



China Classification Society

# **Guidelines for New Technology Qualification (Trial)**

Effective on September 1, 2023

Beijing

## **Foreword**

These administrative guidelines are hereby formulated by China Classification Society (CCS) to standardize the qualification of new marine technology products, promote their application on real ships and the transformation of scientific and technological achievements, and facilitate the high-quality development of ship supporting products.

For the purpose of easy understanding, the terms and abbreviations in the following text apply to these guidelines.

These guidelines are written and updated by CCS through the website <http://www.ccs.org.cn>. Users can provide feedback on these guidelines to [mp@ccs.org.cn](mailto:mp@ccs.org.cn) if they have any opinions.

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# Guidelines for New Technology Qualification

## 1. General

### 1.1 Purpose

CCS has formulated these Guidelines for New Technology Qualification (hereinafter referred to as “these guidelines”) to standardize the qualification of new marine technology products, promote their application on real ships and the transformation of scientific and technological achievements, and facilitate high-quality development of ship supporting products.

These guidelines provide a systematic engineering qualification method for the qualification of new technology. It aims to confirm that the new technology meets the expected stage design and application goals through a multi-stage systematic and consistent evaluation of new technology from concept verification to operation validation. Engineering and risk assessment is performed at each stage to check whether the new technology product reaches an acceptable level of safety for ship applications. In addition to the requirements of these guidelines, relevant guidelines may also apply to the qualification of new technology.

### 1.2 Definition

New technology: it refer to the product that does not have mature application experience in the field of ship/marine manufacturing, and/or there are no specific and clear requirements in CCS specifications, guidelines, etc., and there are no recognized international, national, or industry standards that can be directly used as survey basis. It includes but is not limited to novel designs, innovative manufacturing or processing techniques, and new products designed to meet the technical requirements of conventions or guidelines that are intended to enter into force or have not yet entered into force, or the product first applied to ships. This type of products does not have relevant survey basis in CCS specifications, guidelines, and other documents, and cannot be directly applied on board through

design approval, type approval, and factory approval. New technology refers to the (integrated) systems, devices, components, metal materials, non-metallic materials, manufacturing processes, etc., which can be divided into the following four categories:

- (1) Technical improvement of existing marine products;
- (2) New products using existing technology;
- (3) New technologies adopted by existing marine products;
- (4) New products developed with new technologies.

### 1.3 Scope of Application

These guidelines apply to the product qualification and inspection throughout the entire cycle of new technology from design and development to operation. It is generally applicable to:

- (1) Innovative design of products that do not yet meet the conditions for design approval, type approval, and factory approval;
- (2) Innovative design of complex system products;
- (3) Products with equivalent designs that differ from traditional standard designs;
- (4) Innovative technical principles or solutions;
- (5) Evaluation services for scientific research achievements.

### 1.4 New Technology Qualification (NTQ) Process

The NTQ process is divided into four sequential stage according to technology maturity, including concept verification stage, prototype validation stage, system integration stage and operational stage.

CCS issues corresponding qualification certificates or compliance statement documents according to the qualification stage. In the concept verification stage, a concept verification certificate is issued; in the prototype validation stage, a principles prototype verification certificate/engineering prototype verification certificate is issued; during the system integration stage, a design approval certificate is issued; in the operational stage, a declaration of compliance for the operational

stage is issued.

The client voluntarily applies for different qualification stages, and after CCS carries out validation and qualification according to the requirements of different stages. The NTQ process is shown in Fig.1.

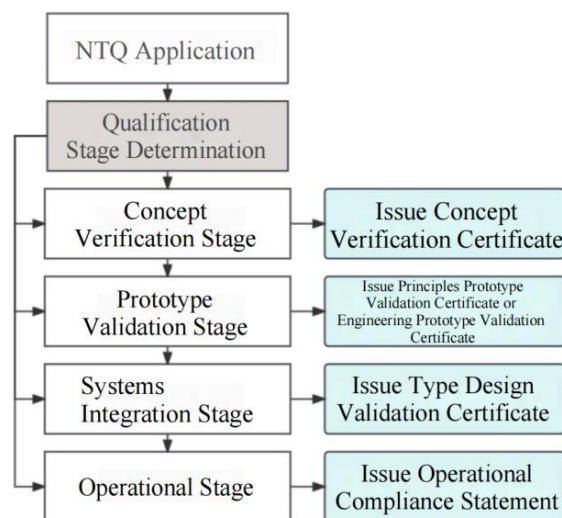
The ascending order and description of the qualification stage are as follows:

Concept verification stage——validate technology feasibility and concept;

(1) Prototype validation stage——technology qualification verification (including principles prototype verification or engineering prototype verification );

(2) System integration stage——realize product finalization through technology verification of practical application scenario;

(3) Operational stage——promote product quality improvement and technology improvement through operation.



1.5 Fig. 1 New Technology Qualification Process Type Approval

If the new technology has completed the prototype validation stage or the system integration stage, and can be consistently manufactured with the same design and specifications, type approval can be made according to CCS guidelines. If the client applies, after CCS evaluation, type approval can also be carried out after operational stage approval is made.

## **2. New Technology Qualification Application**

### 2.1 General requirements

2.1.1 The client should submit a written application for qualification to CCS, including the product name, overview of new technology, purpose and using restrictions, client expectations, qualification stage, qualification plan and timeline, inspection safety conditions and cost payment arrangements, contact information, etc. Clients can also use the “Qualification Service Notice” recommended by our company.

2.1.2 The client should submit the necessary documents for qualification in accordance with the requirements of 2.2 below.

2.1.3 After the above information is evaluated, CCS should designate personnel or form a working group to determine the qualification stage or model recommendations, and arranges for subsequent qualification.

2.1.4 If the new technology has already completed the concept verification stage or other R&D stages before the client applies, CCS can evaluate the current stage and issue applicable stage verification certificates or compliance statement documents based on client needs and the evaluation results. Afterwards, start from this stage and continue with the subsequent stages of qualification. In addition, new technology qualification can be terminate at any stage.

### 2.2 Documents Submitted by The Client

#### 2.2.1 New Technology Qualification Plan (NTQP)

The NTQP is a programmatic document prepared by the client. It can be used to track the technical maturity level and qualification activity status of new technology, verify and confirm whether the new technology meets the expected verification stage’s ability. The NTQP allows can be continuously updated during the approval process, and should typically include the following contents:

- (1) Briefly introduce the objectives, functions, performance, and application

scenarios of new technology;

(2) Describe current status of design and qualification activities;

(3) Provide key R&D/manufacturing nodes;

(4) Determine the validation stage of new technology;

(5) The specific plans for qualification activities generally include but are not limited to the scope, objectives, and methods of qualification activities; product performance requirements and their sources, engineering evaluations at different stages, risk assessments, and their timelines.

### 2.2.2 Technical Description Document (TDD)

The client prepares a TDD for new technology product and submits it to CCS for review. The TDD should clarify the definition, basic functional and performance requirements of the new technology product, and continuously update and maintain in the subsequent qualification stage. The TDD generally includes the following applicable contents:

#### 2.2.2.1 Defining System Requirements

##### (1) Goals

The goals defined for the new technology should identify the applicable 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, etc.

##### (2) Functional Requirements

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

## (2) Performance Requirements

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

## (4) Design Conditions

The system design conditions describe all applicable loading requirements under the environmental and operating conditions. This should include, but not be limited to, the natural environment (e.g., temperature and salt mist), 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:

- (a) Pressure and temperature induced loads and fluctuations;
- (b) Static and dynamic loads;
- (c) Fatigue and fracture effects;
- (d) Wear and vibration effects;
- (e) Material degradation;
- (f) Accidental loads.

## (5) System Interface Requirements

The system interface requirements define all internal and external physical and functional interfaces (e.g., mechanical, electrical, etc.) relevant to the new technology. Interfaces among system elements should also include interfaces with the human element. The system interface definition confirms that various elements

of the system can functionally and physically interact with each other and with all external systems they connect to or communicate with.

(6) Human System Integration Requirements

During the design process, specific areas, stations, or equipment arrangement that would require concentrated human engineering attention should be defined. Any special requirements, such as constraints on allocation of functions to personnel and communications and personnel/equipment interactions, should be specified.

(7) Maintainability

All components of new technology are confirmed to be monitored, inspected, and maintained based on existing practical experience. If the accessibility of components within the system needs to be determined, clarify the maintenance cycle of each component.

(8) Reliability (if applicable)

Reliability is the ability of a system or component to function under stated conditions for a specified period of time, and determines the robustness, consequences, and redundancy of the system through risk assessment or a means of verifying reliability(e.g., mean time between failures(MTBF)).

#### 2.2.2.2 System description

The TDD is a design review document prepared by the client, which is relatively detailed and can be continuously improved throughout the entire technology qualification process. However, the TDD submitted to CCS should include available information based on the maturity of new technology design.

The TDD prepared by the client generally includes but is not limited to the following:

- (1) Equipment list;
- (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: (a) piping and

instrumentation diagrams (P&IDs); (b) block diagrams (including system interface); (c) design schematics; (d) general arrangements; (e) materials and specifications; (f) design analysis methodology and related reports; (g) installation analysis; (h) test reports;

(6) Control and safety system details;

(7) Operational, maintenance, and inspection strategies;

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

(9) Quality, health, safety and environmental philosophies;

(10) Other.

### 2.3 New Technology Qualification Plan and Activities

The NTQP defines a roadmap for progressing the new technology through the appropriate qualification stages. The objective of the NTQP is to provide a summary of qualification activities that need to be performed at each stage in order to demonstrate the ability of the new technology to meet the requirements specified in the TDD. The NTQP for each subsequent stage is updated based on the findings from the previous stage activities and discussions between the client and CCS. Qualification within each stage is comprised of a set of iterative activities that include engineering evaluations and risk assessments to verify new technology design.

Figure 2 summaries the iterative NTQP process.

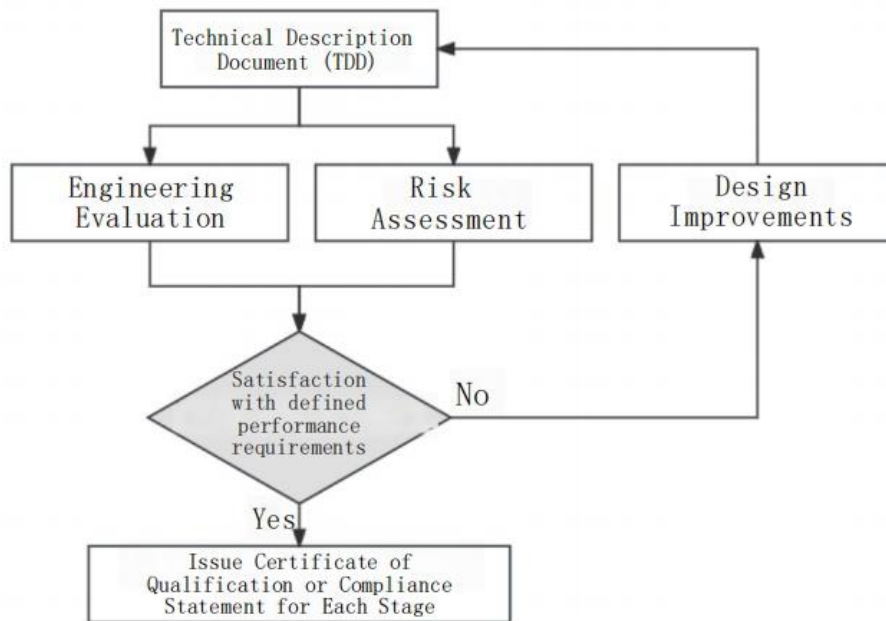


Fig. 2 New Technology Qualification Stage Iterative Process

### 2.3.1 Risk Assessment

For a new technology requesting qualification, a risk assessment is to be performed or updated at each stage as applicable. Prior to performing the risk assessment, a risk assessment plan should be prepared and submitted to CCS for review. After the risk assessment has been completed, a risk assessment report should be prepared and submitted to CCS for review.

The primary objective of the risk assessment is to identify technical risks and uncertainties associated with the proposed design and document all foreseeable hazards, their causes, consequences, and potential risk control measures considering the new technology in its proposed application and operating environment. All possible interfaces, and known integrations are to be evaluated as part of this assessment. The risk assessments during the qualification process of new technology will vary from qualitative to quantitative based on the maturity of technology and the information available at that stage.

All risk assessments performed must consider personnel safety, asset protection, and environmental protection.

It is recommended that the risk assessment be carried out by a multidisciplinary team that includes the design team and the end-user. The risk assessment methods should be selected based on specific circumstances and discussed with CCS before conducting risk assessment.

The risk assessment plan should include the following information:

(1) Assessment scope: description of the proposed new technology including physical and operational boundaries; intended service application of the new technology;

(2) Evaluation team: design team and relevant experts, participants, risk analysts;

Assessment preparation: all available new technical information (e.g., design principles, drawings, programs, etc.); recommended risk assessment methods (e.g., FMECA); recommended risk assessment criteria (e.g., risk matrix);

After risk assessment, the client should prepare a risk assessment report that includes the following information:

(1) Scope of risk assessment:

(2) Description of the proposed new technology including physical and operational boundaries, intended service application of the new technology;

(3) Risk Assumptions and Data References;

(4) Engineering Documents: technical drawings;

(5) Risk Assessment Worksheets that

Identifies hazards associated with the new technology in its current boundary conditions (application and operating environment); identifies scenarios associated with each identified hazard; identifies causes of the hazardous scenario; identifies consequences of the hazardous scenario; identifies existing risk control measures for each hazardous scenario; estimates the likelihood (frequency) and the severity of the consequence; evaluates the risk of the hazardous scenario by measuring it against the acceptable risk criteria agreed; 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: action items and/or recommendations.

Exemption from risk assessment: when the failure of new technology or any of its components poses no risk to personnel, ships, and the environment or is a known low risk, the risk assessment can be exempted. The reasons for exemption from risk assessment should be explained in the new technology approval plan and confirmed by CCS.

### 2.3.2 Engineering Evaluation

Engineering evaluations are used to verify and validate that the new technology is capable of performing acceptably with respect to the safety and function

according to the requirements of each stage. This is achieved gradually for each qualification stage through specific qualification activities as the technology matures. The types of activities for engineering evaluation are:

(1) Review Engineering Design Requirements: As the technology matures, and more detailed design information becomes available, the functional and performance requirements are reviewed/updated as needed;

(2) Technical Analyses and Simulations: Engineering design analyses and simulations are used to verify the technology at the 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 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.

### 2.3.3 Design Improvements

2.3.3.1 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.

2.3.3.2 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 TDD. The updated

qualification activities should aim to meet these new requirements. Design improvements should be tracked in the NTQP.

2.3.3.3 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.

2.3.3.4 An appropriate design change management process should be established to review, evaluate, and document design improvements during the design and development of the technology.

### **3. New Technology Qualification Stages**

#### **3.1 Conception Verification Stage**

The concept verification stage aims to verify the safety of the concept in practical applications through design analysis, functional and model testing, and reliability testing (as applicable). During this stage, risk assessments of compliance with specifications, conventions, or regulations or alternative designs should be conducted. The objective of this evaluation is to carefully consider the functional substitution of new products and technologies for existing statutory products stipulated in conventions and regulations, with a focus on the basic functions and safety reliability of the products.

##### **3.1.1 Qualification Requirements**

###### **3.1.1.1 Engineering Evaluation Requirements**

###### **3.1.1.1.1 Engineering Design Review**

(1) At the Concept Verification Stage, the concept feasibility is confirmed and the engineering design is reviewed to verify that the functionality and performance of the new technology can be satisfied. The complete system, subsystem and component level requirements should be defined to verify the correctness of design.

(2) The performance requirements should state how the technology will perform its function and how the system requirements will be met. In addition, the requirements for the integration of subsystems and components and system

configuration and interface requirements should be defined. At the concept verification stage, system requirements should be reviewed, design constraints should be incorporated into the system requirements and design information, and the materials used in the product should be reviewed.

(3) A preliminary manufacturing plan should be submitted for review and should include the manufacturing methods and processes, the facilities, the production schedule, and the quality assurance requirements.

#### 3.1.1.1.2 Functional and Model Testing

(1) The performance of new technology should be verified through tests, and the type of tests depends on the characteristics of the new technology. Functional and model tests should be conducted under intended environmental and operational conditions, including identifying key failure modes in risk assessments, verifying the system functional, performance, and reliability requirements, and verifying the results obtained from the analysis model.

(2) The material performance should be verified through material testing, and the raw materials or components specified in the product material specification should be used during the testing. It is to verify the performance of new materials or materials that have a significant impact on system performance through destructive testing or non-destructive testing. The service life performance of materials can be tested in a short period of time through accelerated testing methods, and reliability tests can also be conducted.

(3) The test plans should be submitted for review. The test plans should define the test requirements and methods to verify that the product satisfies the design requirements. The test plans should include test conditions, test methods, intended test results, measured parameters, testing instruments, and accepted result criteria.

#### 3.1.1.2 Risk Assessment Requirements

3.1.1.2.1 Risk assessment at the concept verification stage is to identify the technical risks related to the design of new technology. Concept design data and other relevant data need to be provided for risk assessment, and designing risk assessment should consider the following aspects:

- (1) Any design modifications from the Concept Verification Stage
- (2) Updated functional and performance requirements
- (3) Updated system composition
- (4) Interfaces and system integrations (as applicable)
- (5) All potential failure modes, failure causes and failure mechanisms in all expected operational modes and life cycle stages
- (6) The effectiveness of existing risk control measures and the need for any additional or more reliable measures
- (7) Closing out any action items as agreed in the Concept Verification Stage

3.1.1.2.2 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. A risk assessment report should be formed. The risk assessment report and new technology qualification plan should be submitted for review.

3.1.1.2.3 A risk assessment technique that is appropriate for reviewing the new technology design should be selected and submitted for review as part of the risk assessment plan. 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. Results from the FMECA should facilitate any design improvements or FMEA verification activities of new technology.

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

- (1) Design risk assessment(e.g., FMECA)
- (2) Update risk assessments as needed based on updated design documentation.
- (3) Perform any additional risk assessments identified while verifying the design and/or updating previous risk assessments.

### 3.1.2 Qualification data

The following qualification data should be submitted for review:

#### 3.1.2.1 Engineering Evaluation Data

##### 3.1.2.1.1 Technical Documents

- (1) Design basis, specifications and/or technical specification of the new technology Product technical characteristics, applicable design basis, specifications, guidelines, standards, etc., relevant technical argumentation, analysis models, etc.

(2) System and function architecture details such as functional flow block diagram Product drawings (e.g., general layout drawings, system diagrams, etc.), research and development task books, technical specifications, and technical documents related to products and manufacturing process, including process flow (as applicable)

(3) Product intended functions, objectives, and basic principles, etc.

(4) Details regarding physical and functional interface(mechanical, hydraulic, electronic, optical, software, human, etc.)

(5) Lessons learned, references and examples of comparable designs

(6) Functional and model test plans

#### 3.1.2.1.2 Preliminary manufacturing plan

#### 3.1.2.2 Risk Assessment Data

(1) Risk assessment plan

(2) Risk assessment report

(3) Risk assessment worksheets

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

#### 3.1.3 Concept Verification Stage Certification

The complete technical documents have been submitted for review and the performance requirements of the new technology have been verified. At the same time, the tasks in the checklist for concept verification stage has been completed, and a concept verification certificate will be issued. The next step will be the prototype and engineering prototype validation stage. The checklist for the concept verification stage is shown in the table below, however, it is not limited to the items in the table.

No.	Item	Yes/No/NA	Evidence
1	Is the concept of new technology is clearly explained?		
2	It defines what special conditions are required for the development of new technologies such as environment, stability, materials, arrangement, safety device, fire-fighting equipment, maintenance manual, working environment, etc.		

3	Have the performance requirements and reliability verification plans for new technology been defined?		
4	Have clear requirements for the development and process of new technology been made?		
5	Have improvements been made and documented based on relevant technical and performance parameters?		
6	Have necessary analysis or calculations been conducted for the concept design?		
7	Is there an assessment plan for the reliability verification of the system?		
8	Have technical documents required for new technology concept verification been provided? (specifications, application regulations, design, modeling, analysis, test results, procedures, risk assessment reports, similar approval records, etc.)		
9	Has risk assessment (e.g., FMECA) been conducted and a risk assessment report been provided?		
10	Has a model or prototype of the new technology been established and the necessary testing items been defined?		
11	Has a production and manufacturing quality assurance plan been provided?		
12	Responding to supplementary items (Safeguard, recommendations, etc.) identified in the risk assessment.		

### 3.2 Prototype Validation Stage

3.2.1 The Prototype Validation Stage has completed conceptual functional, performance, and feasibility validation in the first stage. The objective of this stage is to verify the expected functionality, utility, and necessary reliability through prototype testing. This stage can be divided into the principles prototype verification and engineering prototype verification, and the principles prototype verification

certificate or the engineering prototype verification certificate will be issued separately.

#### 3.2.1.1 Principles Prototype Verification Stage

At the principles prototype verification stage, a prototype can be designed and manufactured based on the principle of similarity for verification testing. At this stage, it should be possible to

(1) Clearly describe the basic application background, functional characteristics, and technical principles;

(2) Develop relevant drawings and technical solutions;

(3) Conduct necessary risk analysis;

(4) Complete the design, manufacturing, and assessment of the principles prototype, and ensure that the main functional characteristics and technical indicators satisfy the requirements;

(5) The feasibility of the technical solutions and approach has been verified through principles prototype testing;

#### 3.2.1.2 Engineering Prototype Verification Stage

At the engineering prototype stage, a full-scale engineering prototype should be manufactured for verification testing. At this stage, it should be possible to:

(1) Clarify the technical performance requirements to satisfy the using requirements;

(2) Ensure that the engineering prototype has been experimentally validated in simulation or using environments, and its functionality and performance have been optimized;

(3) Complete the detailed design of the engineering prototype, and all design indicators satisfy the using requirements;

(4) Complete detailed design risk assessment;

(5) Stable process, complete process documents, and satisfactory trial production conditions;

(6) Reliable quality of key materials and devices to ensure stability;

## 3.2.2 Qualification Requirements

### 3.2.2.1 Engineering Evaluation Requirements

#### 3.2.2.2 Engineering Design Review

The drawings and technical requirements for engineering design should be detailed and defined. The adverse effects of additional loads on load-bearing components, faults/failures of electrical components should be fully considered. In addition, the full-life-cycle impacts of system integration, installation, commissioning, operation, maintenance, and decommissioning should be considered.

##### 3.2.2.2.1 Prototype Testing

The test plans should be detailed and operable to include the testing methods, limiting conditions, intended test data, safety assurance measures, etc. The testing equipment and measuring tools should be identified as valid. For certain test items that cannot or are difficult to be carried out, simulation conditions or virtual experiments can be used for replacing, such as finite element analysis (FEA), computation fluid dynamics (CFD), and other tools accepted by CCS.

The test report should include inputs, assumptions, boundary conditions, the computational models and intended test data (results). The test results should be sorted and analyzed to determine whether the test satisfies intended functional and performance requirements.

##### 3.2.2.2.2 Prototype Manufacturing and Inspection

The manufacturer should develop a detailed production plan and quality assurance plan, and CCS will witness the important nodes and type testing process as per the inspection test plan (ITP) agreed upon by both parties.

#### 3.2.2.3 Risk Assessment Requirements

The main objective of the risk assessments performed in the Prototype Validation Stage is to validate the safety and reliability of the final design products of the new technology. Based on comprehensive review of the risk assessment reports in previous stages, the risks arising from design changes or new technology

description should be re-assessed. Similarly, the output results of risk assessment at this stage can serve as input for risk assessment at the next stage. For certain new technologies with high risk levels, it is recommended to adopt special methods for risk assessment (e.g., FMECA or HAZOP) for certain key links to evaluate the risks resulted from faults or failures in special links throughout the full-life-cycle process. All technical risks identified should be considered and closed for treatment. Design improvements based on identified fault modes should also be verified through functional and utility tests. The following activities should at least be carried out for risk assessment in engineering design:

- (1) Design risk assessment (e.g., design FMECA);
- (2) Process risk assessment (e.g., process FMECA or HAZOP) if applicable;
- (3) Update all previous risk assessments;
- (4) Preventive measures for catastrophic consequences;

### 3.2.3 Qualification Data

The following qualification data should be submitted to CCS for review:

#### 3.2.3.1 Engineering Evaluation Data

(1) Technical documents, including: (a) technical requirements for systems, subsystems, components, etc; (b) detailed design drawings, technical specifications, manufacturing process guidance, and calculation sheets; (c) test plans and reports; (d) special test results, such as those confirmed during design risk assessment (e.g., FMECA);

- (2) Inspection Test Plan(ITP);
- (3) Detailed manufacturing plan;

#### 3.2.3.2 Risk Assessment Data

- (1) Preliminary risk assessment report (upgraded);
- (2) Design risk assessment report (e.g., FMECA);
- (3) Process risk assessment report (e.g., process FMECA);
- (4) Consequence prevention measures;

#### 3.2.3.3 Prototype Validation Stage Certification

After technical document review of the new technology, all performance has been verified, and the tasks in the checklist for prototype validation stage have been completed. A principles prototype validation certificate or engineering prototype validation certificate will be issued. The checklist for prototype validation stage is shown in the table below, however, it is not limited to the items in the table.

No.	Item	Yes/No/NA	Evidence
1	Have the manufacturing requirements of new technology been specified?		
2	Has the manufacturing and assembly process been accepted?		
3	Does the prototype match the principle prototype or the engineering prototype?		
4	Has the new technology passed basic functionality testing of prototype (physical or virtual) or full scale product to demonstrate fitness and design function in a simulated or actual operating environment?		
5	Has a performance data sheet (or curve) been established?		
6	Has the new technology passed durability and accelerated life tests? (if necessary)		
7	Is the degradation of function/performance within expected acceptable limits?		
8	Has the new technology passed system reliability analyses? (if necessary)		
9	Has the operating/destroy limits been confirmed? (if necessary)		
10	Is in-service monitoring necessary or implemented? (if necessary)		
11	Has a process risk assessment been performed and a report been generated (if necessary)?		
12	Has corresponding design risk assessment been conducted?		
13	Have the residual risk and uncertainty been established and documented?		

### 3.3 Systems Integration Stage

The systems integration stage is to verify the compatibility of new technology with the final system and using environment by testing and evaluating its effectiveness and applicability in the specified environment, identify and eliminate errors and faults that may occur during the system integration process, ensure that the product has good performance, reliability, and stability, and thus ensuring its effectiveness and quality in practical applications.

The client should develop system integration testing plans, including detailed testing instructions, product details, limiting conditions, testing scope, testing items, and intended indicators, and submit them to CCS for approval. After the completion of system integration testing, all test procedures and final results should be generated into a summary report and be submitted to CCS for review. During this process, the client should also reassess the process or technical risk points that were not covered in the previous risk assessments, update relevant reports, and propose corresponding risk control measures for the identified risk points.

#### 3.3.1 Engineering Evaluation

3.3.1.1 For electromechanical products, the client can determine the detailed parameters of their system functions and interfaces based on system interfaces and product use requirements, and verify and assess them through interface analysis, system integration testing, and other means. For material products, new materials should be prepared into final products for testing after industrial mass production. The client should define the performance requirements of the final products, and verify and assess them through interface analysis, systems integration testing, and other means.

3.3.1.2 Interface analysis refers to the fact that the addition or incorporation of the new technology does not negatively affect the integrity of the surrounding systems and components. At this stage, the interfaces should be specified in quantitative limiting values, and the client should submit complete interface analysis and necessary engineering solutions to CCS for review.

3.3.1.3 System Integration Testing (SIT): An initial operational test and evaluation should be performed to assess the operational effectiveness and suitability in the intended environment. This test can be conducted in a laboratory that simulates the marine environment or on a real vessel, and the testing environment should be confirmed by the surveyor. During the test, the surveyor should witness the test on site, and ensure that all items are executed according to the approved plans.

### 3.3.2 Risk Assessment

3.3.2.1 The main objective of the risk assessments performed in the System Integration Stage is to evaluate any technical risks resulting from system integration, and these risks were not effectively identified in the previous stage of evaluation. The customer should reassess the previously-submitted risk assessment reports and records, and select appropriate risk assessment methods (e.g., FMECA, HAZOP, or HAZID) for analysis, and control additional risks through risk control measures. For the items that affect ship safety, the client should develop corresponding protective measures, elimination measures, or mitigation measures for fault risks, and modify the design if necessary. The updated risk assessment report, including hazards identification, reliability, availability, and maintainability (RAM) analysis (as applicable), and new technology qualification plan (NTQP), should be submitted to CCS for review.

### 3.3.3 Summary of Submittals

#### 3.3.3.1 Engineering Evaluation Data

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

(2) All documents that describe detailed operational procedures and performance parameters.

(3) Test plans, test data, and test results after system integration.

(4) Plans for in-service survey, monitoring, sampling and testing(as applicable) during operations.

#### 3.3.3.2 Risk Assessment Data

- (1) Updated risk assessment reports (as applicable);
- (2) Other applicable technical safety study report (if any).

### 3.3.4 Issuance of Systems Integration Phase Certificate

After the above documents are submitted to CCS for review, the surveyor will verify all specified performance indicators. After qualified verification, CCS will issue a design approval certificate for the new technology to prove that the technology meets the design requirements and the necessary conditions for system integration. The product can enter the operational stage. The checklist for systems integration stage is shown in the table below, but it is not limited to the items in the table.

No.	Item	Yes/No/NA	Evidence
1	Has the design risk assessment (e.g., FMECA, HAZOP or HAZID) considering full system interfaces been updated and properly documented?		
2	Have all other technical risks been identified/addressed and properly documented?		
3	Has the technology been deployed into a full prototype and fully integrated with the intended system?		
4	Has the function/performance when connected/integrated into a final system been fully tested?		
5	Has the human-machine interface been fully addressed and documented?		
6	Have all system integration requirements been confirmed?		
7	Has installation, hook-up, commissioning and testing been completed as per specifications?		
8	Is there a data collection system in place to document performance and reliability?		
9	Has a detailed in-service inspection/monitoring/sampling plan been defined ?		
10	Can in-service inspection/monitoring/sampling functionality be validated?		

### 3.4 Operational stage

3.4.1 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. At this stage, it is suggested that all parties involved in the project can participate together.

3.4.2 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.

3.4.3 In case of verifying the operational stage by installing it onboard, the applicant or ship owner shall notify the flag state for the relevant information and, if necessary, obtain approval from the flag state.

3.4.4 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.

3.4.5 Establishment of Operational Plan

3.4.5.1 The need and extent of qualification requirements at the Operational Stage 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 Concept Verification Stage, 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 three previous qualification stages will not be overturned in the

Operational Stage. Taking all the above into consideration, the vendor, end-user together with the Society 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.

3.4.5.2 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.

3.4.5.3 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 CCS 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 the Society.

#### 3.4.6 Summary of Submittals

3.4.6.1 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 items are typical submittals that CCS would expect to receive annually:

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

#### 3.4.7 Operational Stage Completion

3.4.7.1 After the completion of this stage, it is proven that the new technology is successful and feasible, indicating operational qualified of the technology. At the request of the client, a “Operational Conformity Declaration” is issued based on the feedback and quality improvement results of the new technology operation.

3.4.7.2 The items in the table below can be considered (but not limited to) as the general inspection items for the operational stage.

No.	Item	Yes/No/NA	Evidence
1	Has the technology demonstrated acceptable reliability and availability in the targeted operating environment?		
2	Has the in-field service monitoring, sampling, and inspection plan been successfully implemented?		
3	Has reliability and integrity performance data been properly collected, analyzed, and documented?		
4	Have any underperforming components of the technology been identified?		
5	If so, then has there been any reliability improvements for failed or underperforming components?		
6	Has there been any performance feedback from projects or suppliers?		
7	Have any unexpected aspects(e.g., interdependencies or influences on performance) or safety concerns been observed?		
8	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 TDD or in-service inspection plan(ISIP)?		
9	Has the design risk assessment(e.g., FMECA) been updated with in-service performance data?		
10	Has the system reliability assessment been updated and properly documented?		

\*\*\*\*\*End\*\*\*\*\*

## Definitions

1. **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.
2. **Approval:** means confirmation that the plans, reports or documents submitted to the Society have been reviewed for compliance with one or more of the required Rules, Guides, standards or other criteria acceptable to the Society.
3. **Availability:** means 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).
4. **Boundary:** means interface between an item and its surroundings (ISO 14224).
5. **Consequence:** means 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.
6. **Engineering Evaluations:** means 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.
7. **Risk assessment:** means an integrated array of analytical techniques, e.g. reliability, availability and maintainability engineering, statistics, decision theory, systems engineering, human behaviour, etc. that can successfully integrate diverse aspects of design and operation in order to assess risk. For example: Failure Mode Effects and Criticality Analysis (FMECA);
8. **Failure:** means the loss of the ability to perform the intended function.
9. **Failure Causes:** means circumstances associated with design, manufacture, installation, use and maintenance that have led to a failure (ISO 14224).
10. **Failure Mechanism:** means a physical or chemical process resulting in a form of damage which will ultimately lead to failure.
11. **Failure Mode:** means the specific manner of failure that the failure mechanism produces.
12. **Functional Specification:** means 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).
13. **Frequency:** means the occurrence of a potential event per unit of time, typically expressed as events per year.

14. **Global Effects:** means total effect an identified failure has on the operation, function or status of the installation or vessel and end effects on safety and the environment.
15. **Hazards:** means conditions that exist which may potentially lead to an undesirable event.
16. **Item:** means any part, component, device, subsystem, functional unit, equipment or system that can be individually considered (ISO 14224).
17. **Local Effects:** means impacts that an identified failure mode has on the operation or function of the item under consideration or adjacent systems.
18. **Maintainability:** means 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).
19. **Manufacturing Plan:** means 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).
20. **Quality Assurance and Quality Control:** means typical quality plans and related processes for controlling quality during production.
21. **Qualification:** means the process of confirming, by examination and provision of evidence, that equipment meets specified requirements for the intended use (API RP 17N).
22. **Qualification Activities:** means 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.
23. **Qualification Plan:** means 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.
24. **Redundancy:** means existence of more than one means for performing a required function of an item (ISO 14224).
25. **Reliability:** means ability of an item to perform a required function under given conditions for a given time interval (ISO 14224).
26. **Risk:** means the product of the frequency with which an event is anticipated to occur and the consequence of the event's outcome.
27. **Validation:** means 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.
28. **Verification:** means 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.
29. **Principles Prototype:** means the model samples designed and manufactured in the early stage of product development to evaluate and verify the feasibility of technical principles or solutions, which can be designed based on the principle of similarity.

30. **Engineering prototype:** means practical samples manufactured through standardized design to evaluate and verify the rationality and correctness of technical designs or solutions, which can be optimized and adjusted under engineering application conditions to verify their performance parameters.

## **Abbreviations**

1. ALARP: As Low As Reasonably Practicable
2. CFD: Computational Fluid Dynamics
3. FEA: Finite Element Analysis
4. FMECA: Failure Mode Effects and Criticality Analysis
5. FTA: Fault Tree Analysis
6. HAZOP: Hazard and Operability
7. HAZID: Hazard Identification
8. ISIP: In-Service Inspection Plan
9. ITP: Inspection Test Plan
10. MTBF: Mean Time Between Failure
11. NTQP: New technology qualification plan
12. QA: Quality Assurance
13. QC: Quality Control
14. RAM: Reliability, Availability and Maintainability
15. TDD: Technical Description Document
16. SIT: Systems Integration Test

