Guide for

Assessment of the Process for Product Reliability

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GUIDE FOR

ASSESSMENT OF THE PROCESS FOR PRODUCT RELIABILITY

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American Bureau of Shipping
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Foreword

The marine and offshore industry strives towards improved operational effectiveness, efficiency, and reliability for their assets. Technological advances in machinery controls, automation and reliability are resulting in increased applications of autonomous functions. Achieving these goals requires maximizing uptime via thorough robust design processes, establishing quantitative condition assessment in service, and improving the overall safety, planning, operations, maintenance, and repair processes. This is accomplished through a lifecycle process executing increased design for reliability, operations and maintenance in a continuous improvement cycle. This cycle aims to improve asset operations with a balanced criticality and risk-based approach.

The requirements presented herein offer designers a path to fulfill these goals through an optional assessment of the reliability process for products intended for marine and offshore applications. The process for product reliability includes a product reliability goal statement, a reliability task or tasks, and reliability assessment method or methods. The defined reliability goal statement includes the product functions and functional failures for a defined operating timeframe and environment. Implemented procedures for product reliability support the reliability goal statement and include a reliability enhancing or sustaining task or tasks measured consistently using standard reliability assessment method or methods.

Products whose reliability process has been assessed in accordance with this Guide may be used by owners, operators and shipyards for the following benefits:

- Guidance when selecting products or systems intended for enrollment in a Preventative Maintenance Program associated with alternative crediting of Special Periodical Survey of Machinery.
- Support improving asset management initiatives for new or existing assets.
- Improving operations and maintenance program performance so that unanticipated repairs and operational disruptions may be minimized.
- Supporting an equipment based contribution in design for reliability of a vessel in complying with the ABS *Guide for Surveys Based on Machinery Reliability and Maintenance Techniques*.

This Guide becomes effective on the first day of the month of publication.

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

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

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CONTENTS

SECTION 1
General

1 Application

This Guide applies to products, machinery, equipment, and their components as referenced in 4-1-1/3.7 of the *Rules for Building and Classing Marine Vessels (MVR)* or the machinery and equipment referenced in 6-1-1 of the *Rules for Building and Classing Mobile Offshore Units (MOU Rules)*. These products, in most cases, require a Design Assessment in accordance with the applicable Rules and standards and the applicant may pursue an optional assessment of their product reliability process in accordance with this Guide. The product is to have a Product Design Assessment (PDA) issued through the ABS Type Approval Program as referenced in 1/1-A3 and 1/1-A4 of the *Marine Vessel Rules or* 1/1-A2 and 1/1-A3 of the *Rules for Building and Classing Offshore Units and Structures*. Assessment in accordance with this Guide represents a technical review was satisfactorily performed of the product's reliability process.

Surveyor attendance is not required as a part of the assessment of the reliability process.

This Guide is not applicable to reliability improvement strategies solely accomplished through the practice of operational product maintenance. However, this restriction is not intended to discourage the incorporation of features to aid maintenance task selection or enhance condition assessment.

This Guide does not address selection, calculation, or evaluation of the product's assessed reliability or reliability metrics, the product's effectiveness, or the estimated life cycle costs. These design and operational aspects are outside the scope of this Guide.

1.1 Reference Rules, Guides and Guidance Notes

The most current issues of the following ABS publications are referenced in this Guide:

- *Rules for Conditions of Classification, Part 1, Chapter 1, Appendices 3 and 4*
- *Rules for Building and Classing Marine Vessels, Part 4, Chapter 1*
- *Rules for Building and Classing Mobile Offshore Units, Part 4, Chapter 1 & Part 6, Chapter 1*
- *Rules for Building and Classing Floating Production Installations*
- *Rules for Survey After Construction, Part 7, Appendix 1, Chapter 14*
- *Guide for Surveys Based on Machinery Reliability and Maintenance Techniques*
- *Guide for Smart Functions for Marine Vessels and Offshore Units*
- *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*

2 Objective

The objective of this Guide is to provide designers an optional PDA endorsement of the product reliability process.

3 Definitions

The following definitions are applied to the terms used in this Guide.

Component: The hierarchical level below equipment. This is the lowest level for which the component can be identified for its contribution to the overall functions of the *functional group* and be identified for its *failure modes*. It is the most convenient physical unit for which a *preventative maintenance plan* can be specified.

Function: The action or actions that a part is designed to perform per the applicable design specifications.

Failure: What constitutes a failure is defined prior to testing based on the reliability requirements and test boundary. Failure is a dynamic definition according to its intended purpose manifested by different practices of design, and manufacturing engineering groups.

Product: Any equipment that is identified within the scope of supply that is a discrete unit or deliverable on the purchase order.

Commentary:

For the purposes of this Guide, products eligible for issuance of a PDA in the Type Approval Program and machinery, equipment, and their components as referenced in 4-1-1/3.1 "Certification of Machinery, Basic Requirements" of the *Rules for Building and Classing Marine Vessels*.

End of Commentary

Reliability: The probability that an item will successfully perform its intended function for a specified interval under stated conditions.

Commentary:

For the purposes of this Guide, a reliability process for a product and the key elements of a product reliability process are provided in 2/1.2.

End of Commentary

4 ABS Type Approval Program

The requirements for products proposed for enrollment in the ABS Type Approval Program are provided in the *Marine Vessel Rules* Part 1, Chapter 1, Appendix 3 or the *MOU Rules*, Part 1, Chapter 1, Appendix 2.

5 Product Assessment and PDA Endorsement

Designers may obtain a PDA indicating the endorsement of the product reliability process (see Section 2/3.2). This endorsement may follow additional mandatory product certification requirements that are required for the product to be installed on a classed vessel.

Certain products require unit certification prior to installation onboard (see the *MVR* 4-1-1/3, for an overall description and 4-1-1/3.7, for a representative listing or the *MOU Rules* 6-1-1).

In addition to the reliability endorsement, the product may be eligible for enrollment in any of the programs of the following Rules or Guides:

- *Guide for Smart Functions for Marine Vessels and Offshore Units*

- *Guide for ABS Cybersafety® for Equipment Manufacturers, ABS CyberSafety® VOLUME 7*
- *Rules for Survey After Construction*, 7-A1-14 *Surveys Based on Preventative Maintenance Techniques*
- *Guide for Integrated Software Quality Management (ISQM)*

6 Alternative Design or Process

Specific requirements in this Guide, or its associated references, may be complied with via the use of alternative arrangements, tools or methods which are set in recognized standards to demonstrate compliance with the requirements herein. However, this is subject to such alternative arrangements or standards being determined by ABS as being not less effective than the overall goals of this Guide or associated references. Where applicable, requirements may be imposed by ABS in addition to those contained in the alternative arrangements or standards so that the intent of this Guide is met.

SECTION 2

Assessment of the Process for Product Reliability

1 Principles of the Process for Product Reliability

This Subsection 2/1 details principles and essential elements of a process for product reliability to understand the scope and applicability of the requirements in this Guide.

1.1 Process for Product Reliability Overview

The requirements in this Guide are to be applied to a product for which reliability tasks have been implemented for product reliability performance improvement or sustainment, and have been measured using selected assessment methods. The combination of a reliability task and one or more assessment methods can be referred to as a product reliability process.

Evaluation and assessment of the reliability process is intended to verify fulfillment of the following:

i) Reliability tasks and assessment methods are used to meet a defined product reliability goal, either to establish inherent reliability in a design, improve reliability based on product past performance or to sustain product reliability in operations. See 2/1.3 for the definition of Reliability Goals.

ii) Processes are incorporated in designer's codes of practice (i.e., design/engineering instructions).

iii) Processes are based on recognized industry standards, or, if customized and produced in-house, are based on first-principal engineering practices. Documented processes can therefore become repeatable. Appendix 1 includes an example list of resources applicable to this process that may be referenced for certain reliability tasks or assessment methods.

The types of products whose reliability processes may be assessed are varied in physical size, complexity, purpose and ratings. Accordingly, this Guide is not prescriptive, but rather provides guidance in the manner that tailored reliability tasks and assessment methods, such as those listed in Table 1 and Table 2, may be developed, implemented, and improved based on product maturity level, reliability goals and reliability assessment feedback throughout the product's lifetime phases.

1.2 Elements of a Process for Product Reliability

Processes for product reliability can be updated throughout the product's life when any relevant feedback information becomes available at any point in the product's lifecycle. The focus of this guide is on the assessment of the processes used to address product reliability.

Three key elements constitute a product reliability process:

1) A defined product reliability goal, as described in 2/1.3

2) Standard tasks or methods used to establish, enhance, improve, or sustain product reliability, as described in 2/1.4.1

3) Reliability metrics to evaluate product reliability against the goal, as described in 2/1.4.2

These elements can be carried out at any product lifecycle phase. Typical product lifecycle phases include:

- Design (or redesign)
- Manufacturing or production, including product testing before release
- Operations after product delivery

Depending on the maturity levels of the product and the product reliability process, the submittal documentation required to assess the process can vary. Generally, the higher product maturity level, the less documentation is required. Example measures for product maturity are not limited to the number of units in production, total recordable operating hours, or months in service. The product maturity level can be divided into three categories:

1) New product

2) Existing product with reliability performance related challenges, requiring mitigation

3) Existing product without significant reliability performance related challenges

1.3 Product Reliability Goals

Product reliability goals form the baseline of a reliability process, distinguished by purpose from safety or design standard performance goals. Safety performance goals focus on eliminating the risks of hazards to life, physical assets, or the environment. Design standard performance goals focus on meeting established engineering design requirements for structures, parts, and product functional criteria. In contrast, while reliability goals may be related to safety or design standards, reliability goals focus on expected product functionality and performance throughout its lifetime. Submittal item requirements for the reliability goal are provided in Section 2/2.1.1.

Based on the definition of reliability provided in Subsection 1/5 in this Guide, a product reliability goal is to consist of three key items:

1) Designer defined product functions and functional failures according to the operating envelope and operating time. These defined functions and functional failures may differ from those of a system composed of many products and components, or that of a complete vessel operating with many systems of products and systems of systems. For the purposes of this Guide, the defined functions and functional failures are to be those of the applicable product only.

2) Designer defined time, operational cycles, or product lifetime during which the product functions under specified conditions. As all products are subject to corrosion, wear, damage, and eventual decline, a defined interval of operations is necessary to establish the context of product reliability performance.

3) Designer defined operating conditions and operating envelope within which the product performs its functions for a defined amount of time. This item is to be identical to the details of intended service and product ratings as identified for the PDA which is to be endorsed for reliability. Product operating conditions are typically chosen for the allowable range of operating conditions or environment for which the product is intended to perform. This includes product operating ranges such as material temperature, output power rating, input power, rotations per minute (speed), or fuel consumption rate. Environmental conditions can also include the ambient air temperature, humidity, air circulation, vibrations, or other dynamic external conditions. Reliability is defined within these identified conditions and may not necessarily apply when the product experiences conditions outside of its defined operating envelope. Conditions outside of a product's operating environment may occur, for example, due to user error or extreme weather events.

Designers typically define target reliability based on design basis documents typically included in PDA documentation supported by field testing and product performance.

1.4 Selection of the Reliability Strategies

1.4.1 Reliability Tasks

The designer chooses one or more tasks to apply to address reliability during the design/redesign, manufacturing or production phases of the product's lifecycle. The tasks are to be chosen such that they improve or sustain product reliability in its intended operating environment.

Tasks for reliability carried out during the design of a product are done to enhance the inherent or built-in product reliability and maximize the product performance within the bounds of its designed operating environment and performance criteria. Alternatively, tasks for reliability carried out during the production or manufacturing of a product are done to control, limit, or improve the impacts on inherent reliability from fabrication, assembly processes, or maintenance/repair procedures.

Table 1 includes typical tasks for reliability during the design or redesign and manufacturing or production phases. The descriptions and examples or techniques listed for these tasks and methods are general in nature and intend to address the application of the reliability process. Alternative tasks may be applied according to Subsection 1/11 of this Guide. Required submittal items for the reliability tasks are provided in 2/2.1.2.

The development of spare parts strategies and maintenance procedures may also be an output of the executed product reliability process. For example, a product designer or manufacturer may update or change the product maintenance plan or repair plan in expectation of improving or sustaining product reliability performance according to the reliability goal. Therefore, the control process of spare parts strategies and maintenance procedures is applicable to this Guide. However, the strategies and procedures themselves are not addressed by this Guide. These items are subject to the requirements in the *Rules for Survey After Construction,* 7-A1-14, *Surveys Based on Preventative Maintenance Techniques* and Sections 2, 3 and 4 of the *Guide for Surveys Based on Machinery Reliability and Maintenance Techniques* and are listed if a vessel owner or operator chooses to enroll machinery in a Program covered by these requirements.

1.4.2 Reliability Assessment

To consistently measure, evaluate, or track reliability performance metrics, the designer also chooses one or more methods of reliability assessment to internally validate product functional reliability performance, progress or accordance with the defined reliability goal. Functional performance metrics are those related to product functions within limits defined by the reliability goal, and do not include incidents or failures due to operator or human error, product misuse, or interference. Various methods for reliability assessment may be used to measure the reliability metrics according to the stated reliability goal, depending on the product's lifecycle phase. For designers, the design and redesign product lifecycle phase plays a prominent role in reliability assessment. Metrics may include quantitative methods such as stated mean time between failure (MTBF), or qualitative methods such as failure, modes and effects analysis or failure modes, effects, and criticality analysis (FMEA/FMECA) to be used for failure mode mitigation, depending on product maturity.

Reliability metrics according to the stated reliability goal should be consistently measured or assessed to reflect the product functional reliability performance. There are many ways to investigate performance factors and product capabilities related to reliability, as well as various methods to test and analyze a product for reliability performance. Table 2 includes typical reliability testing or analysis methods that can be used at various times over a product's lifecycle. Required submittal items for reliability assessments are provided in 2/2.1.3.

TABLE 1
Examples of Product Reliability Tasks in Design and Manufacturing Activities

Product Lifecycle Phase	*Task Name*	*Task Description*	*Task Purpose*	*Examples or Techniques*
Design or Redesign	Critical Component Control	Manage the items, components, parts, or techniques in the design that have high impact on the determination of product reliability. Track performance of critical components. Improve reliability by documenting, analyzing, and planning the reliability impact of critical components.	In new designs or redesign, the reliability can be improved by maximizing the reliability impact of critical components. Critical components often include complex or innovative parts or techniques that have not yet been proven as technologically mature.	Critical component control can be carried out by the following: • Design Guidelines • Design review and modification • Documentation of design decisions • Packaging and Handling Analysis • Historical data tracking and performance of critical components over product lifecycle • Reliability Prediction • Failure Mode and Effects Analysis (FMEA) • Experimental Design Testing / Design of Experiments
	Derating	Reduce design stresses or loads on a product below its rated or maximum allowable levels.	Reducing the allowable stresses or loading limits of a product can inherently improve reliability and increase the safety margins of that product under relaxed operating conditions.	Derating can be accomplished by either: • Reducing operational stress or loading • Increasing product stress capability or loading capability
	Fault Tolerance	Designing or incorporating continuous functionality for a product after a component or part failure.	A product which is tolerant to part or component failure will have inherently higher reliability, increased safety margins, and optimized downtime or repair times.	The mitigation of failure effects can be approached by the following product capabilities: • Fault recovery • Fault masking, i.e., degraded mode of operation or redundancy/partial redundancy features • Fault reaction, i.e., active fault detection, switching to alternate mode of operation

Product Lifecycle Phase	*Task Name*	*Task Description*	*Task Purpose*	*Examples or Techniques*
Design or Redesign (Continued)	Parts Selection and/or Control	Choosing and implementing parts in the product design that operate reliably and fulfill their operational requirements effectively.	An established procedure for parts selection and control can effectively raise inherent product reliability. Parts should be chosen which can operate reliably in the design environment. Parts control procedures should reduce the possibility of compromising inherently designed reliability.	A parts management plan or other procedures to manage part acquisition, required part testing and evaluation, and vendor qualification are important to incorporate parts selection in product capability and overall reliability.
	Spare Parts Strategy / Maintenance Procedure Selection and Control	Choosing an appropriate spare parts strategy or defining a maintenance procedure can support the sustainment of product reliability when it comes in service.	As the designer has the most knowledge of product failure modes and functionalities, it is their responsibility to create and control the instructions provided to users for product maintenance after delivery.	Developing a plan during design, or updating or changing a maintenance plan after product delivery, can be a tactic to improve or sustain product reliability performance according to the defined reliability goal.
	Other Design Task for Reliability	Alternative tasks carried out during the design or redesign stage intended to improve product reliability performance may be used in accordance with Section 1/6 of this Guide.		

Product Lifecycle Phase	*Task Name*	*Task Description*	*Task Purpose*	*Examples or Techniques*
Manufacturing & Production	Selection of Manufacturing Standards	Choosing and implementing manufacturing standards for the fabrication and production processes which support or increase product reliability.	The designer may have a choice in manufacturing or quality standard that affects overall product reliability. Manufacturing standards should be implemented with considerations to reduce product failure modes and enhance reliability.	Robust manufacturing procedures, tolerances or quality requirements typically result in enhanced product reliability over those methods with less stringent or unclear criteria.
	Manufacturing Methods and Control	Implementing manufacturing procedures and management of change procedures for production can preserve inherent design product reliability.	Inherent reliability in design can be easily affected by the quality and consistency of the manufacturing processes. Once manufacturing and quality standards are established, control of the implemented processes is important to avoid degraded product reliability after production.	Implementing robust corporate process instructions for employees to follow for manufacturing procedures and management of change procedures with appropriate involvement from authorities are often used to manage the continuous quality and reliability of produced products.
	Other Manufacturing or Production Task	Alternative tasks carried out during the manufacturing or production stage intended to improve or sustain product reliability performance may be used in accordance with Section 1/6 of this Guide.		

TABLE 2
Examples of Reliability Assessment Methods in Various Lifecycle Activities

Product Lifecycle Phase	*Task Name*	*Task Description*	*Task Purpose*	*Examples or Techniques*
Design or Redesign	Critical Component Identification	Generate the information required for Critical Component Control. Identify the items, components, or parts that have high impact on the determination of product reliability. In CMMS, criticality for each component/part can be assigned after a criticality analysis is conducted.	In new designs or product redesign, the reliability can be improved by documenting, analyzing, and planning the reliability impact of critical components.	The following example can be used to identify critical components: • Criticality is typically evaluated as probability of failure multiplied by failure consequence, where when incorporated with detectability, is sometimes known as Risk Prioritization Number (RPN)
	Reliability Growth Testing and FRACAS Initiation	Establishing key metrics and parameters during the design phase for product reliability growth tracking over its lifetime based on performance requirements and reliability criteria.	Reliability growth is the analysis of reliability improvements over time caused by modifications to the design or manufacturing process. The main goal of reliability tracking is to continually monitor product performance over a long time and maximize reliability performance after inherent reliability is established.	Reliability Growth is a general term for an improvement analysis program using various tasks for addressing reliability and other tasks for monitoring and assessing reliability over time. Combinations of tasks from Table 1 and Table 2 can be used in a Reliability Growth Program.
	Modeling & Simulation	Create and investigate a graphical or mathematical representation of the product and its reliability performance; use simulation methods to validate representation.	Identify components that are bottleneck to reliability performance. A sensitivity study is used to optimize the design/manufacturing/ operations activities.	The following methods can be used to identify bottleneck components, optimize maintenance strategies via modeling and simulation methods • Reliability Block Diagram (RBD) • Fault Tree Analysis (FTA) • Finite Element Analysis (FEA)
	Predictions	Any type of reliability estimate based on available design, analysis or test data, or from data of similar products.	Provide estimates for product life and warranty analysis.	The following methods can be used to make reliability predictions for the product. • Weibull Analysis • Accelerated Life Testing (ALT)

Product Lifecycle Phase	*Task Name*	*Task Description*	*Task Purpose*	*Examples or Techniques*
Design or Redesign (Continued)	Failure Modes, Effects & Criticality Analysis (FMECA)	Determine the effects of failures on product's ability to perform function(s). FMEA is common, while FMECA includes a criticality analysis/ evaluation based on consequences of failure modes.	Examine potential failure modes for their effects on product performance and (for FMECA) to investigate the criticality of failure. Results of FMEA/FMECA are recommended actions to enhance product reliability performance.	
	Other Assessment Method During Design Phase	Alternative assessment methods during the design stage intended to assess reliability may be used in accordance with Section 1/6 of this Guide.		• Component and part load testing

Product Lifecycle Phase	*Task Name*	*Task Description*	*Task Purpose*	*Examples or Techniques*
Manufacturing, Production & Product Testing	Factory Acceptance Testing	Test product during manufacturing or production to check that reliability is not compromised	Ensure the product delivery meets the reliability requirements in design, manufacturing and testing lifecycle phases.	• Burn-in Testing • Environmental Stress Screening • Highly Accelerated Stress Screening • Pressure chamber testing
	Root Cause Failure Analysis (RCFA)	Identify and address causes for product failures during manufacturing testing	Establish mitigation control measures to reduce product failures before product operations	• 5-Why/ Cause Mapping Analysis
	Dormancy Analysis	Investigate the impact of product storage periods or other non-operating conditions (dormancy) on the product reliability performance.	Determining the environmental stresses during nonoperating conditions can highlight areas of improvement to reliability performance.	• Examining nonoperating environmental conditions can expose the effects on the product including corrosion, moisture exposure and other manufacturing defects.
	Other Assessment Method During Manufacturing or Testing Phase	Alternative assessment methods during the manufacturing or product testing stage intended to assess reliability may be used in accordance with Section 1/6 of this Guide.		
Operations	Operational Product Data / Warranty Reporting Analysis	A warranty database tracking all after-market products serves as a depository system to file and track claims.	Analyzing the field failures, product performance or condition monitoring can loop back to improve product design and correct manufacturing process.	• Reliability/Availability Assessment • Pareto of top failures/modes • Root Cause Failure Analysis (RCFA) • Warranty analysis • Durability Assessment • Failure Reporting, Analysis and Corrective Action System (FRACAS) • Preventative Maintenance Optimization (PMO)

2 Analysis Requirements

The reliability goal establishes expectations for a product's functional performance under specified conditions. It provides a baseline of product function and defines the scope of reliability activities.

One or more of the tasks identified in Table 1 is to be used to improve or sustain reliability performance when applicable during the product lifetime according to the defined reliability goal.

Associated with each task from Table 1, one or more reliability assessment methods listed in Table 2 are to be used when appropriate to measure and assess reliability performance according to the defined reliability goal.

2.1 Information to Be Submitted

In addition to the plans and data to be submitted for Type Approval Program as per 1-1-A3/5.1 of the *Rules for the Conditions of Classification*, the following additional information related to the reliability process is to be submitted to an ABS Engineering Office for review to receive assessment of any combination of the reliability process tasks and assessment methods in Table 1 and Table 2. This information may be integrated with design/engineering instructions or as separate documents. The following items are to be provided as applicable:

2.1.1 Documented Reliability Goal

A product reliability goal statement as provided in 2/1.3. The definition of product reliability is to include the defined product function(s), operating environment envelope, and period (time or number of cycles, etc.) over which the product reliability is calculated.

For cases where this information is not integrated throughout product engineering instructions, guidelines, or codes of practice, a description of the manner by which reliability goals are defined is to be provided.

2.1.2 Documentation of Reliability Task

The defined and submitted reliability goal identified in 2/2.1.1 is to be achieved by implementing a reliability task or tasks as identified in Table 1.

Identified product reliability tasks are to be based on recognized industry standards, codes of practice, or first principles engineering approach that are referenced within the submittal items.

A description or record of the reliability improvement task is to be provided for review, including details of the purpose of the task (why it was chosen to improve or sustain reliability), and details of when and how the task was carried out.

2.1.3 Documentation of Reliability Assessment Methods

The reliability assessment method or methods listed in Table 2 are to be identified and based on recognized industry standards, codes of practice, or first-principles engineering methods that are referenced within submittal items.

Submitted assessment processes are to show the reliability goal and indicate how the supporting reliability metrics can be measured, checked, or used as design feedback loop input.

2.2 PDA Endorsement

Compliance with Section 2 of this Guide will be indicated in the endorsement section of the Product Design Assessment Certificate. Details of the specific reliability task and the associated assessment method(s) used for the product will be included in the PDA Certificate.

PDA certificate issuance and updates are to be according to 1-1-A3/5.7.2 of the *Marine Vessel Rules*. Renewal of the Reliability Process endorsement on a PDA is to follow the certificate renewal process according to 1-1-A3/5.7.4 of the *Marine Vessel Rules*.

2.3 Limitations

2.3.1 Changes to Design or Procedures

In the event of a change in the design, standards, processes or procedures as submitted in 2/2.1, the equipment supplier is to notify ABS of those changes for re-assessment and any resulting

effect on configuration, design, and validity of the PDA with the product reliability process endorsement.

Commentary:

After ABS has approved the reliability endorsement for the first time, only those documents which have undergone substantive changes are to be resubmitted for consideration by ABS consistent with any renewal term that is due. Refer to 4-2-1/13.3.5 (f) and (g) of the Marine Vessel Rules for granting renewals of certificates with or without modifications.

End of Commentary

APPENDIX 1

Standards for Reliability Tasks and Assessment

The following table is a partial list of references for product design tasks for reliability, methods to measure product reliability, and reliability assessment methods.

Typical applicable tasks or assessment methods for product reliability are indicated for each reference. References without specific reliability task or assessment methods listed are applicable in general to product reliability.

Reference Title	***Applicable Reliability Task or Assessment Method***
ABS *Guidance Notes on Failure Mode and Effects Analysis (FMEA) for Classification*	FMEA/FMECA
ABS *Guidance Notes on Reliability-Centered Maintenance*	Repair Strategy
ABS *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*	
ABS *Guide for Surveys Based on Machinery Reliability and Maintenance Techniques*	Repair Strategy
Accelerated Test; Statistical Models, Test Plans, and Data Analysis, Wayne Nelson, John Wiley, 1990.	Accelerated Testing
Applied Finite Element Analysis for Engineers, Stasa, F.L., Holt Rinehart and Winston, New York, NY, 1985.	Durability Analysis & Finite Element Analysis
Assurance Technologies: Principles and Practices, Dev G. Raheja, McGraw-Hill, 1991	Design of Experiments, FMEA/FMECA, Fault Tree Analysis, Life Cycle Planning, Modeling and Simulation, & Prediction
AT&T Reliability Manual, Klinger, D.J., Nakada, Y., Menendz, M.A. Van Nostrand Reinhold, 1990.	Accelerated Testing & Prediction
Bayesian Reliability Tests Made Practical, Rome Laboratory, RADC-IR-81-106.	Product Reliability Assessment Testing, Reliability Design Testing/Reliability Qualification Testing, & Test Strategy
Benchmarking Commercial Reliability Practices, Ned Criscimagna, RAC, 1995	Life Cycle Planning
Business Process Reengineering or Quality Improvement, R. Wanner & J. Franceschi, RAC, 1995	

Reference Title	*Applicable Reliability Task or Assessment Method*
DoD Directive 4245.7: Transition from Development to Production, 1985	
Ensuring Software Reliability, Neufelder, A.M. Marcel Dekker Inc., New York, NY, 1993.	Prediction
Failure Mode, Effects and Criticality Analysis, FMEA. Reliability Analysis Center, Rome, NY, 1993.	FMEA/FMECA
Failure Mode/Mechanism Distribution, FMD-91. Reliability Analysis Center, Rome, NY, 1991.	Dormancy Analysis & FMEA/FMECA
Failure Modes, Effects and Criticality Analysis, RAC publication FMECA.	FMEA/FMECA
Fault Tree Analysis Application Guide, RAC publication FTA.	Fault Tree Analysis
Fundamental Concepts in the Design of Experiments, Hicks, C.R., Rinehart and Winston, Inc., New York, NY, 1982.	Design of Experiments
How to Plan an Accelerated Life Test, by William Meeker and Gerald Hahn.	Accelerated Testing
Introduction to Quality Engineering, Taguchi, G. American Supplier Institute, Inc., Dearborn, MI, 1986.	Design of Experiments
ISO 16708:2006 Petroleum and natural gas industries — Pipeline transportation systems — Reliability-based limit state methods	
ISO 20815:2018 Petroleum, petrochemical and natural gas industries — Production assurance and reliability management	
ISO 2394:2015 General principles on reliability for structures	
ISO 8930:2021 General principles on reliability for structures — Vocabulary	
ISO/ASTM 52941:2020 Additive manufacturing — System performance and reliability — Acceptance tests for laser metal powder-bed fusion machines for metallic materials for aerospace application	
ISO/TR 12489:2013 Petroleum, petrochemical and natural gas industries — Reliability modelling and calculation of safety systems	
Mechanical Applications in Reliability Engineering, RAC publication NPS.	Prediction
Maintenance and Reliability Best Practices, Gulati, R. Industrial Press, 2021	
MIL-HDBK-189: Reliability Growth Management, 1981	RGT/TAAF

Reference Title	*Applicable Reliability Task or Assessment Method*
MIL-HDBK-781: Reliability Test Methods, Plans, and Environments for Engineering Development, Qualification, and Production, 1987	Life Cycle Planning, Product Reliability Assessment Testing, RGT/TAAF, & Test Strategy
MIL-STD-2155: Failure Reporting, Analysis, and Corrective Action System (FRACAS)	FRACAS
MIL-STD-785: Reliability Program for Systems and Equipment Development and Production	
MIL-STD-810: Environmental Test Methods and Engineering Guidelines	Life Cycle Planning, Reliability Design Testing/Reliability Qualification Testing & Test Strategy
Nonelectronic Part Reliability Data, NPRD-95. Reliability Analysis Center, Rome, NY, 1995.	Dormancy Analysis & Prediction
Nonoperating Reliability Databook, NONOP-1. Reliability Analysis Center, Rome, NY, 1987.	Dormancy Analysis & Prediction
Practical Reliability Engineering, P.D.T. O'Conner, John Wiley & Sons, 1985	
Product Reliability, Maintainability, and Supportability Handbook, ed. by M. Pecht, CRC Press, 1995	
Quality by Experimental Design, Barker, T.B. Marcel Dekker, Inc., New York, NY, 1985.	Design of Experiments
Quality by Experimental Design, Barker, T.B., Marcel Dekker 1985.	Design of Experiments
RADC-TR -89-281: Reliability Assessment Using Finite Element Techniques, Rome Laboratory, Rome, NY, 1989.	Finite Element Analysis
RADC-TR-66-710: Reliability Prediction - Mechanical Stress/Strength Interference, Rome Laboratory	Durability Analysis & Prediction
RADC-TR-68-403: Reliability Prediction - Mechanical Stress/Strength Interference (Non-Ferrous), Rome Laboratory.	Durability Analysis & Prediction
RADC-TR-82 -177: Reliability Part Derating Guidelines, Rome Laboratory, 1982.	Derating
RADC-TR-84-254: Reliability Derating Procedures, Rome Laboratory, 1984.	Derating
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