranging from zero to seven. Although the definitions of these levels differ slightly (space systems vs oil and gas), the fundamental philosophy remains the same. ABS has developed a stage gate process compatible with the wide range of TRLs (API, US DoD, ISO 16290). However, the numbers levels presented have now been replaced by a series of qualification stages. Comparison of the ABS definition and the industry TRLs are provided in the table below.

TABLE 1
ABS Qualification Stages Comparison with Various Industry TRLs

ABS Qualification Stage	*API RP 17N/Q TRLs*	*US DoD TRLs*	*ISO 16290 TRLs*
Feasibility Stage	0	1	1
	1	2	2
Concept Verification Stage	2	3	3
		4	4
Prototype Validation Stage	3	5	5
	4	6	6
System Integration Stage	5	7	7
	6	8	8
Operational Stage	7	9	9

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SECTION **10**

New Technology Stage Determination

1 Introduction

In order to estimate the current qualification stage of a proposed a new technology, the following table should be used. The questions therein serve as general guidance to understand the design maturity of the technology based on completed qualification activities and thus determine the corresponding qualification stage. The client's design team, ABS, and other identified stakeholders should agree upon the qualification stage identified. All supporting documentation justifying affirmative answers are to be submitted to ABS for review. Negative answers will be reviewed on a case-by-case basis to determine applicability of the question to the technology.

Qualification Stage	*Item #*	*Question*	*Yes/No/NA*	*Evidence to support?*
Feasibility Stage	1	Has what is specifically new and/or unique about the concept been clearly identified?		
	2	Has what specifically needs qualification been defined?		
	3	Have potential applications been identified?		
	4	Have goals, functional requirements, and fundamental objectives (e.g., RAM) for the identified application been identified?		
	5	Have basic functionality and durability of the technology been analyzed?		
	6	Have basic principles been observed and reported?		
	7	Have lessons learned from similar technology been reviewed and documented?		
	8	Have basic design calculations been performed?		
	9	Have conceptual research and development been completed?		
	10	Has a preliminary list of reliability drivers been prepared?		
	11	Has a preliminary fitness assessment (physical interfaces, human etc.) been performed?		
	12	Can engineering drawings(basic configurations, interfaces, and/or PFD's or flow charts) and calculations be submitted for review?		
	13	Have any early stage risk assessment and mitigation studies been performed and documented?		
Concept Verification Stage	14	Has the concept functionality been demonstrated by physical models or "mock-ups"?		
	15	Have laboratory scale material testing and degradation mechanisms been performed?		
	16	Have all conceptual design engineering studies been completed?		
	17	Have preliminary function/performance/reliability engineering studies been completed?		
	18	Have reliability drivers been confirmed?		
	19	Is there documentation that RAM requirements can likely be met?		
	20	Has durability been confirmed by testing or calculation?		
	21	Has a viable manufacturing or fabrication scheme been documented?		
	22	Has preliminary qualitative design risk analysis(e.g., FMECA) been documented?		
	23	Have the initial risk assessments been reviewed/updated to identify any additional technical risks?		

Qualification Stage	*Item #*	*Question*	*Yes/No/NA*	*Evidence to support?*
Prototype Validation Stage	24	Have all items in the manufacturing of the technology been specified?		
	25	Has the manufacturing and assembly process been accepted?		
	26	Has a prototype or full scale production unit been manufactured?		
	27	Has the manufacturing and assembly defects been removed by stress screening?		
	28	Has the technology passed basic functionality testing of prototype (physical or virtual) or full scale product to demonstrate fitness and function capability in a simulated or actual operating environment?		
	29	Has a performance data collection system been established and properly documented?		
	30	Has the technology passed performance, durability, and accelerated life tests?		
	31	Is the degradation of function/performance within expected acceptable limits?		
	32	Has the technology passed system reliability analyses?		
	33	Has the operating/destruct limits been established or confirmed?		
	34	Has the degradation limits and rates been established or confirmed?		
	35	Has the required in-service monitoring needs and means been identified?		
	36	Has a process risk assessment (e.g., process FMECA) been performed and documented (if applicable)?		
	37	Has the final design risk assessment (e.g., FMECA) been completed for all life cycle modes (including assembly, transit, storage, installation, hook-up, commissioning, operation, decommissioning) for all interface permutations and properly documented?		
	38	Have the residual risk and uncertainty been estimated and properly documented?		
	39	Has the reliability study been updated and properly documented?		

Qualification Stage	*Item #*	*Question*	*Yes/No/NA*	*Evidence to support?*
System Integration Stage	40	Has the design risk assessment (e.g., FMECA, HAZOP) considering full system interfaces been updated and properly documented?		
	41	Have all other technical risks and functional requirements been identified/addressed and properly documented?		
	43	Has the function/performance when connected/integrated into a wider system been fully tested?		
	44	Have all mechanical, hydraulic, optical, electronic, software, etc. and human interfaces been fully addressed and documented?		
	45	Have all system integration requirements been confirmed?		
	46	Has installation/hook-up/testing/commissioning with a wider system been completed as per specifications?		
	47	Is there a data collection system in place to document performance and reliability?		
	48	Has a detailed in-service inspection/monitoring/sampling plan been defined and properly documented?		
	49	Can inspection/monitoring/sampling functionality be validated?		
Operational Stage	50	Has the technology demonstrated acceptable reliability and availability in the targeted operating environment?		
	51	Has the in-field service monitoring, sampling, and inspection plan been successfully implemented?		
	52	Has reliability and integrity performance data been properly collected, analyzed, and documented?		
	53	Have any underperforming components of the technology been identified?		
	54	If so, then has there been any reliability improvements for failed or underperforming components?		
	55	Has there been any performance feedback from projects or suppliers?		
	56	Have any unexpected aspects (e.g., interdependencies or influences on performance) or safety concerns been observed?		
	57	Has the technology been reliable for at least one survey (or maintenance or planned replacement) cycle or agreed upon time period as indicated in the SRDD or in-service inspection plan (ISIP)?		
	58	Has the design risk assessment (e.g., FMECA) been updated with in-service performance data?		
	59	Has the system reliability assessment been updated and properly documented?		

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SECTION **11**

New Technology Qualification Plan (NTQP) Template

1 Introduction

The New Technology Qualification Plan (NTQP) should be a high level document that tracks the maturity level and status of qualification activities. These activities help verify and validate the new technology's ability to qualify all desired NTQ stages. The document is not meant to be a collection of engineering reports, methodologies, test data, or plans. The NTQP is to be updated throughout qualification process.

The following sections provide a recommended template for submitting an NTQP as part of the new technology qualification process.

3 New Technology Qualification Plan (NTQP) Template

Executive Summary

3.1 Introduction

- Summarize the project objectives.
- Provide an overview of the new technology and its application.
- Describe current status of design and qualification activities.
- Provide key points of contact.

3.2 New Technology Screening and Stage Determination

3.2.1 System Requirements Overview

- Summarize defined system goals, functional and performance requirements (with reference to appropriate SRDD document(s)).

3.2.2 New Technology Screening

- Summarize the results of the new technology stage determination process.

3.2.3 New Technology Stage Determination

- Summarize the results of the new technology stage determination process.

3.3 New Technology Qualification Activities

- For each new technology item being qualified, list all qualification activities including the following details for each activity

  i) Summarize the qualification activity (scope, objective and method)

ii) Performance Requirement and its source.

iii) Identify the stage in which this qualification activity was determined.

iv) Provide reference to appropriate engineering evaluation report or risk assessment report (include corresponding hazard register nodes) from which this activity was determined.

v) Scheduled Timelines (start/finish).

vi) Provide reference to appropriate engineering evaluation or risk assessment reports that documents the results of the qualification activity.

vii) Comments from the Client & ABS

3.4 References Appendices:

Appendix 1 Summary of Previous Qualification Activities

List all previously completed qualification activities prior to NTQ process with references to appropriate reports.