Guidance for Classification and Construction

Part 1 Seagoing Ships

GUIDANCE ON REVIEW AND APPROVAL OF NOVEL DESIGN

Volume Z

2023 Edition

Biro Klasifikasi Indonesia

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Guidance for Classification and Construction

Part 1 Seagoing Ships

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The following Guidance come into force on 1st July 2023.

Foreword

With the accumulation of experience and know-how practical application in shipbuilding, BKI have been developed this Guidance on Review and Approval of Novel Design (Pt.1, Vol.Z) 2023 Edition intended for Novel Concept approval.

This Guidance accommodates the review and approval of novel concepts as a main chapter in conjunction with the process of qualifying new technology, change management and determination of safety standards as the basis for the classification of ships or facilities which are presented in three Chapters, namely:

- Chapter 1 – Review and Approval of Novel Concepts
- Chapter 2 – Qualifying New Technologies
- Chapter 3 – Management of Change for the Marine and Offshore Industries

The whole procedure and example of procedure for classification of novel design are pictured clearly on those Sections and Annexes.

This Guidance is available to be downloaded at www.bki.co.id. Once downloaded, this Guidance will be uncontrolled copy. Please check the latest version on the website.

Further queries or comments concerning this Guidance are welcomed through communication to BKI Head Office.

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Section 1 Introduction

A. General

This Chapter provides guidance to BKI clients regarding the methodology for classification of novel concepts. An asset such as a ship or an offshore unit becomes a novel concept if the incorporation of any new technology(ies) appreciably alters its service scope, functional capability, and/or risk profile. It is important to note that the term 'novel concept' refers to the entire concept of a ship or facility that incorporates a new technology such as a system or subsystem or an individual component. In order to help determine if a proposed design falls into the "novel" category, Annex B provides a novel concept checklist to gain a general understanding of the variation from existing or proven ship or offshore applications, and thus the degree of novelty. The Chapter presented herein are more suited to an application with a high degree of novelty. If a client is proposing an alternative to one or a small number of current Rules requirement(s), it may be more appropriate to follow the methodologies outlined within the Guidance for Risk Evaluations for the Classification of Marine Related Facilities (Pt.4, Vol.A) in order to gain BKI approval.

This Chapter is intended to work in conjunction with Chapter 2. As qualifying the individual new technologies by using the 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 Chapter 2, Section 2 in order to better understand the NTQ process. It is important to note that the primary focus of novel concept classification is on safety even through the qualification of individual new technologies may have additional functional requirements as requested by the client (e.g., reliability).

The Novel Concept Class Approval process is the process for obtaining class approval for an asset that incorporates new technologies. The process draws upon engineering evaluations and risk assessments in order to determine if the concept provides acceptable levels of safety in line with current offshore and marine industry practice. Once the engineering evaluations and the risk assessment have shown that the proposed novel concept is feasible, BKI will prepare a statement-of-compliance letter attesting to the feasibility of the novel concept and the approval in principle granted in so far as class and statutory issues are concerned, allowing the project to move into the next approval stage. Once the required documents for the final class stage have been completed and all comments addressed, BKI 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 (e.g., owner/operators, shipyards, etc.) of the Novel Concept Class Approval process is preferably to include the end-users or system integrators who integrate new technologies qualified through the NTQ process with conventional technologies and/or the asset. While the NTQ process aids vendors in qualifying new technologies by setting a path for interactions between new technologies and conventional technologies, the Novel Concept Class Approval process takes this a step further by working with both vendors and end-users to fully implement these systems in order to achieve final class approval for the asset.

The overall class approval process for a novel concept is divided into four milestones. First milestone is to determine the most appropriate approval route to obtain class approval. Second is the Approval in Principle (AIP) stage which is an intermediary concept review that confirms feasibility, outlines when and what to submit, the subsequent review process, and potential outcomes. The third milestone builds on the AIP, with the project moving forward concept design phase into detailed design, construction, installation and

ultimately issuance of BKI 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 BKI would follow to achieve these milestones is outlined below in Fig. 1.1. The figure also illustrates the alignment of the new technology qualification process with the evolution of a novel concept.

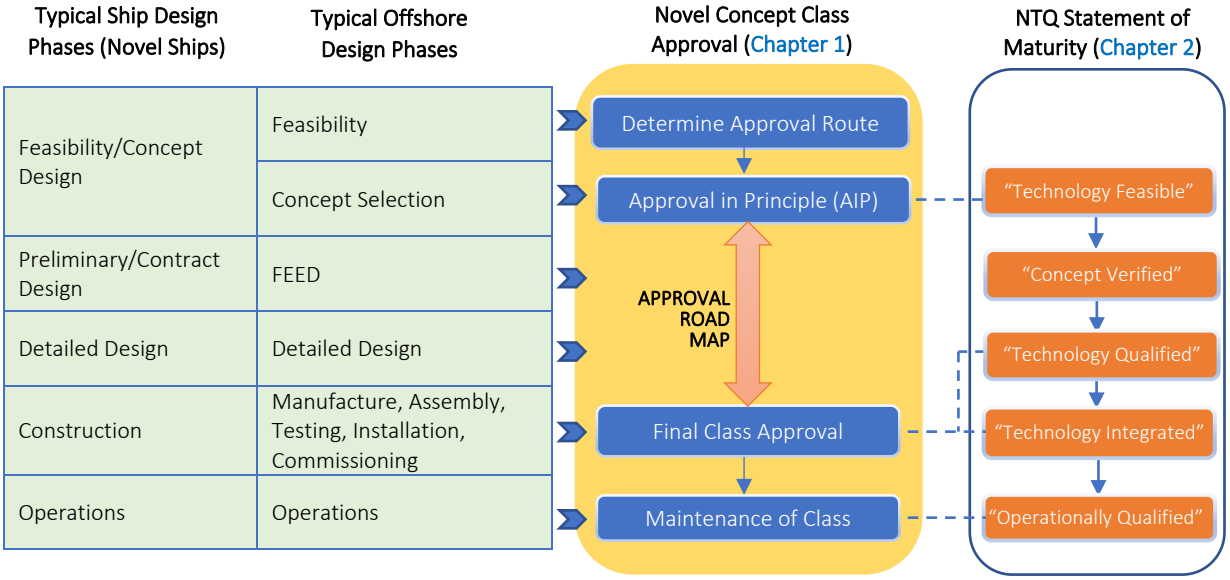

Fig. 1.1 Novel Concept Class Approval Process

B. Class Approval Process

After an asset has been determined to be a novel concept based on a review of the checklist in Annex B and discussions with BKI, then BKI and the client will agree upon a systematic approach to reaching each of the milestones identified in Fig. 1.1. A brief description of these milestones is as follows:

1. Milestone 1: Determine Approval Route

After the client requests qualification of a novel concept using these Guidance, a project kick-off meeting is scheduled. At this meeting, the client presents to BKI an overview of their asset, any known novel aspects along with their expectations and project timelines. BKI and the client will discuss to confirm if the methods presented in these Guidance or Guidance for Risk Evaluations for the Classification of Marine Related Facilities (Pt.4, Vol.A) or a traditional class design review is more appropriate for the application in question.

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

For identified new technologies, BKI 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 Chapter 2.

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

It is realized 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.

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

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

The key considerations in order to achieve AIP include:

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

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

The Approval Road Map typically contains the following information:

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

Further information regarding requirements of the documents to be submitted for AIP are described in Section 2.

3. Milestone 3: Final Class Approval

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

Further information regarding requirements of the documents to be submitted for Final Class Approval are described in Section 3.

4. Milestone 4: Maintenance of Class

As a final condition of class approval, BKI 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, BKI Annual Renewal Surveys, comparable to a Class Renewal Survey, may be necessary as a condition of Class or to gather information necessary to refine its developing Rules for these applications.

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

Further information regarding requirements of the documents to be submitted for Maintenance of Class are described in Section 4.

Fig. 1.2 outlines the process flow for novel concept approval and Class following these Guidance. The process essentially involves conducting certain engineering evaluations and risk assessments equivalent to the level of detail available in the particular project phase with the aim of achieving Class approval. In certain instances, this process will require the intermediate AIP milestone. In other instances, this step may be bypassed as shown on the flowchart.

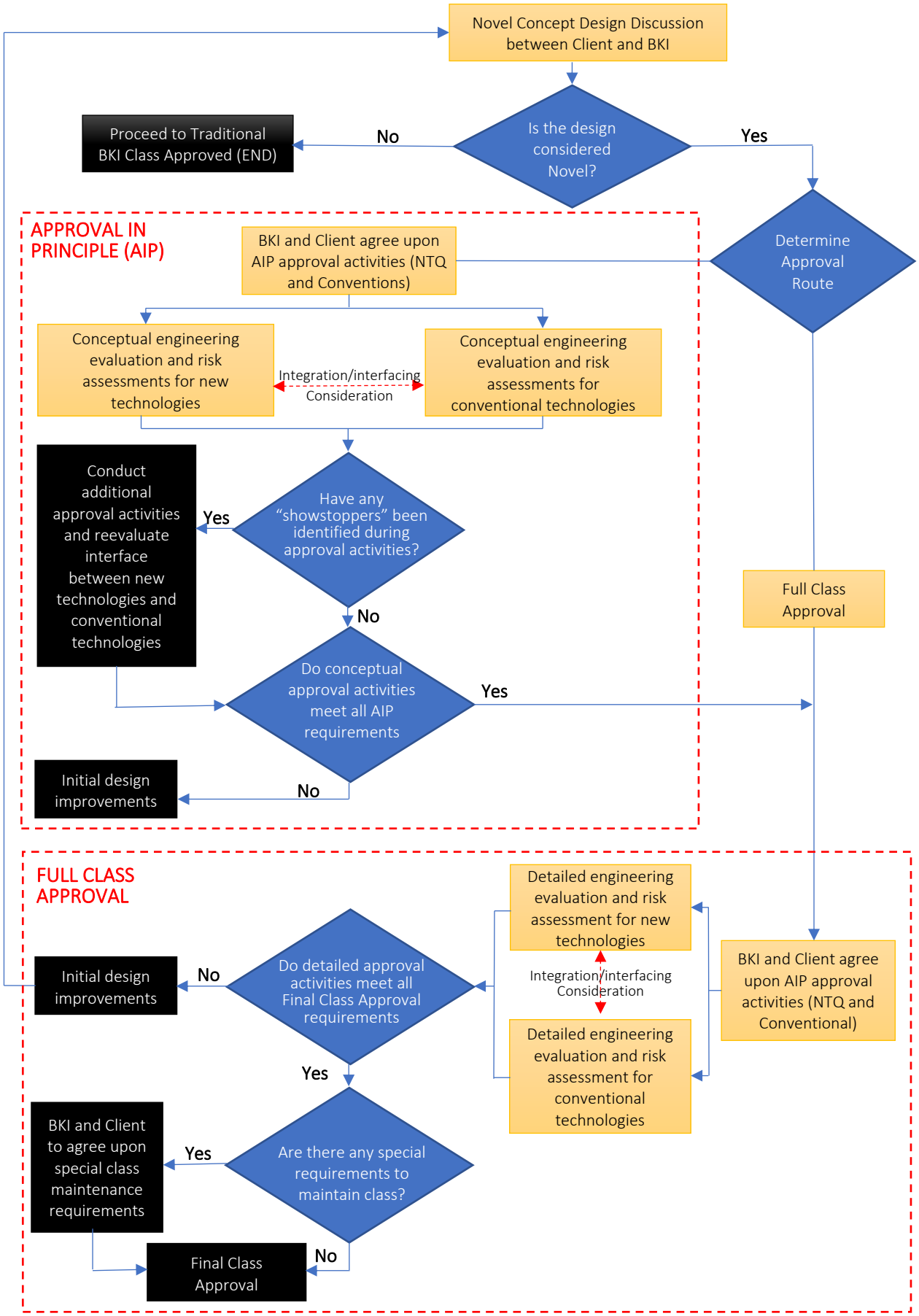

Fig. 1.2 Process Flow for BKI Approval of Novel Concepts

C. Definitions

As Low As Reasonably Practicable (ALARP)

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

Approval

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

Approval in Principle (AIP)

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

Consequence

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

Controls

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

Conventional Technologies

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

Engineering Evaluations

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

Event

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

Existing Application

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

Failure

The loss of the ability to perform the intended function

Failure Mechanism

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

Failure Mode

The specific manner of failure that the failure mechanism produces.

F-N Curve

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

Frequency

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

Hazards

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

Maintenance of Classification

The fulfilment of the requirements for surveys after construction. In the context of a novel concept, this would mean all requirements within the applicable BKI technical rules, as well as any additional requirements outlined in the conditions of class for the concept.

Marine Applications

Applications where the majority of the general requirements for design, construction, installation and continued class of the concept will be derived from the BKI Rules for Classification and Construction, and the codes and standards utilized by the marine industry.

New Application

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

New Technology

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

1) Existing design/process/procedures challenging the present boundaries/envelope of current offshore or ship applications
2) Existing design/process/procedures in new or novel applications.
3) New or novel design/process/procedures in existing applications.
4) New or novel design/process/procedures in new or novel applications.

Novel Concept

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

Offshore Applications

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

Reliability

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

Recognized and Generally Accepted Good Engineering Practice (RAGAGEP)

Refers to the selection and application of appropriate engineering, operating, and maintenance knowledge when designing, operating and maintaining chemical facilities with the purpose of ensuring safety and preventing process safety incidents.

Risk

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

Risk Assessment

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

System-of-Systems

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

D Abbreviations

ALARP : As Low As Reasonably Practicable

API : American Petroleum Institute Recommended Practice

CFD : Computational Fluid Dynamics

EESA : Emergency Systems Survivability Assessment

EERA : Escape, Evacuation, and Rescue Analysis

FEA : Finite Element Analysis

FMECA : Failure Mode Effects and Criticality Analysis

FTA : Fault Tree Analysis

HAZOP : Hazard and Operability

HAZID : Hazard Identification

NTQ : New Technology Qualification

NTQP : New Technology Qualification Plan

PFD : Process Flow Diagram

P&ID : Piping and Instrumentation Diagram

QRA : Quantitative Risk Assessment

SRSD : Systems Requirements and Specification Document

SIT : Systems Integration Test

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Section 2 Approval in Principle

A. Introduction

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

BKI Approval in Principle is a process by which BKI issues a statement-of-compliance that a proposed novel concept that contains new technology complies with the intent of the most applicable BKI Rules, Guidelines and Guidance 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 documents to be submitted necessary to be completed in later phases of the project to obtain final Class approval. The Approval Road Map will generally cover documents to be submitted 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 necessary qualification activities needed to be completed throughout the NTQ process is outlined by NTQP. The qualification activities include a combination of engineering evaluations and risk assessments.

The ability for a novel concept to achieve AIP is contingent upon the new technology to obtain a "Technology Feasible" Statement of Maturity letter, which will be awarded when the requirements for the Feasibility Stage in the New Technology Qualification (NTQ) in Chapter 2 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 Fig. 1.1. For example a client can request an AIP from concept select through the detailed design phase or equivalent. The Approval Road Map will be developed based on the level of detail of the information available upon request for AIP. In all cases, all new technologies need to be qualified via the NTQ process in addition to the verification of conventional technologies in the actual application and operating environments.

B. 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, Guidelines, Guidance 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 SRSD in accordance with Chapter 2, Section 2,B.2 are reviewed along with any available high-level engineering design analysis. The primary focus of novel concept classification is on safety even through the qualification of individual new technologies may have additional functional requirements as requested by the client

(e.g., performance, reliability, etc.). Functional and performance requirements as they pertain to the actual application and operational environment of the novel concept should be defined if known.

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

1) Pressure and temperature induced loads and fluctuations
2) Static and dynamic loads
3) Dynamic loads imposed due to vessel motions
4) Loads imposed due to relative motion/deflection of the vessel
5) Loads imposed from cargo weight or process fluid flow dynamics
6) Fatigue and fracture effects
7) Wear and vibration effects
8) Material degradation and associated loss from damage mechanisms
9) Accidental loads (as applicable)

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

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

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

1. Verification of Feasibility of the Proposed New Technologies

A review of the concept is to be conducted to determine the best method to proving the design. To accomplish this, one must first understand what aspects of the design go beyond current practice and why. Sensitivity studies shall be performed to understand key design parameters. This will enable the designer to determine the most appropriate method to assessment. It may be concluded that various novel aspects of the system require first principles-based approaches to assess their design suitability. The qualification of these new technologies is to follow Chapter 2 which describes in detail the NTQ process and documents to be submitted requirements in order to mature the new technology from early conceptual phases through the implementation of new technologies onto BKI classed assets. All qualification activities, which determining the validity of the design through engineering evaluations and risk assessments are outlined in the New Technology Qualification Plan (NTQP). At a minimum, the engineering evaluation activities that are required at the “Feasibility Stage” of the NTQ should be carried out to prove that the novel concept is feasible to achieve AIP.

The process to identify and qualify new technologies are described in the Chapter 2.

2. Verification of Conventional Technologies

A review of the conceptual design is to be conducted to determine what parts of the system or application can be covered through the application of pre-existing and codified Rules and standards. Wherever

possible, prescriptive Rule or standard based justification shall be performed to validate various aspects of the novel application. However, it must be demonstrated that the codes and standards to be utilized are wholly applicable and that the degree of novelty is not invalidating one or several aspects of the code or standard which are implicit in their application. Lastly, these aspects shall provide for an acceptable safety margin in line with current marine and offshore practice and the applied code or standard. It is important to emphasise 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 Chapter 2, Section 2,C.

3. Verification of Operability

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

4. Verification of Interface Issues

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

5. Verification of Inspectability and Maintainability

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

C. 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 documents to be submitted 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 procedure required to ultimately obtain classification approval. A qualitative risk assessment on the new concept will be required as a minimum, as part of AIP and/or Final Class Approval process that considers both new and conventional technologies, their interfaces with each other and the asset, in the actual application and operational conditions. The risk assessment should focus on documenting all foreseeable hazards, their causes, consequences, and potential risk control measures.

In general, for the concept development phase, a design basis, preliminary engineering and possibly testing results as well as other information, as described in 1. (Risk Assessment Plan) for concept evaluation, will be available. At this phase of concept development (i.e., concept select), a qualitative risk assessment is generally the most suited method. More refined risk assessments, such as quantitative risk assessments or reliability analysis, require considerably more details related to the novel concept and would be more

appropriately applied to later phases of design (i.e., detailed design phase). However, in some cases it may be necessary to conduct quantitative risk assessment during the conceptual design phase.

For the identified new technologies, the Chapter 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.

1. Risk Assessment Plan

The client should develop a risk assessment plan before performing each risk assessment identified. BKI will accept and review any risk assessment plan submitted by the clients. The following should be described in the risk assessment plan:

1) Description of the proposed design
2) Description of direct design, highlighting primary differences and similarities (for comparative studies)
3) Quantitative or Qualitative Risk assessment method(s) to be used and description if using a non-standard method
4) Scope and objectives of the assessment
5) Subject matter experts/participants/risk analysts, including their background and area of expertise
6) Proposed risk acceptance criteria or risk matrix

Further guidance on submitting a risk assessment plan can be found in Chapter 2 and Guidance for Risk Evaluation for Classification of Marine Related Facilities (Pt.4, Vol.A).

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

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

D. 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 essential to obtain final class approval in later stages. Each stage completed throughout the NTQ process can be used as a key milestone to update the Approval Road Map, subsequently reducing the amount of activities that needs to be completed throughout the Novel Concept Class Approval Process.

E. Summary of Documents to be Submitted for Approval in Principle

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

1. Engineering Evaluation

1) Design basis, functional specification and/or technical specification of the new technology
2) Design details such as basic engineering drawings and engineering principles associated with further development
3) System and function architecture details such as functional flow block diagram
4) Design analysis methodology and any available preliminary results
5) Details regarding physical and functional interface requirements (Mechanical, hydraulic, electronic, optical, software, human, etc.)
6) 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)
7) Lessons learned, references and examples of comparable designs

2. Risk Assessment

1) Risk Assessment Plan for the risk assessment identified in the AIP stage and the NTQ plan (if applicable).
2) The appropriate risk assessment report.
3) Hazard Register complete with an action tracking system.

F. Issuing Approval in Principle

1. Issuance of AIP Letter

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

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Section 3 Final Class Approval

A. Introduction

The Approval Road Map developed at the end of the AIP stage, sets the path for all activities that need to be completed in order to be granted Final Class Approval. Typically, the novel concept has progressed to a Detailed Design phase during this stage of the class approval process, where clients will be finalizing the design documents for final review (i.e. the detailed engineering and risk assessments). Clients are expected to have detailed design drawings, PFDs, PIDs, Heat and Material Balance, SIS/Emergency system design, process design, detailed structural layouts and construction plans, and developing operational procedures. At the end of this stage, the "System Integration" stage of Chapter 2, Section 6 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 comply with the agreed-upon acceptance criteria.

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

B. Engineering Evaluation for Final Class Approval

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

The completion of "Prototype Validation" stage of the NTQ process is typically recommended for a new technology to be considered for the Final Class Approval stage. If the identified new technologies have not been awarded the corresponding "Technology Qualified" Statement of Maturity then all engineering evaluation activities that are required at the "Prototype Validation" stage and the less mature stages (if applicable) of Chapter 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, the class approval for a Novel Concept can be issued.

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

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:

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

2. Calculation Documents

In this stage, all the engineering design, calculations, and testing up to the "Prototype Validation" stage should be performed and completed if not carried out during the NTQ process, taking into account the list of outstanding items identified in AIP stage. All functional and performance requirements of the integrated system related to safety as outlined in the system requirements and specification document (SRSD) 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. Verification of Interface Issues

The novel application must 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 ships or offshore unit and external to it as applicable.

4. Verification of Inspectability and Maintainability

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

C. 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 Chapter 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 ships system.

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

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

1) HAZID
2) Failure Modes and Effects Analysis (FMEA)
3) Hazard and Operability Analysis (HAZOP)
4) Quantitative Risk Assessment (QRA)
5) Emergency Systems Survivability Assessment (EESA)
6) Escape, Evacuation, and Rescue Analysis (EERA)
7) Any additional studies identified previously in the approval process

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

1. HAZID

An updated HAZID may be conducted based on the current state of the design during the final class stage. This analysis should focus on technical risks resulting from system integration and operations that have not been previously evaluated during the NTQ process. In addition, the HAZID should identify the hazards related to the whole offshore unit or marine ships. 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.

2. Failure Modes and Effects Analysis (FMEA)

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

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

If a preliminary FMEA was conducted during the AIP stage or the NTQ process, the items identified as part of that study should be reviewed during this FMEA and updated. Further guidance on FMEA techniques can be found in Guidance Notes on Risk Assessment for the Marine and Offshore Oil and Gas Industries (Pt. 4, Vol. 1).

3. HAZOP

The client may conduct a HAZOP to identify the hazards and the potential operating problems of the process systems that have not been previously evaluated during the NTQ process. This study should be based on any of the currently accepted methods used in industry and follow recognized code or standard. 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.

4. Quantitative Risk Assessment (QRA)

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

4.1 Hazard Categories

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

1) 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).

2) 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, ships, or critical support system) from other ships.
   - Quantify the risks of collision of the novel concept into other ships 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.)
3) Cryogenic Spill Assessment
   - Where applicable address the risk associated to the loss of containment of cryogenic systems to both health and safety of personnel and survivability of critical systems (as an example for ships this would include reviewing integrity requirements of hull structures when exposed to cryogenic materials).
   - Address the potential for loss of cryogenic containment to impact other non-cryogenic equipment which could lead to escalation of consequences.
4) Structural Risk Assessment
   - Quantify the risks associated with all identified critical structural elements of the novel concept. This should address the consequences to loading scenarios identified throughout the risk and design process.
   - Address design loading cases in respect to risk and possible minimum (regulatory) standards.
5) Fire and Explosion Risk Assessment
   - Quantify the risks of fire and explosion to and from the novel concept. Fire and explosion events should be based on recognized code or standard which should be clearly identified as part of the study documentation. Additionally events should include those identified throughout each hazard identification process.
   - Address the potential for escalation of consequences from fire and explosion events.
6) Gas Dispersion Risk Assessment
   - Quantify the risks of gaseous dispersion for the novel concept. This should include review of flammable and toxic materials associated with the novel concept.
   - Address endpoints/probits used for evaluation where applicable (toxic).
   - Include potential events identified in previous study work (see hazard registry).
   - Address potential risks associated with exhaust or vent stacks (this may include assessment of risks associated with flame out release from flare systems).
7) 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.

8) Gaseous Ingress Assessment

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

Note:

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

4.2 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):

1) 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.

2) Consequences

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

– End Points

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

3) Frequency

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

4) Risk Presentation

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

5) Recommendations

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

4.3 Documentation

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

1) Scope of Assessments and categories of risk reviewed.
2) Overview of the current state of design at the time the assessment was conducted.
3) 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.
4) 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.
5) All assumptions used provided in the form of an Assumption Log.
6) Detailed discussion of risk results and requirement mitigations.

5. 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:

1) Define requirements for survivability of the novel concept.
2) Identify what systems of the novel concept are critical to survivability.
3) Analyzed critical systems to determine if and to what level these systems will survive during a major accident event. Major accident events should be taken from the events analyzed during the QRA.
   - Critical systems which are identified as “fail safe” under emergency conditions should not require further analysis. There are cases in which this may not hold “true”. Thus all “fail safe” elements should be reviewed for effectiveness. Example: It is noted that under fire conditions spurious signals can be generated in electrical cabling so the fail state of the cable is not guaranteed. Optical Fibers however do not generate spurious signals.
   - Critical systems which are not “fail safe”, the vulnerability of their components against foreseen incidents is assessed. A system is vulnerable if it could fail in the major accident event under consideration. The client may utilize a check list to document the assessed vulnerability of the systems major components.
   - Critical systems that are found to be vulnerable, are to be considered at risk and such risk should be mitigated. Where critical systems are deemed not vulnerable, further analysis for these systems is not required.
4) Systems should be reviewed for redundancy, if a system’s components are duplicated or if another independent system exists which fulfills the same function and remains serviceable, the client may use this justification for survivability.

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

6. Escape, Evacuation, and Rescue Analysis (EERA)

The client should conduct an Evacuation, Escape, and Rescue Analysis which assesses the provisions of the escape, evacuation and rescue of the novel concept if needed and has not been done during the NTQ process. The purpose of this assessment should confirm that suitable means of escape, evacuation and

rescue have been incorporated in the design of the facility such that any ensuing risk to personnel is demonstrated to be ALARP or tolerable (relative to the client's selected risk criteria).

6.1 Objectives

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

1) Identify escape and evacuation routes, systems, locations, and equipment which are utilized during an emergency.
2) 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.
3) Identification of EER goals and assess whether the EER facilities will satisfy the goals. Show that mitigation or management is implemented in order to satisfy goals which have not been met.

6.2 Information to be Documented

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

1) The major accident events selected as representative and why these events have been selected.
2) The hardware systems selected for use in such events and why they have been selected.
3) The role and key features of the chosen systems which will form the input to the relevant performance standards.
4) The number of personnel for whom the facilities should be designed.
5) The managerial arrangements for the control of EER events and the basis for the development of emergency procedures, drills and exercises.
6) 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.
7) An endurance time analysis which assesses the time needed to carry out all steps of the EER process.

6.3 Emergency Response

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

1) Incident detection
2) Raising alarm
3) Assessing the incident and activating the response
4) Access to muster stations
5) Muster
6) Egress from muster areas
7) Evacuation
8) Escape
9) Recovery and rescue
10) Place of safety

Note:

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

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

7. Final Class Approval Stage Risk Assessment Plan

BKI requires that a Risk Assessment Plan be development and submitted to BKI prior to conducting any detailed risk assessment. Contents that should be included in the risk assessment plan (e.g., scope of the risk assessment, selection of risk assessment techniques, and risk acceptable criteria, etc.) can be found in Section 2, C.1. Further guidance on developing a detailed risk assessment plan can be found in the Risk Evaluation Guide.

D. Management of Change

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

The details of MoC processes are provide in Chapter 3. Management of Change for the Marine and Offshore Industries.

E. Documents to be Submitted

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

1. Engineering Evaluation

1) Statement of relevant codes and standards applied and the deviations made to their application with respect to the novel features and conventional technologies.
2) Detailed design documents including detailed drawings, PFDs, PIDs, product specifications, detailed calculations, detailed structural layouts and construction plans, detailed operational procedures etc.
3) All documents that describe requirements for system-of-systems functionality and interfaces (if not done during the NTQ process).
4) Summary report outlining the changes made to the design throughout the NTQ and Novel Concept Class Approval processes.
5) System integration test plans, test data, and test results summarized in a report (if not done during the NTQ process).
6) Plans for in-service survey, inspection, monitoring, sampling and testing (as applicable) during operations (if not done during the NTQ process).

Note:

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

2. Risk Assessment

1) Risk Assessment Plan for the detailed risk assessment.
2) Updated risk assessment reports from the AIP stage.
3) Risk assessment reports for the risk studies conducted in the Final Class Approval stage.
4) Other applicable technical safety studies.
5) Final Hazard Register with all action items closed out.

F. Issuing Final Class Approval

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

The approval is depend on the ability to achieve a “Technology Integrated” statement of approval for the NTQ process.

Section 4 Input to Surveys and Maintenance of Class

A. Obtained information

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

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

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

1. Input to Survey during Construction

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

1.1 Critical Areas

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

1.2 Verification and Witness of Testing

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

1) Material testing
2) Destructive testing, such as burst tests, fatigue testing and other types of failure testing (can be on prototypes, small scale or full scale models)
3) 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.
4) Functional testing covering FAT's and commissioning type test to confirm that the application or system performs as intended.

2. Input to Survey during In-Service Operation

The class approval process for a novel concept will require BKI 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 Renewal Survey for in-service monitoring:

1) Maintenance schedules are to be enhanced in order to maintain a target failure probability assumed in the design phase. This requirement could be coupled with a full scale Reliability Centered Maintenance program developed in parallel to the design program.
2) Inspection scope/frequency must be modified to cover monitoring of critical areas so as to confirm that critical design assumptions with respect to various failure modes are correct and also to reduce the probability of failure through enhanced inspection requirements. This requirement could be coupled with or part of a proposed Risk Based Inspection program.
3) 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.
4) Pilot Testing of Novel Features. BKI may require information be gathered as necessary, to justify the concept or to refine its Rules, Guidelines, and Guidance for these applications. These enhanced requirements may or may not be required throughout the life of the application or they may be required on the initial assemblies while relaxing requirements to conventional prescriptive Class requirements for subsequently constructed assemblies of the same design.

Section 5 Government and Regulatory Involvement

A. General

In some instances, there can be some administrations required for acceptance of a novel concept. For ships, these administrations will be the port states and the flag State that the ships 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 ships. The present document covering guidelines for these types of novel ships 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.2 dated 9 April 2018. The guidelines are a rational and systematic process for assessing risks relating to maritime safety. The process of building up a body of knowledge for a novel concept must generally follow this guideline to enable BKI to work within the final need to provide the required trading certificates necessary for operation of the ships in the maritime community. The development of this documentation from the start of concept approval will enable the Administrations involved to evaluate the concept and clearly assess the results of the mitigation provided to minimize the defined risks from this concept operating within the marine community. The Flag State may also provide these studies to IMO for subsequent evaluation to enable the organization the ability to establish final regulations where necessary for the concept not presently found within the codified regulations of IMO.

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

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

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Annex A Sample Risk Matrix

Frequent Incident is likely to occur at this facility within the next 5 years.	4	**LIKEHOOD**				**High Risk**
Occasional Incident is likely to occur at this facility within the next 15 years.	3			**Medium Risk**		
Seldom Incident has occurred at a similar facility and may reasonably occur at this facility within the next 30 years.	2		**Low Risk**			
Unlikely Given current practices and procedures, incident is not likely to occur at this facility.	1					
			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 $100K, negligible downtime.	Some equipment or structural damage at an estimated cost greater than $100K, 1 to 10 days of downtime	Major damage to installation at an estimated cost than $1 MM but less than $10 MM, 10 to 90 days of downtime	Major or total destruction to installation estimated at a cost greater than $10 MM; downtime in excess of 90 days.

Note:

The description (including stated values) within the risk matrix are only provided for reference. It is acceptable for the client to use different description or risk matrix when agreed with BKI.

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Annex B Novel Concept Checklist

A. General

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

1) Establish if the new design qualifies as a novel concept and whether the use of these Guidance are appropriate for evaluating the concept and;
2) Gain a general understanding of the variation from existing or proven marine or offshore applications, and thus the degree of novelty.

The checklist is meant to act as a trigger that would indicate that the proposed design might be categorized as novel, and thus potentially require additional considerations and evaluation outside the standard class approval process as prescribed in the BKI Rules. The number of yes/no answers gained from the use of the checklist does not directly dictate what evaluations need to be performed in order to class the design. Rather, the answers provide an indication that discussions with BKI should be initiated to confirm there is a mutual understanding between the designers and BKI on how the design may deviate from existing applications, the degree of novelty present, the lack of suitable Rules, codes and standards to address that novelty and what plan of action will be required to address these deviations. In general, where a high degree of novelty is confirmed from the checklist, then these 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 Guidance for Risk Evaluation for the Classification of Marine Related Facilities (Pt.4, Vol.A). BKI and the client will have to mutually agree as to what constitutes a high degree of novelty and therefore the appropriate document to be used in the approval process.

B. Novel Concept Checklist

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

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

The next category relates to novel processes (e.g., chemical or hydrocarbon processing/production), activities, storage within marine or offshore applications, or subsea systems. Novel processes may include new types of hydrocarbon production that have not been applied commercially before, or it may include

the extension of a process that has never been applied on an offshore application. Novel activities may include the use of a vessel or offshore unit for purposes other than the original design purpose. Novel concepts may include a new type of mooring system for an offshore floating installation. Novel storage applications may include the application of new types of cargo tanks to transport highly volatile gases or liquids. In all of these examples, the proposed function of the vessel or offshore unit is affected by the application of the new technology, concept or activity. The last checklist category covers possible new or novel ancillary systems in which the function of the vessel or offshore unit could be impacted by the performance of this system.

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

1) The general design application is not considered a novel concept;
2) It does not include new unproven technology; or
3) 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 Guidance for Risk Evaluation for the Classification of Marine Related Facilities (Pt.4, Vol.A) would generally be more appropriate for the proposed marine or offshore application.

However, it is important to note that prior to proceeding further with the design, the client should initiate communications with BKI 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 BKI to discuss the proposed application. This will start the initial process of clarifying whether or not the design concept should be categorized as novel, precisely defining the novel concept and identifying potential ramifications on the ship or offshore unit classification approval. The process for evaluating the novel concept is described in Section 1 and detailed in Sections 2 and 3.

It is important to note that any answer of "No" on the checklist also does not necessarily indicate the requirement for additional reviews or analyses. It does however, indicate that some discussion related to the design concept should be initiated with BKI early on in the approval process to confirm no unforeseen issues related to the design with respect to classification review and approval are exist. 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 BKI 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 B.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 ship 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., BKI, API, IMO, ASME, ISO) 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?	

Table B.1 Novel Concept Checklist *(continued)*

No.	Checklist Questions	Yes/No/NA*
Stationkeeping Aspects		
SK1	Is the proposed mooring system design considered to be within the current experience boundaries for the ship 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 ship or floating facility?	
	Are the environmental and operating parameters for the thruster system within experience boundary for the vessel or floating facility?	
	Is the control system for the thruster system considered to be within the current experience boundaries for the ship or floating facility?	
	Are the potential consequences associated with failure of the thruster system considered to be similar to other thruster applications?	
Structural Aspects		
S1	Is the proposed hull or main structure design considered to be within the existing experience boundaries for the ship 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 a typical 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 ship 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 ship or offshore unit?	
	Is the electric power generation system considered to be within the current experience boundaries for the ship or offshore unit?	
	Is the fuel system used for electric power generation considered to be within the current experience boundaries for the ship or offshore unit?	
	Is the control system for power generation considered to be within the current experience boundaries for the ship or offshore unit?	
	Are the power requirements for the ship 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 ship 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 ship 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?	

Table B.1 Novel Concept Checklist *(continued)*

No.	Checklist Questions	Yes/No/NA*
MS4	Is the proposed propulsion system design considered to be within the current experience boundaries for the ship or floating facility?	
	Is the fuel system considered to be within the current experience boundaries for the ship 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 ship 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 ship or floating facility?	
	Is the control system for steering considered to be within the current experience boundaries for the ship or floating facility?	
	Are the guidance and navigation systems considered to be within the current experience boundaries for the ship or floating facility?	
Process Systems		
P1	Are there any existing commercial applications of the proposed process systems that will be on the ship or offshore unit?	
P2	Are there existing onshore applications of the proposed process systems that will be on the ship or offshore unit?	
P3	Are there marine or offshore applications of the proposed process systems that will be on the ship or offshore unit?	
P4	Can the chemical process aspects, such as fluid/gas separation or distillation, be isolated from potential adverse effects of the marine environment (e.g., ambient conditions, ship 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 ship or offshore unit?	
SC2	Are there existing onshore applications of the proposed storage systems that will be on the ship or offshore unit?	
SC3	Are there marine or offshore applications of the proposed storage systems that will be on the ship or offshore unit?	
	Can the storage systems be isolated from the unique aspects of the marine environment (e.g., ambient/corrosive conditions, motions)?	
SC4	Are the potential consequences associated with this offshore application of the storage system or facility considered to be the same as other similar commercial applications?	
SC5	Is the storage equipment layout similar to existing ship 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, loading 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?	

Table B.1 Novel Concept Checklist *(continued)*

No.	Checklist Questions	Yes/No/NA*
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, ship 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

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Section 1 Introduction

A. Overview

1. This Chapter describe the BKI approach for qualification of new technologies to confirm their ability to perform intended functions in accordance with defined performance requirements. This Chapter also provide details of documents to be submitted, the BKI review process and the key interaction points with BKI during the new technology development.

2. This document introduces a systems engineering approach to qualification that allows for systematic and consistent evaluation of new technologies 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 in order 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 results in a Statement of Maturity being issued by BKI attesting to the maturity level of the new technology.

3. The process is also compatible with approaches based on Technology Readiness Levels (TRLs), (e.g. API RP 17N/Q, ISO 16290/NASA); and can be tailored to projects that require the use of multiple pathways to qualification. The comparison of BKI Qualification Stages with industry TRLs can be found in Annex B.

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

B. Background

1. 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.

2. Ships and offshore units which contain new technological features or designs that are not currently governed by Rules, Guidelines, Guidance and existing industry standards may still be qualified and/or approved by BKI through the process described in this Chapter. This qualification is on the basis that the Rules, Guidelines, Guidance 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 Chapter.

3. This Chapter 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 BKI classed assets.

4. The integration of the new technology qualification process and the Novel Concept Class Approval process provides end users of the qualified technologies with the added benefit 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 has been systematically identified and mitigated.

C. Application

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

2. A new technology for the purpose of this Chapter 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:

1) Existing design/process/procedures challenging the present boundaries/envelope of current offshore or marine applications
2) Existing design/process/procedures in new or novel applications
3) New or novel design/process/procedures in existing applications.
4) New or novel design/process/procedures in new or novel applications

3. An asset such as a ship or an offshore unit becomes a novel concept if the incorporation of any new technology(ies) significantly alters its service scope, functional capability, and/or risk profile. Novel concepts are typically presented to BKI for review and class approval following the process in Chapter 1.

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

1) To qualify new technology that may need to be classed or certified at a later date
2) To simultaneously qualify new technology identified while seeking class approval for a novel concept
3) To qualify a new technology independent of the need to be classed or certified

4. If the proposed new technology is intended for incorporation on an asset to be classed by BKI, then it is recommended that the new technology complete up to and including 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 BKI at any level of indenture as desired such as component, sub-system or system level.

5. 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 Chapter is primarily intended for the qualification of new technologies, the approach could also be applied to qualify existing technologies.

D. New Technology Qualification Process

1. 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:

1) Feasibility Stage
2) Concept Verification Stage
3) Prototype Validation Stage
4) System Integration Stage
5) Operational Stage

2. 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 between the client and BKI. 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, namely, engineering evaluations and risk assessments.

3. 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 BKI for this qualification service. In such cases, BKI would 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 restarted at an agreed upon time.

4. Fig. 1.1 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 BKI for review can be found in later Sections.

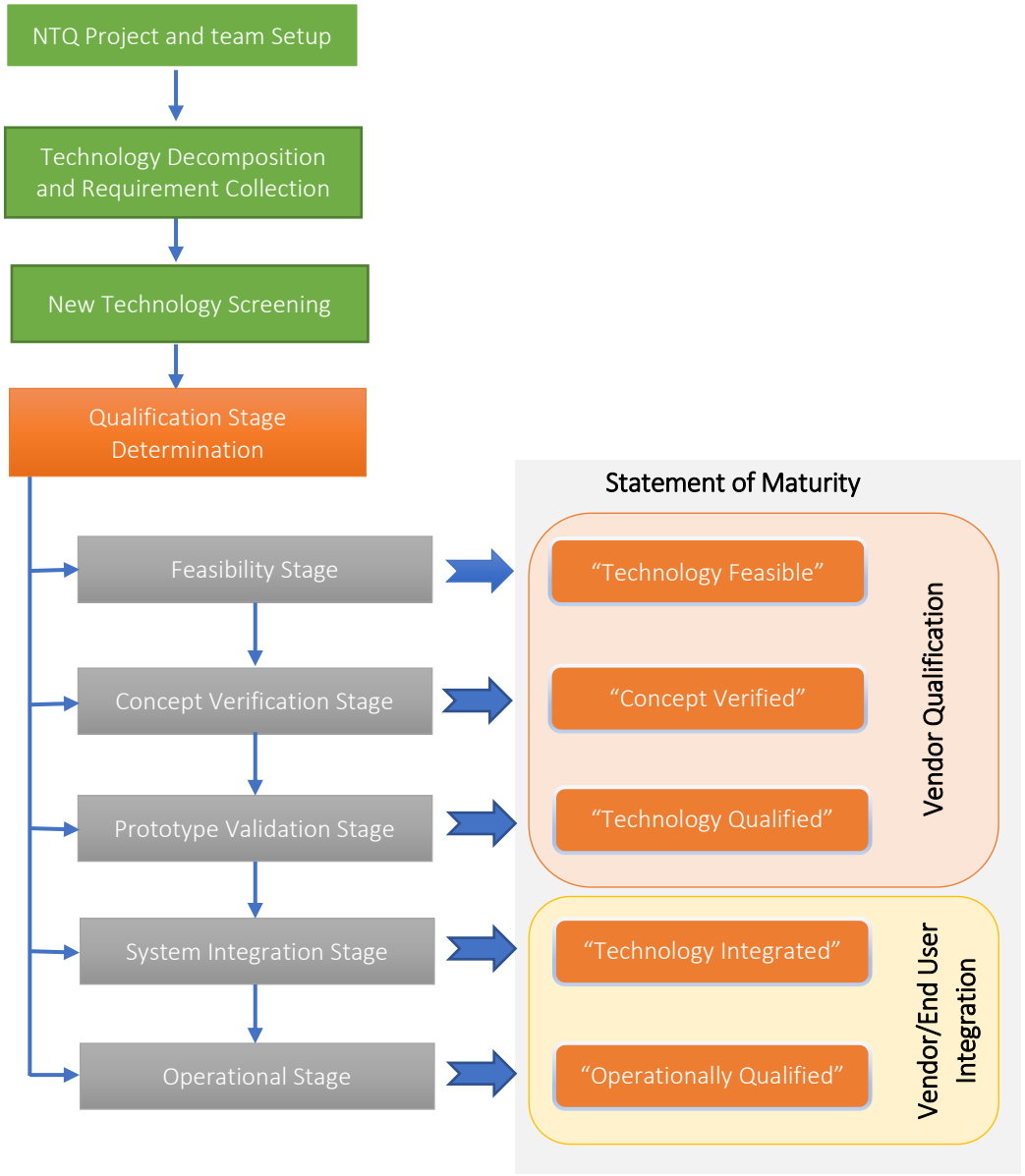

Fig. 1.1 New Technology Qualification Process

E. Type Approval

1. 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 BKI Type Approval. During the Prototype Validation Stage, if all the engineering evaluations have been completed, a Design Approval can be issued prior to further consideration for BKI Type Approval. The BKI Type Approval is a voluntary option for the demonstration of compliance of a system or product with the defined performance requirements as derived from Rules, Guidelines, Guidance or other recognized standards. It may be applied at the request of the vendor or manufacturer. The suitability of the BKI Type Approval for the proposed new technology will be determined on a case-by-case basis.

2. Specific requirements and details regarding the BKI Type Approval Program can be found in Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use (Pt. 1, Vol. W).

F. Definitions

As Low As Reasonably Practicable (ALARP)

See Chapter 1, Section 1, C.

Approval

See Chapter 1, Section 1, C.

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

See Chapter 1, Section 1, C.

Controls

See Chapter 1, Section 1, C.

Critical Assumption

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

Engineering Evaluations

See Chapter 1, Section 1, C.

Failure

See Chapter 1, Section 1, C.

Failure Causes

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

Failure Mechanism

See Chapter 1, Section 1, C.

Failure Mode

See Chapter 1, Section 1, C.

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

See Chapter 1, Section 1, C.

Global Effects

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

Hazards

See Chapter 1, Section 1, C.

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 must be satisfactorily completed if the manufacturer wants a product to be labelled “Type Approved” under the BKI 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 BKI-classed assets. The process involves BKI Engineers verifying product compliance with manufacturers’ specifications, applicable BKI 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

See Chapter 1, Section 1, C.

Risk

See Chapter 1, Section 1, C.

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 BKI 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.

G. Abbreviations

HFE : Human Factors Engineering

ITP : Inspection Test Plan

MA : Manufacturing Assessment

MTBF : Mean Time Between Failure

PDA : Product Design Assessment

PPE : Personal Protective Equipment

QA : Quality Assurance

QC : Quality Control

RAM : Reliability, Availability and Maintainability

RBD : Reliability Block Diagram

SIT : Systems Integration Test

Other abbreviations may refer to Chapter 1, Section 1, D.

Section 2 Qualification Process

A. New Technology Qualification (NTQ) Project and Team Setup

1. The project kick-off meeting should be scheduled once the client (vendor/system integrator/end-user) requests for the qualification of a new technology using this Chapter. A brief overview of the proposed technology along with the expectations, any ongoing qualification activities (if initiated) and project timelines is to be presented to BKI by the client during the kick-off meeting. BKI will advise the client if new technology qualification is the most appropriate path for proceeding and recommend further steps.

2. The establishment of a new technology qualification team is to be performed after the kick-off meeting. The qualification process involves the interaction of two teams: the client team (design team) and the BKI review team.

3. BKI team may establish a special multidisciplinary review consists of BKI staff members which is depending on the complexity of the proposed new technology. The composition of the team will vary depending on the technical areas involved in the project as well as the physical location of the client's engineering and testing facilities. One of the members will be nominated as the leader of NTQ project to act at as the client's main point of contact throughout the NTQ process. All BKI team members will be covered under the confidentiality/non-disclosure agreement that is normally signed between BKI and clients for the qualification services.

4. It is encouraged whenever possible to include BKI, system integrators and end users of the new technology early in the qualification process. If applicable, input from regulatory agencies (including flag Administration) will also help align the qualification activities with requirements or other expectations.

B. New Technology Decomposition and Requirements Collection

1. General

A systems engineering approach is pursued for the NTQ process 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 requirements for the functional requirements
- Performing qualification activities to verify and validate the performance requirements

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

- Mapping the functional requirements of the system to item(s) (e.g., subsystems or components) for identifying the 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.

The NTQ process can be tailored depending on the type of item for which the client is seeking qualification. This is applied by considering the different categories of new technology as defined in Section 1,C 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). As instance, the overall maturity level of the system is equal or lower than that of the sub-systems, which are equal or lower than that of the individual components. Fig. 2.1 is depicted the decomposition, system hierarchy and interactions between all elements.

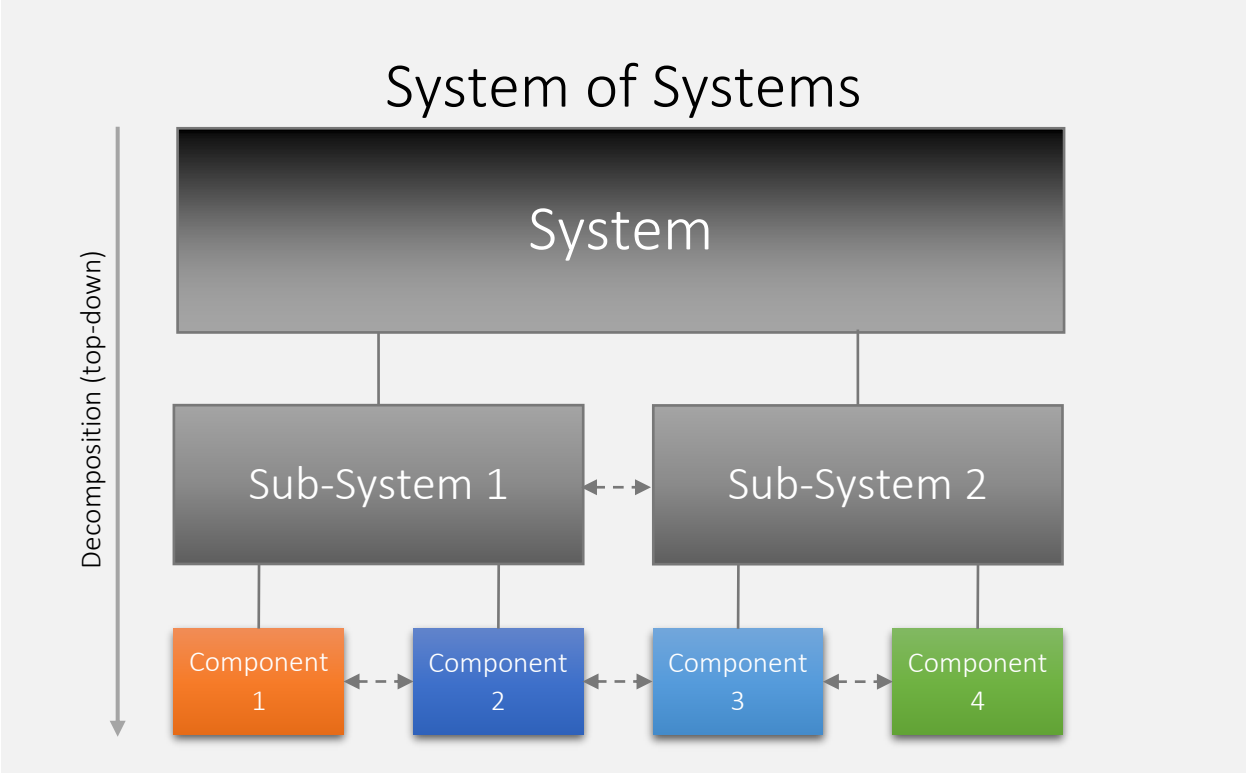

Fig. 2.1 New Technology System Hierarchy

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

2. New Technology System Requirements and Specification Document

A System Requirements and Specification Document (SRSD) should be developed for the new technology and maintained throughout the NTQ process. The baseline requirements for the new technology are defined and set by SRSD 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 SRSD will need to be updated accordingly.

2.1 Defining System Requirements

2.1.1 Goals

The goals defined for the new technology should identify the 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.

2.1.2 Functional Requirements

The functions that required to be performed by the system are defined in functional requirements. The functional requirements should be mapped to specific items that will perform the function and normally includes a description of the function to be performed, the environment in which the function should be performed, the conditions where the system should start the function and the conditions under which the system should terminate the function.

2.1.3 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. In the early design stages the performance requirements may be defined qualitatively and progressively more quantitatively during subsequent stages of technology maturation. Where the performance requirements are not defined because of the novelty of the new technology, the extrapolation of the performance requirements should be performed from existing Rules, Guidelines, Guidance and/or other industry standards. Relevant requirements from Flag Administration should be also considered. The performance criteria are the acceptance criteria against which the results of each qualification activity are evaluated.

The requirements should be defined according to ISO 13879 "Petroleum and natural gas industries – Content and drafting of a functional specification". The aspects to consider for inclusion while defining functional requirements and related performance requirements may vary depending on the new technology to be qualified but typical considerations include:

2.1.4 Design Conditions

The system design conditions are to 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 to, the following:

- 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)

2.1.5 System Interface Requirements

All internal and external physical and functional interfaces (e.g., mechanical, electrical, etc.) relevant to the new technology are to be defined by the system interface requirements. 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.

2.1.6 Human System Integration Requirements

It is important that human factors be considered during early design stages. Human factors play an important role for the system to work safely and effectively in achieving 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.

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

The focus of HFE is the design of the Human-System Interface (HSI). 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.

The specific areas, stations, or arrangement of equipment that would require concentrated human engineering attention should be defined during the design process. Any specific 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 lifecycle of the system.

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

- Guidelines for the Bridge Arrangement and Equipment on Seagoing Ships (Pt.4, Vol.2).
- Standard Human Engineering Program Requirements for Ships and Marine Systems, Equipment and Facilities, Standard 1337. American Society of Testing and Materials, ASTM, 2010.
- Common Requirements, Architectural Components & Equipment (C-CR-002). Norwegian Oil Industry Association and the Federation of Norwegian Engineering Industries, NORSOK, 1996.
- Working Environment (S-002). Norwegian Oil Industry Association and the Federation of Norwegian Engineering Industries, NORSOK, 2004.
- Ergonomic principles in the design of work systems, ISO 6385, 2016.

2.1.7 Maintainability

Maintainability is to specify the requirements of maintainability quantitatively that apply to maintenance in the planned maintenance and support environment. Examples are as follows (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

2.1.8 Reliability

Reliability is degree to which a system, product or component performs specified functions under specified 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.

2.1.9 Safety and Environment

The requirements for safety and environment applicable to eliminating or minimizing hazards related to human, environment, and asset.

2.1.10 System Life Cycle Sustainment

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

2.1.11 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 BKI Cybersecurity 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 Guidelines for Maritime Cybersecurity (Pt.4, Vol.4).

2.2 System Description

The detailed technology description is also to include in SRSD. This could help to provide evidence or demonstrate the ability of the technology to meet defined system requirements by an involvement of additional documentation. Generally, the system description of the new technology includes the following, but not limited to:

1) List of equipment
2) Comparison with existing similar technologies
3) Lessons learned from similar technologies
4) Possible applicable standards, codes, or industry practices
5) Relevant engineering documents as applicable:
   – General arrangements

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

6) Operational, maintenance, and inspection strategies
7) Control and safety system details
8) New or unproven manufacturing, assembly, transit, storage, installation, hook-up, testing, commissioning, and decommissioning details
9) Quality, health, safety, and environmental philosophies

The SRSD needs to be submitted to BKI for review. The SRSD is not intended to be a single consolidated document but a design review package that compiles the relevant documents.

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

C. Screening of New Technology

Once the new technology has been described, a systematic screening process is required in order 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 Section 1,C, 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 could follow the conventional BKI certification process.

It is helpful for new technology items, to identify whether similar technology exists and whether relevant Rules, Guidelines, Guidance, and/or industrial standards apply fully or partially for this new technology. Identifying the new technology items provides a basis for reducing the scope of qualification to only those items that require to be addressed through the NTQ process. The screening process may be performed by vendors independently or in a workshop setting/approved by BKI, which will help support/guide the process. Sample of systematic screening process is shown in Table 2.1.

Table 2.1 Systematic Screening

Item	Description	Similar Technology Exists?	Relevant Rules, Guidelines, Guidance, 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 (fully) Standard 2 (No)…	Yes	i	
2		No	Standard 1 (partially) Standard 2 (partially)…	Yes	ii	
3		This technology exists	N/A	No	N/A	

Table 2.1 Systematic Screening *(continued)*

Columns:

- *Description:* Description of elements of the new technology item(s) (e.g., subsystems)
- *Similar Technology Exists?:* Identifying 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 Rules or Standards for This or Similar Technology:* List of any Rules, Guidelines, Guidance or 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 Section 1, C:
  - *i)* : Existing technology challenging current boundary/envelope
  - *ii)* : Existing technology in new applications
  - *iii)* : New technology in existing applications
  - *iv)* : New technology in new applications
- *Notes*: Other information or justification relevant to the screening process (e.g., conditions for applicability of standards, recommendations for qualification, etc.).

The result of systematic screening and supporting information is to be submitted for BKI review.

D. New Technology Stage Determination

Based on the results from the new technology screening process and review of the SRSD, BKI and the client will agree on a determination of the maturity level. An appropriate qualification stage will be assigned to proceed, with qualification activities. The detailed questionnaire for determining the technology maturity level and qualification stage can be found in Annex C.

A more mature design could result in the ability to start at a later qualification stage, thus minimizing the level of effort and time it takes to complete 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)

E. New Technology Qualification Plan and Activities

The New Technology Qualification Plan (NTQP) defines a roadmap for progressing the new technology through the appropriate qualification stages. The aim of the NTQP is to provide a summary of qualification activities that required to be performed at each stage in order to demonstrate the ability of the new technology to meet the requirements specified in the SRSD.

The initial NTQP should be developed based on the results in the screening process in C. The NTQP for each subsequent stage is updated based on the results from the previous stage activities and discussions between the client and BKI. A NTQP template is provided in Annex D.

Qualification within each stage is consisted 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 improvements and/or modifications of design to the requirements specified in the SRSD. All design

improvements and/or modifications should be documented in the NTQP with necessary technical justification. Fig. 2.2 summarizes the iterative NTQP activities.

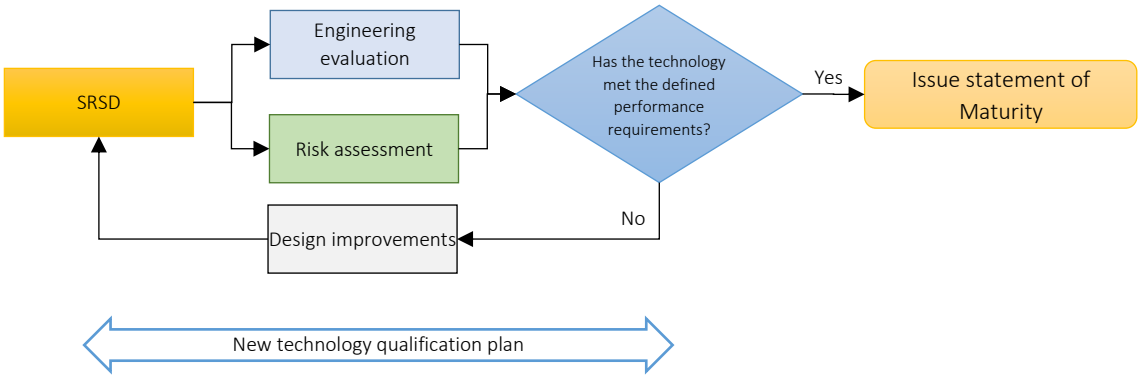

Fig. 2.2 New technology qualification stage iterative process

1. Risk Assessment Requirements

As stated in E, a risk assessment is to be prepared and submitted to BKI for review.

A risk assessment for a new technology requesting qualification through the NTQ process is to be conducted/updated at each stage as applicable. The risk assessment will vary within the NTQ process from qualitative to quantitative which is depending on the maturity level and information available at that stage. The risk assessment main objectives is to identify technical risks and uncertainties associated with the proposed design and document of 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 must consider the following areas:

1) Personnel safety
2) Asset protection
3) 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. The participation of BKI in the risk assessment is also recommended. Reference Notes on Risk Assessment for the Marine and Offshore Oil and Gas Industries (Pt.4, Vol.1) Sec.3,A.4 provides an overview of how to assemble an appropriate risk assessment team.

A risk assessment plan should be prepared and submitted to BKI for review, prior to performing the risk assessment. The risk assessment plan should include the following information:

1) Scope of the Assessment
    a) Description of the proposed new technology including physical and operational boundaries
    b) Intended service application of the new technology
2) Assessment Team
    a) Subject matter experts/participants/risk analysts, including their background and areas of expertise
3) 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)

Once the risk assessment has been completed, a report that includes the following information should be submitted to BKI for review:

1) Scope
   a) Description of the proposed new technology including physical and operational boundaries
   b) Intended service application of the new technology
2) Risk Assumptions and Data References
3) Supporting Engineering Documents
   a) Technical drawings
   b) Technical data/specifications
4) 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 causes of the hazardous scenario,
   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)
5) Conclusions and Recommendations
   a) Action items and/or recommendations

Further guidance on developing risk assessment plans can be found in Reference Notes on Risk Assessment for the Marine and Offshore Oil and Gas Industries (Pt.4, Vol.1) Sec.3.

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 BKI prior to performing a risk assessment. Table 2.2 shows some of typical recommended risk assessment techniques and their common uses.

Table 2.2 Recommended Risk Assessment (RA) Techniques

RA techniques	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 to identify and assess the functional failures of a system or subsystem.	Used for all types of systems and processes.

Table 2.2 Recommended Risk Assessment (RA) Techniques *(continued)*

RA techniques	Description	Common Uses
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 how 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:

- Reference Notes on Risk Assessment for the Marine and Offshore Oil and Gas Industries (Pt.4, Vol.1) Sec.3
- Guidance for Risk Evaluation for the Classification of Marine Related Facilities (Pt.4, Vol.A)
- 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

2. Engineering Evaluation

An 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 activities for engineering evaluation consists of:

1) Review of Engineering Design Requirements

   As the new technology matures, and more detailed design information becomes available, the functional and performance requirements are reviewed/ updated as needed.

2) Technical Analyses and Simulations

   Engineering design analyses and simulations are used to verify the technology at earlier qualification stages

3) Validation Testing

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

4) Interface Analyses

   Interface analyses of the new 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.

5) Verification of Operability

Operational testing and the collection of test data are required to verify the new technology satisfy the operational requirements.

6) Verification of Inspectability and Maintainability

The various components of the new technology must be reviewed to confirm that they can be monitored, inspected and maintained in a manner consistent with existing practice.

7) 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.

3. 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 SRSD. 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.

3.1 Hierarchy of Risk Control Measures

Inherently safe design exists in something as a permanent 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:

1) 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.

2) 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.

3) Administrative

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

4) 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. Inherently safe design asks the question, “can it be safer?”

The goals of inherently safe design can be summarized as follows:

- 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.

3.2 Management of Change (MoC)

During the course of technology design and development, design improvements are inevitable 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/change including equipment, materials, procedures and conditions.

The methods 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 labour intensive than in later stages.

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

1) Clear roles and responsibilities
2) Appropriate organizational preparation
3) A written MoC program manual that includes MoC forms
4) Pilot roll-out before the full-scale deployment, training of affected personnel, and
5) Close attention when integrating MoC with existing programs.

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

- Chapter 3 of this Guidance
- 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

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Section 3 Feasibility Stage

A. 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 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, Guidelines, Guidance, other recognized industry standards and recommended practices.

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

B. Qualification Activities

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 SRSD in Section 2, B.2 are reviewed along with any available high-level engineering design analysis to verify that the proposed concept is feasible.

2. 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 BKI for review in the form of a risk assessment plan as discussed in Section 2, E.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:

1) HAZID identifying possible hazards, events, and outcomes related to the impact on personnel, asset, environmental, and reputation
2) 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.)
3) 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 BKI 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 BKI will recommend an alternative approach as needed to meet the new technology Feasibility Stage requirement.

C. Documents to be Submitted

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

1. Engineering Evaluation

1.1. SRSD (System Requirement and Specification Document)

1) Design basis, functional specification and/or technical specification of the new technology
2) System and function architecture details such as functional flow block diagram
3) Design details such as basic engineering drawings and engineering principles associated with further development
4) Design analysis methodology and any available preliminary results
5) Details regarding physical and functional interface requirements (mechanical, hydraulic, electronic, optical, software, human, etc.)
6) 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)
7) Lessons learned, references and examples of comparable designs

2. Risk Assessment

1) Risk assessment plan in accordance with Section 2, E.1.
2) The appropriate risk assessment report identified in B.2.
3) Hazard Register complete with an action tracking system.

D. Feasibility Stage Completion (Technology Feasible)

Once the above deliverables have been submitted to BKI 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

A. 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 SRSD 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.

B. Qualification Plan Activities

1. Engineering Evaluation

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 that 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 BKI review.

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 or 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 BKI. 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 BKI 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 8) and 9) listed in Annex A.

2. 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 the following:

- 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 BKI for review.

A risk assessment technique that is appropriate for reviewing the new technology design should be selected and submitted as part of the risk assessment plan to BKI. 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 BKI 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 Reference Notes on Risk Assessment for the Marine and Offshore Oil and Gas Industries (Pt.1, Vol.1).

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

- Design risk assessment (e.g., FMECA) as described above.
- Update Feasibility Stage risk assessments as needed based on updated design documentation.
- 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 modelling 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 BKI review. The data sources used, their applicability and any related assumptions should be documented within this report.

C. Documents to be submitted

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 BKI for review:

1. Engineering Evaluation

1) SRSD
   - Documents that describe the concept verification design requirements
   - Design documents that include but not limited to the configuration, drawings, PFD/P&ID, analytical models, etc.
   - Functional and model test plans, test data (as requested), and test results
2) Preliminary manufacturing plan

2. Risk Assessment

- Updated risk assessments from the Feasibility Stage (as applicable)
- Updated Hazard Register with updated action items closed out

- Preliminary design risk assessment (e.g., FMECA) report
- Preliminary system RAM analysis report (as applicable)

D. Concept Verification Stage Completion (Concept Verified)

Once the above have been submitted to BKI for review and all specified performance requirements have been verified, then 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.

Section 5 Prototype Validation Stage

A. 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.

B. Qualification Plan Activities

1. Engineering Evaluation

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 must 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 analysed. 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 BKI for review. A preliminary system-of-systems interface analyses and system integration testing plan may be developed at this stage and submitted to BKI for review before the System Integration Stage.

1.2 Prototype Testing

Prototype testing is intended to prove that the interactions between the systems/subsystems/ components should reliably perform under relevant loading and environmental operating conditions. 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 BKI 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 international or national standard (e.g., NIST, ANSI, ISO, SNI, 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 must be reviewed by BKI 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 analysed to determine whether the prototype satisfies specified functional and performance requirements in its actual environment. A prototype test report is to be submitted to BKI for review. Further guidance on prototype testing can be found in references 8), 9) and 10) listed in Annex A.

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 BKI for review. Further guidance on developing a manufacturing plan can be found in references 14) and 24) listed in Annex A.

1.4 BKI Survey

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

2. 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 made 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, BKI 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 BKI 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 BKI for review:

1) Final design risk assessment (e.g., design FMECA)
2) Final process risk assessment (e.g., process FMECA or HAZOP) if applicable
3) Update all previous risk assessments as needed based on updated final design level documentation
4) 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 BKI review.

C. Document to be Submitted

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

1. Engineering Evaluation

1) SRSD
   – 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).

2) Inspection Test Plan (ITP)

3) Detailed manufacturing plan.

2. Risk Assessment

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

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

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

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

5) Final hazard register with all action items closed out.

D. Prototype Stage Completion (Technology Qualified)

Once the above deliverables have been submitted to BKI for review and all specified performance requirements have been verified, then 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.

E. BKI 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 BKI 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 BKI Type Approval.

Section 6 Systems Integration Stage

A. Introduction

The Systems Integration Stage is the fourth stage of the NTQ process. The discussions between vendor and end-user are held to understand the compatibility of the technology with final operating system and operating environment. To confirm the compatibility of the item, an interface analysis is to be performed. The technical risks during operations that have not been addressed during previous risk assessments are to be evaluated and relevant reports are 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 SRSD are validated through testing before (or during) commissioning. Plans for in-service survey, inspection, monitoring, sampling and testing (as applicable) are determined.

B. Qualification Plan Activities

1. Engineering Evaluation

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 completed. In addition, the operational procedures should be developed, and detailed operational performance parameters should be defined. System interface and integration requirements are to be submitted to BKI for review.

1.2 Interface Analysis

It should be analyzed that the addition or incorporation of the new technology does not impair 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 BKI for review.

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 must 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 BKI for review before the system integration testing. All test procedures and test results are to be summarized in a report and submitted to BKI for review.

1.4 BKI Survey

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

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

2. 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 determined and submitted as part of the risk assessment plan to BKI for review. The use of a process FMECA, HAZOP or HAZID are recommended. The risk assessment scope is 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 to BKI for review.

C. Document to be Submitted

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

1. Engineering Evaluation

1) SRSD
   - All documents that describe requirements for system-of-systems functionality and interfaces.
   - 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.

2. Risk Assessment

1) Updated risk assessment reports from the previous stages (as applicable)
2) Other applicable technical safety studies (e.g., RAM).

D. System Integration Stage Completion (Technology Integrated)

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

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Section 7 Operational Stage

A. 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 must 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 must be completed and the information to be supplied to BKI. In this stage of the project, it is recommended that the qualification process involves members with operational background. 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 (SoM).

The activities of the Operational Stage are as follows:

1) Implementation of in-service survey, inspection, monitoring, sampling and testing plans
2) Collection and analysis of reliability, availability, maintainability (RAM analysis) and other operational performance data as needed
3) Comparison of operational data above with previously specified performance requirements, goals and criteria
4) Performance of root cause analyses for any observed failure and using feedback to introduce modifications for improvement
5) 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 these Guidance for classification or certification purposes, the primary reason 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.

B. Qualification 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 BKI 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 BKI 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 BKI.

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

- Guidance for Survey Based on Reliability-Centered Maintenance (Pt.7, Vol.I)
- Guidance for Survey Using Risk Based Inspection for the Offshore Industry (Pt.5, Vol.A)
- Guidance for Hull Inspection and Maintenance Program (Pt.7, Vol.D)
- Guidelines for Floating Production Installations (Pt.5, Vol.3) Annex 10
- API RP 17N Recommended Practice Subsea Production System Reliability, Technical and Integrity Management

C. Documents to be Submitted

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

The following documents are typical submitted that BKI would expect to receive annually in order 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, BKI should be notified as soon as practical.

D. 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 BKI), then a Statement of Maturity (SoM) stating the operational qualification of the technology will be issued.

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Annex A References

A. Reference for Qualifying New Technologies

1) API RP 17N Recommended Practice Subsea Production System Reliability, Technical and Integrity Management. American Petroleum Institute, 2009.
2) ISO 16290. Space systems – Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment. International Organization for Standardization, 2013.
3) IEC 60300-3-4. Dependability Management: Application Guide- Guide to the Specification of Dependability Requirements. International Electrotechnical Commission, 2022.
4) ISO 13879. Petroleum and natural gas industries -- Content and drafting of a functional specification. International Organization for Standardization, 1999.
5) BKI Reference Notes on Risk Assessment for the Marine and Offshore Oil and Gas Industries (Pt.4, Vol.1)
6) ISO 17776. Petroleum and Natural Gas Industries – Offshore Production Facilities – Guidelines on Tools and Techniques for Hazard Identification and Risk Assessment. International Organization for Standardization, 2000.
7) ISO 31010. Risk Management – Risk Assessment Techniques. International Organization for Standardization, 2009.
8) ISO 17025. General requirements for the competence of testing and calibration laboratories. International Organization for Standardization, 2005.
9) IEC 60068. Environmental Testing. International Electrotechnical Commission, 2013.
10) Waid, M. (2011). Manufacturing Planning Guide.
11) Guidance for Survey Based on Reliability-Centered Maintenance (Pt.7, Vol.I).
12) Guidance for Survey Using Risk-Based Inspection for the Offshore Industry (Pt.5, Vol.A).
13) Guidelines for Floating Production Installations (Pt.5, Vol.3) Annex 10. Offshore Hull Construction Monitoring Program
14) BKI Guidelines for Machinery Conditioning Monitoring (Pt.1, Vol.3).
15) BKI Guidance for Hull Inspection and Maintenance Program (Pt.7, Vol.D)
16) BKI Guidance for Crew Habitability on Ship (Pt.7, Vol.B).
17) BKI Guidance for Crew Habitability on Offshore Installation (Pt.7, Vol.C).
18) Guidelines for the Bridge Arrangement and Equipment on Seagoing Ships (Pt.4, Vol.2).
19) ASTM Standard Human Engineering Program Requirements for Ships and Marine Systems, Equipment and Facilities, Standard 1337, 2010.
20) NORSOK Common requirements, architectural components & equipment (C-CR-002), 1996.
21) NORSOK Working environment (S-002), 2004.
22) ISO 9001. Quality management systems – Requirements, 2015.
23) API Specification Q1. Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry. American Petroleum Institute, 2014.

24) AS 9100 Revision C. Quality Management System – Requirements for Aviation, Space and Defense Organizations, 2009.

25) INCOSE 2015. Systems Engineering Handbook – A Guide for System Life Cycle Processes and Activities, version 4.0. Hoboken, NJ, USA: John Wiley and Sons, Inc., ISBN: 978-1-118-999400.

B. Reference for Management of Change

1) API RP 750, Management of Process Hazards, American Petroleum Institute, Washington, DC, 1990.

2) API RP 75, Recommended Practice for Development of a Safety and Environmental Management Program for Offshore Operations and Facilities, American Petroleum Institute, Washington, DC, 2019

3) Arendt, J. S., Resource Guide for the Process Safety Code of Management Practices. Chemical Manufacturers Association, Inc., Washington, DC, 1990.

4) Guidelines for Hazard Evaluation Procedures (Second Edition with Worked Examples), Center for Chemical Process Safety, New York, 1992.

5) Guidelines for Management of Change for Process Safety, Center for Chemical Process Safety CCPS (2008).

6) Health Safety and Environment Case Guidelines for Mobile Offshore Drilling Units, International Association of Drilling Contractors, Houston, TX, 2010.

7) Process Safety Management of Highly Hazardous Chemicals (29 CFR 1910.119), U.S. Occupational Safety and Health Administration, May 1992, available at www.osha.gov.

8) Oil and Gas and Sulphur Operations in the Outer Continental Shelf – Safety and Environmental Management Systems, Final Rule (30 CFR Part 250), U.S. Department of the Interior, October 2010, available at www.regulations.gov.

9) Biro Klasifikasi Indonesia (BKI). Reference Notes on Risk Assessment Applications for the Marine and Offshore Oil and Gas Industries (Pt.4, Vol.1), 2012

Annex B Comparison of Qualification Stages with Industry TRLs

A. 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. This developed a stage gate process compatible with the wide range of TRLs (API and ISO 16290). However, the numbers levels presented have now been replaced by a series of qualification stages. Comparison of the BKI definition and the industry TRLs are provided in the table below.

Table B.1 Qualification Stages Comparison with Various Industry TRLs

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

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Annex C New Technology Stage Determination

A. Introduction

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

Table C.1 Questionnaire for determining the technology maturity level and qualification stage

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 fundamental objectives and requirements (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?		

Table C.1 Questionnaire for determining the technology maturity level and qualification stage
(continued)

Qualification Stage	Item #	Question	Yes/No/NA	Evidence to support?
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., FMEA, FMECA) been documented?		
	23	Have the initial risk assessments been reviewed/updated to identify any additional technical risks?		

Table C.1 Questionnaire for determining the technology maturity level and qualification stage
(continued)

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 FMEA, FMECA) been performed and documented (if applicable)?		
	37	Has the final design risk assessment (e.g. FMEA, 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?		

Table C.1 Questionnaire for determining the technology maturity level and qualification stage
(continued)

Qualification Stage	Item #	Question	Yes/No/NA	Evidence to support?
System Integration Stage	40	Has the design risk assessment (e.g. FMEA, FMECA, HAZOP) considering full system interfaces been updated and properly documented?		
	41	Have all other technical risks been identified/addressed and properly documented?		
	42	Has the technology been deployed into a full prototype and fully integrated with the intended system?		
	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?		

Table C.1 Questionnaire for determining the technology maturity level and qualification stage
(continued)

Qualification Stage	Item #	Question	Yes/No/NA	Evidence to support?
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 SRSD or in-service inspection plan (ISIP)?		
	58	Has the design risk assessment (e.g. FMEA, FMECA) been updated with in- service performance data?		
	59	Has the system reliability assessment been updated and properly documented?		

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Annex D New Technology Qualification Plan (NTQP) Template

A. 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 intended 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.

B. New Technology Qualification Plan (NTQP) Template

Executive Summary

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.

2. New Technology Screening and Stage Determination

2.1 System Requirements Overview

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

2.2 New Technology Screening

- Summarize the new technology screening results.

2.3 New Technology Stage Determination

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

3. New Technology Qualification Activities

- For each new technology item being qualified, list all qualification activities including the following details for each activity
  - Summarize the qualification activity (scope, objective and method)
  - Performance Requirement and its source.
  - Identify the stage in which this qualification activity was determined.

- Provide reference to appropriate engineering evaluation report or risk assessment report (include corresponding hazard register nodes) from which this activity was determined.
- Scheduled Timelines (start/finish).
- Provide reference to appropriate engineering evaluation or risk assessment reports that documents the results of the qualification activity.
- Comments from the Client & BKI

4. References

Annex A Summary of Previous Qualification Activities

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

Annexes (other)

Section 1 Introduction

A. General

A Management of Change (MoC) system is a combination of policies and procedures used to evaluate the potential impacts of a proposed change 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 in the facility or ship including equipment, materials, operating procedures and conditions, and personnel.

This chapter highlight key considerations for developing and maintaining a successful MoC process for ships and offshore facilities. The process is consistent with safety and environmental management systems (SEMS) best practices.

This Chapter explain the main principles to be considered and describe key functions and interconnection for consideration at various levels of a representative organization. In order to educate and assist management representatives and personnel responsible for initiating and coordinating changes, models and examples are provided to be used in planning and developing an effective MoC system.

Successful organizations are dynamic and constantly undergoing change in striving for innovative and cost effective solutions to achieve sustainability in a robust and competitive business environment. A disciplined management of change system will not only minimize significant impacts on safety and the environment, but will incorporate strategies in managing the associated business risks on quality, continued commerce, and security.

B. Manage Change Objectives

The objectives of manage change are described as follows:

- To provide well documented MoC program can be used to demonstrate an organization’s commitment to the implementation of risk mitigation efforts. It is important because history has many examples of inadequately managed changes that resulted in catastrophic accidents.
- To provide an effective MoC implementation program due to the operational characteristics of ships or offshore. Such as limited time space for emergency repairs carried out at sea spares are to remain until appropriate spares can be procured and the human factor (limited crew, crew fatigue, and crew change schedule) can lead to the implementation of changes whose associated impacts are not thoroughly understood.
- To provide organization with vital insight in deciding upon and concluding change with capability to sufficiently analyze and understand the effects and consequent risk associated with the impact of a proposed change. Risk management strategies and strong administration form the basis of an effective MoC program.
- To establish policies to manage equipment, operational and organizational deviations from the existing condition will improve safety, promote environmental compliance, safeguard property, and preserve business reputation. Designing safety into the MoC program can effectively decrease the occurrence of undesirable change induced incidents. Studies into the causes of incidents reveal that severe injury accidents occur at a disproportional rate during unusual and non-routine work activities.

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Section 2 Recognition of a Change

A. Program Scope

A system that requires change management to be carried out for every single modification is likely to become more stringent and avoided. For this reason, it is important to pay special attention to the activities and systems for which the MoC program will be implemented, the life-cycle applicability of the MoC, the type of changes to be evaluated, and boundaries and overlaps with other administrative programs or elements.

1. Activities and Systems within the scope of MoC Program

An MoC program can include the whole enterprise, or alternatively, have a physical scope limited to certain systems or activities. The reasons for limiting the scope on the program can arise from the desire to enhance the effectiveness of the program, or the fact that the program was born to help deal with problems in a specific area, or to support a regulatory compliance effort.

The criticality of a system or activity can be used as a parameter for determining whether or not a system should be part of the MoC program scope. The basis is that impacts associated with a critical system change are likely to be of serious consequences, thus managing through an MoC program could make a significant and positive difference.

The systems and activities that may be considered critical in a marine environment because of their potential health, safety and environmental impacts, will highly depend on the type of ship or offshore facility, the operations carried out, and the hazardous materials/cargo handled. Typical examples of systems and high-level activities which may be considered critical is shown in Table 2.1. Note that each activity involves numerous types of subtasks, all of which should be governed by an MoC program. For example, construction activities in the offshore industry include initial construction, onsite construction, repairs, modifications, pipe laying operations, sand blasting and painting, welding, crane operations, electrical equipment modification, decommissioning of facility, etc.

Table 2.1 Critical activities/ systems typically governed by an MoC program

Marine	Offshore
– Propulsion – Steering – Navigation – Cargo (containment, handling and monitoring) – Structure (repair, modification, sand blasting, welding, hoisting/lifting, electrical, etc.)	– Drilling – Production – Processing – Construction – Well Services (workover, completion, servicing) – Pipelines
Common to Marine and Offshore	
– Emergency systems (fire protection, gas detection, life-saving, life support) – Communications – Ballast control – Hazardous areas – Supervisory control systems (computer programs) – Security – Fuel gas – Utilities	

Note:

Although criticality of systems is used as criteria for a limited-scope MoC program, changes in non-critical systems can also present significant impacts, thus highly justifying the need and benefits of more comprehensive MoC programs.

1.1 Example of scope of MoC program - Contracted equipment and personnel

In offshore activities, credence on specialized contracted operators presents some unique challenges. For example, an offshore lease-holder company fields utilizes mobile offshore drilling units, owned and operated by a drilling contractor, for drilling, construction, well servicing, etc. These activities can present significant health, safety, and environmental impacts. All parties involved are likely to have some degree of liability if accident occurs during these activities. The lease-holder company shall require an MoC program for these critical activities, even when carried out by contractors. The contractors may have their own MoC program to manage changes, but the lease-holder must be satisfied that is in line with the lease-holder's goals from such a program and that it is functioning adequately.

2. Life-cycle phases

The MoC process is applicable throughout the life-cycle of a ship or offshore facility, but it may be distinctively applied at each stage. When developing an MoC program, one important aspect to define is the life-cycle stages for which it will be required.

A typical breakdown of the life-cycle of a ship or offshore facility would include the following stages:

- Design
- Construction
- Start-up
- Operation (including inspection and maintenance)
- Dry-dock or extended shutdown
- Decommissioning

The techniques employed to evaluate the change, the people available for review and approval, the time frames for reviewing and implementing the change, etc., will differ between stages. During a facility design stage, there are many changes, but there will be fewer records to update than if the change occurred at an operating stage of the facility. When evaluating changes at a design stage, the impact or risk assessment techniques, which are a strong function of the available information, may be different than for more mature life-cycle stages. Tools such as software simulations, quantitative risk analysis, etc., prove invaluable at the early stages, even though they are more effort and resource intensive.

At operating stages, the changes will require a larger amount of information to be reviewed and updated such as drawings, maintenance and inspection plans, training programs, emergency plans, etc. In older operating ships or offshore facilities, the access of information may involve old paper records instead of completely electronic documentation.

Towards the end of life, the change management may be simplified. It may involve fewer closeout tasks, fewer updates of associated documentation, less rigorous sign-off procedures, limited or no training needed as a result of the changes, etc. There will be a decommissioning plan, where the impacts of all the activities planned have been carefully analyzed and mitigated against. The definition of the types of changes to be managed may then become "deviations from the decommissioning plan".

3. Types of Changes

Most changes controlled by an MoC program fall into one of the following categories: equipment, operational or organizational changes.

3.1. Equipment

This category addresses equipment or technological changes. Examples of equipment changes may include:

- New equipment
- Replacement or modification of equipment (equipment, ship components, infrastructure including emergency replacements when out at sea)
- Replacement or modification of computer hardware
- Modification to software (logic, interlocks, controls, alarms, instrumentation)
- Bypasses around equipment that is normally in service
- Disabling of safety/critical systems for testing, calibration or repair/replacement, if not covered by procedure
- Modification or removal of safety equipment (fire-fighting equipment, first aid equipment, escape and evacuation, personal protective equipment, etc.)
- Changes to structural support, layout, or configuration
- New maintenance chemicals
- New/changed solid/liquid/gas effluents (e.g., produced fluids, waste products, by-products)
- Change to the utilization of an equipment
- Changes resulting from recommendations originated from non-conformances, root-cause analysis, hazard identification studies, etc.
- Contracted equipment and facilities (e.g., drydocks, repair facilities, contracted drilling equipment for offshore, etc.)

Marine-specific examples include the acqusition of a new ship into a fleet – it could be a sister ship or a completely new type of ship. Offshore-specific examples include new production or process facilities, newly acquired facilities, new fluids used (e.g., process additives, drilling muds, workover completion fluids, pipeline utilization change).

3.2. Operational

Changes in administrative controls or management system that define the way processes are conducted throughout the organization. Examples of operational changes include:

- Deviation from preventive maintenance or mechanical integrity programs
- Deviation from inspection program or testing frequency
- Deviation from testing methods
- Deviation from repair requirements
- A response to external circumstances that is not defined in standard procedures
- Change to a controlled document
- Implementation of new procedures
- Operations outside current operation procedures and parameters

Marine-specific operational changes include change in trading patterns, new routes or ports, change of ship type (e.g., multi-purpose vessels (when changing between modes)), change in cargo (different specs or new cargo type (e.g., food/fuel)). Offshore-specific operational changes may include changes with personnel transfer to and from the offshore facility such as different or larger aircraft or vessel or other logistics change, deviations from well construction/execution plan, deviations from a simultaneous operations (SIMOPS) plan, etc.

3.3. Organizational

This category includes personnel and staffing modifications, such as changes to crew, personnel, management structure, shift manning, company-wide policies, regulations, etc. Changes such as realignment of organizational resources resulting from acquisitions, mergers, new joint ventures and alliances should be evaluated to provide consistency with health, safety, quality, and environmental (HSQE) objectives and to minimize adverse effects on the enterprise risk. When organizational changes take place (changes in reporting relationships, elimination of positions, restructuring, etc.), a change control is needed to verify that the reassignment of responsibilities is clearly evaluated and explicitly documented. More examples of organizational changes may include:

- Changes to on-board management
- Crew turnover/crew change-out by a predetermined percentage
- New crew on board (e.g., different reporting requirements)
- New contractors (e.g., repair crews, crewing agencies, dry docks, repair facilities, etc. For offshore, the list can be extensive: well services, drilling contractors, crew transportation, etc.).
- Transfer of Class
- New and forthcoming regulations
- Acquisitions, mergers, new joint ventures and alliances
- Elimination of positions or restructuring
- Change of key shore-based staff supporting the ship or offshore facility
- Flag change or new flag into fleet
- Crew new to company or new full crew nationality

There may be changes that overlap one or more categories (for example, a major technological change may necessitate modifications to equipment, operations and organization). These categories illustrate to the developers and users of the management system what may constitute a change. However, the MoC process set forth in these Guidance Notes is the same regardless of the type of change.

4. Changes not subjected to the MoC program

Addressing all types of modifications with the MoC program will undeniably reduce the overall effectiveness of the system without adding significant risk reduction. Changes that are not typically governed by the MoC program include the following:

4.1 Replacement in kind

A replacement-in-kind is a change wherein an item, process, or person meets the specified criteria for the item it is replacing, if such criteria exist. This may take the form of an identical replacement, or an alternative that is specifically designed within specifications criteria and therefore will not adversely affect the function of the system.

An MoC program should waived changes that constitute a replacement-in-kind and focus on evaluating proposed temporary or permanent changes that are outside of the existing specified criteria.

It is common that even a replacement obtained from the same manufacturer may have small differences from the original item it is replacing. The manufacturer may have utilized upgraded machinery, slightly employed different materials of construction, or may have stored the equipment at different environmental conditions. However, these physical changes may be considered minor component modifications that fall within the tolerable range of existing documented specifications. The limited risk of replacement-in-kind can be controlled outside the MoC program using other tools such as purchase requisition processes, checklists, safe work practices, etc.

4.2 Change control via other administrative systems

Changes that the company chooses to control via other management process such as:

- Routine personnel changes (crew rotation, shift or tour changes) controlled by operating procedures, safe work practices, training, etc.
- Routine in-service changes where the operating procedures provide appropriate guidelines for the change, and the operating procedures have been adequately reviewed prior to becoming effective

MoC is only one system among many management system practices normally in place within an organization. A shipping or offshore company will likely have comprehensive administrative systems to manage designated issues such as procurement, crew staffing, project management and job risk assessment, etc.

An organization may opt to employ these administrative systems to control certain types of ordinary changes without the need of the MoC program. This point can be illustrated by looking at project management during design and construction. One of the best methods of preventing and controlling occupational injuries, illnesses, and fatalities is to “design out” potential risks early in the design process. During preliminary design stages, changes are constantly taking place as more detailed information is presented and the technical blueprint matures. It is impractical to consider implementing an MoC for every change or option considered by design (and sometimes construction) teams. Nonetheless, a control mechanism for change management should be effectively incorporated into project management so that changes are monitored through to completion to minimize the potential risk of failure in project objectives, and in turn, improve safety through design.

Careful consideration should be taken in aligning the MoC process with or developing it in conjunction with existing company policies and regulatory requirements. An organization may choose to control certain changes outside of the MoC program by employing their uniquely customized strategy for controlling the risk of the change. Activities whose changes are to be controlled under other administrative programs should be documented as clear exceptions to the MoC program.

Interfaces with other safety management processes should also be outlined in the MoC program. The MoC program will most likely receive inputs from and provide outputs to other business areas. For instance, proposed changes involving equipment replacements are likely to request, as well as provide, equipment specifications data to the procurement department. Similarly, the review of a proposed personnel change onboard, will need data on competencies, education, training, and experience on the personnel involved in the change from human resources and staffing. The interrelationship of core activities and policies should be well defined and understood to avoid duplication of effort, or omission of important activities. Early consultation with personnel responsible for comparable management processes currently in place in the organization is key to promoting efficiency in the MoC program design.

4.3 Domestic activities (janitorial, food, beverage, laundry, housekeeping, etc.)

4.4 Other types of changes as defined by the company

4.5 Example changes not subjected to the MoC program

4.5.1 Controlling changes outside the MoC Program – Sometimes It Makes Sense

A new sailing route is a common type of change for ship. Before sailing on a new route, there are many issues that need to be evaluated to determine their significant and what action may be required to deal with them:

- Navigation (up-to-date charts and navigational aids),
- Tides and weather,
- Pilots,
- Security (up-to-date information on war/piracy activity),

- Additional traffic,
- Crew familiarity,
- Under-keel clearance,
- Communication,
- Sovereignty,
- Duration (water, fuel, provisions),
- etc.

The evaluation of these issues is standard duty for navigating officer (usually the second mate) responsible for defining the voyage. The navigating officer is likely to use a checklist for navigational plan changes, as well as discuss the planned voyage with the master who would sign off on it. This is normal and routine practice and the subject of extensive professional training and judgement. Subjecting this evaluation to new requirements using the MoC system will likely be unnecessary, and add extra burden to personnel at the bridge. Route changes are thus, a good example of change that most marine companies would choose to control using processes outside the MoC program.

B. Recognition of a Change

All employees should have the independence to suggest modifications that they believe will have a positive impact on their workplace. The MoC process is initiated when someone, anyone, either identifies the need for change, or recognizes that a change situation is developing.

The first consideration after recognizing a potential change is deciding whether or not the change is a replacement-in-kind. When there are no specifications or guidelines available, it is up to the judgment of those involved in the change to decide if it is an in-kind replacement. There are three questions that should assist in this decision.

1) Does the change involve identical specifications?
2) Does the change involve identical service parameters?
3) Is it a routine replacement?

A positive answer to ALL three questions usually confirms an in-kind replacement. The considerations on how the change affects the factors mentioned in Table 2.2 can also aid in the determination of whether a change is in-kind or not.

Table 2.2 Factors for In-Kind Determination

Area of change	Description in-kind determination
Specifications Physical, mechanical, electrical, or chemical specifications	Considerations should include materials of construction, measurements, grade weight, strength, tests, performance, maintenance chemicals, etc. A change in vendor or manufacturer for the item should trigger a management of change process which involves procurement as well as the responsible technical personnel.
Service Operating conditions/range	Service temperature, service pressures, fluids to which replacement item is exposed, if exposed to atmospheric conditions, etc.
Routine Replacement is due to item being at the end of its usable life	Replacement at the end of the item's usable life. If the replacement is an upgrade, then it should be treated as a change. Routine replacements that are occurring more frequently than anticipated could indicate a persistent problem with the item. In such cases, an investigation should take place to determine if an underlying change condition may have developed and be the cause of the failures.

When attempting to evaluate 'non-physical' modifications such as those to personnel, organizational structure, reporting, and procedures, it is considered best practice to employ the assistance of competency and training matrices in deciding if the adjustment may present a risk to current operations and be considered a 'change' in the work environment. These matrices would include factors such as competencies, length of service, experience in industry, training with similar systems/equipment, etc. Any specifications such as existing policies, processes and procedures, organizational charts, etc., should be considered in deciding if a proposed organizational change constitutes a replacement-in-kind.

If doubt persists regarding whether a change is in-kind, the conservative and safe approach is to proceed with the MoC process, or consult with the company's MoC coordinator who can help with the determination.

Table 2.3 provides typical examples of change scenarios that can be encountered in the marine and offshore industries and reasoning to assist the decision of whether or not they are to be controlled by the MoC program.

Table 2.3 MoC Decision Checklist for Typical Marine and Offshore Changes

Change	If the answer to any question is "No", change is to be controlled by the MoC system	Yes	No
Ship/Facility Mode	– Is the new mode of operation equivalent to a previous mode of operation that was managed successfully?	□	□
	– Is the present crew familiar with this mode of operation?	□	□
	– Have all shore and shore-interface modifications for the new mode of operation been carried out before?	□	□
	– Does mode change require modification to procedures and manuals?	□	□
New equipment or software	– Does the new equipment/software have same performance, functional, material, maintenance, control systems and dimensional specifications as old equipment?	□	□
	– Are the existing procedures applicable to this new equipment/software?	□	□
New hazardous cargoes/ hydrocarbon/ chemical	Does new cargo/hydrocarbon/chemical have similar properties to previous in terms of:		
	– Fire and explosion	□	□
	– Toxicity	□	□
	– Corrosiveness	□	□
	– Reactivity	□	□
	– Spill response	□	□
	– Physical properties (boiling and freezing points, thermal expansion, decomposition, vapor pressure)	□	□
	– Chemical compatibilities with other cargos/materials handled?	□	□
Handling new cargoes/material	– Are existing equipment and crew skills adequate for safe handling, loading or unloading of the new cargo/material?	□	□
	– Are procedures for handling new cargoes/materials available?	□	□
Personnel	– Does the new candidate meet the competencies, training, education, and experience requirements for the position?	□	□
	– For organizational changes ashore (eliminating positions, restructuring, etc.), do reporting relationships, job responsibilities, work load, etc., remain unchanged?	□	□

Table 2.3 MoC Decision Checklist for Typical Marine and Offshore Changes *(continued)*

Change	If the answer to any question is "No", change is to be controlled by the MoC system	Yes	No
Contractors	Changes to contractors working in areas or activities so designated by company or regulation, should be subject to MoCs, unless the contractor change is a "replacement-in-kind". A positive answer to all the questions below is a good indication of replacement-in-kind.		
	– Have contractors worked with company before?	□	□
	– Are contractors familiar with company regulations and personnel?	□	□
	– Have contractors worked with this type of ship/facility before?	□	□
	– Have contractors worked with this type of equipment before?	□	□
	– Have contractors worked in this location before?	□	□
	– Have contractors been qualified (competency, financial, insurance, billing) by the company before?	□	□
	– Will there be company resources to properly monitor and supervise the quality of the work and the safety of the contracted personnel?	□	□
Corrective Action Requests/ Hazard Analysis Recommendations	Changes initiated as a result of a non-conformance, corrective action, incident investigation, hazard analysis, etc., can have the potential to affect onboard and shore operations and as such should be evaluated via the MoC system.		
	– Is the change a replacement in kind?	□	□
	– Is the type of change exempt from the company's MoC program?	□	□
New regulations, procedures, standards, registry	The preliminary impact analysis may take the form of a gap analysis to identify the new requirements proposed and how the new requirements change the current ways. This type of change almost always requires an MoC to comprehensively identify potential impacts and develop an implementation plan.	MoC almost always required	

Section 3 Management of Change Process

A. Definitions

Approver

A member of management or senior officer who reviews the initial change form to confirm the need for change and validate the preliminary impact assessment and the implementation plan. If the change has major impacts and it is particularly complex, the approver is strongly suggested to request further detailed risk assessment. Ultimately, the approver decides if the change can be executed.

Change

Changes are modifications, additions, or substitutions for any aspect within the organization that are outside the company's present specifications.

Change Owner

Supervisor/officer with responsibility in the area where the change is proposed and who works with the initiator in preparing the change form request. If the initiator shipboard is an officer or above, then the initiator and the change owner are one and the same.

Initiator

Person proposing change or identifying an occurring potential change. It can be anybody within the company. The initiator works with the change owner to prepare the supporting documentation requested by the MoC program

MoC

Acronym for "Management of Change". It is also used to refer to a proposed change that is going through the management of change process.

MoC Form

The MoC form is essentially the record for each change. The form is essential to allow the necessary information to be gathered and recorded efficiently and effectively.

MoC Log

The MoC log functions like a register or record book of all changes onboard. The information contained in the log can show at a glance which changes are open, which are about to expire, and which are late and where actions need to be taken. The MoC log can be paper-based or electronic.

Onboard MoC Coordinator

Someone onboard who keeps a log of all the MoCs and current status of each change. This may be one of the onboard engineers whose responsibility is similar to those of the shore-based MoC coordinator. His/her job is to verify that changes are completed in time and updated and closed out as required. The onboard MoC coordinator has the responsibility to see that all the change owners onboard are on track with their MoCs.

Replacement-in-kind

When an item, process, or person meets the existing specified criteria for the item it is replacing, it is typically not considered a change, but a replacement-in-kind.

Shore-side MoC Coordinator

The shore-side MoC coordinator tracks MoC program performance, including the status of MoCs and MoC actions, and undertakes audits of MoC programs fleetwide. This role typically falls upon someone shore-based with HSQE responsibility, although a ship may have an on-board MoC coordinator in addition to the shore-side coordinator.

B. MOC Process

Regardless of a company's culture, organization, values, and programs, the key steps discussed in this Subsection should be considered when designing any formal management of change program. The process determined in these Guidance defines six steps, as follows:

1) Initial Review
2) Senior Review
3) Detailed Risk Assessment
4) Approval
5) Implementation
6) Verification and Closeout

An overview of the MoC process is depicted in the flowchart of Fig. 3.1.

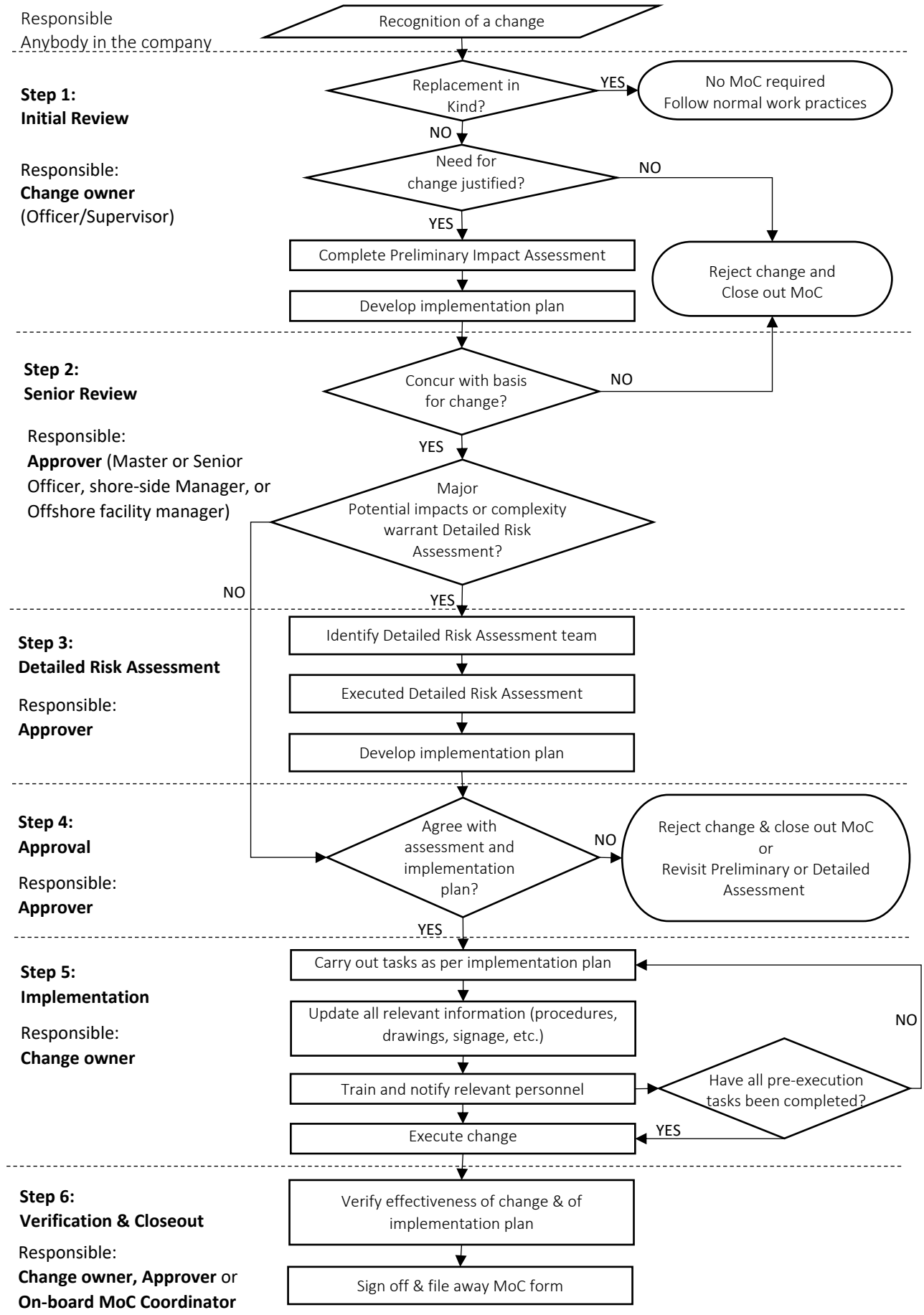


Fig. 3.1 MoC Process Flowchart

C. Step 1: Initial Review

This step involves stating the justification for the change, as well as developing an initial assessment of the hazards associated with the change and proposing an implementation plan with risk control options.

An Initial Review would typically involve completing a checklist or initial sections of the MoC form to guide the user through the required analysis. It would typically address the following aspects:

1) Justification and coverage:

   Is the change needed? Is it a replacement-in-kind and thus outside the MoC program? Is it to be controlled via the MoC program or some other management system?

2) Preliminary impact assessment

   What are the potential impacts of the change? The change owner and initiator are required to brainstorm the potential consequences of the change. In particular, the possibilities of significant safety, environmental, economic, and business implications should be listed.

3) Implementation plan

   What controls are proposed to reduce the risk associated with identified impacts? How will the change be properly executed to minimize additional risk? A draft implementation plan should be determined to indicate the way in which the change will be executed, including administrative or engineering control measures recommended to mitigate risks caused by the change. The plan should also detail actions concerning the update and development of documentation to support the design and operation of the revised system.

The MoC process described herein is targeted for permanent changes. However, two special types of changes, emergency and temporary, need to be controlled but demand slight modifications to the standard approach. It is very important to identify in this initial review if the change is emergency or temporary so that they are handled appropriately. The MoC process variations for controlling emergency and temporary changes is addressed in I., whereas detailed guidance for conducting the Initial Review is given below.

1. Justification and Coverage

This task is essential to minimize the potential of starting an MoC process for a change that does not warrant it. As a starting point for any change proposal, there should be an explanation of the proposed modification, including the reasons why it is necessary and what is expected to be achieved. There should be enough description and detail to allow the approver of the change a clear understanding of the situation.

The initial reviewer should verify the applicability of the change within the MoC program by confirming that the change is a type of change covered within the company's MoC program and is not a replacement- in-kind.

Individuals that can find themselves in the capacity of performing Initial Reviews should be well conversant in the MoC program to allow them to spot a change that does not meet program criteria for evaluation under the MoC program. The change owner should also have awareness of other mechanisms in place to control the particular change. MoC Process Flowchart

2. Preliminary Impact Assessment

Once it is decided that the change is a type that needs to be managed within the MoC program, the next task is to brainstorm the potential impacts associated with the change. A change is normally proposed because it is advantageous. However, a change that is not properly evaluated can also bring negative impacts that outweigh its benefits. The ultimate goal of an MoC program is to control the change process to minimize or eliminate any adverse impact on safety, property, and the environment, as well as quality, security, or any other aspect of interest to the company.

The preliminary impact assessment is very important in an MoC program, and it should appropriately identify all potential impacts associated with the change. Training on hazard identification and hazard management is essential to secure completeness in the preliminary impact assessment. A useful tool to help the Initial Reviewers complete the preliminary impact assessment is a checklist, as well as prompts and guidance built into the MoC Form. A sample preliminary impacts checklist and MoC form can be found in Annex A and Annex B, respectively. Additional guidance on conducting impact assessments can be found in the Reference Notes on Risk Assessment for The Marine and Offshore Oil and Gas Industries (Pt.4, Vol.1)

The MoC program can be made more efficient if the detail and resources for the risk assessment are scaled up or down depending on the complexity and anticipated impact of the change. Up to this point, the change process has involved the identifier of the change (initiator) and the change owner, which could be one and the same person. If the change is simple and impacts are deemed to be minor, the evaluation done by the initiator and change owner should satisfy, and there is no need for further assessment. On the other hand, a change that has been preliminarily assessed during the Initial Review as having major potential impacts is likely to need further assessment to more clearly identify the potential outcomes and measures to mitigate the risks. These detailed risk assessments usually escalate the number of resources and subject matter experts needed for the assessment, as well as the depth of the analysis, as described in E.

Personnel and organizational changes require a special approach to identify risks. One such approach is mapping of tasks and individuals from the existing situation to the proposed one. The mapping involves identifying all personnel affected by the change and identifying the tasks each person carries out. The list of tasks must include their primary tasks and any special roles such as emergency responder, in addition to competences needed and time expected to be spent on each task. This information is then carefully compared checking that for each individual the workload is reasonable, simultaneous tasks can be realistically accomplished, that the competencies match the requirements for the task – or identifying the training needed to enable the personnel to carry out the expected tasks.

3. Implementation Plan

The implementation plan describes how the change will be executed and identifies specific actions, time limits, and responsibilities for addressing any HSQE issue or any negative impact prior to the change being implemented. Typical action items in an implementation plan would be to determine the specific controls to mitigate risks associated with the change, the types of notification needed, training, documentation, etc.

An implementation plan shall not only indicate the actions needed for the execution of the change, but also assign responsibility for each action and identify a timeline for the actions to be completed.

D. Step 2: Senior Review

Once the impacts are assessed in the Initial Review, the senior review step involves presentation of the initial analysis to the designated approval authority. Before a change can be implemented, the approver should review and concur with the basis for the change, confirm that the preliminary impact assessment did not identify significant concerns warranting cancellation of the proposed change, and provide agreement with the implementation plan. If the approver has a concern regarding the outcome of the Initial Review, one of several alternatives can be chosen:

- The Initial Review is repeated but with a focused objective to provide substantial input in addressing the concerns raised by the approver, or
- The change is rejected, and the MoC form is considered ‘closed’ and retained for future reference.
- A more detailed form of risk assessment is requested to be developed and the resulting implementation plan approved before the change may be executed, as described in E. Step 3.

E. Step 3: Detailed Risk Assessment

When the preliminary impact assessment identifies that the change has potential for major consequences, or the complexity of the change do so, then a greater degree of surveillance is required to assess the potential risks. In these cases, the change owner or the approver is strongly advised to request a second more thorough and comprehensive risk assessment.

One of the main differences between the preliminary impact assessment and the detailed risk assessment is the number of people involved. The detailed risk assessment would be carried out by a team including subject matter experts from various disciplines. This detailed risk assessment should provide further clarification into the nature of risks to be controlled and as an output, produce a list of requirements or controls to be implemented before effecting change.

The risk assessment should be based on failure scenarios that force the risk analyst to think in terms of what could go wrong. The potential failure modes and impacts in a ship or offshore facility will vary depending on the operations it is undergoing when the failure occurs, thus all relevant operations are to be considered. Typical operations to keep in mind for a ship are loading/offloading, transit in open waters, transit in close quarters, laden transit. In an offshore facility, the list of operations is very lengthy, and would include drilling, production, construction, anchoring, heavy lifts, diving, simultaneous operations, etc.).

The full benefits of change management are only realized when the risk analyst takes a life-cycle approach in identifying issues associated with the change. The risks resulting from the change can occur before, during, and after change implementation. For example, before a change that involves tapping into an existing system is implemented, preparation activities can negatively affect an interconnected system. While the change is being executed, there are typical safety concerns for the people involved in the repair, as well as potential effects on the interconnected systems. After the change is implemented, the added load can result in problems with the existing system.

Typical failure scenarios should not only consider failures associated with all modes of operations, but also potential failures or impacts throughout the entire life cycle, such as:

- Removal of the old device/system/procedure
- Installation of the new system
- Transition from one state to another
- Change in place
- Maintenance to support the new system
- Safety and environmental concerns associated with decommissioning when end of life is reached

This is substantially more than just considering how the new system can fail and the consequences arising therefrom.

Once failure scenarios are identified, the consequences can be assessed on the basis of negative impacts to health and safety, the environment, crew and ship or offshore facility security, and financial/commercial values.

A wide range of risk assessment tools can be used to determine the extent of the potential risks (i.e., consequences and likelihood of occurrence). The following tools and techniques are typical examples of types of risk assessments performed for managing change:

- Hazard identification and assessments, such as What-If, HAZID, HAZOP, for equipment changes
- Structural analysis required by naval architects
- Engineering analysis required for equipment modifications
- IT analysis and approval for software changes

- Competency analysis required by HR for crew related issues.
- Legal analysis required by Legal Department to determine if a change contravenes prevailing legislation in different jurisdictions
- Organizational development analysis for an organizational change

Additional guidance on hazard identifications can be found in the Reference Notes on Risk Assessment for the Marine and Offshore Oil and Gas Industries (Pt.4, Vol.1).

The first step of a risk assessment is to identify all likely potential undesirable events and then to evaluate the risks they present in terms of how often they are likely to happen and how severe the consequences will be if the loss occurs. Once this information is ascertained, the next step is to determine how the risk, and therefore the change, will be managed. The detailed risk assessment outcome will typically lead to options such as:

1) Terminating the risk (i.e., do not proceed with the change)
2) Managing the risk of the change using good technical experience, controls, procedures, engineering controls, etc., or
3) Proposing alternative solutions to the problem that originated the change.

An important element in the decision is evaluating the costs of the selection and weighing them against the risks so that a reasonable decision can be made.

If the option to manage the risk is the one recommended by the detailed risk assessment, an implementation plan must be developed. Such a plan should describe how the change will be executed, what specific actions must be carried out, including the risk control options, as well as time limits and responsibilities for addressing any HSQE issue or any negative impact prior to the change being implemented.

F. Step 4: Approval

If the implementation plan presented in either the Preliminary Impact Assessment or the Detailed Risk Assessment is approved, the change may be executed.

It is strongly recommended that the results of the initial impact analysis be confirmed and validated by the approver. A change whose potential impacts have been poorly analyzed may result in insufficient implementation planning. This will increase risk exposure and the likelihood of significant and unfavourable impacts.

In order to adequately perform the technical review, it is critical that the approver be competent in the field or domain where the change is occurring. For instance, in a shipping company, a non-engineering shore- based manager typically has not acquired the necessary competencies to solely provide acceptance for a structural change. Such a change is typically reviewed for approval by an appropriately qualified engineer or naval architect.

If the approver does not approve with the outcome of the assessments and the proposed implementation plan, he or she can reject the change and close out the MoC or ask for the Preliminary or Detailed Assessment to be revisited.

G. Step 5: Implementation

The implementation step is about executing the change and implementation plan. It also includes updating the documentation to reflect the change, communicating the change, and training personnel on the change.

1. Documentation

Management of change requires effective documentation control. Documents from different areas such as drawings, procedures, checklists, permits, emergency response plans, training manuals, software code, signage, etc., may need to be updated to reflect an approved change. A well thought out checklist should be in place to help identify all the management processes that can be impacted by the change. The documentation of such an impacted management process should also be updated if needed (procurement, maintenance, training, mechanical integrity, emergency response, etc.).

Procedures should be updated to reflect the desired modification and utilized as a manner of employee training. When modifying equipment, typical documents revised are process and mechanical procedures, flow diagrams, safe work specifications, inspection methods, maintenance and testing frequencies, etc.

2. Communication and Training

Before the change is implemented, all affected personnel should be aware of the change that will take place. The change owner should emphasize consequences of concern and special precautions to be taken as a result of the change.

Change should be communicated to all personnel who may be affected by the change. This notification should occur before the change is implemented. For the case of emergency changes where by nature the change cannot be communicated beforehand, the notification should take place immediately after the execution of the change to advise oncoming shift personnel. For crews that alternate tours of duty, a formal mechanism should exist so that when the crew comes onboard, they are all made aware of the change that took place while they were off duty. The manner and breadth of communication/training should be reflective of the complexity of change (examples are e-mail, announcements in meetings, tool box talks, safety meetings, full awareness campaigns, formal training, etc.). Relying on passive notifications such as entries in log books or documentation in procedures should not be the sole way of communicating to personnel since they could easily be overlooked by personnel that need to be aware of the change.

Changes involving significant revisions to current practices will require training of relevant personnel. An awareness training, or in some cases, detailed training of the new practice should be provided.

In addition to notifying the people immediately affected by the change, there should be consideration of the need to inform other departments (procurement, maintenance, training, etc.), shore-based organization (HSE manager/ISM designated person regarding the adjustment in operations and/or risk, updating the enterprise wide information system), and external stakeholders (class, regulatory, Flag state, etc.)

Any modifications to documentation or process drawings, updates to risk assessments and reviews, should also be communicated to demonstrate transparency of the MoC process.

3. Execution

Before executing the change, the change owner should confirm that all risk control measures from the risk assessments are on target with the implementation plan, and that the affected personnel are trained and informed of the change. Then and only then should the change be put in place.

H. Step 6: Verification and Closeout

Once any change is implemented, it is good practice to revisit it in the short-term to assess effectiveness.

Companies may find it difficult to finish the update to documentation before the needed change is executed. This verification step will check that the follow-on work was performed prior to closing out the MoC.

Temporary changes should be monitored to confirm that before expiring they are either converted to a permanent change by completing the MoC process or reverted to their original state.

Therefore, some of the questions to be answered during this verification step are as follows:

- Are the changes meeting their intended functions?
- Are the actions from the implentation plan being complied with and meeting the intended function?
- Have the temporary changes expired? If so, can the system revert to its original state? If the answer is “no”, proceed to convert to a permanent change, restarting the MoC review process.

1. Closeout

All changes that have gone through the MoC review process, even if they were eventually rejected by management, should be signed-off and retained for audit and inspection. This is an essential step to be able to audit the MoC program and monitor the program for continual improvement.

A summary of the typical evaluations carried out in each step of the MoC process is presented in Fig. 3.2

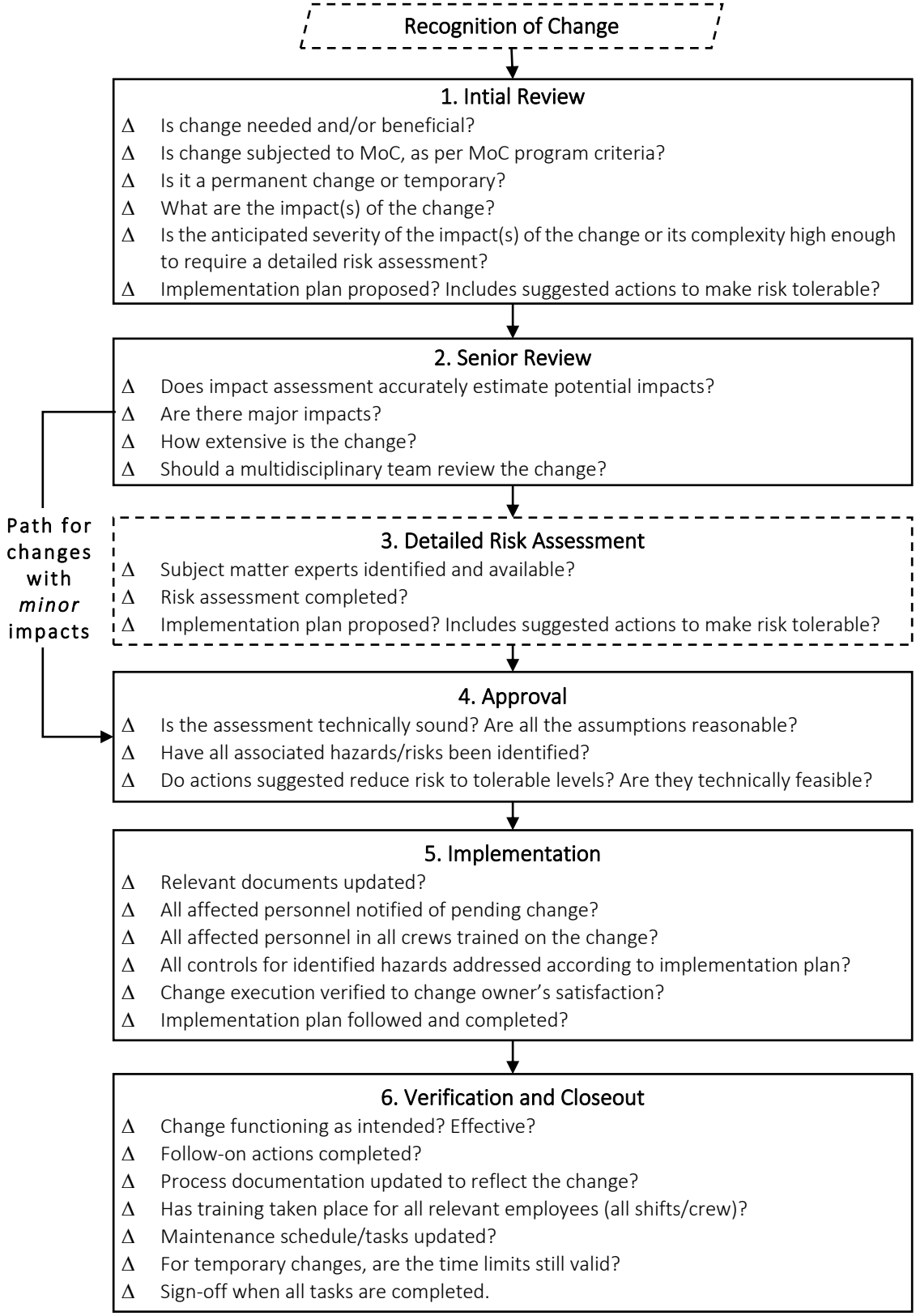


Fig. 3.2 MoC Process Summary

I. Special Circumstances: Temporary and Emergency Changes

It should be identified during the Initial Review if the change falls into the category of temporary or emergency. This distinction is important as the MoC program should offer some flexibility to control changes under these special circumstances.

1. Temporary Changes

A temporary change is one that is intended to exist for a short and predetermined period of time. Management of change procedures for temporary changes should follow the same process as a permanent change, but they are only valid for a specific time limit as they may carry a higher level of risk that is acceptable only for a short term.

Temporary changes must have a specified time limit to ensure they are returned to the original system condition or that further steps in managing the change are addressed (i.e., converting the temporary change into a permanent change).

The intent is to make the change, and at some future date, the system will revert to its present or design condition. The time limit for the change should be specified such that if the change does not revert to the original condition, then a permanent change should be implemented. Note that a conversion from a temporary to a permanent change requires that the MoC process be initiated. This new process is intended to highlight improvements to the proposed change, such as new risk control measures that offer a lower risk than the current temporary situation. The new MoC may highlight a situation that, although tolerable for the short term, would be unnaceptable on a permanent basis. Temporary changes normally require less effective documentation than permanent changes. Thus, another important reason to re-initiate the MoC process when converting a temporary change to a permanent one is to identify required updates to documents, procedures, training, etc.

Temporary Changes = Temporary Risk Mitigation Actions

A fire alarm sensor in the engine room malfunctions and needs to be deactivated until the required spare is available. A temporary MoC is carried out. As part of the implementation plan, the measures to mitigate the risk include ensuring the engine room remains manned, if operating under Unattended Machinery Space. For this temporary change, the engine drawings, design documentation did not require changing, but instead, a revised temporary procedure was implemented to manage the change.

The company should define in the program the maximum length of time permitted for a temporary change (such as six months, or until the next dry dock period, etc.). Some companies offer some space in the mandatory time for a temporary change to be converted to a permanent change by providing the ability to extend the time limit for the temporary change by one or two cycles. In either case, a system should be set up to review all temporary changes around the expiration date to verify that:

i) The system was returned to its original condition, or

ii) Conversion was initiated to make the change a permanent part of the system (new MoC required), or

iii) The period for validity of the change was extended.

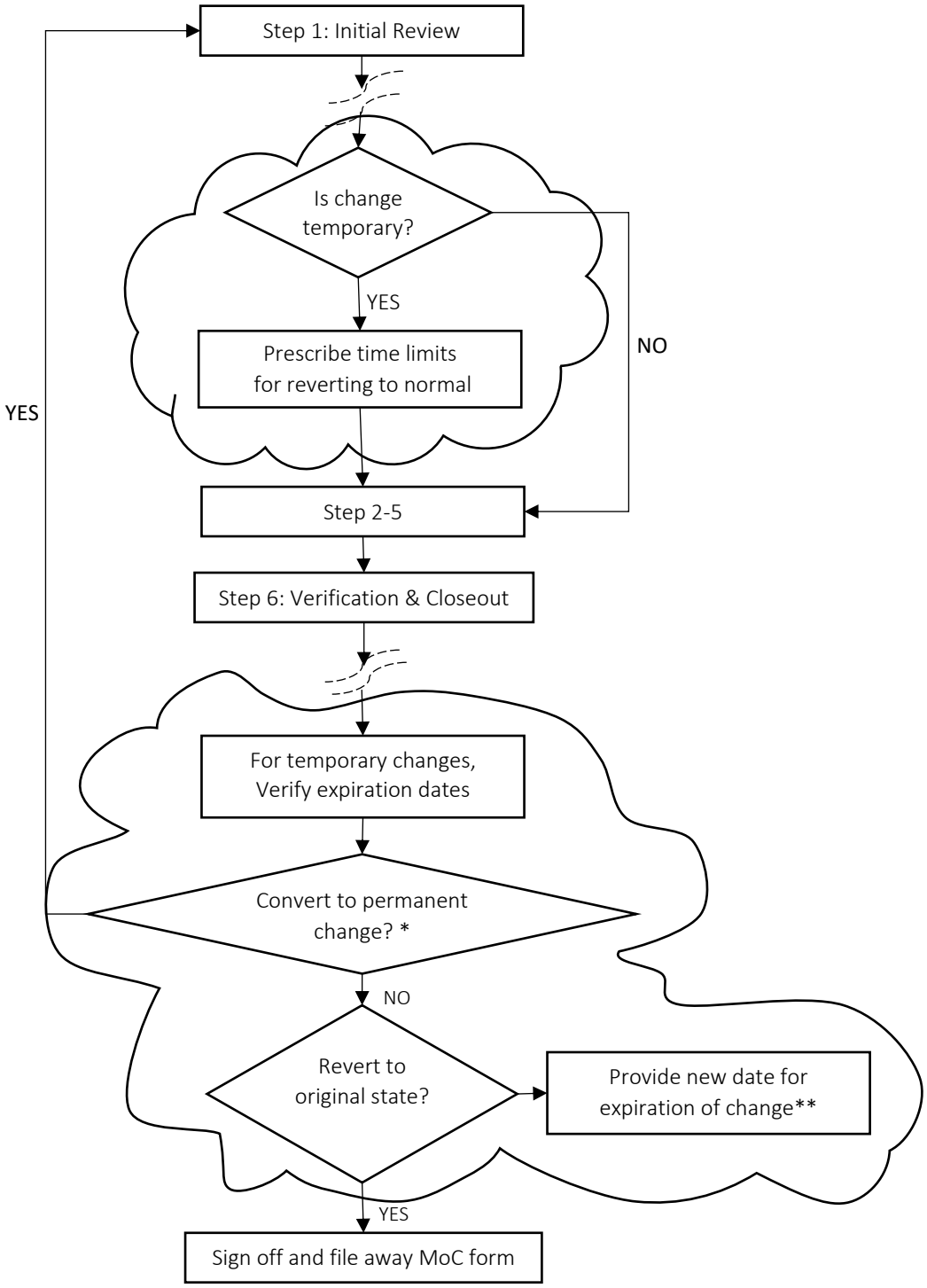
Note that extending the validity of the temporary changes should not be allowed, except for exceptional circumstances. Such an extension requires careful consideration and documentation in the MoC form, which includes as a minimum, re-validating the impact or risk assessment, and proper approvals.

Examples of temporary changes may include:

- Testing/calibration/repair or replacement that requires disabling safety/critical systems
- Installing temporary piping, clamps, connections, utility connections, or hoses:

- Temporary change in routing
- Temporary crew change
- Temporary change of contractors onboard
- Short term use of a new port
- Workaround procedure
- Temporary operation with specific safeguards bypassed or inoperative.
- Temporary de-activation of security features for carrying out maintenance or operation

Fig. 3.3 presents the process to be followed for temporary changes.



Note:

** A conversion from a temporary to a permanent change requires that the MoC process be re-initiated. In many cases, a higher risk is acceptable for temporary changes. A second pass is intended to highlight improvements to the proposed change, such as new risk control measures that offer a lower risk than the current temporary situation.*

*** Time extensions on temporary changes should not be allowed except for exceptional circumstances. Any such extension requires careful considerations and documentation in the MoC form.*

Fig. 3.3 MoC Process for Temporary Changes

2. Emergency Changes

An emergency change is a change that must be performed in a true emergency. Generally, the situation is such that action is required quickly, and the persons required to provide approvals may not be available to meet the requirements of the written MoC process. In these "emergency" situations, safety could be endangered by waiting for completion of the formal MoC process. In an emergency situation, the change should be reviewed to the best of the staff's abilities. This emergency MoC process should involve a risk assessment using any and all available resources and time to evaluate the risks involved with the change and it may be verbal, rather than written. The focus should be on the immediate risks only. The verbal implementation plan should also be developed and carried out by relevant personnel, with approval from the highest ranking personnel available with domain expertise. The approver for temporary MoCs in a ship should be the Master or the Chief Engineer.

In an offshore facility, the approval of emergency MoCs should fall in the person with ultimate work authority (UWA) at the facility. In the event of an emergency creating an imminent risk or danger, the person with the UWA is has the ultimate authority for safety and decision making at a facility. This procedure to ensure such a high level approval for temporary MoCs will help avoid a cultural trap where team members resort to emergency measures to circumvent the formal MoC process.

At first opportunity after the emergency has been controlled, the change must be fully evaluated and documented using the MoC procedure. The reviews will dictate if the change should be:

- Reversed to continue operations as in the pre-emergency status or
- Converted to a temporary or permanent change.

Taking advantage of the time and resources not afforded in the midst of an emergency, the output from the MoC process review can also propose a different change to address the problems that caused or resulted from the emergency.

Situations such as the following may require an emergency MoC:

- Correction of a deficiency that would cause an immediate threat to safety of the ship or offshore facility or personnel/environment
- Imminent environmental release
- Impending external threats that could result in a loss of cargo, such as natural disasters, security threats or extreme temperatures

Fig. 3.4 presents the process to be followed for emergency changes.

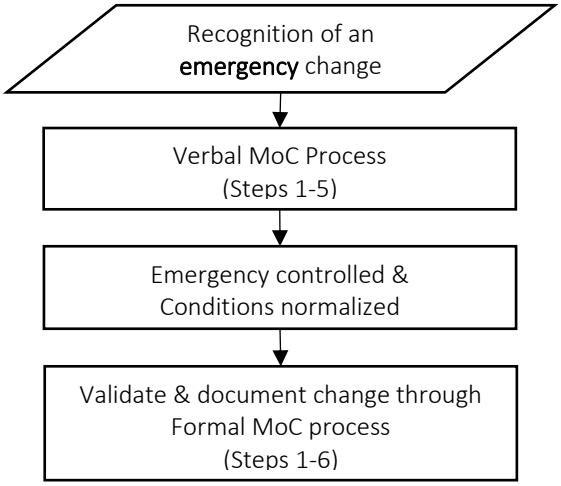


Fig. 3.4 MoC Process for Emergency Changes

Section 4 MoC Program Implementation

A. MOC Program Implementation

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

1) Clear roles and responsibilities
2) Appropriate organizational preparation
3) A written MoC program manual that includes MoC forms
4) Pilot roll-out before the full-scale deployment, training of affected personnel, and
5) Close attention when integrating MoC with existing programs.

B. Roles and Responsibilities

The implementation of a management of change program requires actions by many individuals and departments. Specific roles and responsibilities will differ depending on location and circumstance. For example, onboard a large ship, there may be more than one person assigned to the responsibilities outlined below. However, on a small ship, one person may be assigned multiple roles and responsibilities within the MoC process. The MoC program procedures should describe the roles and titles for key personnel within the MoC program.

Main responsibility for the proposed change before start-up rests with the individual responsible for the area. but in general, the roles described below typically support an efficient program.

1. Initiator

The initiator is the person proposing a change or identifying that a change occurred and who works with the change owner to prepare the supporting documentation requested by the MoC program. It can be anybody within the company. If the initiator is an officer level or in a supervisory position in the area where the change is proposed, he or she will also be the change owner and conduct the Initial Review. If the initiator is someone not in a supervisory position, he or she should seek assistance from his or her supervisor for conducting the next step.

The initiator's competencies should include:

- Safe behavior training, with an emphasis both on recognizing the need for changes and potential changes that occur in the system.
- Knowledge of the MoC system, with particular emphasis on the types of changes covered, definition of replacement in kind, and how to initiate the MoC process.
- Basic awareness of preliminary impact assessment

2. Change Owner

The change owner is a person of supervisor/officer level with responsibility in the area where change is proposed and who works with the initiator in preparing the Initial Review. If the initiator shipboard is an officer or above, then he or she can also prepare the Initial Review as the change owner.

The change owner has main responsibility for the change and, in addition to being in charge of the Initial Review, the change owner will be also be in charge of monitoring the implementation of the change (e.g., coordinating the revision and update of documentation impacted by the change and communicating the change to affected personnel). The responsibility for training may fall on the change owner or on the person who is in charge of training for the organization.

It is a primary responsibility of the change owner to confirm that the change was implemented according to the implementation plan, and subsequently, to verify that it is functioning as intended.

Required competencies for the change owner should include:

- In depth knowledge of the MoC program
- Well versed in conducting a Preliminary Impact Assessment
- Strong writing skills if he or she may be responsible for updating procedures and other documentation
- Communication and training skills, if he or she may be responsible for communicating the change to the relevant personnel, or train them on the change

3. Approver

An effective MoC program requires a structured approval process that complements the management structure, the complexity of the activities involved, and the levels of competence onboard or at the shore-base. The approver appraises the Initial Review to confirm the need for change and validate the preliminary impact assessment and the implementation plan. If the change has major impacts and it is particularly complex, the approver is strongly suggested to request further detail risk assessment. The program should prevent situations where the change owner and the approver are the same individual to create an unbiased process with adequate reviews and second opinions.

The detailed risk assessment, if deemed necessary, is performed by a team of subject matter experts (individuals with strong competencies in the fields or domains where the change is taking place and impacts are being felt). The approver of the change is normally the same person that determines who are the relevant experts to carry out the risk assessment. The approver also signs off on the risk assessment outputs, including the implementation plan, and designates the personnel to carry out the implementation plan.

In the shipping industry, appropriate approval authority is typically a Senior Officer such as Master, Chief Officer, or Chief Engineer. In some instances, the approval authority may also fall on a shore-based manager with key organizational duties. On an offshore installation, a member of the facility management should approve it.

Required competencies for the approver are:

- In depth knowledge of the MoC program
- Knowledge of Preliminary Impact Assessment and Detailed Risk Assessment
- Administrative and managerial skills

4. Onboard MoC Coordinator

The individual onboard in charge of keeping an up-to-date log of all the MoCs and current status of each change. His/her job is to verify that changes are completed in time and updated and closed out as required. The change owner is responsible for the change, but the onboard MoC coordinator has the responsibility to see that all the change owners onboard are on track with their MoCs (Step 6: Verification and Closeout).

The onboard MoC coordinator could also be the one verifying the expiration date of temporary changes and verifies the change owner has indeed finished all of his or her actions in order to close the MoC. For instance, if a temporary MoC is about to expire and it has not been converted to a permanent MoC, it is the responsibility of the onboard MoC coordinator to remind the change owner of the pending actions and get the MoC closed out or converted to a permanent MoC or, in rare cases, get an extension. A program can opt to have the onboard MoC cordinator in charge of closing out the MoC form.

The onboard coordinator competencies should include knowledge of the MoC program and basic adminstrative and managerial skills.

5. Shore-based MoC Coordinator and Other Shore-based Support

The shore-based MoC coordinator tracks MoC program performance, including the status of MoCs and MoC actions, and undertakes audits of the MoC program. This role typically falls upon someone with HSQE responsibility. Other departments that will need to be counted on for on-demand support to the MoC program include:

- Engineering and Operations.

  Identify/review equipment and operational changes, participate in preliminary or detailed risk assessments, etc.
- Safety and Environmental.

  Review change against HSE regulations to verify compliance with codes, regulations and company practices.
- Structural Engineering.

  Identify/review structural changes, participate in change risk assessments, etc.
- Process.

  Identify/review changes affecting the topsides and process of offshore process facilities, participate in preliminary or detailed risk assessments, etc.
- Procurement.

  Procure the in-kind replacement requested, identify potential non-in-kind replacements, and provide the change owner with suppliers' specification and other data to aid in the in-kind determination of a replacement, etc.
- Training.

  Support for changes that require more in-depth training than that which the onboard staff can provide
- Human Resources.

  Provide personnel qualification matrices and define lines of reporting, participate in risk assessments for organizational changes.

A summary of the roles and responsibilities in the MoC process is presented in Fig. 4.1.

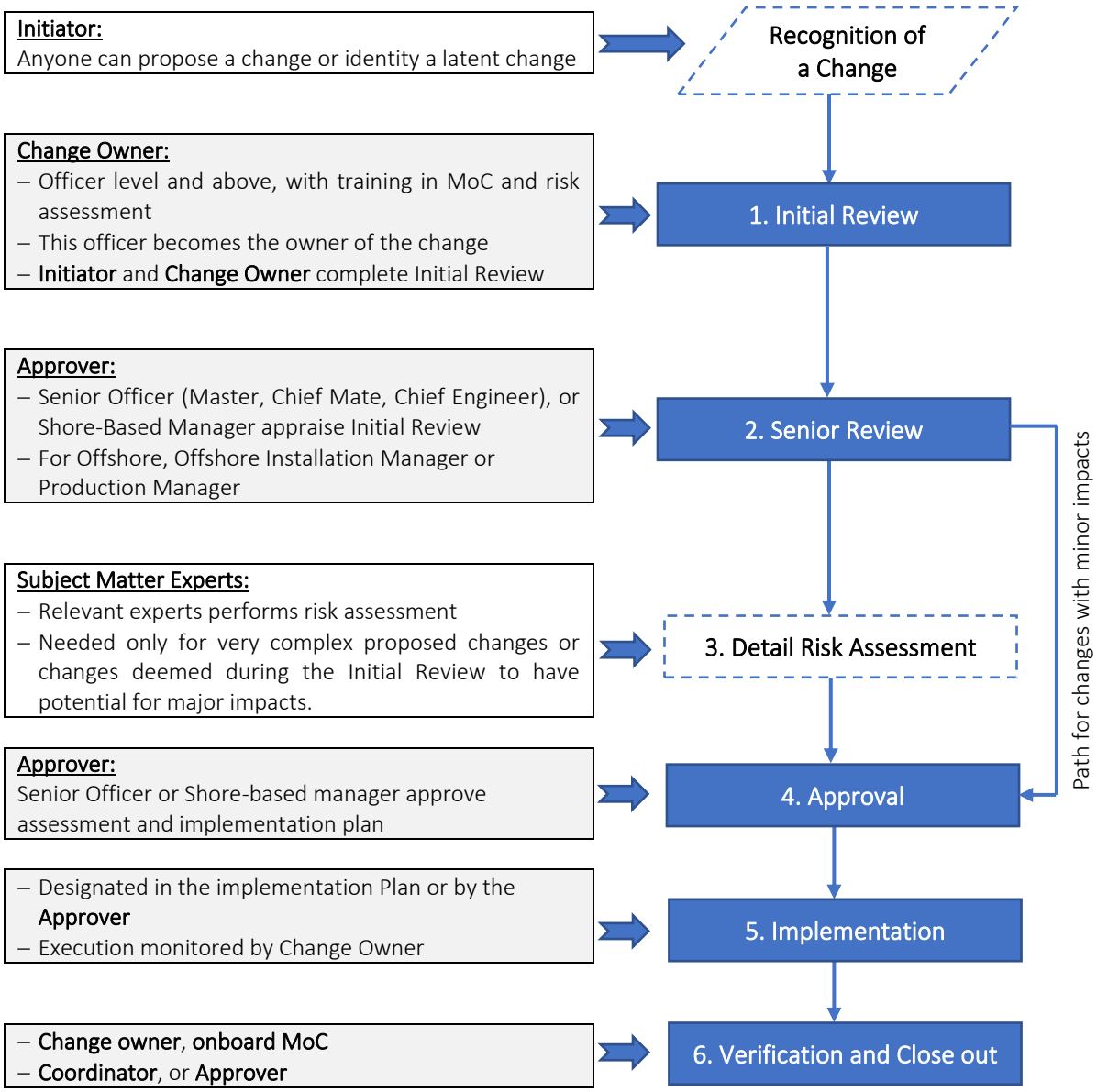


Fig. 4.1 Roles and Responsibilities in the MoC Process

C. Organizational Preparation

Organizational preparation is integral to successful implementation of management of change. Management should lead the commitment toward execution of MoC. This should be exemplified in the policy and vision of the organization. Management should also allocate the required resources to achieve successful implementation of the program. This commitment should be demonstrated throughout all levels of management, and across various business segments within the organization.

1. Culture

The MoC program implementation plan should take into consideration the existing culture of the organization and should assist in creating an environment that encourages commitment to the program. Proactive approaches such as change management can be counterintuitive to companies with low safety culture maturity whose primary goal is to get the job done as quickly and with as little investment in resources as possible.

In order to implement a successful management of change culture, the organization itself may first be required to undergo change. It is not uncommon that permanent employees comfortable with their core responsibilities are less tend to welcome change. Over time, self-satisfaction can obscure the importance of safety, and unless the importance of safety in the organization is emphasized, opportunities for eliminating unsafe behaviours are not realized. Thus, preventing negative perceptions toward a new initiative focused on management of change is important for successful implementation.

Employees must be educated to understand the benefits of managing change. The value of an MoC program for protecting personnel safety, the integrity of the facility, and the environment must be recognized by employees if implementation is to be successful. The MoC program should not be viewed as a 'paperwork exercise' that negatively impacts an employee's ability to efficiently meet work obligations and tasks. Engaging employees early in the design and development stages of the program will promote buy-in and help to control negative perceptions.

2. Management Support

Management commitment is necessary in developing a work environment conducive to the successful implementation of MoC. From the crew's perspective, company concern is inferred when the master, chief engineer, or shore-based manager discusses MoCs with employees on a regular basis. When standard business metrics include MoC and when managers participate in change reviews, the company's commitment is evident. Failure to achieve this important objective may cause MoC to appear as a trend that will not be continuously scrutinized by management.

Often for employees, the actual test regarding the permanency of and commitment to the MoC program occurs when they see management reactions to the MoC process when challenged by competing operational goals. If the requirements of MoC are suspended even temporarily for the benefit of business and economic advantage, the practice of MoC in the minds of the employees is underestimated. Thus, continual engagement and commitment (e.g., asking questions on program performance, rewarding successful program metrics, taking action to improve the efficiency and quality of the program, etc.) make it clear that the MoC program is viewed by management as a standard for conducting business.

3. Resources

The level of effort required to manage an MoC program must be clearly estimated at the development stages. There needs to be enough people with capacity to take on MoC preparation, review, analysis, and approval, as well as audit and tracking. For example, all officer-level personnel should be trained in the MoC program, including how to conduct a preliminary impact assessment. Consider documenting the MoC roles as responsibilities within job descriptions and assessing personnel performance matrices during annual appraisals. Reinforce personal accountability for tasks within the MoC program by implementing leading performance metrics such as attendance at MoC review meetings, length of time in approver's hands, number of MoCs closed within the specified time, and number of MoC actions completed (see Section 5, B. for more on performance metrics).

An MoC process that utilizes onboard personnel for reviews and approvals will be more efficient than one that relies heavily on onshore resources. There will be cases, however, when the collective experience onboard will need to be supplemented by onshore expertise. The fact that shore-based staff may only be available during the shore-base normal working hours may present a problem for proposed changes that require shore-based review or approval, but also a quick turn-around. The MoC program should outline clear lines of communication and responsibility to improve access to relevant and experienced personnel.

Resources in the form of documentation and data will also be needed during the review of a proposed change. For example, the Preliminary Impact Analysis and the detailed risk assessment will benefit from up-to-date machinery and process information available to perform the required reviews. This can be a challenge in the marine and offshore industries where information can be distributed between the ship or offshore facility and the shore-base. A solution is to include a shore-based representative with remote

access as part of the assessment team. If this cannot be accomplished, then special provisions may be created in the review process for review by a competent person prior to approval when attempting to assess risk.

Historically, MoC teams were composed of operations, engineering, and maintenance personnel. Proactive organizations demand significant participation from cross-sections of the organization. Procurement professionals can provide enormous support in risk control by reviewing contractor quality, training, and experience standards prior to bid meetings. Information Technology (IT) departments may be required to set up electronic MoC programs (which should be user tested and established before full rollout). Communication or Human Resources departments may be involved in the preparation of training materials and information sharing. Other departments may be responsible for preparing support materials such as spreadsheets and files, or preparing all the other tools and forms necessary to conduct an MoC.

A company wishing to keep track of time spent in the management of change process can implement a specific MoC charge number that personnel can use to accurately record the time spent. This information would be valuable for trending, efficiency analysis and continuous improvement of the program.

D. MoC Program Manual

It is important to document the processes and procedures of the MoC program to establish the rules for the program, educate personnel on the process, and provide consistency in the implementation. This written program should outline the basics of the process. The MoC program should clearly state the manner for updating process documentation. An effective formal document control system will support change management and provide reliable access to current information, preventing the use of superseded versions. A robust documentation system that is simple and not inconvenient has a greater chance of being adopted by personnel.

The MoC program documentation should be aligned with that of other management processes to reduce repetition, increase the opportunity for standardization, and ease implementation and compliance with internal and regulatory policies.

Two important tools need to be present for a smooth implementation of the MoC program:

- the MoC form; and
- the MoC log.

E. MoC Form

The MoC form is essentially the documented record of all evaluations, approvals, and actions associated with a change. The development of the MoC form is essential to allow the necessary information to be gathered and recorded efficiently and effectively. Information typically requested in an MoC form includes, but is not limited to, the following:

- MoC Reference Number (should be same as in the MoC log)
- Date
- Names and department of initiator and change owner
- Description of proposed change, including the reason/technical basis for the change
- Type of change (emergency, temporary, or permanent)
- Preliminary Impact Assessment (may include a checklist to facilitate process)
- Implementation Plan
- Questions or criteria to decide if detailed risk assessment is needed

- Approvals
- Prescribed time limits and status reviews for temporary changes
- Documents that need updating (may include a checklist to facilitate identification)
- Change summary communication list
- Training needed

See Annex B for sample MoC form.

F. MoC Log

The log functions like a register or record book of all changes on board. The information contained in the log can show at a glance which MoCs are open, which are about to expire, which are late and where actions need to be taken. This ensures MoCs do not stay open for long periods of time. The MoC log typically contains the following information:

- MoC Reference Number
- Date
- Department
- Change owner
- Brief description of change
- Type of MoC (temporary, emergency, or permanent)
- Status
- Temporary changes expiration date
- Approver

The log also can play an important function for emergency changes. MoC programs can allow for emergency changes to follow the MoC program in an abbreviated and verbal (i.e., not documented) format until the emergency is controlled, at which point the change should be documented and the standard MoC process followed. The emergency task team shall, as a minimum, obtain an MoC reference number from the log, which will provide the reminder to follow up on the change through the MoC program.

1. Handover of MoC Responsibilities

A tour of duty can be measured in terms of days, weeks, or months at a time, and sometimes there is not enough time in a tour of duty to complete all the change activities. This puts a significant strain on an MoC program as the change activities need to continue under a different crew than the crew that initiated the change. The crew turnover procedure should include official handoff of the MoC responsibilities.

For a ship or offshore facility, it makes sense to have one log which collects MoC information for all departments. A new crew coming onboard can take a look at the log and see the status of all MoCs without having to go to each department and pull the MoC files, which could be several sheets with attachments.

The log can be paper-based or it can be electronic (e.g., a spreadsheet).

G. Pilot Roll-Out

Implementing the MoC program on a pilot ship or offshore facility will help achieve a smooth transition throughout the organization. This can be taken as a test run opportunity to identify issues and resolve problems before complete roll-out. The pilot roll-out should be monitored and assessed with results analyzed to provide system improvements. This strategy allows the system to be evaluated to improve the

efficiency and effectiveness of the program. Implementation of a program that has not been appropriately analyzed may prove destructive as users may become frustrated with a difficult system.

The omission of pilot implementation to ease the learning process has burdened some organizations with ineffective systems. Clear and concise instruction and good engagement with crews and employees will assist greatly in the effective implementation of MoC. Even for multiple facilities, it is advisable to begin implementation with a pilot trial focused on communication, training, and encouragement. Ships or offshore facilities selected for pilot programs should be chosen based on the following overall characteristics:

- Culture – A ship or offshore facility in which crew is receptive to system improvements with strong management support and direct involvement in safety, and which other employees consider as a leader in safety in the corporation and are an example to others.
- Need – A ship or offshore facility that has many changes on a regular basis, or where past experience has resulted in incidents which could have been avoided with an effective MoC program, and employees and management are motivated to remedy the problem.
- Existing Systems – A ship or offshore facility that has existing systems that will make the adoption of an MoC program much easier (i.e., an efficient management system which could have an MoC program added to it, existing risk-based systems, or advance hazard review processes will make the MoC program much simpler to implement).

The pilot program will also give management an opportunity to demand employee feedback to effect program improvements before implementing across the whole organization. This yields greater user acceptance and “buy-in” by having employees present feedback to shape the final design.

H. Training in MoC

Training personnel to understand the principles and procedures of the MoC program is essential to implementing a successful program.

Awareness training is necessary for all personnel affected by the introduction of the MoC program to ensure correct recognition of relevant changes and correct implementation of the system. Specific training will be necessary for personnel expected to originate change requests, conduct preliminary impact assessment, and review and approve changes.

All those who can make a not in-kind change should be familiar with the MoC process and should be capable of filling out the request for change (usually the first part of the MoC form) and should understand what happens to it once filled out. All supervisors need to be familiar with the process and their role in the process. All those who may be involved or who could be asked to review MoCs should also receive training.

Effective training requires good relevant examples of changes to be controlled as well as replacement-in-kind. Examples should show ship/department specific examples of management of change in similar scenarios to those with which personnel are likely to be confronted. Issues that should be addressed in training include:

- Determining if a change is to be controlled by the MoC program
- How to complete the MoC log
- How to complete an MoC form
- Permanent, temporary, and emergency changes
- Preliminary Impact Assessment
- Detailed Risk Assessment
- Approval process

- Documentation, communication, recordkeeping related to MoCs
- Handover of open MoCs at shift/crew change
- Lessons learned from MoCs

Best practice also suggests that refresher training should be implemented to promote continued improvement of the utilization of the system. Training that is well crafted and delivered to meet the needs of an employee results in engagement rather than resistance.

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Section 5 MoC Program Monitoring

A. MoC Program Monitoring

MoC enforcement in the marine and offshore industries presents a set of unique challenges. Ship captains, for example, are under significant pressure to meet schedules irrespective of weather conditions, and it is easy for changes to happen more quickly than an MoC process would allow. There is also more autonomy in the functioning of a ship or offshore facility and greater isolation from shore-based management. It would be much easier for onboard changes that require MoC to be performed uncontrolled without repercussions and in many cases discovery. The bypass of steps in the MoC program is more difficult onshore given the number of persons present and involved in the process and the level of vigilance by coordinators and supervisors.

The program is implemented for legitimate and important reasons and therefore should be utilized correctly unless extreme situations prohibit it. Compliance with the MoC program can be improved by:

- Communication of the importance of MoC and support from the top of the organization
- Effective administration, monitoring, and tracking of the program, and
- Continual improvements to optimize the program

Effective administrative strategies should be in place to operate and maintain the MoC program, starting from accurate and timely completion of MoC forms to the monitoring and continuous improvement of the program

To optimize operation of an MoC program it is important to audit and monitor the system. An MoC program requires clear direction and sufficient resources to run smoothly. One of the resources necessary should be act as of the MoC coordinator(s) and the level of administrative support. The role of the MoC coordinator is to monitor the operation of the system, resolve any issues that may arise, and have overall responsibility over the maintenance of the program records and documentation. In the marine and offshore industries, this role usually falls under someone within the shore-based HSQE team. Depending on the needs of the system; it may be that only part-time resources are necessary. However this should be carefully considered in the design and implementation stage. As previously mentioned, a lesson learned from other industries is that under-resourcing this role can lead to abandonment of the whole system.

The MoC coordinator will be responsible for the implementation of the program and making sure changes that go through the program are completed in time. He or she will check for compatibility and alignment with other management processes and other site procedures. The coordinator will verify compliance with the MoC program through regular audits and reviews. Evaluation and assessment of MoC by the coordinator can highlight improvements required to optimize the system.

The MoC coordinator must carefully monitor any temporary and emergency MoC changes, checking that temporary changes are followed up by the change owner within their given validity dates, and check for abuse on the use of emergency MoCs.

Another function of the MoC coordinator can be to provide assistance to determine the risk associated with a change. Thus, it is important that the MoC coordinator is trained in risk assessments, and is well competent for risk identification.

Although most changes will be completed within individual departments, the MoC coordinator can support their efforts by resolving questions and issues that may arise as to the use of the MoC program or disagreements concerning requirements for management of change.

The coordinator should review MoC records for quality and circulate lessons learned and remedial measures implemented to fix problems.

B. Performance Indicators

Program performance indicators and efficiency metrics can aid in system improvements by easily identifying areas of poor MoC performance. These metrics will help determine if sufficient resources are allocated within the program, provide data to monitor the program's ability to prevent incidents, and measure continual improvement over time. Parameters that can be measured to indicate performance and efficiency of an MoC program include the following:

- Number or percentage of modifications that bypass the MoC program
- Percentage of temporary changes that exceeded their validity dates
- Number of changes initially rejected due to incomplete or poorly completed MoC forms
- Percentage of changes that take place before the actual MoC approval step
- Percentage of maintenance work orders that were misclassified as replacement-in-kind rather than changes
- Percentage of changes implemented for which the related documentation was not updated
- Average time period for a change to complete the MoC process
- Average number of manhours spent on a change to complete the MoC process
- Decrease in number of change-related incidents/accidents
- Percentage of personnel that believe the MoC program is effective

C. Record keeping

MoC records must meet corporate recordkeeping requirements as a basic minimum. Ideally, MoC records should be kept locally for quick reference and possibly centrally for archival purposes. MoC records should also be kept in a system that distinguishes MoC records by areas/equipment for easy retrieval. MoC records shall also be distinguished by status (i.e., open or closed) to facilitate regular audits that verify the performance of the MoC program. There is greater urgency for the local storage of draft, pending approval, approved, and open changes, as these may be part of day-to-day operations.

The owner of the change maintains responsibility for the change until it is closed out and needs to have easy access to the MoC record. Updates to documentation should be quick and communicated to relevant personnel immediately so that all personnel involved with the change have access to the most recent and relevant information on which to base decisions. The necessary information that should be gathered and retained for every change would typically include:

- A description of the proposed change
- List of required risk assessment reviews and subsequent recommendations
- Confirmation of approvals for the changes
- Status reviews (for temporary changes)

– Change summary communication list

Some if not all of the items above can be documented within an MoC form (see sample in Annex B).

Efficient record keeping is essential to successful operation of any MoC program. Records of MoC forms for all changes should be archived for use in monitoring individual changes. Records should be kept according to company recordkeeping retention policy, either in a paper based system or electronically.

Record keeping and "sign offs" pose greater challenges onboard if copies of MoC records need to be maintained with the ship or offshore facility as well as onshore management. The shortened duration that ships are in home port limits the opportunity for hand transfers and MoC team meetings. Transfers will often have to be electronic and organizations must take care in preventing revision control from becoming problematic. This is when the use of electronic MoC programs for the cataloguing of change forms with their supporting documentation may be beneficial.

D. Continual Improvement

Continual improvement of the MoC program should be considered when designing the system, but it is also important throughout the operation of the process. Part of the documented procedures should address how the system can be modified effectively to incorporate improvements. Methods of data gathering should be outlined so that all affected by the MoC program have the opportunity and the means by which to offer feedback for improvement.

Part of the improvement process will be to start with a simple paper system and refine the operations and distribution systems. Then areas for improvement will be to optimize the form, add checklists based on information gathered in old forms to clarify further replacement-in-kind and preliminary impact assessment, judgement on minor/major impacts, improve distribution to relevant personnel, improve the assessment/review processes with more structured review approaches, combine sessions to make processes more efficient, look at electronic distribution and archiving of documents, develop key performance indicators (KPIs) and track performance, issue lessons learned, and expand the process to other areas of the business or other locations/ships.

E. Suggested Reading

Additional information regarding management of change and risk assessment can be found in Ch.2, Annex A., B.

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Annex A Preliminary Impact Assessment

A. Tools for Preliminary Impact Assessment

There are a number of different ways in which companies may conduct a preliminary impact assessment for managing change. The methods that follow illustrate some options that companies have chosen to perform a preliminary impact assessment. For example, a subjective evaluation of the hazards can be complemented by the use of a checklist, and a risk matrix can be used to effectively rank the risks identified with any identification methodology.

1. Hazard Checklist

A checklist of potential hazards can be developed. The change owner can use this checklist to identify the hazards that apply, to determine the potential impacts of each hazard, and to decide whether a change should be considered minor or major. Guidance for thresholds of minor or major impact can be added to the checklist or the subjective judgment of the initiator may be used. It is considered that organizations that utilize the checklist method have made significant advances towards best practice risk management in that they have utilized their staff to adopt an MoC process, assess each change against a checklist of impacts, and make subjective determinations regarding the severity of the impacts. These determinations are also validated by at least one higher-ranking person in the event of a minor impact and possibly several for a major impact. One disadvantage of the checklist is that users may limit themselves to the hazards listed in the checklist, and not strive to identify any unique impact that is not already listed. Any item checked on the checklist as an impact should be addressed in the implementation plan with action items to reduce or eliminate this impact potential. A sample impact checklist is shown in Table A.1.

Table A.1 Impact Checklist

Organization	Processes	Electronic Systems
Can the change have an impact on:	*Can the change have an impact on:*	*Can the change have an impact on:*
☐ Management systems	☐ Temperature	☐ Software
☐ Responsibilities	☐ Pressure	☐ Data
☐ Work practices	☐ Flow	☐ Computer hardware
☐ Staff movement	☐ Level	**Structural**
☐ Contractors	☐ Material composition	*Can the change have an impact on:*
☐ Company reputation	☐ Reaction conditions	☐ Structure
☐ Regulatory compliance	☐ Flammability	☐ Stability
☐ Insurance	☐ Services/Utilities	☐ Pipelines
		☐ Port facilities
Environment	**Safety and Health**	**General Arrangement/Access**
Can the change have an impact on:	*Can the change have an impact on:*	*Can the change have an impact on:*
☐ Effluent - solid	☐ Personal safety	☐ General arrangement
☐ Effluents - liquid	☐ Fire fighting	☐ Emergency access
☐ Effluents - gas	☐ Means of escape	☐ Maintenance access
☐ Noise	☐ Fire protection	☐ Lighting
☐ Regulatory compliance	☐ Fire detection	☐ Alarms
☐ Spills	☐ Life-saving equipment	☐ Handrails/ladders
☐ Marine eco-system	☐ Emergency procedures	☐ Platforms/walkways
Maintenance and Inspection	☐ Local exhaust ventilation	☐ Vehicles
Can the change have an impact on:	☐ Mechanical isolation	☐ Fire fighting
☐ Trip and alarm testing	☐ Electrical isolation	☐ Facility/Ship access
☐ Maintenance procedures	☐ Instrument isolation	**Offshore Operation**
☐ Inspections	☐ Fire protection of cables	*Can the change have an impact on:*
☐ Portable equipment	☐ Earthing and bonding	☐ Drilling
☐ Piping/valve standards	☐ Area classification	☐ Diving
☐ Vessel (container) rating	**Instrumentation and Hardware**	☐ Helicopter
☐ Relief valves	*Can the change have an impact on:*	☐ Towing
☐ Pressure isolation	☐ Alarm panels	☐ Crane operations
☐ Construction/ installations	☐ Electrical systems	☐ Production
☐ Pipelines *	☐ Lifting equipment/procedures	☐ Offloading
☐ Drydocking	☐ Design pressure	☐ Anchoring
Operating Procedures	☐ Design temperatures	**Ship Operations**
Can the change have an impact on:	☐ Materials of construction	*Can the change have an impact on:*
☐ Operating instructions	☐ Relief rate	☐ Navigation
☐ Start-up of equipment	☐ Vessels	☐ Recovery from blackout
☐ Normal operation	☐ Vents	☐ Cargo operations
☐ Shutdown of equipment	☐ Pipework/support/bellows	☐ Ballasting operations
☐ Preparation for maintenance	☐ Valves/relief valves/busting disc	☐ Berthing
☐ Abnormal/emergency operations	☐ Orifices	☐ Anchoring
☐ Commissioning equipment	☐ Filters	☐ In-port
Crew and Human Factors	☐ Instrumentation	☐ Station keeping
Can the change have an impact on:	☐ Corrosion/erosion	☐ Propulsion
☐ Crew workload	☐ Vibration	☐ Maneuvering
☐ Workplace stress	☐ Spares	☐ Communications
☐ Crew communication	**Work Environment**	☐ Towing
☐ Crew understanding	*Can the change have an impact on:*	☐ Crane Operations
☐ Crew morale	☐ Working conditions	**Security**
☐ Crew performance	☐ PPE	*Can the change have an impact on:*
☐ Ergonomics	☐ Work surfaces	☐ Security/Security systems
	☐ Housekeeping	
	☐ Types of tools	

2. Hazard Identification

Hazard identification is a simple technique involving a team of at least two people led through a brainstorming exercise to systematically identify hazards. As it applies to MoC, the exercise goal is to look for possible risk impacts associated with a proposed change and identify appropriate risk management strategies. A hazard identification exercise needs a team of at least two people with knowledge and experience in the area where the change will be taking place. The knowledge and experience of the people participating in the hazard identification exercise affect their ability to recognize and evaluate the potential hazards and impacts of the change, and propose effective risk control measures.

A procedure for performing a hazard identification exercise for evaluating changes is described in the following steps. The hazard identification is typically recorded in a tabulated format with qualitative descriptions.

- Step 1: Define the change, including the system or activity it is associated with.
- Step 2: Identify the differences, even fine ones, between the existing situation and proposed change.
- Step 3: Evaluate the possible effects of notable differences.
- Step 4: Generate recommendations to better control significant impacts associated with the change.
- Step 5: Use a risk matrix to characterize risk impacts of the change

Table A.2 shows an example of a hazard identification review.

Table A.2 Sample Hazard Identification for Installation of a Lifting Appliance on Deck for Hose Handling on an Oil Tanker

No.	Differences/ Impacted Areas	Hazard (during installations & operation)	Detailed Description of impacts (consequences)	Existing Risk Control Measures	Risk Consequence/ Likelihood	Recommendations	Residual Risk Consequence/ Likelihood
1.	Cargo Operations	Impact while operating lifting appliances.	Potential for injuries if personnel are hit by moving parts of the appliance, or dropped objects.	None	Medium Risk Significant/ Occasional	Note in procedures and place cautionary sign in the radius of impact.	Low Risk Significant/ Seldom
2.	Emergency Access	Appliance blocking the escape ways.	Potential for the appliances to hinder emergency access.	Appliance size is 2m H x 0,5m D x 1m W and not located near emergency access	Low Risk Serious/ Unlikely	No additional recommendations.	
3.	Structure	Inadequate understructure support.	Potential for cracks on main deck, above cargo tanks. Potential for oil to leak out, or air entering the inert gas space of the cargo tank. Explosive atmosphere in cargo tank.	None	High Risk Serious/ Frequent	Provide reinforcement for the under-deck structure to support the weight of the new lifting appliance.	Low Risk Serious/ Unlikely
4.	...						
5.	...						

3. Risk Matrices

Risk matrices can be utilized to help assess the risks (likelihood and consequences) of a change once the impacts have been identified. The combination of consequences and likelihood of an event occurring can be categorized. The organization must pre-define these categories and should have a method for prioritizing and dealing with the outcomes. Each organization can determine the range of acceptable and unacceptable risks. An organization can proactively select criteria relevant to its own business model to assist in determining the change impact. For instance, any change with a potential impact to cause multiple fatalities or long-term impact to the environment may be considered a change with major impact, and one that requires detailed risk assessment. These criteria can be extended to other important business parameters such as any impact to schedule or any impact with a cost above a threshold value (e.g., $1 million).

If the change is simple and impacts are deemed to be minor, there is no need for further assessment. This provision will make the system more efficient and place emphasis where it is most needed.

The sample risk matrix in Fig A.1 has three distinctive risk regions: High, Medium and Low. These regions should be tied to predetermined criteria. The criteria can be tied to action items and/or to decisions on whether or not to request further risk analysis. For example, impact(s) of changes that fall in the High Risk Region of the matrix (high likelihood and high consequence), should require a Detailed Risk Assessment be carried out. On the other extreme of the risk matrix, if the impact is assessed to be in the Low Risk Region of the matrix (low consequence and low likelihood), there is no need for a detailed assessment. When a change has at least one impact in the Medium Risk Region of the matrix (medium risk), the initial and senior reviewers use their discretion as to whether or not a more detailed risk analysis is required.

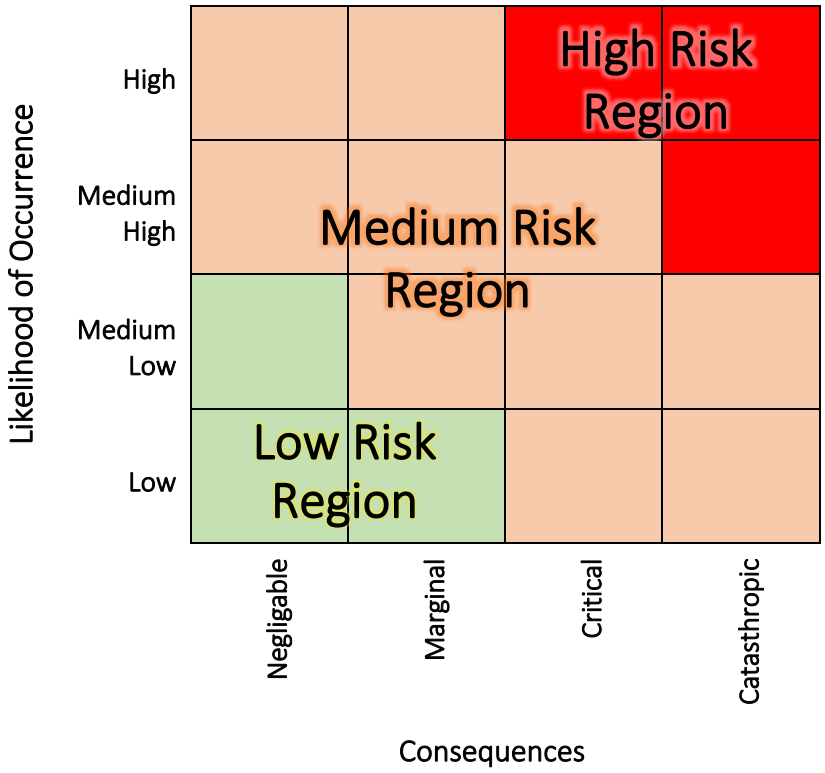

Fig. A.1 Sample Risk Matrix

4. Positive Impacts

A change is usually proposed because it is considered as beneficial. The change may optimize an operation, reduce costs, improve safety, etc. During the preliminary impact assessment, beneficial impacts are likely to come to light, along with the negative impacts associated with the change. However, the ultimate goal of an impact or risk assessment is to identify the unfavourable impacts of a change so they can be properly mitigated. The best place to record beneficial impacts is not in the risk assessment part of the MoC form, but on the section where reason and justification for the change is given.

5. Job Safety Analysis vs MoC

Proactive companies use job safety analysis (JSA) as a technique to eliminate or reduce the occurrence of undesirable incidents during work tasks. The goal of a JSA is to assess the hazards associated with a task and the means by which they can be eliminated or reduced to an acceptable level. The difference between the hazard identification done for purposes of the JSA and one done with the purpose of MoC is their focus. JSA are primarily used for controlling hazards to the safety and health of the workers, thus reducing occupational accidents to the **personnel while executing the task**. The MoC assessments focus on the potential impacts of the change **to the whole system and throughout the life-cycle of the change**, from installation to decommission.

An example would be the installation of a new lifting appliance on a deck structure of an oil tanker. The JSA for the task of installing the appliance will identify problems such as potential injuries from personnel slipping and falling due to spilled hydraulic oil. The action item to control this hazard would be to keep handy rags or absorbent material to clean up any spills resulting from connecting to the hydraulic system.

The MoC analysis for installing a lifting appliance will identify hazards and impacts to the system, both during the installation as well as in-service (i.e., what impacts to the system/enterprise may result from operating with the lifting appliance). One such impact is the effect of the weight of the appliance on the under-structure. Over time, the under-structure support, if not designed to support the lifting appliance, can result in cracks on the main deck above the cargo tanks. There is potential for oil to leak out, or air to enter the inert gas space of the cargo tank resulting in an explosive atmosphere in the cargo tank. The action item to mitigate this impact is to provide reinforcement for the underdeck structure to support the weight of the new lifting appliance.

A company having both a JSA and MoC should use the JSA for the work tasks needed to execute a change, but the JSA should not be the only mechanism for identifying the hazards associated with the change. As their focuses are different, the JSA and the MoC analyses are not interchangeable, but complimentary. The hazard identification carried out as part of the MoC process is more comprehensive than the typical JSA as it focuses on the potential impacts of the change to the whole enterprise and throughout the life-cycle of the change from installation to decommissioning, as summarized in Table A.3.

Table A.3 Focus of Hazard Identification for JSA and for MoC

Focus	JSA (typical)	MoC
Identify and control impacts to:	Personnel (occupational safety)	Enterprise (safety and health, property, environment, reliability, efficiency, quality, etc.)
Identify and control impacts that occur during:	Job tasks (physical execution of the change)	Change complete lifecycle of the change (cradle to grave)

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Annex B Two Completed MoC Examples

A. Example 1: Addition of Lifting Appliance on Deck of an Oil Tanker

1. General

1.1 Request for Change

MoC Tracking No	:	13/099
Initiation Date	:	15 Nov 2022
Required Implement. Date	:	30 Nov 2022
Vessel	:	Subur Makmur (Oil Tanker)
Modification Title	:	Addition of Lifting Appliance on Deck
Change Initiator	:	Erick Elos, Superintendent
Position/Department	:	Repair Superintendent (shore-based)
Change Owner	:	H. Ramli
Position/Department	:	First Officer

Description of proposed change *(Give written details of change)*

Add a new lifting appliance to the hydraulic system on main deck in vicinity of cargo manifold.

Drawing, Sketch of Spec attached : ☒ Yes ☐ No

Reason and justification for change *(e.g., safety/quality/environmental/cost)*

This new appliance will aid in handling of cargo hose for loading/offloading cargo. It will speed up the hose connection operation and reduce potential injuries due to manual handling.

Type of Change *(tick on box)*

☒ Permanent
☐ Temporary
☐ Emergency

If change is temporary, please specify time limit, but not exceed 6 months:

_____/_____/____

If drydock is necessary for permanent repairs, time limit should be until the next drydock.

1.2 Preliminary Impact Assessment

Impact Checklist. Check all that apply

Organization	*Processes*	Auxiliary Systems
Can the change have an impact on:	*Can the change have an impact on:*	*Can the change have an impact on:*
☐ Management systems	☐ Temperature	☐ Auxiliary Systems
☐ Responsibilities	☐ Pressure	☐ Redundant/ Backup Systems
☐ Work practices	☐ Flow	☐ Software
☐ Staff movement	☐ Level	☐ Electronic Data
☐ Contractors	☐ Material composition	☐ Computer hardware
☐ Company reputation	☐ Reaction conditions	**Structural/ *Mechanical Integrity***
☐ Regulatory compliance	☐ Flammability	*Can the change have an impact on:*
☐ Insurance	☐ Services/Utilities	☒ Structure
Environment	**Safety and Health**	☐ Stability
Can the change have an impact on:	*Can the change have an impact on:*	☐ Pipelines
☐ Effluents - solid	☒ Personal safety	☐ Port facilities
☐ Effluents - liquid	☐ Fire fighting	**General Arrangement/Access**
☐ Effluents - gas	☐ Means of escape	*Can the change have an impact on:*
☐ Noise	☐ Fire protection	☒ General arrangement
☐ Regulatory compliance	☐ Fire detection	☒ Emergency access
☒ Accidental spills	☐ Life-saving equipment	☒ Maintenance access
☐ Marine eco-system	☐ Emergency procedures	☐ Lighting
Maintenance and Inspection	☐ Local exhaust ventilation	☐ Alarms
Can the change have an impact on:	☐ Mechanical isolation	☐ Handrails/ladders
☐ Trip and alarm testing	☒ Electrical isolation	☒ Platforms/walkways
☐ Maintenance procedures	☐ Instrument isolation	☐ Vehicles
☐ Inspections	☐ Fire protection of cables	☐ Fire fighting
☐ Portable equipment	☒ Earthing and bonding	☐ Facility/Ship access
☒ Piping/valve standards	☐ Area classification	**Offshore System & Operation**
☐ Vessel (container) rating	**Equipment & Instrumentation**	*Can the change have an impact on:*
☐ Relief valves	*Can the change have an impact on:*	☐ Drilling
☐ Pressure isolation	Hydraulic System *(list system)*	☐ Diving
☒ Construction/ installations	☐ Alarm panels	☐ Helicopter
☐ Pipelines *	☒ Electrical systems	☐ Towing
☐ Drydocking	☒ Lifting equipment/procedures	☐ Crane operations
Operating Procedures	☒ Design pressure	☐ Production
Can the change have an impact on:	☐ Design temperatures	☐ Offloading
☒ Operating instructions	☐ Materials of construction	☐ Anchoring
☒ Start-up of equipment	☐ Relief rate	**Ship System & Operations**
☒ Normal operation	☐ Vessels	*Can the change have an impact on:*
☒ Shutdown of equipment	☐ Vents	☐ Navigation
☐ Preparation for maintenance	☐ Pipework/support/bellows	☐ Recovery from blackout
☐ Abnormal/emergency operations	☐ Valves/relief valves/busting disc	☒ Cargo operations
☐ Commissioning equipment	☐ Orifices	☐ Ballasting operations
Crew and Human Factors	☐ Filters	☐ Berthing
Can the change have an impact on:	☐ Instrumentation	☒ Anchoring
☐ Crew workload	☐ Corrosion/erosion	☒ In-port
☐ Workplace stress	☐ Vibration	☐ Station keeping
☐ Crew communication	☐ Spares	☐ Propulsion
☐ Crew understanding	**Work Environment**	☐ Maneuvering
☐ Crew morale	*Can the change have an impact on:*	☐ Communications
☒ Crew performance	☒ Working conditions	☐ Towing
☒ Ergonomics	☐ PPE	☒ Crane Operations
	☐ Work surfaces	**Security**
	☐ Housekeeping	*Can the change have an impact on:*
	☐ Types of tools	☐ Security/Security systems

Explain the possible way(s) in which the checked impact(s) from the Impacts Checklist can be realized. Describe existing risk control measures for each, as well as any recommendations to reduce risk. Use the Risk Matrix in Annex A to aid in assigning a consequence and likelihood ranking for the potential impact.

Preliminary Impact Assessment

Name : Erick Elos, Superintendent
Position/Department : Repair Superintendent (shore-based)

Name : H. Ramli
Position/Department : First Officer

No.	Differences/ Impacted Areas	Hazard (during installations & operation)	Detailed Description of impacts (consequences)	Existing Risk Control Measures	Risk Consequence/ Likelihood	Recommendations	Residual Risk Consequence/ Likelihood
1.	Design pressure Electrical system Utilities	Undersized hydraulic pumps and motors for this new equipment.	Lifting appliance or other equipment that is served by hydraulic system may not be able to function at full capability. Delays in vessel arrival and departure. Financial penalties.	n/a	TBD Significant/ TBD	Design review of hydraulic system design capacity.	TBD
2.	In-port Anchoring Cargo Operations	Cutting into pipping to install appliance connection.	Potential for debris to enter the hydraulic system. Potential to damage downstream equipment (mooring winches and anchor windlasses) with debris and render it inoperable. Inability to conduct mooring operations on that side of the ship.	The filters in the hydraulic system are upstream of line offering poor protection from installation debris. Redundancy of anchoring/mooring equipment.	Medium Risk Significant/ Occasional	Purchase and install a temporary strainer immediately downstream of the lifting appliance to catch installations debris. This will be replaced with spool piece when system has been positively identified as debris-free via hydraulic oil samples.	Low Risk Minor/Unlikely
3.	Spills	Leaks of hydraulic oil from improper installations.	Slipping hazard. Contact with hydraulic oil may be a mild health issue. Potential for hydraulic oil to the water/pollution. Potential for money fines.	n/a	Medium Risk Significant/ Occasional	Pressure testing followed by visual examinations.	Low Risk Significant/ Seldom
4.	Construction/ Installation Earthing/ bonding	Crew may not have the right knowledge for installing the equipment.	See peaks/spills.	n/a	Medium Risk Significant/ Occasional	Assess capabilities of crew and officers at installing hydraulic systems. If needed, use riding crew or outside contractors.	Low Risk Significant / Seldom
5.	Emergency Access	Appliance blocking the escape ways.	Potential for the appliance to hinder emergency access.	Appliance size is 2m H x 0,5m D x 1m W, away from emergency access.	Low Risk Minor/Unlikely	No additional recommendations.	
6.	Structure	Inadequate understructure support	Potential for cracks on main deck, above cargo tanks. Potential for oil to leak out, air to enter the inert gas space of the cargo tank. Explosive atmosphere in cargo tank.	Inert gas system	High Risk Serious/ Frequent	Provide reinforcement or the under-deck structure to support the weight of the new lifting appliance.	Low Risk Serious/ Unlikely
7.	Personnel Safety	Impact while operating lifting appliances.	Potential for injuries if personnel are hit by moving parts of the appliance, or dropped objects.	None	Medium Risk Significant/ Occasional	Note in procedures and place cautionary sign in the radius of impact.	Low Risk Significant/ Seldom

1.3 Implementation Plan Summary

Summarize actions from the preliminary impact assessment and the risk assessment, if one was done. Include any additional actions needed for the execution of the change.

No.	Action Items	Responsible	Due Date
1.	Design review of hydraulic system design capacity.	Repair superintendent	20 Nov 22
2.	The necessary reinforcement of structure to support the weight of the lifting appliance cannot be done while the ship is trading. Reinforcement to be performed next shipyard visit schedule for December 28, 2022. Target installation of the lifting appliance for 1Q2023.	Repair superintendent	Dec 2022
3.	Assess the capability of crew and officer installing the hydraulic systems. If needed, recommend using a riding crew or outside contractors.	Master	20 Nov 2022
4.	As part of installations, conduct pressure testing of the hydraulic system, followed by visual examinations to look for any potential leaks.	Repair Superintendent	During lifting appliance installations
5.	Install a temporary strainer/filter immediately downstream of the lifting appliance to catch installations debris.	Repair Superintendent	During lifting appliance installations
6.	Sample the hydraulic oil within two weeks of installation of the lifting appliance.	Engine room	Two weeks after installations
7.	Replace temporary strainer with a spool piece when the system has been positively identified as debris free via the samples above	Engine room	Two weeks after installations

2. Senior Review

Senior Reviewer (Approver)* : Manner Elos, Master
Position/Department : Master
Date : 17 Nov 2022

** Senior Reviewer and Change Owner cannot be same person*

Is there any major impact(s) falling in the High Risk (RED) portion of the risk matrix that cannot be further mitigated? ☐ Yes ☒ No	Do you consider this change to be complex ☐ Yes ☒ No
Further Study	
☐ If the answer to any of the above is YES, recommend this change should be investigated further. Conduct a detailed risk assessment and re-submit the MoC (**3.**). Specify subject-matter expert that should participate in the detailed risk assessment:	
Reject	
☐ Reject the change. Explain reason	
Approve	
☒ Skip 3. Continue to 4.	

3. Detailed Risk Assessment Review

Attach copies of Detailed Risk Assessment, if one was performed. Amend Implementation Plan as necessary.

Detailed Risk Assessment Contributors		
Name:	Position/ Department:	Date: .....
Name:	Position/ Department:	Date: .....
Name:	Position/ Department:	Date: .....
Name:	Position/ Department:	Date: .....

Not Applicable

4. Approval

I am satisfied that change is justified, it has been adequately designed, its impacts adequately considered and the necessary actions planned.
☒ Proceed with implementation of the change
☐ Proceed with implementation of the change with the modifications to the Implementation Plan as explained below
Explanation and modification to Implementation Plan: .....
Date: 20 November 2022 **Signed (Approver*)** Manner Elos, Master *Approver and Change Owner cannot be the same person.

5. Documentation and Training

List documents requiring updating, or new documents required.

Type of Documentation	List Documents	Responsible	Target Date	Date Completed	Verified by
Drawing					
Pipping	Hydraulic system	Repair Supt.	1Q2023	26 Jan 2023	HRI
Electrical	One line diagram	Repair Supt.	1Q2023	26 Jan 2023	HRI
Equipment	Crane Drawings	Repair Supt.	1Q2023	26 Jan 2023	HRI
Layout	General Deck Layout	Repair Supt.	1Q2023	26 Jan 2023	HRI
Spare parts list					HRI
Operating Limits	Crane loading chart, hydraulic/ electrical limits for crane	Repair Superintendent	1Q2023	26 Jan 2023	HRI
Standard Operating Procedure	Crane handbook, hose connection procedure	Repair Superintendent	1Q2023	13 Jan 2023	HRI
Startup/SD/Emergency	Crane handbook	Repair Superintendent	1Q2023	13 Jan 2023	HRI
Maintenance procedure/ schedule	Crane handbook	Repair Superintendent	1Q2023	13 Jan 2023	HRI
Emergency response procedure					
Other admin. procedures					
Other					

Identify any training needs

Area	List Training Required	Responsible	Target Date	Date Completed	Initials
Deck:	Crane Operations	First Mate	TBD	31 Jan 2023	HRI
E/R:	Maintenance & repair	Chief Engineer	TBD	13 Jan 2023	HRI
Others:	.....	.....	.....	.....	.....

6. Verification and Closeout

Verification

Lifting appliance is working as intended in the Implementation Plan.

Sampling indicated the hydraulic oil system is free of installations debris.

Temporary filter has been removed and a spool pierce installed.

Date: 14 Februari 2023

Signed:

H. Ramli

Position: First Officer

Temporary Change

This Temporary change has been reverted to normal condition/converted to permanent MoC

Permanent MoC reference .....

Signed *(Initiator)* ..... Date .....

Signed *(Approver)* ..... Date .....

MoC Closed Out

I am satisfied that the change and the post change actions have been completed.

Date: 14 Februari 2023

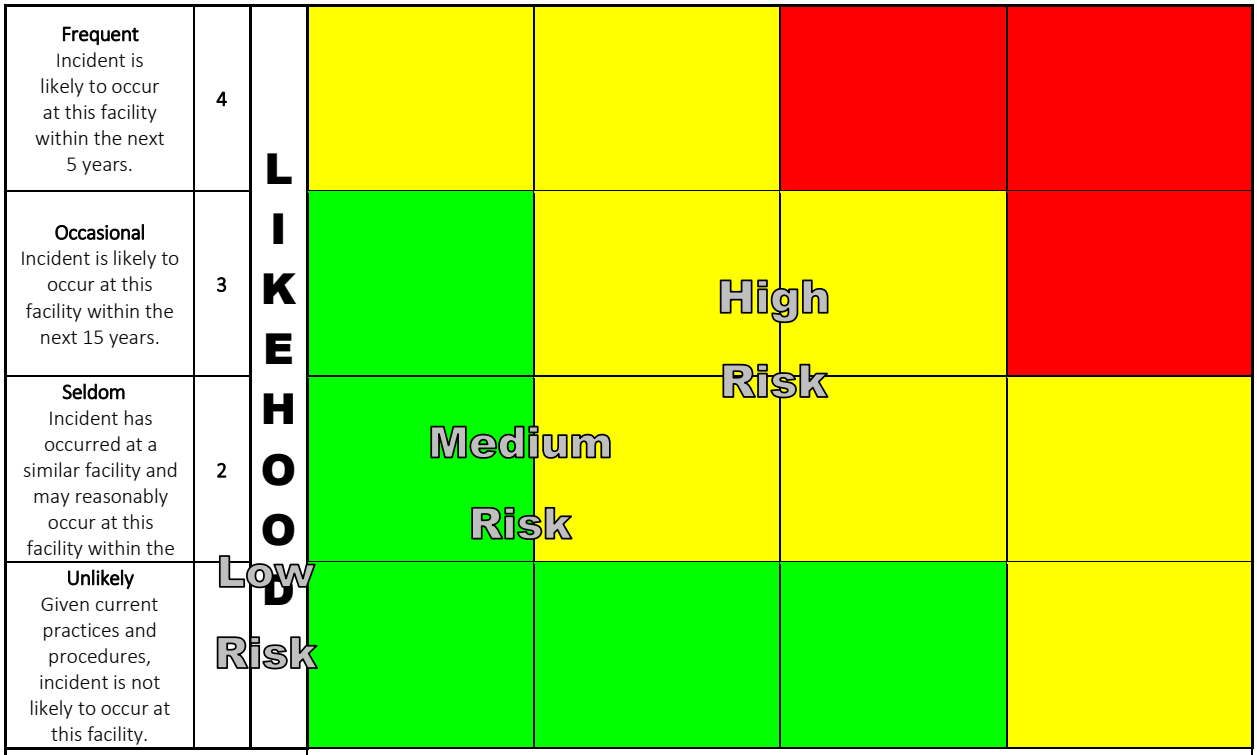
Signed:

H. Ramli

Position: First Officer

Annex A Risk Matrix

Use the attached risk matrix and action criteria for prioritizing the actions generated during the Preliminary Impact Assessment and the Detailed Risk Assessment (if one is conducted).



	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 $100K, negligible downtime.	Some equipment or structural damage at an estimated cost greater than $100K, 1 to 10 days of downtime	Major damage to installation at an estimated cost than $1 MM but less than $10 MM, 10 to 90 days of downtime	Major or total destruction to installation estimated at a cost greater than $10 MM; downtime in excess of 90 days.

Action Criteria

Risk	Preliminary Impact Assessment	Detailed Impact Assessment
Low	No need for Detailed Impact Assessment. Implement suggested risk control actions.	Recommend implementation of suggested risk control actions.
Medium	Detailed risk assessment to be conducted, if deemed necessary by relevant personnel.	Suggested risk control actions must be implemented.
High	Detailed risk assessment shall be carried out.	Control actions must be implemented to reduce risk to Medium or Low

B. Example 2: Addition of Electrical Receptacle in Deckhouse Next to Accommodation

1. General

1.1 Request for Change

MoC Tracking No	:	11/100
Initiation Date	:	2 Mar 2020
Required Implement. Date	:	30 Mar 2020
Vessel	:	Offshore 500 (Offshore Facility)
Modification Title	:	Addition of electrical receptacle in deckhouse
Change Initiator	:	Herry Sandy, Electrical
Position/Department	:	Electrician/Engineering Department
Change Owner	:	Ismail, Engineer
Position/Department	:	First Assistant Engineer

Description of proposed change *(Give written details of change)*

Addition of electrical receptacle in deckhouse adjacent to accommodation space, tapping up from an existing electrical circuit (115V) from the accommodation.

Drawing, Sketch of Spec attached : ☒ Yes ☐ No

Reason and justification for change *(e.g., safety/quality/environmental/cost)*

There is an inadequate number of electrical receptacles in the deckhouse to operate handled tools.

Type of Change *(tick on box)*

☒ Permanent
☐ Temporary
☐ Emergency

If change is temporary, please specify time limit, but not exceed 6 months:

_____/_____/____

If drydock is necessary for permanent repairs, time limit should be until the next drydock.

1.2 Preliminary Impact Assessment

Impact Checklist. Check all that apply

Organization	*Processes*	Auxiliary Systems
Can the change have an impact on:	*Can the change have an impact on:*	*Can the change have an impact on:*
☐ Management systems	☐ Temperature	☐ Auxiliary Systems
☐ Responsibilities	☐ Pressure	☐ Redundant/ Backup Systems
☐ Work practices	☐ Flow	☐ Software
☐ Staff movement	☐ Level	☐ Electronic Data
☐ Contractors	☐ Material composition	☐ Computer hardware
☐ Company reputation	☐ Reaction conditions	***Structural/ Mechanical Integrity***
☐ Regulatory compliance	☐ Flammability	*Can the change have an impact on:*
☐ Insurance	☐ Services/Utilities	☒ Structure
Environment	***Safety and Health***	☐ Stability
Can the change have an impact on:	*Can the change have an impact on:*	☐ Pipelines
☐ Effluents - solid	☐ Personal safety	☐ Port facilities
☐ Effluents - liquid	☐ Fire fighting	***General Arrangement/Access***
☐ Effluents - gas	☐ Means of escape	*Can the change have an impact on:*
☐ Noise	☐ Fire protection	☒ General arrangement
☐ Regulatory compliance	☐ Fire detection	☐ Emergency access
☐ Accidental spills	☐ Life-saving equipment	☐ Maintenance access
☐ Marine eco-system	☐ Emergency procedures	☐ Lighting
Maintenance and Inspection	☐ Local exhaust ventilation	☐ Alarms
Can the change have an impact on:	☐ Mechanical isolation	☐ Handrails/ladders
☐ Trip and alarm testing	☒ Electrical isolation	☐ Platforms/walkways
☐ Maintenance procedures	☐ Instrument isolation	☐ Vehicles
☐ Inspections	☒ Fire protection of cables	☐ Fire fighting
☐ Portable equipment	☐ Earthing and bonding	☐ Facility/Ship access
☐ Piping/valve standards	☒ Area classification	Offshore System & Operation
☐ Vessel (container) rating	***Equipment & Instrumentation***	*Can the change have an impact on:*
☐ Relief valves	*Can the change have an impact on:*	☐ Drilling
☐ Pressure isolation	Electrical System *(list system)*	☐ Diving
☐ Construction/ installations	☐ Alarm panels	☐ Helicopter
☐ Pipelines	☒ Electrical systems	☐ Towing
☐ Drydocking	☐ Lifting equipment/procedures	☐ Crane operations
Operating Procedures	☐ Design pressure	☐ Production
Can the change have an impact on:	☐ Design temperatures	☐ Offloading
☐ Operating instructions	☐ Materials of construction	☐ Anchoring
☐ Start-up of equipment	☐ Relief rate	***Ship System & Operations***
☐ Normal operation	☐ Vessels	*Can the change have an impact on:*
☐ Shutdown of equipment	☐ Vents	☐ Navigation
☐ Preparation for maintenance	☐ Pipework/support/bellows	☐ Recovery from blackout
☐ Abnormal/emergency operations	☐ Valves/relief valves/busting disc	☐ Cargo operations
☐ Commissioning equipment	☐ Orifices	☐ Ballasting operations
Crew and Human Factors	☐ Filters	☐ Berthing
Can the change have an impact on:	☐ Instrumentation	☐ Anchoring
☐ Crew workload	☐ Corrosion/erosion	☐ In-port
☐ Workplace stress	☐ Vibration	☐ Station keeping
☐ Crew communication	☐ Spares	☐ Propulsion
☐ Crew understanding	***Work Environment***	☐ Maneuvering
☐ Crew morale	*Can the change have an impact on:*	☐ Communications
☐ Crew performance	☒ Working conditions	☐ Towing
☐ Ergonomics	☐ PPE	☐ Crane Operations
	☐ Work surfaces	Security
	☐ Housekeeping	*Can the change have an impact on:*
	☐ Types of tools	☐ Security/Security systems

Explain the possible way(s) in which the checked impact(s) from the Impacts Checklist can be realized. Describe existing risk control measures for each, as well as any recommendations to reduce risk. Use the Risk Matrix in Annex A to aid in assigning a consequence and likelihood ranking for the potential impact.

Preliminary Impact Assessment

Name : Herry Sandy, Electrical
Position/Department : Electrician/Engineering Department

Name : Ismail, Engineer
Position/Department : First Assistant Engineer

No.	Differences/ Impacted Areas	Hazard (during installations & operation)	Detailed Description of impacts (consequences)	Existing Risk Control Measures	Risk Consequence/ Likelihood	Recommendations	Residual Risk Consequence/ Likelihood
1.	Area classification	Wrong cable installed or improper installation. Potential for developing an ignition source	Potential for fire in the deckhouse	Gas Detection	Medium Risk Serious/ Seldom	Use armored cables for the tie-in	Low Risk Serious /Unlikely
2.	Electrical system	Existing circuit	Potential for overloading and tripping the circuit breaker on existing system. Partial blackout of the accommodation.	Circuit breaker. Emergency diesel generator.	Low Risk Minor/ Occasional	Existing safeguards are considered adequate.	Low Risk Minor/ Occasional
3.	Structure	Bulkhead penetration	Loss of watertight integrity between the accommodation and the deckhouse		Medium Risk Serious / Seldom	Use watertight penetration seals. Penetration must be watertight and gas-tight to maintain the watertight integrity of the structure.	Low Risk Serious/ Unlikely

1.3 Implementation Plan Summary

Summarize actions from the preliminary impact assessment and the risk assessment, if one was done. Include any additional actions needed for the execution of the change.

No.	Action Items	Responsible	Due Date
1.	Use armored cables for the tie-ins	HC	During installation
2.	Use watertight penetration seals to maintain the water and gas tight integrity of the accommodation structure.	HC	During installation

2. Senior Review

Senior Reviewer (Approver)* : Fulan Chief
Position/Department : Chief Engineer
Date : 3 Mar 2020

** Senior Reviewer and Change Owner cannot be same person*

Is there any major impact(s) falling in the High Risk (RED) portion of the risk matrix that cannot be further mitigated? ☐ Yes ☒ No	Do you consider this change to be complex ☐ Yes ☒ No
Further Study	
☐ If the answer to any of the above is YES, recommend this change should be investigated further. Conduct a detailed risk assessment and re-submit the MoC (**3.**). Specify subject-matter expert that should participate in the detailed risk assessment:	
Reject	
☐ Reject the change. Explain reason	
Approve	
☒ Skip 3. Continue to 4.	

3. Detailed Risk Assessment Review

Attach copies of Detailed Risk Assessment, if one was performed. Amend Implementation Plan as necessary.

Detailed Risk Assessment Contributors		
Name:	Position/ Department:	Date: .....
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Name:	Position/ Department:	Date: .....

Not Applicable

4. Approval

I am satisfied that change is justified, it has been adequately designed, its impacts adequately considered and the necessary actions planned.
☒ Proceed with implementation of the change
☐ Proceed with implementation of the change with the modifications to the Implementation Plan as explained below
Explanation and modification to Implementation Plan: .....
Date: 3 March 2020 **Signed (Approver*)** Fulan Chief *Approver and Change Owner cannot be the same person.

5. Documentation and Training

List documents requiring updating, or new documents required.

Type of Documentation	List Documents	Responsible	Target Date	Date Completed	Verified by
Drawing					
Pipping					
Electrical	One line diagram	First Asst. Eng.	6 Mar 2020	26 Jan 2023	IE
Equipment					
Layout					
Spare parts list					
Operating Limits					
Standard Operating Procedure					
Startup/SD/Emergency					
Maintenance procedure/ schedule					
Emergency response procedure					
Other admin. procedures					
Other					

Identify any training needs

Area	List Training Required	Responsible	Target Date	Date Completed	Initials
Deck:	.....	.....	.....	.....	.....
E/R:	.....	.....	.....	.....	.....
Others:	.....	.....	.....	.....	.....

6. Verification and Closeout

Verification

Receptacle is working as intended and the cable penetration is water and gas tight.

Date: 10 March 2020

Signed:

Ismail Engineer

Position: First Assistant Engineer

Temporary Change

This Temporary change has been reverted to normal condition/converted to permanent MoC

Permanent MoC reference .....

Signed *(Initiator)* ..... Date .....

Signed *(Approver)* ..... Date .....

MoC Closed Out

I am satisfied that the change and the post change actions have been completed.

Date: 10 March 2020

Signed:

Ismail Engineer

Position: First Assistant Engineer

Annex A Risk Matrix

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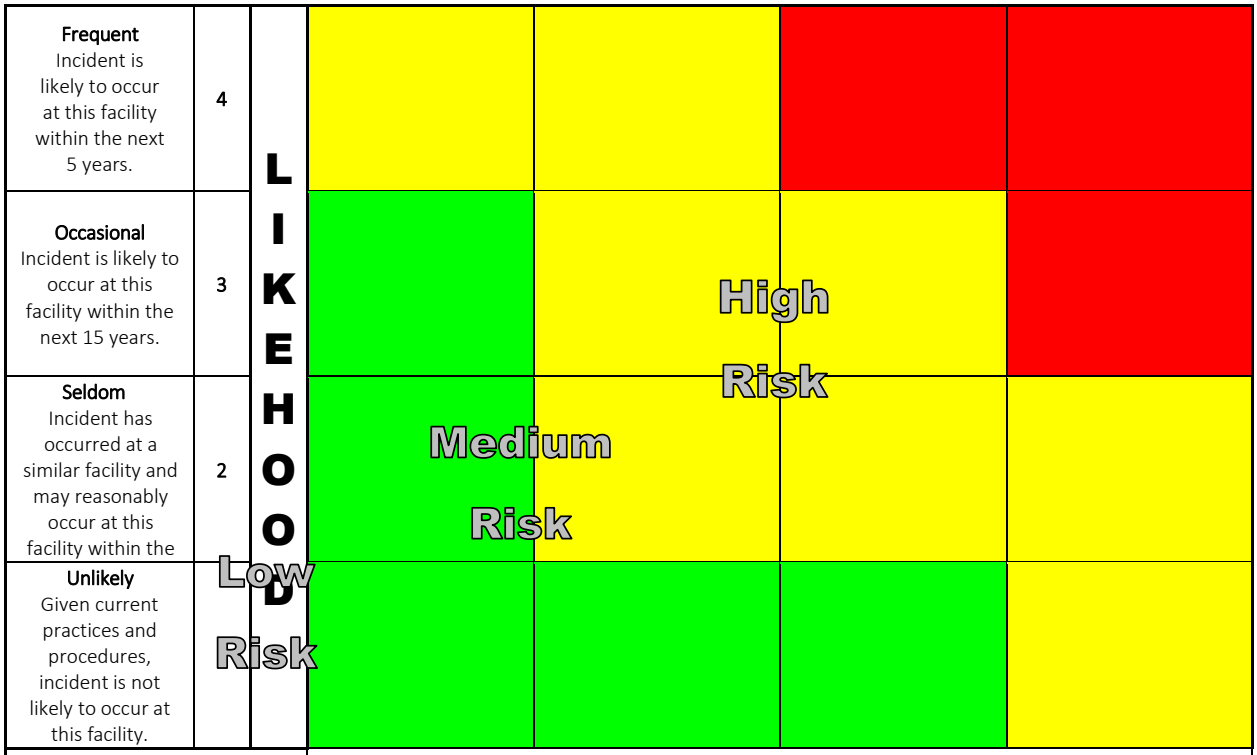

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