



Rules for Classification and Construction
Part 5 Offshore Technology

GUIDANCE FOR LIFE EXTENSION OF FLOATING PRODUCTION INSTALLATIONS

Volume D

2024



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The following Guidance come into force on 1st April 2024.

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Foreword

The Guidance for Life Extension of Floating Production Installation contains technical requirements and procedure for life extension and relocation of floating production installation in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\)](#). This Guidance divide into six section as follows:

- Section 1 General
- Section 2 Life Extension Process
- Section 3 Baseline Information
- Section 4 Baseline Survey
- Section 5 Engineering Reassessment
- Section 6 Condition of Life Extension
- Annex 1 Hull Strength and Fatigue Reassessment for Ship-Type Installations
- Annex 2 Fatigue Reassessment of Ship-Type FPIs Considering Onboard Validated Historical Loading Information
- Annex 3 Fatigue Reassessment of FPI Structures (Except for Hull Structures of Ship-Type Installations)

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

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Section 1 General

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A. Introduction

A floating production installation (FPI) is a site-specific unit with a defined design life, typically 20 years. The defined design life in many cases is based on the estimated life of the initial reservoirs to be produced and may not be fully indicative of the life the unit. When an FPI reaches the end of its design life, many factors can influence the decision to extend life for continued service. In some cases, aging units are still economically producing, either due to the re-evaluated life expectancy of the reservoirs or higher recovery rates enabled by new technologies. Another common scenario is the discovery of new fields in the vicinity of an existing facility, creating tie-back opportunities. When the expected life of the new discovery or when production from existing reservoirs exceeds the stated design life of the FPI, the life extension evaluation process takes place to verify that the unit will be able to operate in conformance with existing safety standards beyond its design life.

When an FPI is intended to continue operating beyond its design life, the asset owner is required to initiate a life extension process with the assistance of the Classification Society. An effective life extension process allows the continued service of a unit in a way that mitigates risks and also minimizes production loss.

B. Scope

This Guidance provides classification requirements associated with FPI life extension. It is to be used in conjunction with and as a supplement to [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.1, A.3.6.5](#).

This Guidance focuses on the requirements for structures and stationkeeping systems during the life extension process. Requirements for marine system and the associated equipment, machinery, safety systems, and production facilities as applicable, are the same as required during the service life and are to be fully in compliance with the FPI Rules.

Life extension of import/export systems is not within the scope of this Guidance.

C. Application

This Guidance is applicable to existing floating production installations of all hull forms (i.e., ship-type installations, column stabilized installations, tension leg platforms (TLPs), Spar Installations (Spars) and hybrid designs, etc.) with service notations such as:

Floating Production, Storage and Offloading System: **FPSO (hull type)**

Floating Production (and Offloading) System: **FPO (hull type)**

Floating Storage and Offloading System: **FSO (hull type)**

Floating Offshore Installation: **FOI (hull type).**

This Guidance is not applicable to mobile offshore units.

This Guidance is applicable to life extensions conducted for continued service at the same site or a relocated site.

D. Classification Notations

1. LE as Additional Notation

Where requested by Owner, an additional notation **LE (number of years) year**, where **(number of years)** refers to the extended life of the unit and **year** refers to the year of maturation, may be assigned to a FPI intended to continue its service in the same location for the first five years or less, provided the requirements in [Section 2, D](#) are met. The **LE** notation is to replace the existing **FL**, **RFL**, **FLM**, or **RFLM**.

The **LE** notation can only be granted once in the lifecycle of an FPI. For any additional request of life extension beyond the first five years, **LE** is no longer valid and is to be replaced by **RFL** or **RFLM**.

2. Fatigue

For an FPI with the design fatigue life specified in the **FL (number of years), Year, FLM (number of years), Year, RFL (number of years), Year** or **RFLM (number of year), Year** notation, once the requirements in [Section 2, C](#) are met and life extension is granted, the existing **FL**, **FLM**, **RFL** or **RFLM** notation with year of maturation is to be updated accordingly.

Where none of the fatigue notations was previously assigned to the unit, **RFL** and/or **RFLM** are to be assigned once the life extension is granted.

E. Classification Procedures

The overall classification procedure and corresponding references for FPI life extension are summarized in [Figure 1.1](#)

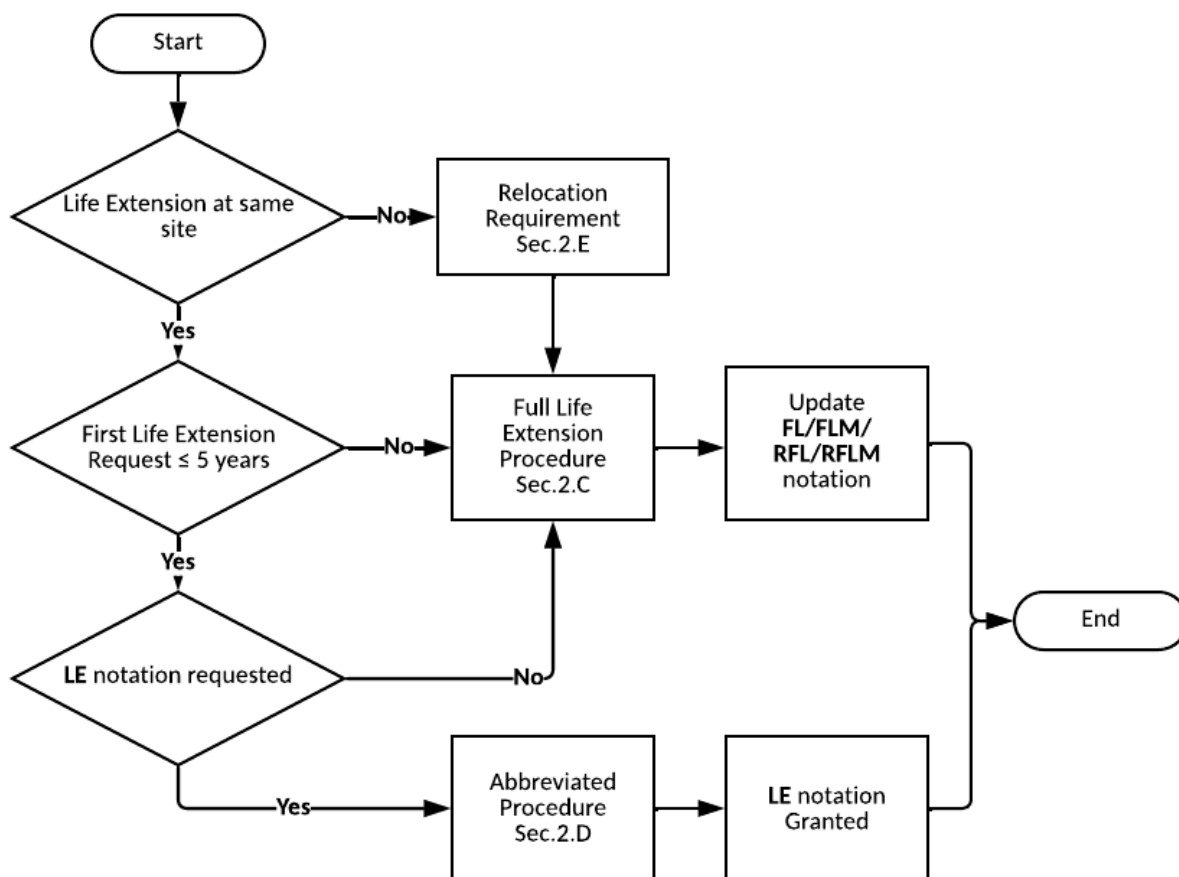


Figure 1.1: Life Extension Classification Roadmap

F. Applicable Design Codes

In general, design review and survey will be based on the following, except as modified in this Guidance:

- 1) For structures, stationkeeping systems, machinery systems or equipment not modified and maintained per original design:
 Design review is to be based on the Rule or design codes used in the original design with current environmental data.
- 2) For added or modified structures, stationkeeping systems, machinery systems or equipment:
 Design review is to be based on the Rule or design codes used at the time of implementation with current environmental data
- 3) Surveys will be based on the current BKI requirements

G. Schedule

The life extension process includes data collection, engineering, and survey activities which could be timeconsuming. Should the Owner decide to extend the service life beyond original design life, it is recommended that the Owner contacts BKI as early as possible. A typical time frame providing for a suitable window to conduct such activity is at least two and a half years before the unit’s maturation date

H. Alternatives

BKI will consider alternative arrangements, novel features, and designs as part of the life extension process which can be shown, through either satisfactory service experience or a systematic analysis based on sound engineering principles, to be not less effective than those found in this Guidance

Risk assessment techniques may be used to demonstrate that alternatives and novel features provide acceptable levels of safety commensurate with current offshore and marine industry practice. The risks addressed are primarily those affecting the safety of an installation, facility or operation, but the methods discussed can also be applied to other categories of risk. Risk assessment may be used to identify the various technical risks and their severity associated with the life extension of an asset. Based on the level of risk assigned, a mitigating approach is to be applied, either in terms of the level of robustness in the approach or added measures that may lend confidence in the risk mitigation. The [Reference Notes on Risk Assessment Applications for the Marine and Offshore Industries \(Pt.4, Vol.1\)](#) provides guidance to BKI clients on how to prepare a risk evaluation.

Risk evaluations for the justification of alternative arrangements or novel features may be applicable either to the installation as a whole, or to individual systems, subsystems or components.

I. Abbreviation & Reference

1. Abbreviation

AIM	Asset Integrity Management
BKI	Biro Klasifikasi Indonesia
CVI	Close-up Visual Inspection
DYLA	Dynamic Loading Approach
DLP	Dynamic Loading Parameter
ESF	Environmental Severity Factor
fdf	Fatigue Design Factor
FPI	Floating Production Installation
GVI	General Visual Inspection
ISE	Initial Scantling Evaluation
ISIP	In-Service Inspection Program
LE	Life Extension
NDT	Nondestructive Testing
NDCV	Nominal Design Corrosion Values
OEM	Original Equipment Manufacturer
OPB	Out-of-Plane Bending
PMA	Permanent Means of Access
RAO	Response Amplitude Operator
RBI	Risk Based Inspection

2. Reference

2.1 BKI References

Guidelines for Floating Production Installation	(Pt.5,Vol.3)
Guidance for Survey Using Risk Based Inspection for the Offshore Industry	(Pt.5,Vol.A)
Guidance for Fatigue Assessment of Offshore Structures	(Pt.5,Vol.B)
Guidelines for Dynamic Loading Approach	(Pt.7,Vol.2)
Guidelines for Spectral - Based Fatigue Analysis	(Pt.7,Vol.3)
References Notes on Risk Assessment Applications for the Marine and Offshore Industries	(Pt.4, Vol.1)
Guidance on Review and Approval of Novel Design	(Pt.1, Vol.Z)

2.2 Design and Integrity Management Codes

API 2A-WSD	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design
API RP 2MET	Derivation of Metocean Design and Operating Conditions
API RP 2FPS	Planning, Designing, and Constructing Floating Production Systems
API RP 2SIM	Recommended Practice for the Structural Integrity Management of Fixed Offshore Structures
API RP 2I	In-service Inspection of Mooring Hardware for Floating Structures
API RP 2FSIM	Recommended Practice for Floating Systems Integrity Management
API RP 2RIM	Recommended Practice for Risers Integrity Management
API RP 2MIM	Recommended Practice for Mooring Integrity Management
API RP 2T	Recommended Practice for Planning, Designing, and Construction Tension Leg Platforms
NACE-SP 0176	Corrosion Control of Submerged Areas of Permanently Installed Steel Offshore Structures Associated with Petroleum Production

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Section 2 Life Extension Process

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A. General

When an FPI exceeds the original design life, an evaluation is to be made and appropriate actions are to be taken to extend the life up to the new operating life of the installation under the site-specific environmental conditions

This Section outlines the general life extension process and lays out the life extension procedures in the following three scenarios.

- 1) Life extension at the same site, see [C](#).
- 2) Short life extension up to five years at the same location, see [D](#).
- 3) Life extension at a new location, see [E](#).

Those procedures provide details regarding the steps to be followed in order to assess an installation for a possible life extension. Details pertaining to the life extension process are given in [Section 3](#) through [Section 6](#).

B. Overview

The classification or continuance of classification of an existing installation for extension of service beyond the design life requires review, surveys and engineering analyses in order to re-verify the adequacy of the installation for its extended services.

The life extension process follows the three phases listed below and is also shown in [Figure 2.1](#):

- 1) Investigation phase
 - Data collection and desktop study by Owner
 - BKI engagement in documentation completeness check and initial engineering review of baseline information
 - Baseline survey
- 2) Determination phase
 - Life extension assessment
 - Provision of conditions for life extension
- 3) Implementation phase
 - Conditions implemented
 - Survey documents updated and Class notation changed

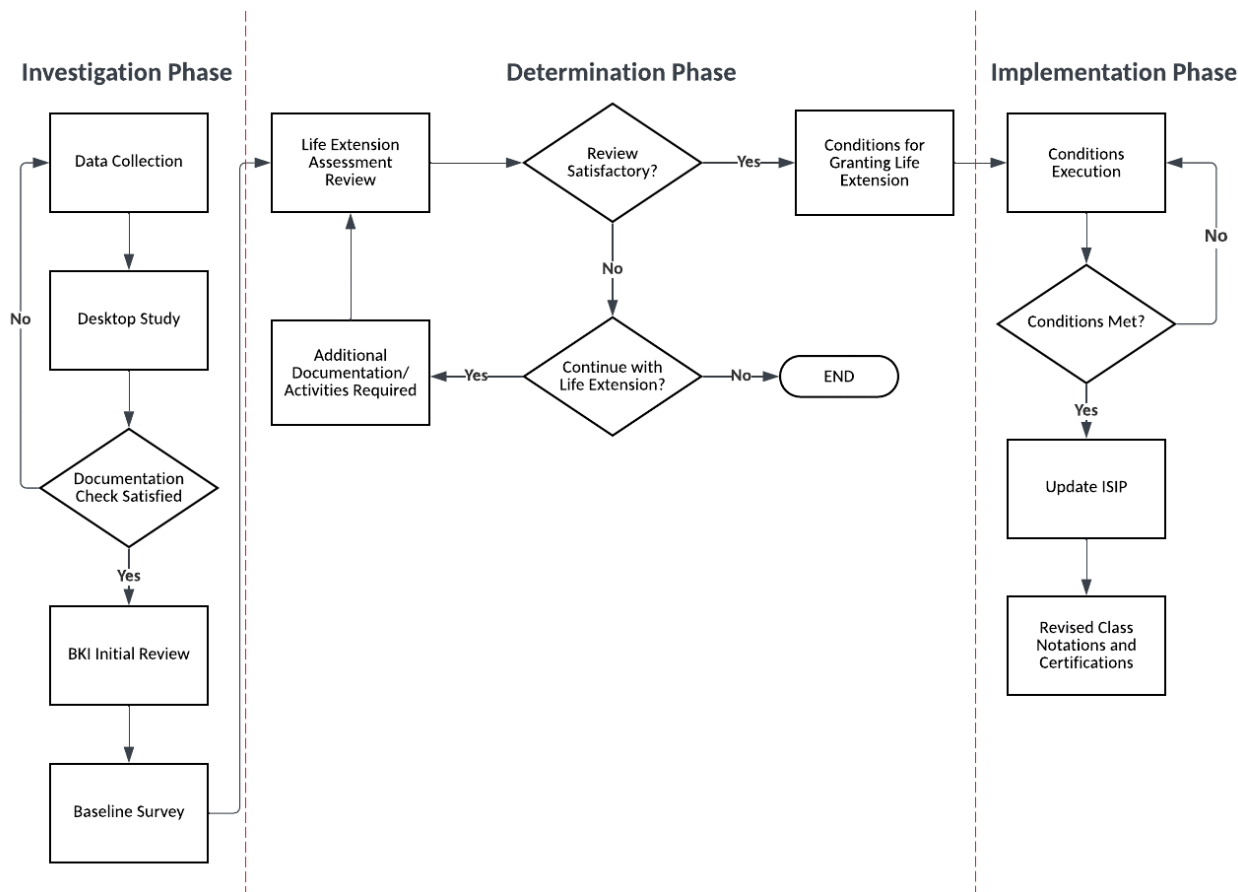


Figure 2.1: Life Extension Process

C. Life Extension at Same Site

1. General Life Extension Procedure

The general procedure for the classification of an existing installation for extended service at the same site is as follows:

1.1 Baseline Information

Owner is to collect and review the baseline information in accordance with Section 3. A desktop study of the baseline information is to be carried out by the Owner to identify critical locations and locations with low fatigue life. Such locations are to be included in the baseline survey. BKI will review the desktop study report and verify the scope of the baseline survey.

Low fatigue life means that the calculated fatigue life is less than 1,25 times the total target fatigue life, which is the original design fatigue life plus the requested extended life.

1.2 Baseline Survey

BKI is to perform a baseline survey of the structure, mooring systems, tendons for TLP, and outfitting to establish the condition of the unit. The baseline survey is to be carried out in accordance with Section 4.

1.3 Life Extension Assessment

Based on the baseline information and baseline survey, life extension assessment is to be performed.

- 1) Evaluation of baseline survey report, see Section 4, F

2) Engineering reassessment

Engineering reassessment is to be in accordance with [Section 5](#). The reassessment is to include, but not limited to, structure, stability, mooring system, tendon system for TLP, and cathodic protection system.

1.4 Condition of Life Extension

Based on the findings of the baseline survey and the results of engineering reassessment, a list of action items is to be established as the conditions of life extension, see [Section 6, B](#). Examples of conditions of life extension are:

- Inspection of structural areas where analysis results indicate locations as being highly stressed regions. Damaged members and connections are to be repaired or strengthened.
- Critical areas with low fatigue life are to be visually examined and Nondestructive Testing (NDT) performed as appropriate. Low fatigue lives may be improved either by strengthening or grinding the welds. Intervals of future periodic surveys are to be determined based on the remaining fatigue lives of these connections.
- Substantial corroded areas are to be either cropped and renewed, reinforced, or have adequate corrosion arresting measures approved and implemented prior to life extension.
- Any other findings from the baseline survey are to be gathered and remedial plan proposed.

1.5 Implementation of Conditions

Prior to granting the life extension, all conditions of life extension are to be addressed and verified to be satisfactory.

1.6 Revision of In-Service Inspection Program (ISIP)

Upon conclusion of life extension process, the Owner is to revise the related documents (i.e., ISIP, operating manual, loading manual, etc.) to reflect any changes and conditions for life extension. Those documents are to be submitted for approval. See [Section 6, D](#).

2. BKI Register

Upon the satisfaction of the requirements in [1.](#), the Class certificate is to be issued for life extension. Where applicable, the existing spectral fatigue analysis (SFA), fatigue life (FL), fatigue life of mooring system (FLM), remaining fatigue life (RFL) or remaining fatigue life of mooring system (RFLM) notation with year of maturation is to be updated accordingly.

Where none of the fatigue notations was previously assigned to the unit, RFL and/or RFLM notation with year of maturation are to be assigned once the life extension is granted.

D. Short Life Extension up to 5 Years at Same Site

1. Abbreviated Procedure

If the first life extension request for an installation remaining at the same site is for five years or less, engineering reassessment in [C.1.3.2](#) is not required, unless considered necessary for the completion of the Class Surveys. All other steps in the general life extension procedure as specified in [C.1](#) are to be followed.

2. Notation for Abbreviated Procedure

Upon the satisfaction of the requirements in 1. a notation **LE (number of years) year** will be assigned to an FPI to replace any existing notations such as **FL, RFL, FLM, RFLM** or **SFA**.

3. Application Limit

The abbreviated procedure is not to be applied under the following conditions:

3.1 Additional Request for Life Extension after the First Five Years

This abbreviated approval procedure can only be applied once in the lifecycle of an FPI. Once an FPI has been granted life extension following this abbreviated procedure, additional requests for life extension will be considered as the total additional life beyond the original design life, and are to be in accordance with the full procedure as described in C. For example, if the design life of an installation is 20 years and it receives a life extension of five years, a second five year life extension will be a ten-year extension to the original design life.

3.2 More Severe Environmental Condition

If the environmental conditions for the field or operating area are more severe than the original approval due to new environmental data or changing environmental conditions, the Coastal State may require the use of new environmental conditions for life extension, in which case the general procedure in C. will apply.

3.3 Modification Beyond the Original Design Envelope

When changes such as configuration, loading, addition of facilities, watertight/weathertight integrity, corrosion/wear allowance, or mooring system, are beyond the previously approved design envelope, the general procedure in C. is to be followed.

E. Life Extension at a New Location

If an existing installation is intended to remain in service beyond its original design life and also be relocated to a new site, the requirements for life extension described in C. are to be applied in addition to the requirements for relocation requirements in the [Guidelines for Floating Production Installation \(Pt.5, Vol.3\)](#) as follows:

- [Sec.1, A.3.4.3](#) for strength requirements for ship-type FPIs
- [Sec.1, A.3.5.2](#) for strength requirements for other types of offshore installations
- [Sec.1, A.3.6.4](#) for fatigue requirements for all types of FPIs
- [Sec.1, A.8](#) for significant changes to the operating conditions

Section 3 Baseline Information

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A. General

Life extension process begins with data collection, which is recommended to start five years prior to the expiration of the design life. The collected data forms the baseline information to enable the Owner to decide on the feasibility and economics of the life extension. For an initial life extension assessment, it is essential to have the original design reports, documents, original and as-is plans, specifications, survey records during fabrication, installation, and past service. The Owner is to verify that any assumptions made are reasonable and the information gathered is both accurate and representative of actual conditions at the time of the life extension assessment.

If the information cannot be provided, reassessment of the installation is required. For a first life extension up to 5 years, actual measurements or testing may be utilized in lieu of reassessment.

B. Documentation for Life Extension

The documentation listed below is to be available in order to proceed with the life extension process. The procedure and result of life extension are based on availability and quality of the submitted documentation.

1) Designs Drawings

- General arrangements, tank capacity plan, key structural plans, machinery diagrams and system drawings, foundations connected to hull structure along with associated underdeck reinforcement if added, tank vents and overflow arrangement, corrosion protection plan, Trim and Stability booklets, and Loading Manuals.
- Drawings for mooring system and all components, including ropes, chains, connectors, and anchoring system (piles or anchors), and mechanical components.

2) Existing Design Analyses

- Scantling calculations, global and local strength analyses, buckling analyses, and fatigue analyses
- Stability analysis
- Global performance analysis
- Mooring analysis
 - Strength and fatigue analysis for the turret mooring system including turret structure, support structure, turret gantry, chain table, mooring lines and accessories, mooring equipment, anchoring system, turret main bearings, swivels, swivel stack, driving arms/mechanisms, and structural connectors.
 - Strength and fatigue analysis for spread mooring system including fairlead, chain stopper, mooring hull interface structure, mooring lines and accessories, and anchoring system.
- Tendon Strength and Fatigue Analysis

3) Existing ISIP or Survey Plan and results/findings, including revision history

- 4) Survey and complete gauging reports including all tanks and spaces
- 5) Owners/Operators reports covering inspection, repairs, replacements, maintenance, and operational history
- 6) Composite Repair Installation and In-Service Data
 - Composite Repair System
 - Installation information including date, installer, post installation testing and results, and provision of mitigations that may be required
 - Fire rating
 - Defect or anomaly data including number and description
 - Applicable drawing or plan
 - In-service inspection data
 - Permanent repair information if applicable
- 7) Weight control record
- 8) Current coating conditions of all compartments
- 9) Tank usage history (past and present)
 - Contents of tanks
 - Average length of storage of the contents
- 10) Estimated corrosion rates
- 11) Latest underwater inspection report for mooring lines including conditions for wear, corrosion, and out-of-plane bending
- 12) Record of modifications, including updated drawings
- 13) Records of installation (piles orientation, inclination, mooring chain bar size, pile driving records, etc.)
- 14) Data for tendon connectors containing non-metallic components. Owner is to approach original equipment manufacturer (OEM) to ascertain the following:
 - Component original design life
 - Expected types of degradation failure (progressive or sudden), and performance consequences
 - Possible methods for testing or observing in situ
 - Current condition assessment
- 15) Metocean data
 - Updated metocean data of site, metocean history (normal and extreme events) from monitoring system or hindcast analysis
- 16) Measured data
 - Owner is to provide assurance of the measured data quality, which is to be validated by BKI
 - Measured load history of mooring lines, risers, tendons, etc.
 - Measured historical loading data, and hydrostatic properties applicable to RFL assessments, gathered continuously throughout the vessel's operational life where installations follow the process of fatigue reassessment in [Annex 2](#)

- 17) Desktop study report containing an assessment of existing design, additional engineering analysis performed in service, and proposed future plan/schedule for life extension, including examination, repairs, or replacement due to life extension
- 18) Description of modifications to be carried out for life extension
- 19) Retrieving, inspection, testing, and installation procedures for mooring components that are intended to be retrieved and relocated to a new location for life extension

C. Initial Review of Baseline Information

The following procedure is to be followed:

- 1) Owner is to check the completeness of the baseline information and determine the actions to address missing information
- 2) Owner is to review the extent of the original design analyses and determine the need for further analyses
- 3) Owner is to perform desktop study to assess the condition of the unit and propose any additional items for baseline survey over and above normal Class Renewal Survey activity, including the need for weight verification (deadweight survey or equivalent). Critical locations and locations with low fatigue life are to be included in the baseline survey.
- 4) BKI is to review the baseline information and desktop study report and verify the scope of the baseline survey.

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Section 4 Baseline Survey

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A. General

Surveying an existing installation witnessed and monitored by an BKI Surveyor is necessary to determine a baseline condition upon which justification of continued service can be made. The baseline survey includes the following activities:

- 1) Review of reports of previous surveys and maintenance
- 2) Agreement on a survey procedure
- 3) Complete survey (including underwater inspection) to verify that an accurate assessment of the installation's condition is obtained

1. Scope of Baseline Survey

Generally, the scope of the baseline survey is to be not less than the next upcoming Class Renewal Survey in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.3, B.6.](#)

Additional items to be included in the baseline survey are to be determined in accordance with [Section 3, C.](#)

2. Schedule

The baseline survey information can be gathered during the surveys prior to the life extension. All items are to have examination results. Any overdue parts or items are to be brought up to date or examined sufficiently to determine their conditions for the life extension.

3. Gauging Data

Gauging within 15 months is considered valid.

Gauging older than 15 months can be used if a wastage correction is made based on estimated corrosion rates. Estimation of corrosion rates is to be made by the Owner by considering any corrosion protection measures, the type and temperatures of stored fluids and other variables affecting the corrosion rate. Alternatively, for hull of ship-type installations, the general corrosion rates for plating and structural members in [Table A1.1](#) can be used as minimum anticipated future corrosion rates for spaces which have not been stored with produced water or off-spec oil.

4. System and Equipment

Survey of marine systems and associated equipment, machinery, safety systems, production facilities, as applicable, are to be in full compliance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.3](#). Any modifications that were not previously reviewed or approved are to be included in the baseline survey.

B. Structures

The baseline survey for structures is to include all items listed under the next upcoming Class Renewal Survey for Hull given in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.3, B.6.2](#), and in addition, the following are to be performed.

- 1) For additional items identified from the initial review of baseline information in accordance with [Section 3, C](#), General Visual Inspection (GVI), Close Visual Inspection (CVI) or Nondestructive Testing (NDT) are required, as appropriate.
- 2) NDT (i.e., thickness measurement and crack detection) is to be carried out according to the ISIP to establish an accurate assessment of the current condition.
- 3) Areas originally designed as non-inspectable are not required to be inspected at this time. At the Owner's request, BKI may consider the reduction of safety factors for fatigue life for past service life if a single inspection is carried out. Extent of such inspection is to be agreed upon between Class and Owner.
- 4) Hull interface structure between the position mooring system and the hull structure with low fatigue life is to be examined using NDT techniques.

C. Mooring Systems

The baseline survey is to include all items listed in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.3, B.6.3](#), and in addition, the following steps are to be followed. Reference can be made to API RP 2I for guidelines for inspecting mooring components.

- 1) Carry out GVI of mooring lines, accessories, mooring equipment (i.e., windlasses, chain jacks, chain stoppers, etc.), and piles. Additional inspections such as CVI and/or NDT (wet magnetic particle inspection (MPI) or similar) may be applicable for suspect areas identified by the GVI.
- 2) Carry out GVI of turret bearings, bogies, and wear pads. If accessible, bearings and races are to be inspected.
- 3) Inspect for cracks, corrosion, dimensional checks, and wear, as much as possible. A length of each mooring chain at those critical locations, such as fairlead, splash zone, touch-down area, and any other suspicious areas identified in the past operation history, is to be cleaned so that the overall condition of each chain can be satisfactorily verified. If pitting and grooving are found on those chain links, dimensions and shapes of those pitting and grooving are to be reported together with close-up pictures/videos for further assessment. Underwater inspection techniques such as laser scan may be used.
- 4) Inspect wire ropes and synthetic ropes for mechanical damage, twist and sheathing conditions, including anodes, on wire sockets (if installed).
- 5) Verify mooring pretension values are consistent with those used in the design and assessment.
- 6) Verify mooring line configuration changes due to trenching at touchdown, scouring around the foundation, etc.

Non-accessible areas are to be discussed and agreed upon between BKI and Owner.

D. Tendons

The following are to be performed:

- 1) Carry out GVI of the entire length of all tendons including tendon components using divers or remotely operated vehicles (ROVs) as appropriate.
- 2) Carry out visual inspections and surface flaw detection to the extent specified by BKI on tendon joints as well as top and bottom tendon connectors.
- 3) Carry out thickness measurement of tendons to the extent specified by BKI.
- 4) Carry out measurement of heights and visual examinations where possible of top and bottom flex elements to record any noticeable degradation such as height loss.
- 5) Verify condition of coating and anodes. Anode depletion percentages are to be recorded.
- 6) Verify that operating drafts and tendon pretensions are consistent with the design values and any changes are to be reported.
- 7) Check for flooded tendon sections in entire length of all tendons.
- 8) Verify that Tendon Tension Monitoring System (TTMS) is fully functioning. Any degradation is to be reported.

Non-accessible areas are to be discussed and agreed upon between BKI and Owner.

E. Outfitting

Personnel access and egress including walkways, permanent means of access (PMA) structures, gratings and handrails are to be addressed as part of the baseline survey.

F. Evaluation of Baseline Survey Report

Upon completion of the baseline survey, the baseline survey report is to be evaluated to establish a list of conditions for granting life extension. Any findings from the baseline survey are to be addressed and remedial plans are to be proposed. See [Section 6](#).

Findings related to marine system and associated equipment, machinery, safety systems, and production facilities as applicable, are to be addressed based on [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.3](#).

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Section 5 Engineering Reassessment

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A. General

Engineering reassessment is required when the installation is relocated for life extension or when the life extension request is beyond five years at the same location.

The engineering reassessment of an existing installation is to incorporate the results of the baseline survey in Section 4. Specifically, deck loads, wastage, marine growth, scour, and any modifications and damages are to be incorporated into the reassessment. Where available, the original fabrication materials and fit-up details are to be established such that proper material characteristics are used in the reassessment and any stress concentrations are accounted for.

This Section presents the engineering reassessment criteria for the entire installation including structure, stability, mooring system, tendon system (for TLP), cathodic protection system, etc.

The results of the reassessment are considered to be an indicator of areas needing careful inspection and monitoring during the extended life. Possible modifications or replacement of classed items to allow continued service of the installation are to be developed.

B. Environmental Conditions

The latest site-specific environmental conditions are to be developed for life extension assessment. Metocean data and analyses when used as the basis for life extension assessment should be collected and processed by recognized consultants as per API RP 2MET (ISO 19901-1) or equivalent standard.

If the current site-specific environmental conditions are more severe than the original design environmental condition, the current site-specific environmental conditions are to be applied.

Measured historic data can be also used for fatigue assessment provided that the data consistency and accuracy are certified/verified by recognized parties and accepted by BKI.

C. Remaining Fatigue Life

One of the following conditions is to be satisfied by the fatigue assessment:

- 1) The original fatigue analysis indicates that the fatigue lives of all joints/critical details and mooring system are sufficient to cover the extension of use. The fatigue environmental data used in the original fatigue analysis remain valid or are deemed to be more conservative.

- 2) New fatigue analysis covering all structural elements (hull, turret, hull interfaces, position mooring system) shows that the remaining fatigue life is sufficient until the requested year of maturation. The remaining fatigue life can be calculated by means of an analysis as described in [Annex 1 to 3](#).

A critical area or critical detail is defined in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Annex 10, C and D](#).

D. Structures

1. Hull Structure of Ship-Type Installation

Hull structural reassessment of ship-type installations includes strength, fatigue and cathodic protection assessment. The re-evaluation of the cathodic protection system is to follow [H](#).

1.1 Strength and Fatigue Reassessment Procedure for Ship-Type Hull Structure

The strength and fatigue assessment of hull structure is to follow the steps listed below and shown in [Fig.5.1](#). Detailed procedures for initial scantling calculation (ISCal) and Global strength assessment (GSA) are outlined in [Annex 1](#).

- 1) Check if the design parameters have been changed or a scantling reassessment is necessary. If not, go to [step 3](#)). Design parameters include environmental conditions, geographical location of the unit, loading conditions, external loads, pressures, temperatures, etc.
- 2) Determine the reassessed scantlings through ISCal and GSA based on new rules at the time of contract for the life extension. Go to [step 4](#)).
- 3) Check if the original strength and fatigue analysis have been performed. If not, ISCal and GSA are to be carried out based on new rules at the time of contract for the life extension.
- 4) Review analysis and check if the gauged scantlings meet the strength requirement and the remaining fatigue lives meet the requirements in [C](#). If yes, skip [step 5](#)).
- 5) Establish a list of action items for structures that do not meet the strength or fatigue requirements in [step 4](#)). Those action items are considered as the conditions of life extension. Possible action items could be:
 - Crop and Renew
 - Modification or Reinforcement. Modification plans with technical justification through ISCal and GSA are to be submitted for approval.
- 6) Update ISIP plan

1.2 Additional Considerations

Wastages are to be incorporated into the reassessment model. [Annex 2](#) provides some guidance on establishing gross and net scantlings taking consideration of wastages.

The following may be considered as an alternative to GSA when required for life extension.

- Dynamic Loading Approach (DYLA) and Spectral Fatigue Analysis (SFA)
 - DYLA in accordance with BKI [Guidelines for Dynamic Loading Approach \(Pt.7, Vol.2\)](#)
 - SFA in accordance with BKI [Guidelines for Spectral-Based Fatigue Analysis \(Pt.7, Vol.3\)](#)
 - DYLA and Load Component Spectral Fatigue Analysis (LC SFA), see [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec. 4, C.4.5.3.4](#)

- Cargo block model or Full ship length model analysis as defined in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec. 4, B.1.3.4](#)
- Other acceptable finite element analysis

1.3 Remaining Fatigue Life Procedure Based on Historical Loading Data

Accurate and continuous onboard data of historical hydrostatic loading conditions and associated environmental conditions for 5 years or more can be considered for reassessing the remaining fatigue life as described in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Section 4,A.3.2.5.3](#). The procedure for ship-type installations is given in [Annex 2](#).

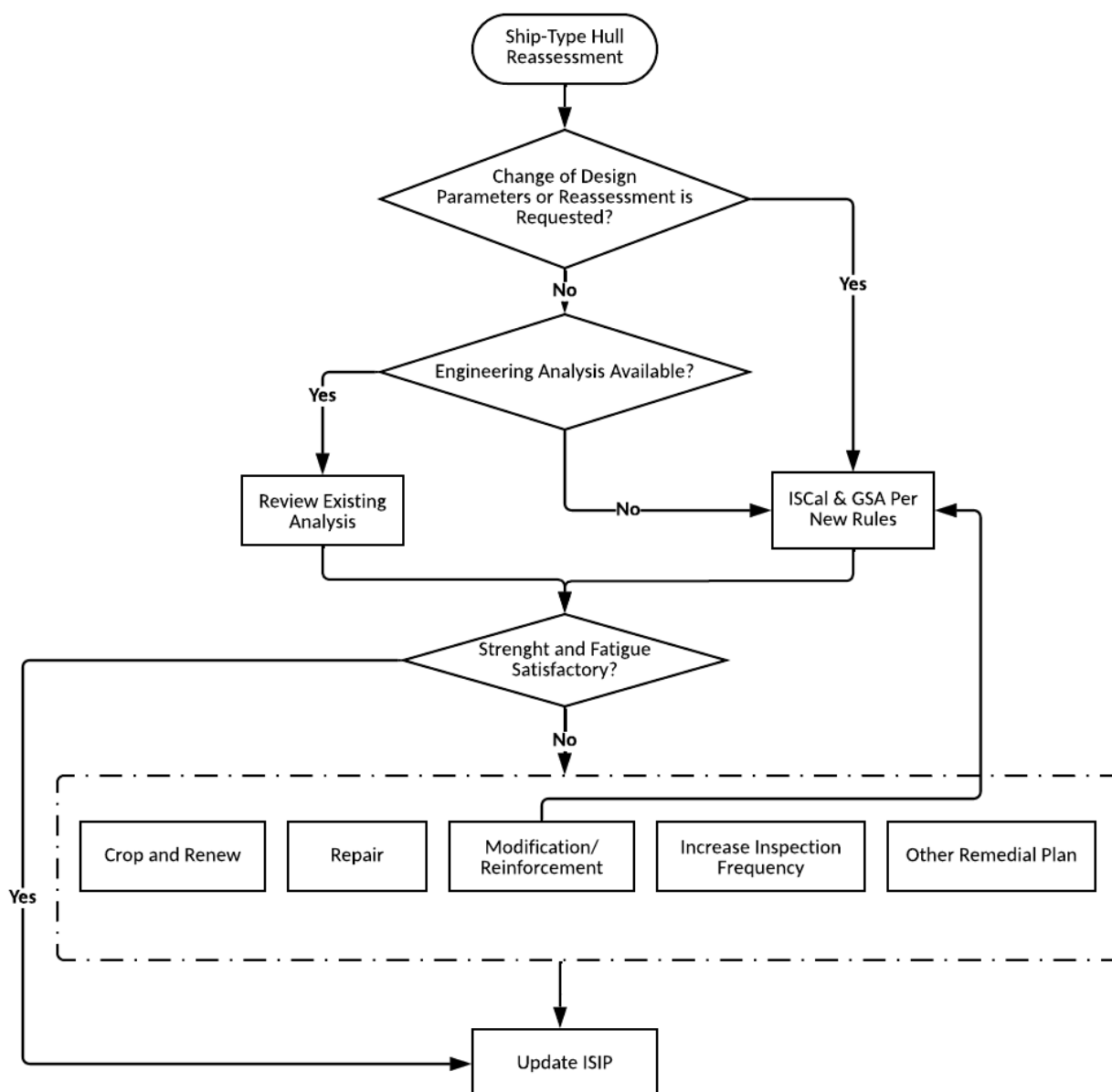


Figure 5.1: Ship-Type Hull Structure Reassessment

2. Other Structures of All FPIs

Other structures are structures other than hull structure of ship-type installations, which could be:

- Hull Structure of Non-Ship-Type Installations

- Hull Interface Structure of All FPIs (Ship-Type and Non-Ship-Type installations)
- Topside Structure of All FPIs (Ship-Type and Non-Ship-Type installations).

Reassessment for these structures generally includes strength, fatigue, and cathodic protection analysis except that fatigue analysis is optional for topside structure of ship-type installations as specified in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Section 4,A.5.](#)

Structural reassessment is to follow the procedure shown in [Fig.5.2.](#) The re-evaluation of the cathodic protection system is to follow [H.](#)

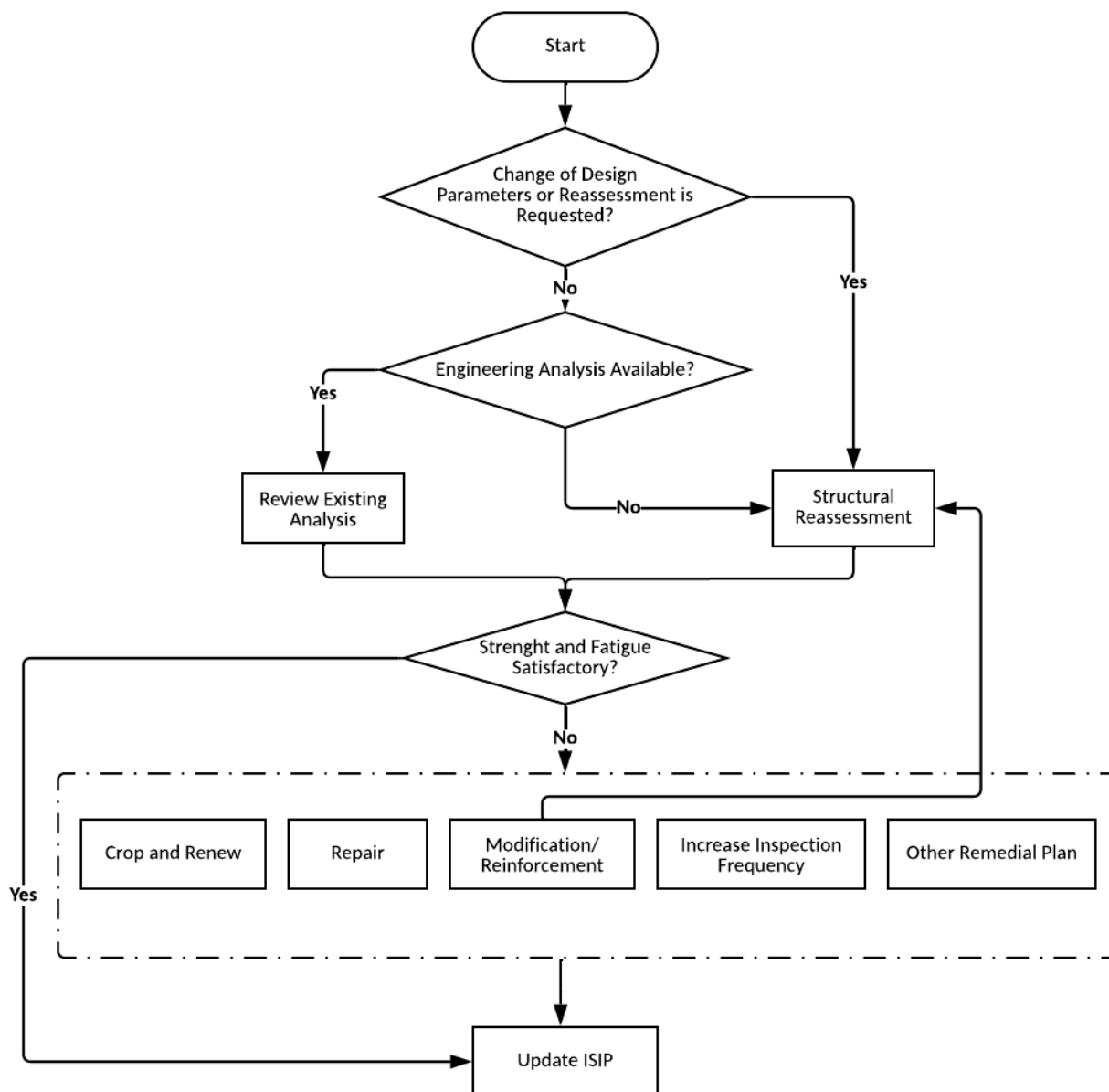


Figure 5.2: Structure Reassessment of Structures other than Ship-Type Hull

Structures under as-is conditions are to be reassessed based on new data including increased weights, metocean environmental condition changes, structural modifications, etc., and to incorporate the significant wastages and configuration changes in the structural model.

2.1 Strength Reassessment

The strength reassessment is to be performed for the environment conditions in [B.](#)

Structural assessment of existing Installations in hurricane condition is to meet API RP 2FPS.

Assessment of operational and damaged conditions is to follow the [Guidelines for Floating Production Installation \(Pt.5, Vol.3\)](#).

2.2 Fatigue Reassessment

The remaining fatigue life is to be greater than the requested years for life extension multiplied by the safety factors for fatigue life.

The fatigue safety factors are to be in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.2, B.3.2.4 Table 2.1](#). However, if a fatigue safety factor greater than the Guidelines requirement was used in the original design, the fatigue safety factor can be reassessed based on the actual criticality and inspectability provided it is not less than the [Guidelines for Floating Production Installation \(Pt.5, Vol.3\)](#).

A detailed procedure for remaining fatigue life assessment is given in [Annex 3](#) which includes an example of calculations for non-inspectable critical areas.

E. Stability Reassessment

When there are changes in deadweight, lightship, loadings and site-specific environmental conditions, an updated stability analysis is to be carried out using the Rules in effect when the installation was classed. However, if the unit has undergone a major modification during its service, the Rules in effect at the time of major modification are to be applied.

A modification which, for example, substantially changes the dimensions and hull buoyancy or changes the type of the unit will usually constitute a “major modification”. For the purpose of compliance with statutory requirements, whether a modification constitutes a major modification is dependent on the applicable statutory instrument/regulations, IMO Circulars and/or flag administration, and is to be determined in consultation with the flag and Coastal States, which have the final decision-making authority.

The intact and damage stability of the installation are to be evaluated in accordance with the requirements of the flag and Coastal States. See [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec. 2, C.1.6](#). The Operating Manual is to be updated accordingly.

F. Mooring Systems

1. General

Mooring systems are to be reassessed for any change that could affect mooring responses. This includes, but is not limited to, change in mooring configuration, mooring components, metocean environmental conditions, trenching effect, and fiber rope creep.

Strength, fatigue, and cathodic protection assessment are to be carried out for the entire mooring system including mooring lines, mooring accessories, mooring equipment, and anchoring system. The evaluation of cathodic protection system is to follow [H](#).

1.1 Global Performance

Global performance or mooring analysis, with new metocean data and other changes are to be submitted for review.

Global performance responses such as motion, acceleration, offset, air gap, etc., are to be within the original design criteria unless such responses are properly considered in other related disciplines such as structure, riser, etc.

2. Strength Reassessment

The strength reassessment of a mooring system is to be carried out in accordance with applicable requirements in the [Guidelines for Floating Production Installation \(Pt.5, Vol.3\)](#). The strength factor of safety for mooring lines is to be in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Table 6.3](#).

For life extension assessment, the total corrosion and wear allowance is to consider the total mooring design life, which is the original design life plus the requested extended life. For example, for a 10-year life extension with the original design life of 20 years, the total corrosion and wear allowance is 15 mm if the corrosion/wear rate is 0,5 mm/year.

The future corrosion/wear rates in the extended years are to be based on the past service history or the corrosion/wear rate specified in the [Guidelines for Floating Production Installation \(Pt.5, Vol.3\) Table 6.6](#).

3. Fatigue Analysis

- 1) The fatigue analysis is to be carried out unless all following conditions are met.
 - Original platform design condition remains unchanged.
 - Baseline inspection found the mooring system conditions meet the original design requirement.
 - The original calculated mooring life exceeds the original design life plus the extended lifetime.
- 2) When chain links are subject to constraints by chain hawse, chain stopper or bending shoes, new mooring fatigue analysis is to consider the effect of out-of-plane bending, in-plane bending, and tension-tension (OPB/IPB/TT) even if those effects were not considered in the original design. This consideration does not apply to replaced chain links if the intended service life of the chain is less than the served time of replaced chain segment. See [Guidelines for Floating Production Installation \(Pt.5, Vol.3\) Sec.6, B.3.3.3](#).
- 3) When evaluating the fatigue damage from past services, recorded single extreme events, such as significant hurricanes beyond a 10-year return period, are to be taken into consideration.
- 4) Where a mooring system has been operating for a period of time with one or more mooring lines missing, those operation conditions are to be included in the fatigue analysis for the affected mooring lines.
- 5) The design parameters from the field measurements in the past service period can be used in fatigue analysis in lieu of the original design parameters.
- 6) Service history of the replaced mooring components is to be taken into consideration when performing fatigue analysis.
- 7) For fatigue analysis, when determining the reference breaking strength of common chain links, the diameter is to be taken as the as-measured nominal diameter at end of the original design life minus half of the corrosion and wear allowance in the extended years. For example, for a 10-year life extension with the original design life of 20 years, the total corrosion and wear allowance is 12,5 mm if the corrosion/wear rate is 0,5 mm/year.
- 8) The original fatigue safety factor for non-inspectable mooring components may be reduced when justifications submitted by the Owner show a reduction of the uncertainty in the original design and is subject to the following conditions:
 - No past findings
 - Corrosion rate within the original design assumption
 - Reliable load/metocean history

However, the fatigue safety factor is not to be less than three. This reduction can only apply to the past service life. The fatigue safety factor during extended years is to be in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\) Table 6.4](#).

4. Additional Considerations

The following items are to be considered for the mooring system if applicable.

- 1) If pitting/groove is found, its impact on the chain's strength and fatigue is to be evaluated via finite element analysis on the specific chain links, based on the inspected results.
- 2) Unsheathed six or eight strand wire ropes are to be replaced for the extended years once their original life expectancy recommended by the manufacturer is used up.
- 3) For mooring systems with sheathed spiral strand steel wire ropes, if the life extension period exceeds the warranty period provided by the steel wire rope manufacturer, the requirement of reassessment, in-situ inspection, retrieval for inspection and testing or future inspection and monitoring are to be considered.

5. Single Point Mooring Systems

Where single point mooring systems are installed, mechanical components including, but not limited to, turret main bearings, swivels, swivel stack, driving arms/mechanisms, and structural connectors, are to be reassessed for strength and fatigue based on as-is conditions and current metocean data. The mechanical components are to be analyzed in accordance with the [Guidelines for Floating Production Installation \(Pt.5, Vol.3\) Sec.6, C.9.3](#).

6. Anchoring Systems

Structural integrity (strength and fatigue) and holding capacity of anchoring systems are to be re-evaluated in case the mooring line extreme load or fatigue loads are increased, or when there are scouring or other changes in the foundation.

The cathodic protection system is to be re-evaluated per [H](#).

G. TLP Tendons and Tendon Connectors

When design loads or modifications have been identified, such as tendon components updates, metocean environmental condition changes, seabed changes, any other possible changes affecting the tendon responses, etc., tendons and tendon connectors are to be reassessed.

1. Reassessment Analysis

Tendon system models are to be developed and updated incorporating as-is platform and tendon conditions while assessing tendon strength and remaining fatigue life. The strength and fatigue reassessments of tendons are to be carried out using as-is conditions.

The environmental conditions in accordance with [B](#) are applied to verify the adequacy of the tendon system based on the applicable design code as shown in [Sec.1.F](#). Robustness check of tendons as per [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.5, B.4.1.3](#) and/or API RP 2T is to be performed. Global performance or tendon and foundation system analysis with new metocean data and other changes are to be submitted for review.

In the tendon reassessment, inadvertent disconnect in storm conditions is to be addressed, and consequence analysis of component failure is to be carried out.

When evaluating the fatigue damage from past services, recorded single extreme events, such as significant hurricane beyond 10-year return period, are to be taken into consideration.

2. Tendon Tension Monitoring System

The TTMS is to be fitted if not currently installed or repaired if not in working order. The requirement for the TTMS follows the recommendations in API RP 2T.

The monitored tendon tension is to be used to monitor platform weight during the platform's service life, provide load history of the tendon system to estimate fatigue damage accumulated, and provide performance data during severe weather conditions to validate the design and improved design prediction tools.

Tendon pretensions are to be calibrated with the design values in the baseline survey. Any changes on pretensions are to be considered in engineering assessment and updated in its operation manual.

H. Cathodic Protection System

The cathodic protection system is to be re-evaluated to prove that the system is sufficient to cover the extended service life. For the design of cathodic protection systems, refer to the appropriate National Association of Corrosion Engineers (NACE) standards, such as SP0176 or other recognized standards.

If anode depletion is found to be significant during the baseline survey, one of the following is to be carried out:

- 1) Cathodic protection reassessment is to be submitted to demonstrate that the cathodic protection system is effective to cover the extended service life.
- 2) A replacement plan is to be submitted for review and approval. Installation is to be performed to the satisfaction of the attending Surveyor.
- 3) An alternative corrosion protection system (e.g., impressed current system) is to be selected. The system details are to be submitted for review and installation is to be performed to the satisfaction of the attending Surveyor.

I. Review of Engineering Reassessment Results

If the results of engineering reassessment show that the installations are not suitable for life extension, a list of actions is to be created as conditions for granting life extension.

The following are examples of actions based on review of engineering assessment:

- New critical areas identified based on the reassessment are to be examined using Nondestructive Testing (NDT) techniques and verified to be satisfactory.
- Low fatigue lives may be improved either by strengthening or grinding the welds. Interval of future periodic surveys are to be determined based on the remaining fatigue lives of these connections.
- If the fatigue reassessment is not satisfied for the requested years of life extension, the following mitigation measures may be considered:
 - Fatigue improvements, if feasible, in accordance with the [Guidance for Fatigue Assessment of Offshore Structures \(Pt.5, Vol.B\)](#) or other recognized standards
 - Increased inspection frequency
 - Modification of design loading conditions, particularly if the original metocean data has been updated
 - Make the originally non-inspectable structure accessible for inspection
- The mooring reassessment may call for additional monitoring, inspection, sampling, testing, or change in inspection frequency, which are to be incorporated in the ISIP and to be reviewed by BKI.

- Any limitation on operations such as changes on limiting sea states for offloading, evacuation, etc., resulted from the mooring assessment are to be included in the Operating Manual.
- If the result of reassessment identifies required repairs and/or modifications to achieve life extension, the Owner is to develop and submit such plans required for review and approval.
- Fatigue-prone areas introduced by modifications are to be identified and assessed.

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Section 6 Conditions of Life Extension

A.	General	6-1
B.	Conditions of Life Extension	6-1
C.	Repairs and Modifications	6-2
D.	Revision of the ISIP	6-2

A. General

The findings through baseline survey in conjunction with engineering reassessment will form the basis for determining the conditions to class the FPIs for continued operation.

Conditions of life extension usually include both engineering review and survey activities. Prior to granting the life extension, those conditions are to be addressed by Owner and verified by BKI. The ISIP plan and operating manual are to be updated accordingly.

B. Conditions of Life Extension

The conditions of life extension include, but are not limited to:

- 1) For areas, such as produced water tanks, uncoated voids or other tanks, subject to rapid corrosion, an effective plan to prevent rapid corrosion in these areas is to be provided and included in the ISIP for approval.
- 2) Substantial corrosion areas identified are to be either cropped and renewed or reinforced or have adequate corrosion arresting measures approved and implemented prior to life extension. Alternatively, reassessment is to be submitted to justify the acceptance of the structure as-is.
- 3) The corrosion protection system is to be re-evaluated to verify that existing anodes and/or protective coatings are capable of serving the extended design life of the installation. If found necessary by the re-evaluation, replacement of the existing anodes or installation of additional new anodes are to be carried out. The condition of protective coatings, if found deficient, is to be rectified and maintained, or additional examination is to be conducted to verify the continued satisfactory condition.
- 4) Any areas determined to be critical to the structure are to be free of cracks.
- 5) Cracks or damaged joints, members, connections, and mooring components found during the baseline survey are to be repaired to the satisfaction of the Surveyor. Alternatively, technical justification is to be provided and submitted for approval.
- 6) Marine growth has been cleaned to the Surveyor's satisfaction and corrosion is found to be within the allowable design limits.
- 7) Enhanced survey programs are to be provided to monitor those structural elements or details with lower fatigue life which cannot be modified or renewed on site. Those programs are to be included in the ISIP for approval.
- 8) Actions are to be proposed to increase the fatigue life of structural elements or details with a fatigue life below the new intended design fatigue life.
- 9) If significant pitting/grooving on steel mooring components are found, these components may be replaced, or put under close monitoring. A remedial plan is to be proposed and submitted for approval.
- 10) Unsheathed six or eight strand wire ropes are to be replaced for the extended years once their original life expectation is used up.

- 11) Any degradation on tendon components such as bulging of rubber or height loss of flex elements is to be evaluated by the Owner. The original manufacturers are to be consulted. A remedial plan is to be proposed and submitted for approval.
- 12) All composite repairs that are currently installed at the time of the life extension are to be revalidated for suitability, replaced, or permanently repaired to the as-built condition. The ABS Guidance Notes on Composite Repairs of Steel Structures and Piping provides guidelines on the bonded composite repairs of steel structures and piping.
- 13) For the mooring system in the extended years, suitable arrangements and/or equipment for the crew to periodically verify that each mooring leg remains intact are to be provided. Suitable arrangements might include, but are not necessarily limited to, mooring line load monitoring arrangements, inclinometers, laser measuring devices, excursion monitoring systems (GPS), and submersible cameras. These arrangements are to be able to last throughout the service life of the installation, and the following are to be taken into account during the design of such arrangements:
 - Robustness and reliability
 - Serviceability and maintainability
 - Validation and periodic verification/testing
- 14) Any other findings from the baseline survey and engineering assessment are to be gathered and remedial plan proposed.
- 15) Additional items are to be determined on a case-by-case basis during life extension process.

Prior to granting the life extension, all conditions of life extension listed above are to be addressed and verified to be satisfactory.

C. Repairs and Modifications

1. Repairs

Where repairs to the FPI or its elements identified by life extension assessment are planned, a complete repair procedure, including the extent of the proposed repair and the need for the surveyor's attendance, is to be submitted to and agreed upon by the Surveyor reasonably in advance. All repairs found necessary by the Surveyor are to be completed to his/her satisfaction.

2. Modifications

Plans of any proposed alteration or modification are to be submitted by Owner and approved by BKI before the work is commenced, and such work, when approved, is to be performed to the satisfaction of the Surveyor.

D. Revision of the ISIP

The ISIP is a comprehensive program that outlines the procedures to be followed and the inspection frequency of the hull and mooring system of a floating facility. The ISIP is to be developed or revised to incorporate the results from surveys, engineering analyses, corrosion protection evaluation and mitigation of structural and equipment damage and/or deficiency.

The ISIP is to follow the requirement in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.3, B.3](#). A Risk Based Inspection (RBI) plan approved in accordance with the [Guidance for Survey Using Risk Based Inspection for the Offshore Industry \(Pt.5, Vol.A\)](#) may be considered as the ISIP as long as it includes all components of the ISIP.

Upon conclusion of the life extension process, the Owner is to revise the ISIP to reflect any changes and conditions for life extension:

- New inspection intervals and scope

- New critical areas and inspection points identified
- Additional requirements for inspection or NDT on initial design critical areas
- Additional structural elements not previously included in the plan or added as part of the life extension process
- Other inspection requirements identified during the process.

The updated ISIP is to be submitted for approval.

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Annex 1 Hull Strength and Fatigue Reassessment for Ship-Type Installations

A.	General	A1-1
B.	Future Corrosion Rate	A1-1
C.	ISCal for Life Extension	A1-3
D.	Global Strength Assessment (Simplified Fatigue Analysis) for Life Extension	A1-4
E.	Dynamic Loading Approach and Spectral Fatigue Analyses for Life Extension	A1-5

A. General

This Annex supplements the requirements of hull strength and fatigue assessment for the ship-type installations given in [Section 5, D.1](#).

B. Future Corrosion Rate

For ship-type installations, estimation of anticipated future corrosion rates is to be made by the Owner, by considering any future corrosion protection measures to be used, in-service experience, the type and temperatures of stored fluids and any other variables significantly affecting the corrosion rate.

In case the anticipated future corrosion rates are not available, the general corrosion rates for plating and structural members given in [Table.A1.1](#) are to be used as minimum anticipated future corrosion rates.

The minimum corrosion margins are equal to the minimum anticipated future corrosion rates multiplied by the expected service years. At the time of life extension, the required scantlings are the renewal scantlings as determined by the reassessment calculation plus the minimum corrosion margins.

In view of the higher anticipated corrosion rates for structural members in some regions, such as areas suspected of accelerated corrosion, increased corrosion rates are to be considered for required scantlings. The Owner may specify additional corrosion rates based on maintenance plans.

Table A1.1: General Corrosion Rate for Life Extension

Structural Element / Location		General Corrosion Rates for Life Extension [mm/year]		
		Cargo Tank	Ballast Tank Effectively Coated	Void Space ³⁾⁴⁾
Deck Plating		0,100	0,100	0,080
Side Shell Plating		N.A.	0,100	0,050
Bottom Plating		N.A.	0,100	0,050
Inner Bottom Plating		0,090	N.A.	N.A.
Longitudinal Bulkhead Plating (for uncoated tanks)	Between Cargo Tanks	0,100 (0,150)	N.A.	N.A.
	Other Plating	0,120		0,050

Table A1.1: General Corrosion Rate for Life Extension (continued)

Double Hull

Structural Element / Location		General Corrosion Rates for Life Extension [mm/year]		
		Cargo Tank	Ballast Tank Effectively Coated	Void Space ³⁾⁴⁾
Transverse Bulkhead Plating (for uncoated tanks)	Between Cargo Tanks	0,100 (0,150)	N.A.	N.A.
	Other Plating	0,120		0,050
Transverse & Longitudinal Deck Supporting Members		0,100	0,100	0,050
Double Bottom Tanks Internals (Floors and Girders)		N.A.	0,100	0,050 ⁵⁾
Web of Stiffeners on Deck		0,120	0,120	0,080
Flange of Stiffeners on Deck		0,120	0,120	0,080
Web of Stiffeners on Side Shell		N.A.	0,140	0,050
Flange of Stiffeners on Side Shell		N.A.	0,100	0,050
Web of Stiffeners on Bottom		N.A.	0,100	0,050
Flange of Stiffeners on Bottom		N.A.	0,150	0,050
Web of Horizontal Stiffeners on Longitudinal Bulkheads (for uncoated tanks)		0,180 (0,210)	0,210	0,080
Flange of Horizontal Stiffeners on Longitudinal Bulkheads		0,120	0,120	0,050
Web of Stiffeners on Transverse Bulkheads		0,100	0,100	0,050
Flange of Stiffeners on Transverse Bulkheads		0,130	0,130	0,050
Web of Horizontal Girders (for uncoated tanks)		0,100 (0,250)	0,120	0,080
Face Plate of Horizontal Girders		0,100	0,100	0,050
Web of Transverse Webs and Swash Bulkheads/Struts		0,080	0,090	0,050
Face Plate of Transverse Webs and Swash Bulkheads/Struts		0,070	0,090	0,050
Vertical Stiffeners and Supporting Members Elsewhere		0,050	0,050	0,050
Non-vertical Longitudinals/ Stiffeners and Supporting Members Elsewhere		0,080	0,100	0,050

Table A1.2: General Corrosion Rate for Life Extension

Single Hull)⁶⁾:

Structural Element / Location	General Corrosion Rates for Life Extension [mm/year]		
	Cargo Tank	Ballast Tank Effectively Coated	Void Space ³⁾
Side Shell Plating	0,100	0,100	0,050
Bottom Plating	0,100	0,100	0,050
Web of Stiffeners on Side Shell	0,120	0,140	0,050
Flange of Stiffeners on Side Shell	0,100	0,100	0,050
Web of Stiffeners on Bottom	0,080	0,100	0,050
Flange of Stiffeners on Bottom	0,130	0,150	0,050
Bottom Transverses and Girders (Web and Flange)	0,050	0,080	0,050

Notes:

- 1) Corrosion depends on many factors including coating properties, cargo composition, inert gas properties and temperature of carriage, and actual wastage rates observed may be appreciably different from those provided here.
- 2) Pitting and grooving are regarded as localized phenomena and are not covered in this table
- 3) Void Space: The corrosion rates in ballast tank are to be applied for un-coated/partially coated void space, temporary ballasting usage, or water ingress from adjacent tanks
- 4) Side stringer plating in Void Space: Watertight adjacent to ballast tank 0,1 mm/year
- 5) Watertight bottom girder adjacent to ballast tank: 0,1mm/year
- 6) Unless the modifications are made in the table for Single Hull, the general corrosion rates in the table for Double Hull are applicable to the corresponding structural elements of single hull ship-type installations

C. ISCal for Life Extension

1. Strength Evaluation

The original BKI Technical software analysis may be used for strength verification unless the environmental conditions have been updated or a scantling reassessment is necessary. If this analysis is not available or the design parameters have been modified, then the strength is to be verified using BKI Technical software analysis using the standard 20-year nominal design corrosion values (NDCV) values specified in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.4, C.1.1.4.2 Table 4.8](#). The requirements of [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.4, B.1](#) will be applicable only to reassessed portions of the structure where design, substantial corrosion and renewal scantlings have changed, even in cases where environmental conditions have been updated.

2. Simplified Fatigue Evaluation

If the original fatigue analysis has been performed using BKI Technical software analysis, the remaining fatigue life for all longitudinal stiffener end connections may be used to determine whether or not any of the connections need to be renewed/repared, assuming the environmental criteria have not been updated. If the original analysis is not available or the design parameters have been modified, a re-analysis using BKI Technical software analysis is to be performed. The cumulative fatigue damages from the historical route (if originally converted from a trading tanker), the current and historical sites and the expected future fatigue damage for intended life extension are to be calculated to determine suitability of the end connections. For the detailed procedure for conversions, refer to [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.4, B](#).

D. Global Strength Assessment (Simplified Fatigue Analysis) for Life Extension

1. Model Requirements and Assessment Procedures for Life Extension

As minimum requirements for fatigue, at least one three-hold global model within 0,4L amidships in association with the most unfavorable topside loads and selected associated local models is to be used to assess the hull structure fatigue remaining life, according to [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.4, C.2 and Sec.4, C.4.6.3](#) . The following steps are to be taken:

- 1) For conversions, build Tanker net scantlings model using as-built scantlings and current rules NDCV for 20-year period – get stress ranges for original tanker conditions and obtain fatigue damage due to past service history as tanker.
- 2) Build or modify existing Tanker model considering net scantlings based on as-built or reassessed scantlings at conversion and NDCV from Guidelines in effect at the construction/conversion. In the absence of those requirements, the NDCV is to be considered not less than the ones indicated in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Table 4.8](#) (for a 20-year period) – get stress ranges and fatigue damage for past service history as a ship-type FPI.
- 3) Incorporate the latest thickness measurements* and take into consideration topside weight updates and other modifications. The lesser of as-gauged and reassessed scantlings at conversion is to be used as gross scantlings and define net scantlings based on the current Guidelines NDCV, then calculate the remaining fatigue life. Alternatively, the model can be built using the reassessed net scantlings at the life extension. Special attention is to be paid to screening locations according to the baseline survey.

Note:

* Average of the gauging over each strake for a global model, other methods may be applied.

2. Use of As-gauged Scantlings

When considering the use of as-gauged scantlings, it is important to apply the gauging information available to also represent the structures that have not been gauged so as to best represent the hull in its present condition. Several approaches can be used to accomplish this:

- 1) Average wastage by zone. Take an average value of wastage by zone representing upper/middle/lower thirds of vertical structures, plus added zones for bottom and deck. Apply this information as a wastage percentage to all structures within the zone.
- 2) Refinement of 1) above. Take same approach as above but apply separate values to plate, stiffener and brackets and also divide the vertical and horizontal zones into groups of three bays each.
- 3) Use a “gauged neighbor” approach, which can be applied to varying levels of granularity (plate, strake, bay, zone, etc.). This is applied by denoting the wastage levels of a non-gauged plate or component's neighbor and taking the average of all adjacent neighbors. For example, if plates on either side of a non-gauged plate have gauged wastages of 5% and 10% respectively, then the non-gauged plate receives a wastage of 7,5%.
- 4) Apply a known corrosion rate based on a particular service. This method can be used if an operator is using gauging information to determine wastage rates. In this regard, a total loss can be applied conservatively as the given wastage rate multiplied by x-years of past service and subtracted from the as-built thickness. In this way, future condition can also be predicted for the end-of-life extension period.

The local fine mesh fatigue models are to be built using actual (not averaged) gaugings.

3. Loads and Load Cases

- 1) For model built in 1.1): GSA loads and load cases for trading tankers are to be considered. The client is to provide trading history. In the absence of such information, the previous fatigue damage is to be calculated based on unrestricted service environment.
- 2) For model built in 1.2): GSA loads and load cases for FPSO are to be applied; if available, the measured environmental condition and the wave heading may be utilized.
- 3) For life extension model in 1.3): GSA loads and load cases for FPSO are to be considered. The updated environmental condition and the wave heading are to be taken into account. Changes/ restrictions in loading conditions about the design draft, permissible still water bending moments and still water shear forces, etc., can be considered on client's request.

4. Fatigue Acceptance Criteria

The fatigue acceptance criteria are to follow [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Annex 5](#). When required, strength reassessment is to be in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec. 4, C.4.2 and C.4.3](#).

E. Dynamic Loading Approach and Spectral Fatigue Analyses for Life Extension

1. Model Requirements and Reassessment Procedures

On client's request, a full-length ship model can be used to reassess the hull structure and fatigue remaining life instead of Global Strength Assessment (GSA), according to [Guidelines for Floating Production Installation \(Pt.5, Vol.3\), Sec.4, B.1.3.4.1](#). The following steps are to be taken:

- 1) For conversions, build tanker as-built model.
- 2) Build or modify existing tanker model to consider reassessed scantlings at conversion and additions (turret/mooring, topsides modules, cranes, etc.).
- 3) Incorporate life extension gauging* into scantlings, the lesser of the as-gauged and the reassessed scantlings at life extension (gross or net depending on the methodology used), topside weight updates and other modification (turret/mooring, topsides modules, cranes, etc.). Special attention is to be paid to screening locations according to the baseline survey.

Note:

**Average of the gauging over each strake for a global model, other methods may be applied*

2. Loads and Load Cases

- 1) Tanker as-built model in 1.1): The client is to provide the trim and stability booklet for tanker and trade route history for the accumulative fatigue damage calculation for trading tanker. In the absence of such information, the previous fatigue damage is to be calculated based on unrestricted service environment.
- 2) Reassessed scantlings model at conversion built in 1.2): The client is to provide the trim and stability booklet for existing FPSO operation and transit cases. The measured environmental condition and the wave heading can be taken into account.
- 3) Life extension model in 1.3): The client is to provide the trim and stability booklet for FPSO operation. The updated environmental condition and the wave heading are to be taken into account. Changes/restrictions in loading conditions can be considered on client's request.

3. Acceptance Criteria

When required, the strength reassessment is to be in accordance with the [Guidelines for Dynamic Loading Approach \(Pt.7, Vol.2\)](#).

The fatigue acceptance criteria are to follow [Guidelines for Spectral Based Fatigue Analysis \(Pt.7, Vol.3\)](#).

Annex 2 Fatigue Reassessment of Ship-Type FPIs Considering Onboard Validated Historical Loading Information

A.	General	A2-1
B.	Application of Environmental Severity Factors	A2-1
C.	Identification of Relevant Onboard Historical Loading Data	A2-2
D.	Identification of DLPs Affected by Onboard Historical Data	A2-3
E.	Procedure for Adjustment of Fatigue Assessment of Ship-Type Installations	A2-3

A. General

This Annex outlines the procedures for verifying the hull remaining fatigue strength of a permanently moored ship-type installation using validated historical operational and environmental loading parameters.

Where the original analysis has been done for site-specific environmental conditions in accordance with the [Guidelines for Floating Production Installations \(Pt.5, Vol.3\)](#), the fatigue evaluations for site-specific environments have already been performed and may be used as a basis for determining whether any further evaluations are necessary in association with the consideration of actual operational historical loading information.

B. Application of Environmental Severity Factors

This Subsection relates to the use of the onboard data acquired for historical loading in the determination of Environmental Severity Factors (ESFs) defined in [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Annex 4](#).

The proposed adoption of the acquired data, which impacts the ISCal and GSA phase, is addressed in [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Sec.4, C.3 and C.4](#) respectively, as it affects the ESF alpha (α) and beta (β) factors. For the estimation of Remaining Fatigue Life, only ESF α factors are relevant and will be addressed here.

The ISCal of [Guidelines for Floating Production Installations \(Pt.5, Vol.3\)](#) was based on the tanker's operational conditions (primarily sailing fully loaded on inbound trips and ballasted on outbound trips). Generally, normal ballast loads are defined as between 40% and 60% of the fully loaded draft for regular environmental conditions, and a deeper draft is designed for heavy weather ballast conditions to contain the hull motions in lower drafts during severe weather.

However, this is not the usual operation conditions of a ship-type FPI. To facilitate the estimation of extreme and daily operational loads and stresses on the hull, some coefficients have been provided in the [Guidelines for Floating Production Installations \(Pt.5, Vol.3\)](#) to adjust the global behavior of the FPI when in lower drafts. Also, FPIs are designed to operate with a large range of drafts and cargo distribution in their cargo tanks while considering the simultaneous action of maximum expected hull girder loads, hull motions, acceleration, and pressures.

While this flexibility is positive for the initial design and building stages of an FPSO, it is a conservative approach to the estimation of the Remaining Fatigue Life. These adopted contingencies impose high stress ranges applied to the hull structure, which results in a greater impact on the fatigue damage and fatigue

life, since the fatigue damage is related to stresses on the hull by a power of 4,5 to 7,5 ($m/0.65$), depending on the S-N curve adopted.

In addition, the absence of data on simultaneous loads occurrence leads to the assumption of maximum positive and negative loadings acting in each of the Dynamic Loading Parameters (DLPs) that are relevant to fatigue calculations, which may lead to a significant increase in damage.

C. Identification of Relevant Onboard Historical Loading Data

When the Installation operates under a regular loading and unloading sequence, the main Static Loading Parameters (SLPs) related to stresses acting on the hull can be identified, regularly measured, validated, and compiled to be considered in the life extension fatigue calculations instead of combining maximum values.

The relevant SLPs are:

- Mean value of minimum, intermediate, and maximum operational draft
- Metacentric height in longitudinal and transverse directions (which can be obtained from hydrostatic tables for measured drafts, and tanks sounding/ullage)
- Still Water Hull Girder Bending Moment at each section of the cargo block
- Still Water Hull Girder Shear Forces at each section of the cargo block
- Cargo and ballast tanks filling level – sounding/ullage
- Deadweight mass distribution
- Daily production rate
- Offloading operation start and end time, and offloading volume/weight

The SLPs mentioned above are to be measured at the same time, and in a time interval not greater than the following, so that the intermediate filling of each cargo tank can be adequately considered:

$$t_{\text{interval}} = v_{\text{smallest}} \cdot \gamma_{\text{cargo}} \cdot \frac{6}{d_p}$$

where

- t_{interval} = time interval for cargo tanks sounding/ullage measurement (hours)
- v_{smallest} = smallest cargo tank volume [m^3]
- γ_{cargo} = cargo density [kN/m^3]
- d_p = daily production [kN/day]

Additionally, the SLPs data are to be accumulated continuously for at least five years so that the regular operational loading/unloading sequence can be identified.

From the above data, the maximum and minimum operational drafts can be identified as the average values of associated drafts at the start and end of offloading operations.

Two intermediate drafts are to be considered, as close as possible to an even distribution between maximum and minimum operational drafts.

The offloading cycle period can be defined as the average of the different periods between two offloadings, for all the range of time for which the onboard data has been submitted. Then, the total number of offloading cycles for the entire service life of the FPSO can be estimated based on this offloading period.

Based on these defined drafts, the other associated SLPs may also be obtained as the average of values for the mean drafts defined as minimum, maximum, and intermediate operational drafts.

D. Identification of DLPs Affected by Onboard Historical Data

For the determination of high cycle fatigue stress range loads in the hull structure, the following DLPs related to stresses acting on the hull can be identified based on [Guidelines for Floating Production Installations \(Pt.5, Vol.3\)](#) and [Guidelines for Spectral - Based Fatigue Analysis \(Pt.7, Vol.3\)](#), as affected by onboard historical operational and environmental data:

- Environmental wave conditions and relative heading to the bow (see [Guidelines for Spectral - Based Fatigue Analysis \(Pt.7, Vol.3\) Sec.5, B](#) and [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Annex 5, C.4](#))
- Roll and pitch motions, if available (see [Guidelines for Spectral - Based Fatigue Analysis \(Pt.7, Vol.3\) Sec.5, B](#) and [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Sec.4, C.2.3.5.1.1](#) and 2))
- Acceleration at one defined point at main deck level, if available (see [Guidelines for Spectral - Based Fatigue Analysis \(Pt.7, Vol.3\) Sec.5, B](#) and [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Sec.4, C.2.3.5.1.3](#))
- Hull girder longitudinal and vertical stresses/deflections at locations along cargo block previously defined as target for allowable Stillwater Values, when available (see [Guidelines for Spectral - Based Fatigue Analysis \(Pt.7, Vol.3\) Sec.4, B](#) and [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Sec.4, C.2.2.1, C.2.3.1 and C.2.3.2](#)).

The above listed information may be derived from hydrodynamic analysis based on the hydrostatic properties calibrated from SLPs identified in [C](#). or can also be obtained from onboard measurements. If onboard measurements are to be used, the method and frequency for taking the measurements along with the data collection and analysis are to be agreed to with BKI prior to the start of the measurement program.

If the Owner intends to consider the same historical operational and environmental data or any optimized specific loading sequence as applicable to the extended life of the unit, the indication of the estimated operational loading sequence is to be clearly identified in the Loading Manual, provided that this preferential loading sequence has been successfully implemented into practice by the Owner over the vessel's past operational life, and it is very likely to occur over the vessel's remaining operational life (probability of occurrence over 90%).

The above information is to also be measured at the same time, and in a time interval associated with the relative expected natural period of response. These periods may be obtained from the Response Amplitude Operators (RAOs), generated by BKI Technical software, or equivalent. The peak magnitudes of the associated DLP may be obtained as the average of observed values for each of the drafts defined as minimum, maximum, and intermediate operational drafts.

E. Procedure for Adjustment of Fatigue Assessment of Ship-Type Installations

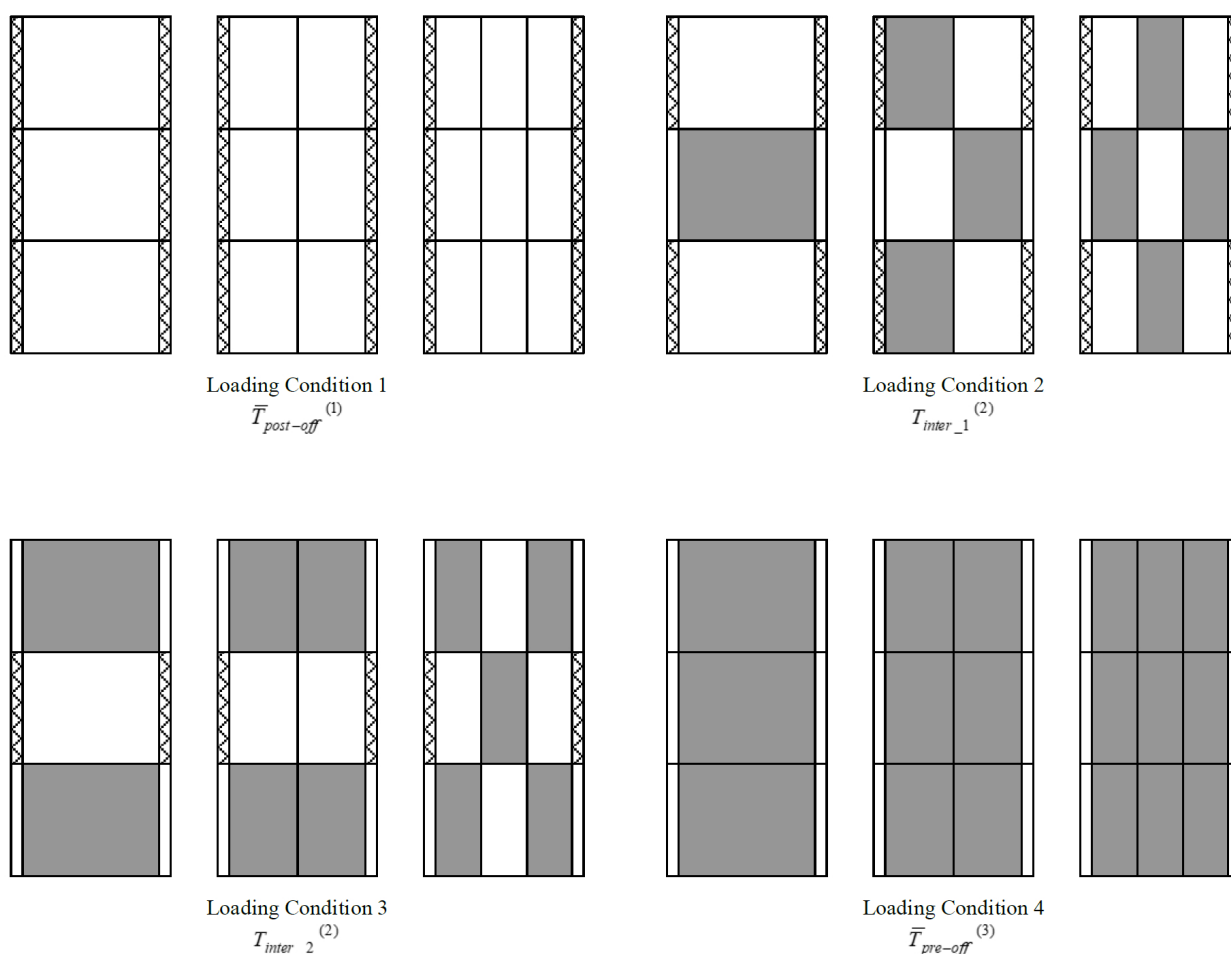
The connections to be considered for the fatigue assessment are the same as those identified in [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Annex 5, B](#). Other additional locations may be selected by the Owner.

The long term stress distribution parameter, identified in [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Annex 5, C](#), may be replaced by a long term parameter calculated based on measurements and/or hydrodynamic simulations for the specified maximum, minimum, and intermediate operational drafts and conditions, for a probability of occurrence of 1×10^{-4} , according to [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Sec.4, A.1.4.3.3](#).

Usually, the typical loading patterns from [Guidelines for Floating Production Installations \(Pt.5, Vol.3\) Fig.A5.2A and Fig.A5.2B](#) for double hulls and single hulls respectively are to be used. However, for specified regular loading sequences, the Owner may submit special loading patterns based on onboard data for the historical loading sequence of each tank and provide an estimation of the remaining fatigue life for each tank portion, along with the specific DLPs for the region.

When using historical loading or future planned loading information, namely using the modified loading patterns in Fig. A2.1 for double hulls and Fig. A2.2 for single hulls, the load combination factors given in Table A2.1 to Table A2.4 can be developed through hydrodynamic analysis for the loading conditions specified in Fig. A2.1 and Fig. A2.2. For the environmental severity factor (ESF) database and ESF beta and alpha definitions, one single database can still be considered for maximum scantling draft associated with the modified load combination factors in Table A2.1 to Table A2.4 as an example. However, additional ESF analyses for the specific intermediate drafts can also be processed, and each one can be associated with coefficients found in Guidelines for Floating Production Installations (Pt.5, Vol.3) Table 4.9A, as calibrated by the Guidelines for maximum ESF betas and alphas related to maximum draft (this requires ESF analyses). This option, although extensive in hydrodynamic calculations leads to a more accurate remaining fatigue life. The developed Table A2.1 to Table A2.4 are to be reviewed and approved by BKI.

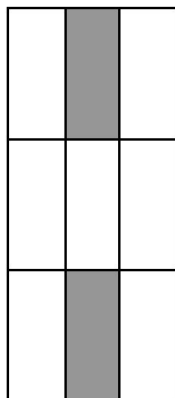
For computation of percentage of time in each draft, the total time is to be computed based on acquired data on board and submitted for review.



Notes:

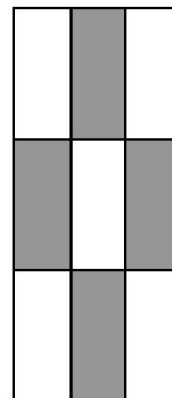
- 1) Minimum operation condition draft - average minimum operational draft of all regular offloadings performed⁴⁾.
- 2) Intermediate drafts - draft equally divided between Loading Conditions 1 and 4 drafts.
- 3) Maximum operation condition draft - average maximum operational draft of all regular offloadings performed⁴⁾.
- 4) Any abnormal offloading operations, that have resulted in premature offloading or abortion of the regular offloading, are to be identified during the historical data capture and submittal.

Figure A2.1: Loading Conditions for Fatigue Strength Assessment - Double Hull and Double Side Single Bottom FPSO/FSO with Loading History Data Submitted



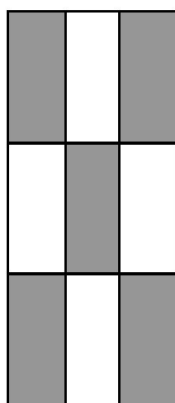
Loading Condition 1

$$\bar{T}_{post-off}^{(1)}$$



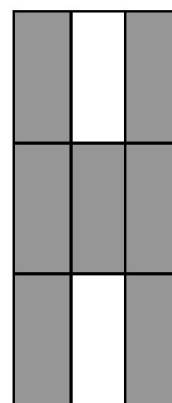
Loading Condition 2

$$T_{inter_1}^{(2)}$$



Loading Condition 3

$$T_{inter_2}^{(2)}$$



Loading Condition 4

$$\bar{T}_{pre-off}^{(3)}$$

Notes:

- 1) Minimum operation condition draft – average minimum operational draft of all regular offloadings performed⁴⁾.
- 2) Intermediate drafts – draft equally divided between Loading Conditions 1 and 4 drafts
- 3) Maximum operation condition draft – average maximum operational draft of all regular offloadings performed⁴⁾.
- 4) Any abnormal offloading operations, that have resulted in premature offloading or abortion of the regular offloading, are to be identified during the historical data capture and submittal.

Figure A2.2: Loading Conditions for Fatigue Strength Assessment – Single Hull FPSO/FSO with Loading History Data Submitted

Table A2.1: Example of Modified Design Fatigue Load Cases for Fatigue Strength Assessment*(Load Combination Factors for Dynamic Load Components for Loading Condition 1)*

	FLC1	FLC2	FLC3	FLC4	FLC5	FLC6	FLC7	FLC8
A. Hull Girder Loads								
Vertical B.M.	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)
k_c	0,90	0,90	0,15	0,15	0,70	0,70	0,80	0,80
Vertical S.F.	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
k_c	0,55	0,55	0,20	0,20	0,40	0,40	0,50	0,50
Horizontal B.M.					(-)	(+)	(-)	(+)
k_c	0,00	0,00	0,10	0,10	0,55	0,55	0,45	0,45
Horizontal S.F.					(+)	(-)	(+)	(-)
k_c	0,00	0,00	0,10	0,10	0,55	0,55	0,45	0,45
B. External Pressure								
k_c	0,50	0,50	0,85	0,85	0,85	0,85	0,85	0,85
k_{f0}	-1,00	1,00	-1,00	1,00	-1,00	1,00	-1,00	1,00
C. Internal Tank Pressure								
k_c	0,40	0,40	1,00	1	0,75	0,75	0,40	0,40
w_v	0,50	-0,50	0,75	-0,75	0,75	-0,75	0,75	-0,75
w	Fwd Bhd 0,20	Fwd Bhd -0,20	—	—	Fwd Bhd 0,40	Fwd Bhd -0,40	Fwd Bhd 0,80	Fwd Bhd -0,80
	Fwd Bhd -0,20	Fwd Bhd 0,20	—	—	Fwd Bhd -0,40	Fwd Bhd 0,40	Fwd Bhd -0,80	Fwd Bhd 0,80
w_t	—	—	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75
	—	—	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75
c_ϕ , Pitch	-0,15	0,15	-0,10	0,10	-0,30	0,30	-0,45	0,45
c_θ , Roll	0,00	0,00	1,00	-1,00	1,15	-1,15	1,00	-1,00
D. Reference Wave Heading and Motion of Installation								
Heading Angle	0	0	90	90	60	60	30	30
Heave	Down	Up	Down	Up	Down	Up	Down	Up
Pitch	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up
Roll	—	—	Stbd Down	Stbd Up	Stbd Down	Stbd Up	Stbd Down	Stbd Up
Notes:								
1 Rule vertical bending moment range = $ M_{ws} - M_{wh} $ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.2)								
2 Rule horizontal bending moment range = $2 \times M_h$ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.3)								
3 For each load condition pair, the stress range due to local pressure is the difference between the stress values for Local Pressure Load Conditions. For example, for Load Condition Pair FLC1 and FLC2, the stress range due to local pressure is the difference between the stress values for FLC1 and FLC2.								
4 For each load condition pair, the stress range is the sum of the absolute stress range values due to Vertical BM, Horizontal BM, and Local Pressure Load Conditions.								

Table A2.2: Example of Modified Design Fatigue Load Cases for Fatigue Strength Assessment*(Load Combination Factors for Dynamic Load Components for Loading Condition 2)*

	FLC1	FLC2	FLC3	FLC4	FLC5	FLC6	FLC7	FLC8
A. Hull Girder Loads								
Vertical B.M.	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)
k_c	0,95	0,95	0,25	0,25	0,95	0,95	0,85	0,85
Vertical S.F.	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
k_c	0,55	0,55	0,25	0,25	0,40	0,40	0,50	0,50
Horizontal B.M.					(-)	(+)	(-)	(+)
k_c	0,00	0,00	0,20	0,20	0,70	0,70	0,60	0,60
Horizontal S.F.					(+)	(-)	(+)	(-)
k_c	0,00	0,00	0,20	0,20	0,70	0,70	0,60	0,60
B. External Pressure								
k_c	0,50	0,50	0,90	0,90	0,90	0,90	0,90	0,90
k_{f0}	-1,00	1,00	-1,00	1,00	-1,00	1,00	-1,00	1,00
C. Internal Tank Pressure								
k_c	0,55	0,55	0,70	0,70	0,20	0,20	0,40	0,40
w_v	0,50	-0,50	0,75	-0,75	0,75	-0,75	0,75	-0,75
w	Fwd Bhd 0,20	Fwd Bhd -0,20	—	—	Fwd Bhd 0,40	Fwd Bhd -0,40	Fwd Bhd 0,80	Fwd Bhd -0,80
	Fwd Bhd -0,20	Fwd Bhd 0,20	—	—	Fwd Bhd -0,40	Fwd Bhd 0,40	Fwd Bhd -0,80	Fwd Bhd 0,80
w_t	—	—	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75
	—	—	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75
c_φ , Pitch	-0,20	0,20	-0,05	0,05	-0,10	0,10	-0,35	0,35
c_θ , Roll	0,00	0,00	1,00	-1,00	1,15	-1,15	1,00	-1,00
D. Reference Wave Heading and Motion of Installation								
Heading Angle	0	0	90	90	60	60	30	30
Heave	Down	Up	Down	Up	Down	Up	Down	Up
Pitch	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up
Roll	—	—	Stbd Down	Stbd Up	Stbd Down	Stbd Up	Stbd Down	Stbd Up
Notes:								
1 Rule vertical bending moment range = $ M_{ws} - M_{wh} $ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.2)								
2 Rule horizontal bending moment range = $2 \times M_h$ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.3)								
3 For each load condition pair, the stress range due to local pressure is the difference between the stress values for Local Pressure Load Conditions. For example, for Load Condition Pair FLC1 and FLC2, the stress range due to local pressure is the difference between the stress values for FLC1 and FLC2.								
4 For each load condition pair, the stress range is the sum of the absolute stress range values due to Vertical BM, Horizontal BM, and Local Pressure Load Conditions.								

Table A2.3: Example of Modified Design Fatigue Load Cases for Fatigue Strength Assessment*(Load Combination Factors for Dynamic Load Components for Loading Condition 3)*

	FLC1	FLC2	FLC3	FLC4	FLC5	FLC6	FLC7	FLC8
A. Hull Girder Loads								
Vertical B.M.	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)
k_c	0,95	0,95	0,25	0,25	0,75	0,75	0,85	0,85
Vertical S.F.	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
k_c	0,55	0,55	0,25	0,25	0,40	0,40	0,50	0,50
Horizontal B.M.					(-)	(+)	(-)	(+)
k_c	0,00	0,00	0,20	0,20	0,85	0,85	0,70	0,70
Horizontal S.F.					(+)	(-)	(+)	(-)
k_c	0,00	0,00	0,25	0,25	0,90	0,90	0,75	0,75
B. External Pressure								
k_c	0,50	0,50	0,95	0,95	0,95	0,95	0,95	0,95
k_{f0}	-1,00	1,00	-1,00	1,00	-1,00	1,00	-1,00	1,00
C. Internal Tank Pressure								
k_c	0,55	0,55	0,75	0,75	0,10	0,10	0,40	0,40
w_v	0,50	-0,50	0,75	-0,75	0,75	-0,75	0,75	-0,75
w	Fwd Bhd 0,20	Fwd Bhd -0,20	—	—	Fwd Bhd 0,40	Fwd Bhd -0,40	Fwd Bhd 0,80	Fwd Bhd -0,80
	Fwd Bhd -0,20	Fwd Bhd 0,20	—	—	Fwd Bhd -0,40	Fwd Bhd 0,40	Fwd Bhd -0,80	Fwd Bhd 0,80
w_t	—	—	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75
	—	—	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75
c_φ , Pitch	-0,15	0,15	-0,15	0,15	-0,20	0,20	-0,45	0,45
c_θ , Roll	0,00	0,00	1,00	-1,00	1,15	-1,15	1,00	-1,00
D. Reference Wave Heading and Motion of Installation								
Heading Angle	0	0	90	90	60	60	30	30
Heave	Down	Up	Down	Up	Down	Up	Down	Up
Pitch	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up
Roll	—	—	Stbd Down	Stbd Up	Stbd Down	Stbd Up	Stbd Down	Stbd Up
Notes:								
1 Rule vertical bending moment range = $ M_{ws} - M_{wh} $ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.2)								
2 Rule horizontal bending moment range = $2 \times M_h$ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.3)								
3 For each load condition pair, the stress range due to local pressure is the difference between the stress values for Local Pressure Load Conditions. For example, for Load Condition Pair FLC1 and FLC2, the stress range due to local pressure is the difference between the stress values for FLC1 and FLC2.								
4 For each load condition pair, the stress range is the sum of the absolute stress range values due to Vertical BM, Horizontal BM, and Local Pressure Load Conditions.								

Table A2.4: Example of Modified Design Fatigue Load Cases for Fatigue Strength Assessment*(Load Combination Factors for Dynamic Load Components for Loading Condition 4)*

	FLC1	FLC2	FLC3	FLC4	FLC5	FLC6	FLC7	FLC8
A. Hull Girder Loads								
Vertical B.M.	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)	Sag (-)	Hog (+)
k_c	1,00	1,00	0,30	0,30	0,80	0,80	0,90	0,90
Vertical S.F.	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
k_c	0,55	0,55	0,25	0,25	0,40	0,40	0,50	0,50
Horizontal B.M.					(-)	(+)	(-)	(+)
k_c	0,00	0,00	0,25	0,25	0,90	0,90	0,75	0,75
Horizontal S.F.					(+)	(-)	(+)	(-)
k_c	0,00	0,00	0,25	0,25	0,90	0,90	0,75	0,75
B. External Pressure								
k_c	0,50	0,50	1,00	1,20	1,00	1,00	1,00	1,00
k_{f0}	-1,00	1,00	-1,00	1,00	-1,00	1,00	-1,00	1,00
C. Internal Tank Pressure								
k_c	0,75	0,75	0,80	0,80	0,10	0,10	0,50	0,50
w_v	0,50	-0,50	0,75	-0,75	0,75	-0,75	0,75	-0,75
w	Fwd Bhd 0,20	Fwd Bhd -0,20	—	—	Fwd Bhd 0,40	Fwd Bhd -0,40	Fwd Bhd 0,80	Fwd Bhd -0,80
	Fwd Bhd -0,20	Fwd Bhd 0,20	—	—	Fwd Bhd -0,40	Fwd Bhd 0,40	Fwd Bhd -0,80	Fwd Bhd 0,80
w_t	—	—	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75	Port Bhd -0,75	Port Bhd 0,75
	—	—	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75	Stbd Bhd 0,75	Stbd Bhd -0,75
c_φ , Pitch	-0,30	0,30	-0,15	0,15	-0,10	0,10	-0,80	0,80
c_θ , Roll	0,00	0,00	1,00	-1,00	1,15	-1,15	1,00	-1,00
D. Reference Wave Heading and Motion of Installation								
Heading Angle	0	0	90	90	60	60	30	30
Heave	Down	Up	Down	Up	Down	Up	Down	Up
Pitch	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up	Bow Down	Bow Up
Roll	—	—	Stbd Down	Stbd Up	Stbd Down	Stbd Up	Stbd Down	Stbd Up
Notes:								
1 Rule vertical bending moment range = $ M_{ws} - M_{wh} $ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.2)								
2 Rule horizontal bending moment range = $2 \times M_h$ (see Guidelines for Floating Production Installations (Pt.5, Vol.3) Sec.4, C.2.3.3)								
3 For each load condition pair, the stress range due to local pressure is the difference between the stress values for Local Pressure Load Conditions. For example, for Load Condition Pair FLC1 and FLC2, the stress range due to local pressure is the difference between the stress values for FLC1 and FLC2.								
4 For each load condition pair, the stress range is the sum of the absolute stress range values due to Vertical BM, Horizontal BM, and Local Pressure Load Conditions.								

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Annex 3 Fatigue Reassessment of FPI Structures (Except for Hull Structures of Ship-Type Installations)

A.	General	A3-1
B.	Hull Structures and Hull Interface Structures of Non-Ship-Type Installations	A3-1
C.	Topside Structures of All FPIs and Major Hull Interface Structures of Ship-Type Installations	A3-3
D.	Safety Factors for Fatigue Life for Extended Service	A3-4

A. General

This Annex outlines the fatigue reassessment procedure for:

- Hull structures of non-ship-type FPIs,
- Hull interface structure for all FPIs,
- Topside structure for all FPIs.

B. Hull Structures and Hull Interface Structures of Non-Ship-Type Installations

1. Accumulated Fatigue Damage

The accumulated fatigue damage, D_p , based on the past service history including:

- 1) Prior service
- 2) Transit
- 3) Site-specific operation at the current environmental criteria is to be calculated as follows:

$$D_p = \sum_i^n D_{pi}$$

where D_{pi} is the accumulated fatigue damage at the i^{th} past service condition.

2. Safety Factors for Fatigue Life of the Accumulated Damages

The safety factors for fatigue life of the accumulated damages are determined in the following conditions:

- 1) Fatigue design factor (FDF or safety factor for fatigue life) for the requested extended life (L) is to be taken the same as that used in the original design according to the [Guidelines for Floating Production Installations \(Pt.5, Vol.3\)](#) and the [Guidance for Fatigue Assessment of Offshore Structures \(Pt.5, Vol.B\)](#). see [Table A3.1](#)

Table A3.1: Fatigue Safety Factor for Fatigue Life (FDF) for Hull Structures

Safety Factor for Fatigue Life (FDF)		
Structure	Inspectable	Non-inspectable
Non-critical	3	5
Critical	5	10

2) In calculating the accumulated damages or used-up fatigue life, the original FDF may be reduced provided that the technical justifications submitted by the Owner reflect a reduction of the uncertainty in the original design and subject to the following conditions:

- No past findings
- Corrosion rate to be within the original design assumption
- Reliable load/metocean history

Original FDF may be reduced if inspection can be performed examining the current condition of the structure to confirm its structural integrity. The reduction in safety factor will depend on the results of the inspection as shown in Table A3.2. Reduced safety factor (φ) reflects that a certain extent of the uncertainty in the original design having been removed due to the inspection and thus, is less than the original FDF.

Table A3.2: Fatigue Safety Factor Reduction Criteria for Hull Structures

Visual Inspection		Nondestructive Test	Fatigue Safety Factor Reduction
General	Close	Magnetic Particle or Dye Penetrant Test, ACFM, UT, etc ¹⁾	
100%	-	-	10%
-	100%	-	20%
-	100%	20%	30%
-	100%	50%	40%
-	100%	100%	50%

Notes:
 1 NDT types to be agreed upon on a case-by-case basis.
 2 % means percent of total weld length.

The reduced safety factor (φ) for the accumulated damage is to be not less than the values in Table A3.3.

Table A3.3: Reduction Safety Factor for Hull Structures

Structure	Reduced Safety Factor (φ)	
	Inspectable	Non-inspectable ¹⁾
Non-critical	2	3
Critical	3 ²⁾	5

Notes:
 1 Reduced Safety Factor, φ , can be used:
 - If non-inspectable area is checked during Drydocking Survey or Underwater Inspection in lieu of Drydocking (IW),
 - For a non-inspectable area if AIM data is available to confirm its current condition and structural integrity.
 2 Original FDF for an inspectable critical structure can be reduced if inspection can be performed examining the current condition of the structure to confirm its structural integrity

3. Predicted Damage for Life Extension

The predicted annual fatigue damage D_e of the structure in “as-is” condition (as-gauged) for the requested extended life is to be calculated at the current site-specific condition using the original wave scatter diagram, or updated scatter diagram if more severe than the original design environmental criteria.

4. Remaining Fatigue Strength Check

The remaining fatigue strength is evaluated by using one of the following criteria:

- 1) The total factored damage including the accumulated fatigue damage for the past service and the predicted damage for life extension should be less than 1,0:

$$D_p \cdot \varphi + D_e \cdot FDF \cdot L \leq 1$$

2) The requested life extension L at the current site is to be less than the remaining fatigue life (RFL):

$$L \leq RFL = \frac{(1 - D_p \cdot \varphi)}{(D_e \cdot FDF)}$$

If the remaining fatigue strength is not satisfied, the following improvements may be performed:

- Fatigue improvements, if feasible, in accordance with BKI requirements or other recognized standards
- Increased inspection frequency
- Modification to the loading condition
- Making the non-inspectable structure accessible for inspection

5. Calculation Example of Non-inspectable Critical Areas

1) For non-inspectable critical areas, after a one-time inspection, Reduced Safety Factor (φ), ranging from five to ten, can be considered for determining the accumulated fatigue damage based on the type (visual, diver, ROV, NDT, etc.) and extent of the one-time inspection.

2) Fatigue Reassessment Example

- The original Safety Factor for Fatigue Life (FDF) is 10 for non-inspectable critical areas.
- Assume that the Reduced Safety Factor (φ) is 5 based on the one-time inspection and that the calculated accumulated fatigue damage (D_p) for the past service is 0,075.
- Assume that the predicted annual fatigue damage (D_e) for the requested fatigue life is 0,005.
- Assume a life extension (L) of 12 years is requested.
- Fatigue Safety Check:

$$D_p \cdot \varphi + D_e \cdot FDF \cdot L = 0,075 \times 5 + 0,005 \times 10 \times 12 = 0,975 \leq 1$$

or

$$L = 12 \leq RFL = \frac{(1 - D_p \cdot \varphi)}{(D_e \cdot FDF)} = \frac{(1 - 0,075 \times 5)}{(0,005 \times 10)} = 12,5$$

- The fatigue safety check is satisfied for the requested extended life of 12 years for the check area at the current site.

C. Topside Structures of All FPIs and Major Hull Interface Structures of Ship-Type Installations

The same methodology and procedure for remaining fatigue strength of hull structures in B. is applied for the remaining fatigue strength assessment of topside structures and other major hull structures as identified in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\) Sec.4, A.4.1](#), except for the original FDFs in [Table A3.4](#) in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\)](#).

Table A3.4: Safety Factor for Fatigue Life (FDF) for Topside Structures

Safety Factor for Fatigue Life (FDF)		
Structure	Inspectable	Non-inspectable
Non-critical	3	5
Critical	5	10

The reduced safety factors (φ) for fatigue life are to be not less than the values in [Table A3.5](#).

Table A3.5: Reduced Safety Factor for Topside Structures

Structure	Reduced Safety Factor (φ)	
	Inspectable	Non-inspectable ¹⁾
Non-critical	1,5	3
Critical	2 ²⁾	5

Notes:

- 1 Reduced Safety Factor, φ , can be used for a non-inspectable area if AIM is available to confirm its current condition and structural integrity.
- 2 Original FDF for an inspectable critical structure can be reduced if inspection can be performed examining the current condition of the structure to confirm its structural integrity.

D. Safety Factors for Fatigue Life for Extended Service

The safety factors for fatigue life in accordance with [Guidelines for Floating Production Installation \(Pt.5, Vol.3\) Table 2.1](#) are selected for life extension as shown in [Table A3.6](#).

Table A3.6: Safety Factors for Fatigue Life for Topside Structures

Importance	Degree of Accessibility for Inspection and Repair		
	Dry Access ²⁾	Underwater Access	Not Accessible
Non-critical	2 ⁵⁾	3	5
Critical ¹⁾	3	5	10

Notes:

- 1 "Critical" implies that failure of these structural items would result in the rapid loss of structural integrity and produce an event of unacceptable consequence.
- 2 "Access" refers to the possibility of a close inspection and repair operation.
- 3 Due to the structural redundancy and accessibility of inspection inherent in typical hull structures of ship-type installations, the applied safety factor is generally 1,0. The approach outlined in [Guidelines for Floating Production Installation \(Pt.5, Vol.3\) Sec.4, A.3.2.5.2 and B.1.3.6.2](#) is to be followed.
- 4 In the event of a safety factor conflict due to different degrees of accessibility to a location, the more stringent safety factor is to be used.
- 5 BKI will consider a reduction in fatigue safety factor from 2 to 1 when the structural detail is readily visible, inspectable and repairable during normal operation.

In calculating the accumulated damages or used-up fatigue life, the reduced safety factors (φ) may be determined in accordance with [Table A3.2](#) but are to be not less than the values in [Table A3.7](#).

Table A3.7: Degree of Accessibility for Inspection and Repair for Topside Structures

Importance	Degree of Accessibility for Inspection and Repair		
	Dry Access	Underwater Access	Not Accessible ¹⁾
Non-critical	1	2	3
Critical ¹⁾	2 ²⁾	3 ²⁾	5

Notes:

- 1 A reduced Safety Factor, φ , can be used for a non-inspectable area if AIM is available to confirm its current condition and structural integrity.
- 2 Original FDF for an inspectable (dry access or underwater access) critical structure can be reduced if inspection can be performed examining the current condition of the structure to confirm its structural integrity.