



GUIDANCE NOTES ON

PRODUCTION RISER LIFE EXTENSION

JANUARY 2021

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

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Foreword

These Guidance Notes provide technical recommendations and guidance on life extension applications for subsea production risers attached to floating production installations (FPIs) that produce and/or store hydrocarbons. These Guidance Notes outline the riser life extension process that includes inspection and assessment of the riser structure and ancillary equipment for the entire subsea riser system. These Guidance Notes are also applicable to subsea injection risers and import/export risers.

These Guidance Notes become 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 these Guidance Notes 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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SECTION 1 Introduction

1 Overview

Many subsea production risers are approaching the end of their original design life. Those risers need to be either decommissioned or be included in an application to the recognized Authority (if applicable) for an extension of their original design life. Due to enhanced recovery or tiebacks from adjacent fields, more and more existing fields are continuing to produce. As a result, life extension of those offshore assets including production risers is becoming more commonplace.

For assessment of existing floating production installations, the ABS *Guidance Notes on Life Extension Methodology for Floating Production Installations* provides guidance when the intended period of operation at the original site or the accumulated operating time at both the original and relocated sites is extended beyond the original design life period. This document focuses on risers attached to FPIs that produce and/or store hydrocarbons.

These Guidance Notes are not intended to serve as a design standard, but rather to highlight the primary activities of the life extension process for risers attached to FPIs. These Guidance Notes present a methodology that can be applied in the riser life extension process for continued service. As such, they may be applied to risers classed by ABS, not classed by ABS, or without class.

2 Scope and Application

These Guidance Notes provide technical recommendations and guidance on life extension application for subsea production risers attached to FPIs that produce and/or store hydrocarbons. These Guidance Notes outline the riser life extension process that includes inspection and assessment of the riser structure and ancillary equipment for the entire subsea riser system. These Guidance Notes are also applicable to other subsea risers in addition to production risers. The applicable riser types are:

- Production Risers
- Injection Risers
- Import/Export Risers

Drilling risers, workover and completion risers are not covered in the scope of these Guidance Notes.

These Guidance Notes should be used in conjunction with the following two ABS Guides:

- *ABS Guide for Building and Classing Subsea Riser Systems*
- *ABS Guide for Classification and Certification of Subsea Production Systems, Equipment and Components*

3 Abbreviations

ABS	American Bureau of Shipping
ASME	American Society of Mechanical Engineers
BPVC	Boiler and Pressure Vessel Code
BS	British Standards
BSEE	Bureau of Safety and Environmental Enforcement
CVA	Certified Verification Agent

DFI	Design Fabrication and Installation
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Causes Analysis
FPI	Floating Production Installation
FPS	Floating Production System
HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
I3P	Independent Third Party
LE	Life Extension
MDR	Master Document Register
OEM	Original Equipment Manufacturer
RIM	Riser Integrity Management
SCR	Steel Catenary Riser
TTR	Top Tensioned Riser
VIM	Vortex-induced Motion
VIV	Vortex-induced Vibration

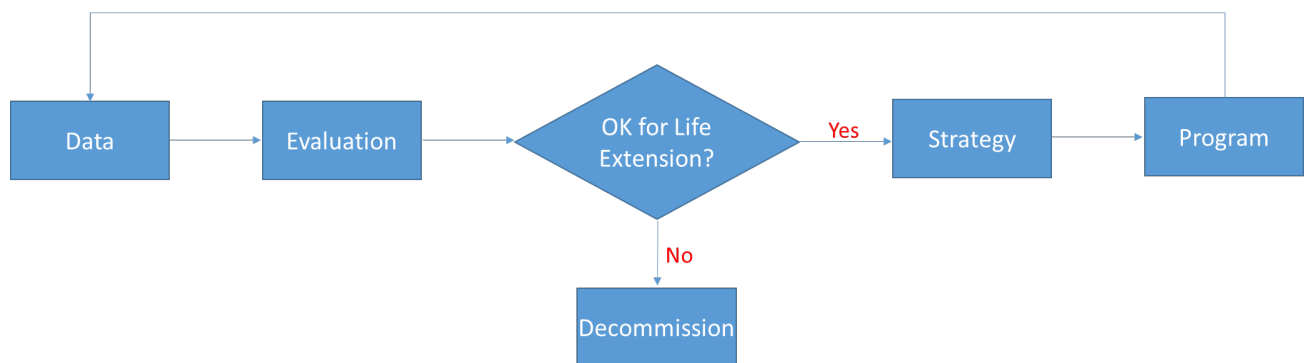


SECTION 2 Riser Life Extension Process

1 General Riser Life Extension Process

Riser life extension requires a life extension assessment created from collected riser characteristic data, condition data, and operating data to confirm the integrity of the riser and its capacity for extended operations under future operating conditions. The assessment may confirm that the riser is fit-for-service in its present condition for the planned extended service life or call for a plan with repairs, component replacement, additional inspection, additional monitoring, or a combination. A high-level riser life extension process is shown in Section 2, FIGURE 1.

FIGURE 1
A High-level Riser Life Extension Process



For riser systems managed in a riser integrity management (RIM) program, riser characteristic data, condition data, and operating data may be readily available for life extension assessment. For risers not managed in a RIM program, additional efforts need to be called for to establish the current riser condition for life extension assessment. For example, a design fabrication and installation (DFI) résumé should be available to provide the data of the original design, including the design code and standards used, all design assumptions, the intended design envelope, any non-conformances and any resulting modifications up to the completion of installation or beyond. If this document is not available, extra efforts need to be called for to obtain the design and as-installed data from the documentation management system. In addition, it is also very important to obtain the production history and riser integrity data after the installation. If those data are not available, conservative assumptions should be made for the life extension assessment, which may lead to a decrease in the extended lifetime.

An inspection is necessary for risers not managed in a RIM program to establish the condition of the riser at the time prior to the life extension assessment. The inspection should at least include the items listed in Subsection 3/2.

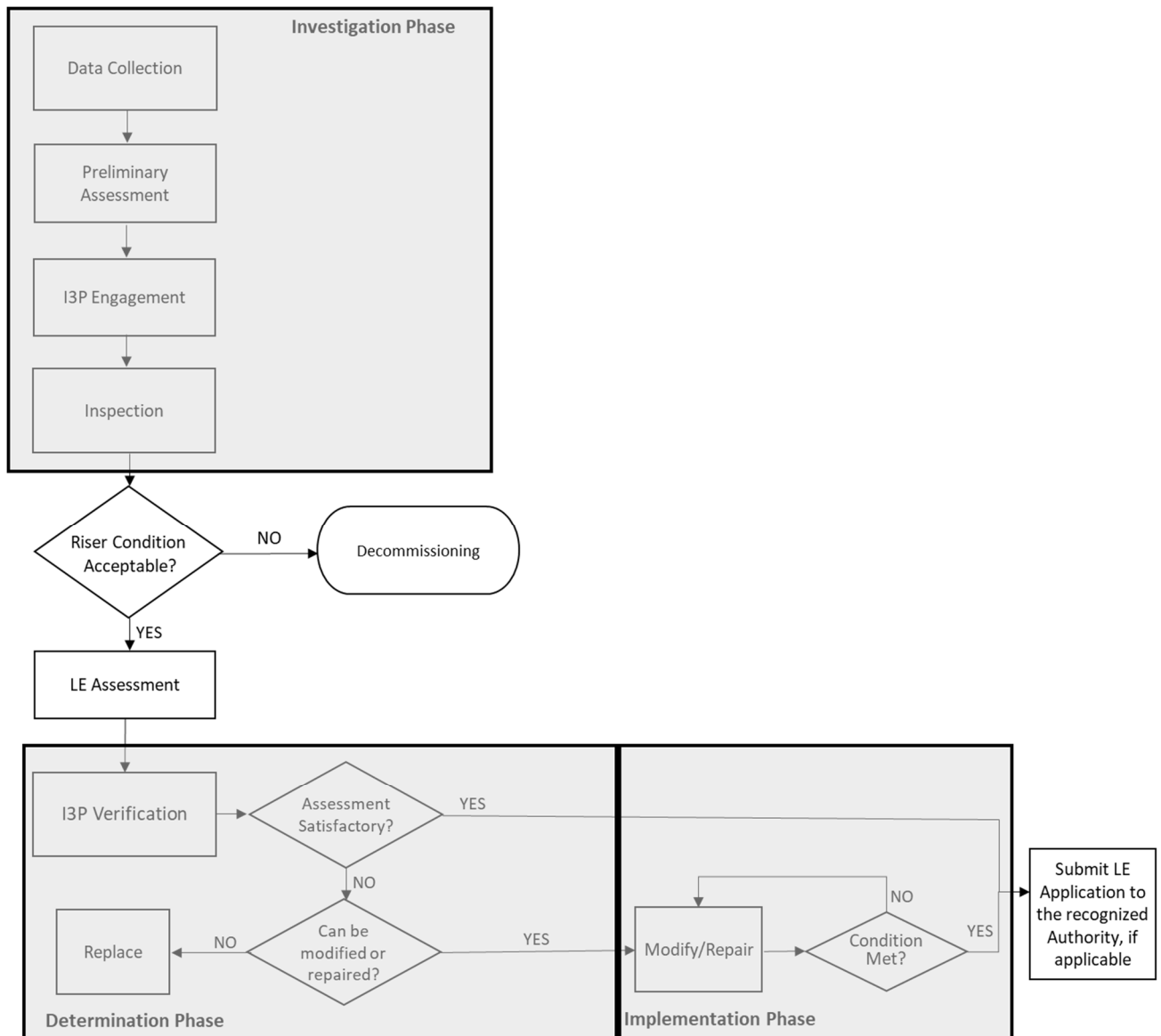
Owners and operators generally require the review of the riser life extension by an independent third party (I3P). Often the recognized authority (if applicable) requires an I3P engagement (note: in the U.S., the term Certified Verification Agent (CVA) is used for verification of riser design, fabrication, installation, and life extension). It is recommended to follow the three phases listed below for riser life extension. The earlier the I3P/CVA engages in the process, the better the readiness of the life extension application.

- i)* Investigation phase
 - Data collection and engineering evaluation
 - Inspection
- ii)* Determination phase
 - Assessment
 - Provision of conditions for life extension, such as modify or repair
- iii)* Implementation phase
 - Conditions implemented

Riser life extension application is usually required to be submitted to the recognized Authority (if applicable) for approval. The recognized Authority (if applicable) may have specific requirements on the qualification of an I3P. It is strongly suggested the Owner to communicate with the recognized Authority (if applicable) for the requirements of riser life extension. The recognized Authority (if applicable) may review the riser life extension application based on potential risks.

A recommended general process for riser life extension with I3P engagement is shown in Section 2, FIGURE 2. For riser life extension applications submitted to the recognized Authority (if applicable) with ABS engagement as an I3P or a CVA, the document submittals are listed in A1/2.

FIGURE 2
General Life Extension Process with I3P Engagement



Appendix 2 is a dedicated section on riser life extension in the U.S. For U.S. applications, refer to Appendix 2 for details.

2 Simplified Process for Risers Managed in a RIM Program

It is preferred to have a RIM program in-place for riser life extension application. The RIM provides a proactive process for demonstrating the integrity of a riser throughout its life on a fitness-for-service basis. The integrity management process relies on gathering and collating information on the riser, periodically evaluating the data, and using the evaluation to set a strategy for subsequent inspection and monitoring.

RIM is a continuous process throughout the service life of the riser. Key riser performance data is collected continuously by robust and consistent monitoring devices. In addition, the riser condition data is collected through scheduled maintenance, inspection, or planned modification and repair to the riser. If any initiator is triggered, such as severe environmental events, accidental conditions, or life extension, the collected data can be used to evaluate the fitness-for-service of the riser. Based on the evaluation, riser maintenance and repair may be scheduled. Strategy plans and program work should be reviewed periodically. If needed, plans

and program should be adjusted to better manage the riser integrity. The details of riser integrity management are illustrated in Appendix 3.

The riser systems may be managed in a RIM program and/or classed by a Class Society. ABS offers the optional notation **A1 Offshore Installation – Offshore Risers** for subsea risers in the *ABS Guide for Building and Classing Subsea Riser Systems* and **CSS – Production** for subsea systems in the *ABS Guide for Classification and Certification of Subsea Production Systems, Equipment and Components*. For classed riser systems, the riser life extension application needs to be submitted to both the Class Society that the riser system is classed with and the recognized Authority (if applicable). Similar to the RIM program, the riser “in-class” status is helpful to the life extension application submitted to the recognized Authority (if applicable), and the Class Society is a natural choice of I3P/CVA, possessing all the survey records on hand to support the life extension application submitted to the recognized Authority (if applicable). The requirements for riser life extension submitted to the Class Society are essentially the same as those for riser life extension submitted to the recognized Authority (if applicable), for which the Class Society will provide help. The document submittals for riser life extension to maintain the ABS class notation are listed in Appendix 1, Subsection 1.

As the recognized Authority (if applicable) may review the riser life extension application based on potential risks, being managed in a RIM program or being classed by a Class Society benefits the riser life extension application submitted to the recognized Authority (if applicable). For example, if the riser has been managed in a RIM program in which the collected data shows the riser to be in very good condition and the fatigue analysis report demonstrates the riser fatigue life exceeds the original design life plus the requested extension lifetime, the life extension of this riser can be deemed as low risk. For a low-risk application with a short requested extension lifetime (e.g., request of extension of 25% of the original design life), the review process of the recognized Authority (if applicable) may be simplified.

The recommended general process for riser life extension denoted in Section 2, Figure 2 is also applicable for risers managed in a RIM program, though some steps may be simplified. For example, the data collection has already been carried out in the RIM program and the latest inspection report and data may be reused in lieu of a dedicated life extension inspection.

Appendix 2 is a dedicated section on riser life extension in the U.S. For U.S. applications, refer to Appendix 2 for details.



SECTION 3 Inspection

1 General

Regular inspection is normally included in the RIM plan or riser maintenance plan. The inspection program should cover all inspectable components of the riser system. The inspection technology should be effective enough to provide credible information of the condition of the riser system.

The inspection program can be prescriptive or risk-based and should include the visual inspection of the riser system above water and below water. The inspection interval may be determined by the Owner based on the experience of a similar riser or by original equipment manufacturer (OEM) recommendations. The inspection interval can be established based on the guideline from API RP 2RD or API STD 2RD, however, if any anomalies found in the riser system from the inspection are significantly different from those expected, the inspection interval should be adjusted to accommodate the unfavorable situations. Details on risk-based inspection for riser systems can be found in the *ABS Guide for Risk-Based Inspection for Floating Offshore Installations*.

For riser life extension application, an inspection should be carried out before commencing the life extension assessment. In some situations, if the most recent inspection can be agreed by the recognized Authority (if applicable) as equivalent to a life extension inspection, the dedicated life extension inspection may be waived.

If the risers are Classed, or a Class Society is nominated as the riser life extension I3P or CVA, Class Society engagement should commence as early as possible.

2 Inspection

Inspection is critical to establish the condition of the riser system at the time prior to riser life extension assessment. It is important to understand the current condition of an existing riser system compared to the original “as-designed” condition and the original “as-built” installation survey.

The inspection should start with an inspection plan that covers:

- i) List of the riser components in the riser system, including locations
- ii) Inspection items and locations
- iii) Contents requirement on the inspection report
- iv) Principles to handle marine growth and debris

The inspection should include the following:

- i) Visual inspection of the riser system above the water
- ii) Verify the conditions of riser body.
- iii) Verify important riser data (e.g., touch down location of the compliant risers).
- iv) Confirm the conditions of internal/external corrosion and erosion, as well as coating and insulation.
- v) Verify the condition of cathodic protection system.
- vi) Confirm the condition of hang-off assembly, including riser porches or J-tubes, flex joints, or taper stress joints, etc.
- vii) Confirm the condition of vortex-induced vibration (VIV) suppression devices (e.g., strakes or fairings).

- viii) Confirm the condition of buoyancy modules, if any.
- ix) Confirm the condition of riser support systems (e.g., riser guides, riser clamps, riser anchor supports, mid-water arch, tether, and tether clamps), if any.
- x) Confirm site soil or topography conditions have not changed much (such as scour, trench, etc.).
- xi) The quantity and estimated weight of marine growth.
- xii) For top tensioned risers (TTRs), confirm the condition of tensioner, topside jumper, riser joint connections, and riser bottom connections.
- xiii) For flexible risers, confirm the condition of armor wires, annulus, outer layer, end fittings, bend stiffeners, bend restrictors, bellmouths, ballast modules, and movement restriction chain and deadweight, if any.

Special attention should be paid to fatigue hot spots during the inspection. For TTRs, the fatigue hot spots are generally:

- i) Tensioner joint/topside buoyancy cans
- ii) Subsea tiebacks connectors and stress joints
- iii) Keel joints
- iv) Joint connected to the stress joint

For Steel Catenary Risers (SCRs), the fatigue hot spots are generally:

- i) Flexible joints
- ii) Strakes
- iii) Touch down regions and trenching

For riser systems designed for regular pigging operations, in-line inspection is strongly recommended to confirm the riser internal conditions. The requirements of in-line inspection may be determined from the results of the risk assessment. Details on risk assessment methods can be found in the *ABS Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*.

3 Inspection Technique

If deemed necessary, additional inspections should be carried out to further identify the anomalies in the areas of interest. Detailed inspection technique can be found in the *ABS Subsea Inspection, Maintenance, and Repair Advisory*.



SECTION 4 Assessment

1 General

Engineering assessment is required to be carried out for life extension application to demonstrate fitness-for-service of the riser system in the proposed extended service period. The assessment may start from a risk screen and simplified analyses based on existing data to determine if additional monitoring, inspection, sampling, or testing are needed. The differences between the design conditions and the actual service conditions should be studied based on collected data to find the design margins for life extension. If the riser condition does not support the requested extension lifetime, modification (including riser structures and service conditions), repair, or replacement of the riser system should be considered. If this occurs, the updated riser data need to be taken into account in the life extension assessment and an I3P/CVA review of the modification/repair/replacement design, fabrication, and installation is usually required for life extension applications submitted to the recognized Authority (if applicable). For the first life extension of a low risk riser with a request for extension of up to 25% of its original design life at the same location, a simplified assessment may be acceptable.

If marine growth levels are different than those expected during the inspection, its impact to riser components functionality (e.g., VIV suppression devices), strength, and fatigue should be considered in the assessment.

Details of assessment method can be found in API RP 2RIM.

2 Functionality

The riser and all its components should be in a good condition to perform their intended function. Inspection and/or testing should be carried out to detect damages or degradation which may impact the performance of their intended function. Life extension assessment should confirm the fitness-for-service of the riser and its components in their current condition, otherwise, action should be taken to restore the riser and its components as fit-for-service. Particular attention should be paid to:

- Cathodic protection system
- Buoyancy modules
- Coatings and insulation
- VIV suppression devices
- Connectors/connections

For riser system life extension application, the effect of the reduced functionality of a damaged/absent component during its possible damaged/absent period needs to be considered in the assessment. For example, if fairings are inspected as not functioning properly, the riser fatigue life should be reassessed to consider this effect.

3 Corrosion

Corrosion is one of the most critical threats to subsea risers. Metal loss can occur with various depths and irregular shapes in subsea risers due to corrosion, erosion, or wear. An inspection should be carried out to obtain the actual amount of metal loss in the riser. It is very important to confirm that the metal loss is still within the corrosion/erosion allowance specified in the original design, otherwise, the riser strength and fatigue capability needs to be reassessed based on the reduced wall thickness and wall loss rate in accordance with recognized industry standards. Modification, repair or replacement should be carried out if the assessment concludes the riser's fitness-for-service is not adequate for life extension. The repair needs to follow established procedure, and an inspection on the repaired area needs to be performed to confirm that the threat has been effectively mitigated.

If excess metal loss is found due to loss of or damage to coatings, anodes or their connectors, necessary repair should be performed, and an inspection should be followed to confirm adequate corrosion protection on the riser system. In addition, the effect of partial loss of corrosion protection on the riser fatigue life should be taken into account in the engineering assessment of riser system. Meanwhile, the riser operating parameters may be changed to reduce the future corrosion rates.

All repairs and modifications should have an I3P/CVA review for life extension applications submitted to the recognized Authority (if applicable).

4 Erosion and Wear

Internal erosion is normally caused by abrasive elements in the production fluid, such as sand, especially in high-curvature areas. The sand concentration in the production fluid is recommended to be monitored during the operation. If the sand concentration is more than the level assumed at the original design, the actual erosion rate will exceed that specified in the original design. Measures should be taken to reduce the erosion rate in this situation, such as changing operating parameters.

Wear is usually caused by repetitive contact between two or more surfaces. A typical example is a catenary riser repetitively touching the seabed in the touchdown zone. Inspections should be performed to check the high wear areas in the riser. Wear rates should be checked against the one defined in the original design. If the measured wear rate is greater than the defined one, measures such as changing operating parameters may be used to reduce the wear rate to normal.

Similar to corrosion, assessment should be carried out if the metal loss due to erosion/wear is greater than the erosion/wear allowance specified in the original design. If the fitness-in-service of the riser system cannot be confirmed, the riser system should be modified, repaired, or replaced. An I3P/CVA review of the repair/modification is needed for life extension applications submitted to the recognized Authority (if applicable).

5 Sealability

The sealing system should be inspected to confirm the possible wear/damage does not compromise its pressure-containment function. For retrievable risers, the sealability assessment should follow the OEM recommendations. For non-retrievable risers, visual inspections and/or pressure tests should be performed. If the operation records show there are deviations to the original design parameters which may affect integrity of the sealing system, an engineering assessment should be carried out to evaluate the possible adverse effects on the sealing systems.

6 Strength

The strength assessment of a riser with reduced wall thickness should be carried out in accordance with the original design standards or industry recognized standards such as API RP 2RD or API STD 2RD. The most critical load conditions for normal operating, extreme, and survival conditions should be selected based on load case matrix in the original design with updated environmental data. The wall thickness in the strength analysis should be the wall thickness measured in the latest inspection less the extrapolated wall loss for the remaining service life from the measured wall loss.

If the metal loss of the riser can be considered as uniform wall loss, global riser analysis using beam elements may be acceptable. If the metal loss is localized and cannot be treated as uniform wall loss, component level finite element analysis should be carried out to assess the critical sections of the riser. Fitness-for-service analysis for a pipe with defects in accordance with recognized industry standards may also be acceptable.

If an inspection shows possible riser buckling or clashing, the related analysis should be carried out to assess the fitness-for-service of the riser system in this situation.

7 Fatigue

The fatigue life assessment should be carried out unless the calculated fatigue life in the original design analysis report exceeds the design life plus the extended lifetime and the inspection/testing data demonstrate the riser system conditions meet the original design requirements. If the riser experienced loads/motions or riser conditions have been changed to sufficiently impact the riser fatigue life, fatigue assessment should be carried out using as many available measured/monitored data as possible such as environmental data, vessel motions, riser motions, and riser conditions. The rate of wall loss should be considered in the fatigue analysis based on inspection data and time of inspections. The greater the amount of measured/monitored data used in the analysis, the more realistic the prediction of the fatigue life of the riser.

The fatigue assessments should consider all the fatigue loads experienced and to be experienced within the total service life of the riser system (including the original design service life and the proposed extension of service life). Riser fatigue damage is primarily composed of wave fatigue, vortex-induced motion (VIM) fatigue and VIV fatigue. Using measured/monitored vessel motion, riser motion, and/or environmental data may greatly benefit the analysis of the riser fatigue life estimation. Other cyclic loads, such as thermal/pressure induced stress cycles and slug-induced vibration, may also be considered in the fatigue analysis for riser systems if they are the concerns of the riser life extension.

For S-N based fatigue analysis, the same S-N curves and safety factors as those used in the original design should be used for the riser fatigue assessment. If there are appropriate technical justifications based on measured data, material fatigue testing, more advanced and calibrated analyses, and more favorable service conditions, alternative S-N curves and safety factors may be acceptable. Alternative S-N curves may be selected from recognized industry standards such as BS 7608, or through material fatigue testing based on materials, environmental conditions, and the service condition. Alternative safety factors on fatigue damage analysis should follow recognized industry standards with reasonable technical justifications.

For fracture mechanics-based analysis, the assessment should follow recognized industry standards. The standard compliance cannot be a “mix-and-match”. For example, if API 579-1/ASME FFS-1 is selected as the assessment standard, the entire fracture mechanics assessment should follow API 579-1/ASME FFS-1. If BS 7910 is selected, the entire fracture mechanics assessment should follow BS 7910. The safety factor of fracture mechanics analysis is usually less than that for the applicable S-N based fatigue analysis, and its recommended value can be found in recognized industry standards, such as ASME BPVC Section VIII Division 3.



SECTION 5 **Modify, Repair or Replace**

Modification, repair, or replacement should be carried out if the assessment concludes the riser's fitness-for-service is not adequate for life extension. All those activities need to be documented and reflected in the live RIM plan. The life extension assessment may be resumed after the modification and repair with an I3P/CVA review of the modification/repair design, fabrication, and installation required for life extension applications submitted to the recognized Authority (if applicable). The as-built data/reports for the modification and/or repair of the riser system need to be provided for its life extension application. The life extension process including modification, repair, and replacement is illustrated in Subsection 2/3.

If the risers are classed, the Class Society will need to be involved in all these activities, from the design, certification of materials, to the implementation, testing, and subsequent inspection.

1 Modify

All the modifications need to be documented and reflected in the RIM plan. Examples of modifications are:

- Modifications to the riser system
- Modifications to the host FPI that affect the riser system
- Modifications of the RIM plan, including additional monitoring and inspections, inspection intervals
- Modifications of operating procedures and major operation parameters

An I3P/CVA review of the modification design, fabrication, and installation is usually needed for life extension applications submitted to the recognized Authority (if applicable).

2 Repair

In the event of damage to risers or components of riser systems affecting the integrity of the riser system, repair may be carried out for safe continuous transportation of hydrocarbons. For the localized repair of non-leaking minor and intermediate damage on risers or riser components, repair clamps may be utilized without the need for an emergency shutdown to the riser system. For repair of riser components, replacement of the retrievable components may be required without the need to retrieve the riser string. Non-critical repairs which do not jeopardize the safety of the riser may form part of a planned maintenance program. Examples of repair are:

- Corrosion coating repair
- Buoyancy module repair
- Cathodic protection repair
- VIV suppression device repair

An I3P/CVA review of the repair design, fabrication, and installation is usually needed for life extension applications submitted to the recognized Authority (if applicable).

3 Replace

If repair of the riser or riser components is unable to bring the riser system back to its desirable condition for the proposed extended service life, replacement of the riser string or riser system is an option for the life extension application of the offshore assets including FPI and subsea equipment. The riser can be retrieved and replaced. The replacement activity should be documented, and the RIM of the replacement riser should start from design, fabrication, and installation again. For new risers, an I3P/CVA review of the design, fabrication and installation is usually required by the recognized Authority (if applicable).



APPENDIX 1 Master Document Register (MDR)

1 Riser Life Extension Application Submitted to ABS

For riser life extension application to maintain ABS class notation, the following documentation should be submitted to ABS for review:

- i)* An application document to propose life extension of the riser system including:
 - Proposed continuing operation life
 - Proposed continuing operation conditions including environmental conditions
 - Inspected riser structure condition
 - Environmental/geotechnical condition changes record
 - Corrosion history, predicted corrosion rate and predicted end of life condition
 - Proposed repair and replacement
 - Future inspection/monitoring plan, inspection interval and acceptance criteria
 - Proposed testing plan including pressure limits and testing interval
- ii)* Analysis reports for life extension of the riser system including:
 - Strength assessment per inspected condition
 - Fatigue damage accumulated based on previous operation history
 - Strength analysis for the riser structure per riser structure condition at the end of proposed life extension under proposed the worst environmental condition considering proposed repair and replacement
 - Remaining fatigue life per inspected riser structure condition and predicted corrosion under proposed continuing operating conditions considering proposed repair and replacement

2 Documents to be Submitted for Review

The recognized Authority (if applicable) generally has specific requirements on the qualification of an I3P or a CVA. The I3P/CVA is usually a third-party possessing technical capability with reasonable company size and related experience. The personnel in the I3P/CVA team should not have served in the design team of the original equipment/system.

For riser life extension to be submitted to the recognized Authority (if applicable) in which ABS is nominated as I3P/CVA (subject to the approval from the recognized Authority (if applicable)), the following documentation should be provided to ABS to carry out life extension I3P/CVA verification:

- i)* Riser life extension basis, including:
 - Life extension methodology and forward-looking RIM plan for the riser system in the application.

- ii)* Inspection report, including:
 - Conditions of riser body and riser data measurement (e.g., riser configuration data)
 - Conditions of internal/external corrosion and erosion, as well as coating
 - Condition of cathodic protection system
 - Condition of hang-off assembly, including riser porches or J-tubes, flex joints or stress joints
 - Condition of VIV suppression devices (e.g., strakes or fairings)
 - Condition of buoyancy modules, if any
 - Conditions of riser support systems (e.g., riser guides, riser clamps, riser anchor supports, mid-water arch, tether, and tether clamps), if any
 - Site soil or topography conditions (such as scour or trench)
 - For TTRs, condition of tensioner, topside jumper, riser joint connections, and riser bottom connections
 - For flexible risers, condition of armor wires, annulus, out layer, end fittings, bend stiffeners, bend restrictors, bellmouths, ballast modules, and movement restriction chain and deadweight, if any
- iii)* Existing integrity management plan, inspection, maintenance, and repair data
- iv)* Input data for consumed fatigue life analysis:
 - Riser design data, including sizing, weight, materials, coatings, and end connections
 - Historical operational data, including pressure, temperature, internal fluid density, and sour or sweet environment
 - Historical environmental data, including monitored or assumed wave and current data and floater motions
 - Design analysis, including strength and fatigue analysis
- v)* Input data for remaining life analysis:
 - Proposed riser data
 - Proposed operational data
 - Proposed environmental data



APPENDIX 2 Riser Life Extension Process in the U.S.

ABS has carried out verification of several projects as a Certified Verification Agent (CVA) for the Bureau of Safety and Environmental Enforcement (BSEE), the U.S. regulatory agency responsible for the approval of riser life extension.

Based on the experience acquired from these activities, below is ABS's understanding of the BSEE requirements for the life extension process. It is the Operator's responsibility to approach BSEE to confirm the procedures in place.

An application needs to be submitted by the Operator to BSEE as follows:

1. Owner notifies BSEE of approaching end of design service life
2. Owner submits life extension application package, including verification plan and CVA nomination
3. BSEE approves verification plan and CVA nomination
4. CVA performs life extension assessment, conclude assessment work, and submits CVA Report
5. Owner communicates with BSEE and addresses comments
6. BSEE approves life extension application

The requirements on the life extension application package, verification plans contents, qualification of CVA, CVA report contents are specified by BSEE. It is strongly suggested that the Owner communicate with BSEE for those requirements proactively to prevent unnecessary delays.

BSEE has specific requirements for the qualification of a CVA. The CVA usually is a third-party possessing technical capability with reasonable company size and related experience. The personnel in the CVA team should not have served in the design team of the original equipment/system. The CVA should carry out the life extension verification only after the CVA nomination is approved by BSEE.

As the approval process takes time, it is strongly suggested to submit the riser life extension application a few years before the original permission expires. It is also strongly suggested that a RIM plan is in-place so that the historical riser condition data, operating data, and environmental data are recorded continuously or periodically. Those recorded data are very important for the assessment of the integrity of the riser system at the time of submitting life extension application.

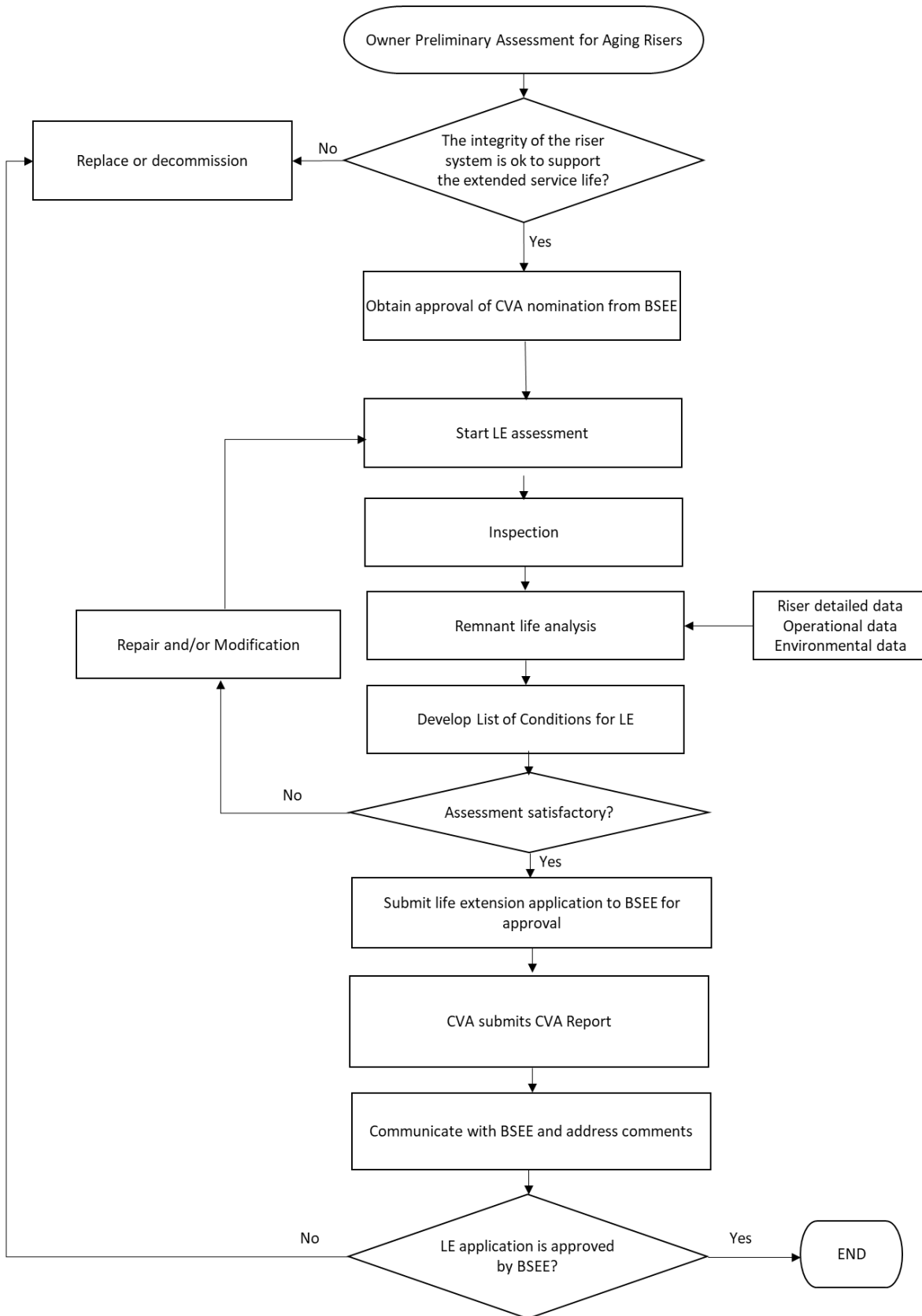
The CVA report should include the inspection findings, strength analysis, and remaining life analysis to demonstrate that the integrity of the riser system can support the riser in the proposed environment under proposed operational condition for the extended service life. All the safety factors used in the analysis should be documented and justified. The overall conservatism can be represented by the combination of the safety factors used for materials, occurrences, and analyses.

BSEE may review the riser life extension application based on potential risks. For example, if the riser has been managed in a RIM program in which the collected data shows the riser to be in very good condition and the fatigue analysis report demonstrates the riser fatigue life exceeds the original design life plus the requested extension lifetime, the life extension of this riser can be deemed as low risk. For a low risk application with a short requested extension lifetime (e.g., request of extension of 25% of the original design life), the review process may be simplified (e.g., review the as-built data/report and latest inspection report, etc.). For other life extension applications, the full process denoted in Section 2, Figure 2 may be applicable.

Riser life extension applications are usually submitted to BSEE in a life extension application package for the whole offshore asset. BSEE may issue individual approvals for subsystems and a consolidated approval letter for the whole system. As each subsystem may be granted different years of extended service life, the consolidated approval letter is governed by the minimum allowed life extension for the subsystems.

A typical riser life extension process for applications submitted to BSEE is shown in Appendix 2, Figure 1. The required document submittals for ABS as a riser life extension CVA is listed in A1/2.

FIGURE 1
Typical Riser Life Extension Process for Applications Submitted to BSEE



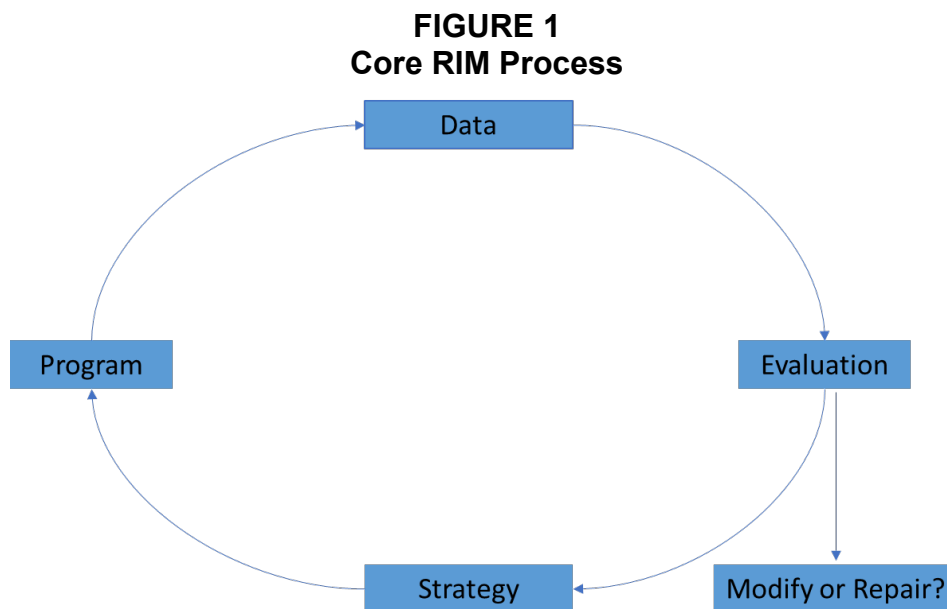


APPENDIX 3 Riser Integrity Management Program

The RIM program provides a proactive process for demonstrating the integrity of a riser throughout its life on a fitness-for-service basis. It is very helpful to riser life extension assessment if a RIM program is already in-place and the riser data, operational data, and environmental data are collected through periodic inspection and continuous or periodic monitoring.

API RP 2RIM provides guidance on the integrity management of risers connected to a permanent FPI used for the drilling, development, production, and storage of hydrocarbons in offshore areas. The RIM provides the Owner a basis for the activities of inspection, maintenance, monitoring, and remediation to validate the fitness-for-service of a riser system for its intended service throughout its service life.

Four important elements of RIM process are shown in Appendix 3, Figure 1: Data, Evaluation, Strategy, and Program. If an initiator is triggered, such as life extension, assessment will be carried out to evaluate the fitness-for-service of the riser for its intended application during its intended service life.



The RIM plan can be risk-based, prescriptive, or a combination of the two. Risk-based RIM is recommended as it optimizes the activities of inspection and monitoring. If the RIM plan is on a prescriptive basis, a risk assessment for the riser system is strongly recommended to be carried out, and the RIM plan should include managing the identified risks of the riser system accordingly. An example of risk category based on the combination of likelihood of failure and consequence of failure is listed in Appendix 3, Table 1. More advanced risk assessment technique or more complicated risk category matrices can be used in the RIM plan to manage the risks of the riser system more efficiently.

The *ABS Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries* provides the guidelines for defining the concept of risk, describing the methods available to assess risk, and in performing successful risk studies. Since the objective of the risk assessment is to demonstrate the fitness-for-service of the riser system and its associated structure and subsystems via risk screening, the assessment should clearly define the risk categories (e.g., risk matrix) and acceptable risk levels.

The riser potential failure modes should be assessed and identified by the suitable technique (e.g. FMEA, FMECA, HAZID, HAZOP, etc). The objectives of the failure mode analysis are to:

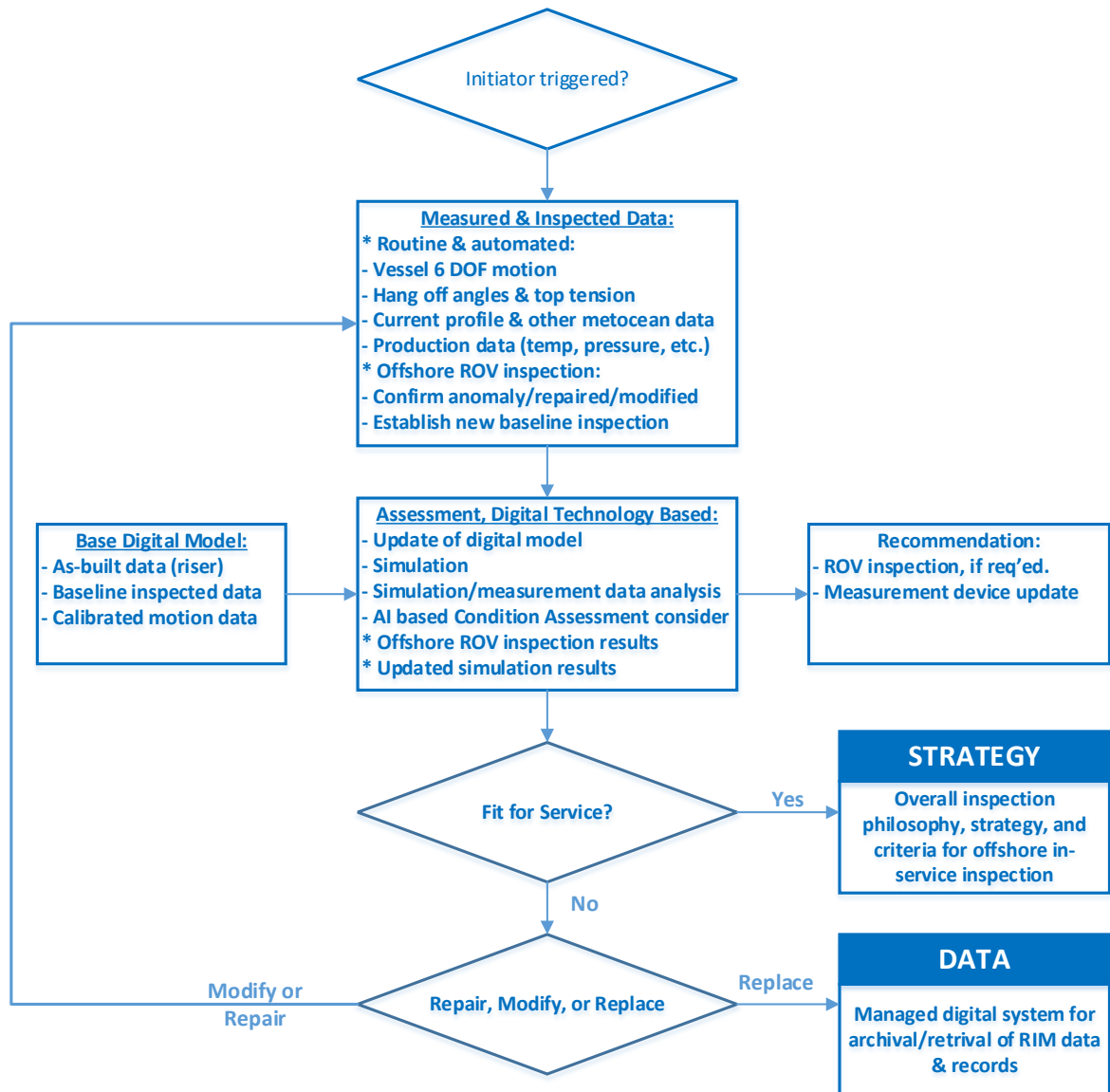
- Identify and provide recommendations to eliminate or mitigate the effects of common failure modes
- Demonstrate effective redundancy
- Identify potential “hidden” failures and determine the effects of a second failure

**TABLE 1
Example Risk Categorization Matrix**

Consequence of Failure	Likelihood of Failure		
	Low	Medium	High
High	Medium	High	High
Medium	Low	Medium	High
Low	Low	Low	Medium

The details of assessment methods and riser assessment process can be found in API RP 2RIM. An example of RIM process for a SCR system is shown in Appendix 3, Figure 2.

FIGURE 2
Example RIM Process





APPENDIX 4 References

1. ABS, *Guidance Notes on Life Extension Methodology for Floating Production Installations*, 2017.
2. ABS, *Guidance Notes on Risk Assessment Applications for the Marine and Offshore Industries*, 2020.
3. ABS, *Guide for Building and Classing Subsea Riser Systems*, 2017.
4. ABS, *Guide for Classification and Certification of Subsea Production Systems, Equipment and Components*, 2018.
5. ABS, *Guide for Risk-Based Inspection for Floating Offshore Installations*, 2018.
6. ABS, *Subsea Inspection, Maintenance, and Repair Advisory*, 2019.
7. API 579-1/ASME FFS-1, *Fitness-For-Service*, Third Edition, 2016.
8. API RP 2RD, *Design of Risers for Floating Production Systems (FPSs) and Tension-Leg Platforms (TLPs)*, 1998, reaffirmed in 2006, with Errata 2009.
9. API RP 2RIM, *Integrity Management of Risers from Floating Production Systems*, First Edition, 2019.
10. API STD 2RD, *Dynamic Risers for Floating Production Systems*. Second Edition, 2013.
11. ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 3: *Alternative Rules for Construction of High Pressure Vessels*, 2019.
12. BS 7608, *Guide to Fatigue Design and Assessment of Steel Products*, 2014, with amendment 2015.
13. BS 7910, *Guide to methods for assessing the acceptability of flaws in metallic structures*, 2019.