# LIFE EXTENSION GUIDE FOR FLOATING PRODUCTION SYSTEMS

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***Disclaimer***

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# Abbreviations

| | |
|---|---|
| BSEE | Bureau of Safety and Environmental Enforcement |
| CVA | Certified Verification Agent |
| DVP | Design Verification Plan |
| FPS | Floating Production System |
| FPSO | Floating Production Storage Offloading |
| ISIP | In-Service Inspection Plan |
| KG | Keel to vertical center of gravity |
| LCG | Longitudinal Center of Gravity |
| MOM | Marine Operations Manual |
| MTN | Marine Safety Center Technical Note |
| NDE | Non-Destructive Examination |
| OEM | Original Equipment Manufacturer |
| OSTS | Office of Structural and Technical Support of BSEE |
| POB | Personnel On Board |
| PS | Pipeline Section of BSEE |
| SCR | Steel Catenary Riser |
| SME | Subject Matter Experts |
| TAS | Technical Assessment Section of BSEE |
| TCG | Transverse Center of Gravity |
| TLP | Tension Leg Platform |
| TTR | Top Tensioned Riser |
| USCG | United States Coast Guard |
| VCG | Vertical Center of Gravity |

# Definitions

**life extension**
The procedure of demonstrating the extension of the operational life of a system (e.g., hull, mooring, riser, etc.) beyond the life specified during the original design and/or as originally permitted.

**life extension inspections**
These are inspections that have been identified as part of the life extension assessment process that are intended to provide additional information on the condition of a structure or system and its fitness-for-service beyond the original approved service life. The life extension inspections are typically conducted in conjunction with scheduled surveys, for example ISIP surveys. However, they will typically include additional inspection scopes to obtain a more comprehensive "baseline" of the current condition.

**longevity drivers [1]**
Any design features, conditions (e.g., loading, degradation, etc.) or unknowns that influence a FPS' technical feasibility or economic viability to achieve the operators desired life extension beyond the original permitted design life.

**evaluation [2]**
An engineering review of integrity data, using engineering judgment, risk assessment, calculations, analysis or other methods, to identify anomalous conditions (i.e., assessment initiator) and determine whether additional detailed assessment or risk reduction is required to demonstrate fitness-for-service.

NOTE: An evaluation can also consist of an engineering review of proposed changes to the floating system to determine their significance on fitness-for-service.

**facility system analysis [2]**
An analysis used to demonstrate the fitness-for-service of a floating system.

NOTE: The analysis can be structural, stability, station keeping or other analysis.

# 1 Introduction

## 1.1 Objective

The purpose of this document is to provide guidance to operators on a process to assess and successfully demonstrate a Floating Production System's (FPS) fitness for future service beyond its original, approved design life, commonly referred to as a life extension. The process contained within this document describes the anticipated timing, tasks, references and regulatory interaction during the assessment and approval process.

## 1.2 Scope

The process described within this document is intended to cover all types of permanently moored FPS's operating in the Gulf of Mexico. This includes:

- Tension Leg Platforms (TLPs)
- Spars
- Semi-submersibles
- Floating, Production, Storage and Offloading (FPSOs) units

Systems of the FPS that are normally included in the assessment process are:

- Hull
- Mooring
- Marine Systems
- Topside Structure
- Riser Systems that transport hydrocarbons (e.g., Top Tension Risers, Flexible Risers, Steel Catenary Risers, gas lift umbilicals, etc.)

## 1.3 General Process and Timing

Figure 1 shows the general life extension assessment process. The first steps of the overall assessment process shown in Figure 1 are typically conducted internally by the operator to determine the technical feasibility and economic viability of extending the service life of the FPS and define the plan to obtain approval for the life extension. This process should be started by the operator well before the currently approved end of permitted life.

Note that much of the data used during the first steps of the assessment process will come from the FPS's existing integrity management programs. If the integrity management programs for the hull and topside structure, mooring and risers are in accordance with API 2FSIM [2], 2MIM [3] and 2RIM [4], respectively, much of the data should be readily available and the life extension is treated as an assessment triggered by the change in field life, within the integrity management programs. Use of standards that are used in lieu of or that contradict those documents incorporated by reference must be approved by BSEE.

A life extension plan is a useful tool to communicate the FPS operator's plans with BSEE. A life extension plan is not a regulatory requirement and will not receive a formal approval from BSEE. The Design Verification Plan (DVP) will be the formal document within a life extension plan that will be formally reviewed and approved by BSEE. With a life extension plan defined, the operator is prepared to initiate discussions with BSEE regarding their plans to extend the service life of the FPS. This kicks-off the formal approval process of the DVP within the life extension plan. The plan should outline the life extension activities (e.g., studies, analysis, inspection, renewals, etc.) that will provide the necessary additional information to demonstrate the fitness of the FPS for future service beyond the approved design life.

The life extension plan describes the activities that will be conducted. The operator's selected Certified Verification Agent (CVA) nomination must be included within the DVP and must be approved before initiating any of the verification duties. The CVA must not participate in the Operator's design or analysis activities, only their independent assessment.

Each system submittal is submitted to the CVA. The CVA will verify the submittal and provide their recommendations on the submittal within a report. The CVA report and the system submittal will be submitted to BSEE for their review and approval. Note that for the platform regulatory document updates (i.e., ISIP and MOM), the operator should inform the USCG and make the documents available, if requested.

Table 1 provides general guidance on the typical timing for the life extension activities. Note that based on recent experience, the regulatory review and approval process can take between 1-2 years to complete. As a result, the operator should begin the life extension process early.

Note that Figure 1 and Table 1 are intended to provide a high-level summary of key activities, typical timings and the general flow of a life extension assessment process. Operators may initiate activities in different order or timings based on their specific circumstances. For example, operators may initiate some of the life extension activities before finalizing the life extension plan. This may be driven by the anticipated long duration to complete certain activities, or the fact that the deliverable from the activity is a critical pre-requisite for other activities. For example, the operator may determine the site specific metocean needs to be updated, and so initiate this activity before finalizing the life extension plan.

*Figure 1 - Life Extension Assessment Process*

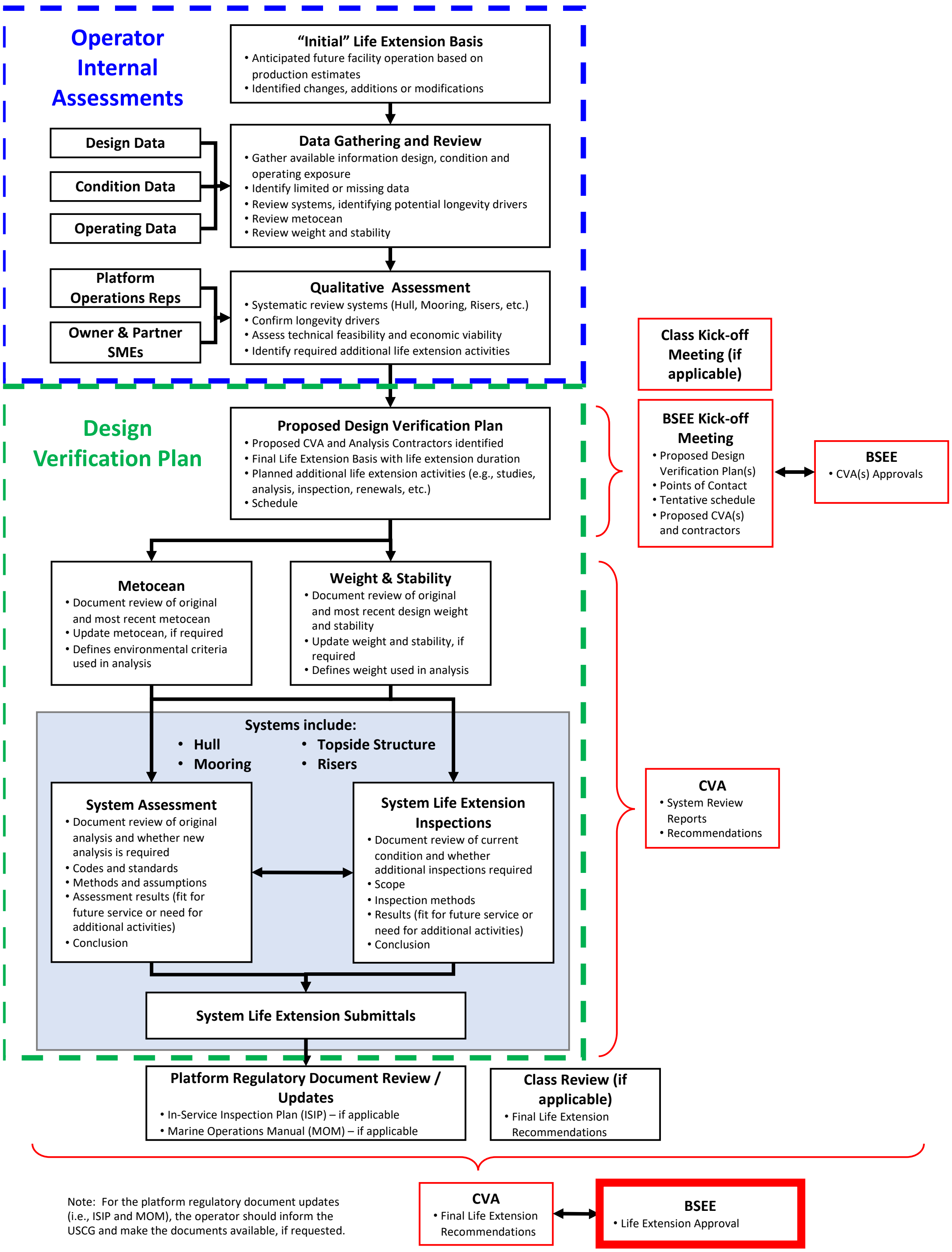


*Table 1 - General Timing of Key Activities*

| Activities | Timing (Years BEFORE End of Approved Service Life) | Comments |
|---|---|---|
| Initial Life Extension Basis, and<br>Data Gathering and Review | 4-5 yrs. | Identifying FPS' longevity drivers, including missing information or gaps in data, early will provide important insight into the level of effort required to conduct the life extension assessment as well as the duration, which is important for planning purposes. |
| Qualitative Life Extension Assessment | 3-4 yrs. | Identifying specific activities needed to address the longevity drivers early may permit synergies with planned operational tasks (e.g. potential life extension inspections identified early may enable these additional inspections to be completed as part of scheduled ISIP surveys thus reducing mobilization costs.) Additionally, activities that may be needed for the assessment of multiple systems, such as revising the metocean criteria, is important to identify early. |
| Design Verification Plan, with nomination of System CVA(s) | 3 yrs. | The plan describes the activities that the operator will follow to demonstrate fitness for future service. Note that the operator will define the CVA(s) work scope based on life extension plans activities. |
| Metocean Review/Update, and<br>Weight and Stability Review/Update | 3 yrs. | If it is determined the metocean needs to be updated, this is often best conducted as soon as possible, since metocean information is required for most system analysis updates. |
| Analysis Updates, and<br>Life Extension Inspections | 2-3 yrs. | As system analysis updates and inspection documentation become available, the operator should submit them to the CVA for review and approval. Best practice would be to engage the CVA before carrying out assessments to ensure alignment on methodology and key assumptions. |
| Regulatory Submittals | 1 yr. | Once the complete submittal package for a given system (e.g., risers, hull, etc.) has been verified by the CVA, the CVA will submit its recommendation to BSEE along with the supporting documentation. Different systems are reviewed and approved by different groups within BSEE. Once all the systems have been approved by the individual BSEE departments, a formal approval letter for the FPS will be provided to the operator. |

## 1.4 Regulatory Bodies, CVA and Class

### 1.4.1 Bureau of Safety Environment and Enforcement (BSEE)

BSEE is the primary regulatory agency that will review and approve the life extension. BSEE has three key internal departments that are involved in the review and approval of a FPS's life extension. These three departments and the associated systems they are responsible for are as follows:

- Office of Structural and Technical Support (OSTS) - hull, mooring, marine systems and topside structures
- Technical Assessment Section (TAS) - Top Tension Risers (TTRs)
- Pipeline Section (PS) - Steel Catenary Risers (SCR), flexible risers and gas lift umbilicals

An individual CVA nomination and life extension submittal for a specific system should be submitted to the responsible department within BSEE. Section 2.4 discusses the submittal process.

### 1.4.2 United States Coast Guard (USCG)

Based on recent life extension assessment experience, the initial interaction and vast majority of the reviews and approvals have been conducted by BSEE. However, the operators should inform the USCG of any updates to In-Service Inspection Plans (ISIP) for the hull structure and Marine Operations Manuals (MOM) and should make them available in the event the USCG wishes to review the updated documents. If the FPS operates under Class, these updated documents should be submitted to Class for review and approval.

Recent life extension experiences also indicated that the USCG may be more involved in the review and approval process of updated ISIP and MOM documents when the FPS is not operating under Class.

### 1.4.3 Certified Verification Agent (CVA)

Like approvals for the design of new FPSs, BSEE requires approved CVA(s) to be an integral part of the life extension review and approval process. BSEE requires that a nominated CVA for each system be submitted and approved by the responsible BSEE department. The CVA nomination and BSEE approval should be done early in the life extension assessment process through the DVP as shown in Figure 1.

The role of each CVA is to provide independent expertise to review studies, analysis, life extension inspection results and verify the execution of this work. As submittals for these activities are completed by the operator or their contracted engineering companies, they are submitted to and reviewed by the CVA. When the completed submittals for a system satisfactorily demonstrate the fitness of that system for the extended service life based on the CVA's review, the CVA will submit their recommendations for life extension for that system and the supporting submittal documentation to BSEE.

The CVA's expertise and independence are very important to BSEE. The CVA's role is to be an independent reviewer. Hence, it is important that the operator (or operator's contractors) developing the submittals is independent from the CVA. Issues with independence can arise when the CVA company is contracted to develop submittals (e.g., analysis) that form the basis of the life extension, while also being in the role of the CVA.

### 1.4.4 Class

For FPS's that are Classed, the operator should also initiate discussions (i.e., kick-off meetings) and interact with the Class Society similar to the interaction with BSEE. However, the covered systems will be limited to those covered by Class. These systems typically include the hull, mooring, marine systems and possibly topside structure.

Since Class has similar life extension review and approval requirements as BSEE for Classed systems, operators may consider nominating the Classification entities as the CVA for those specific systems as has been done on previously approved life extensions. As noted in Section 1.4.1, each CVA nomination should be submitted to the responsible department within BSEE for review and approval.

# 2 Engineering Review and Qualitative Assessment

The primary objectives of the engineering review and qualitative assessment is for the operator to define the basis, identify longevity drivers and develop a plan of activities to accomplish the life extension based on the operator's available information. This typically requires collection of information from Engineering, Operations, subject matter experts and the operator's management.

Outputs from this effort for the development of the Life Extension Plan generally include:

- Confirmation of technical feasibility and economic viability - Confirm no showstoppers and the anticipated future activities (e.g., renewals, maintenance, etc.) can be economically achieved in-situ
- Identification of life extension duration - Determine the desired life extension target life beyond the current approved design life
- Definition of the life extension basis - Define the future operating plans for the FPS (e.g., continue production with no changes, future drilling programs, additions, production fluid composition, etc.)
- Identification longevity drivers consisting of gaps or deficiencies in the design, operating and condition information, which form the basis of the required life extension plan activities
- Definition of work scope and identification of contractors and CVA for the life extension plan (e.g., inspection, analysis, renewals, etc.)

This work is typically completed internally by the operator before kicking off the formal life extension process with BSEE, since the operator should have a good understanding of the life extension basis, economics and overall anticipated engineering and inspection effort before approaching BSEE.

## 2.1 General Process

The process typically begins with a review of the future production forecasts and economics for the FPS. This provides initial insight into the potential target life extension duration. Available design, operating and condition data is collected on the systems and thoroughly reviewed.

A good reference describing this review and assessment process is the document entitled "Assessment and Decision-Making Framework" developed as part of DeepStar Project: 12401 - Continued Service Guidance for Aging Floating Infrastructure [1]. Additionally, Annex B of API 2FSIM [2] provides an overview of the "collect" and "assess" tasks that represent the review and initial assessment.

## 2.2 Data Requirements

The life extension process typically requires a wide variety of data in order to document and understanding the existing design, current condition and forecast the fitness for future service. Design, condition, and operating history data help to establish the facility's current state. The following sections provide a high-level summary of the types of data that may be required during the life extension process. Additional information on data requirements for the hull, mooring and risers can be found with API 2FSIM [2], 2MIM [3] and 2RIM [4], respectively.

### 2.2.1 Design

Design data provide information on how the facility is designed, constructed and installed while also defining arrangements and components that make up the systems. This data also contains information relating to the design philosophy, specific safeguards, the safety factors used and the intended service life. Note that design information may include the original design documentation, conversion documentation and any other assessments that have been conducted since the facility's installation. Typical design documentation includes the following, when available:

- Basis of Design
- Design analyses (e.g., stability, structural, station keeping, etc.)
- Structural drawings and general arrangements
- P&IDs for all marine systems
- Mooring system drawings and component details
- Corrosion protection plan and corrosion protection systems
- As-installed reviews and analyses
- Risk and consequence studies
- Inspection reports at construction and installation
- Inspection plans and operations and maintenance manuals

In some cases, a complete set of the original design documents may not be available and this may necessitate the need for additional life extension activities (e.g., analysis or inspections).

### 2.2.2 Condition

Condition data provides information on the current condition of the facility's systems. This should include structural conditions, condition of corrosion protection systems, existing anomalous conditions, prior repairs or replacements as well as preventative maintenance currently being performed. Condition documentation typically includes the following, when available:

- Inspection reports during service
- Monitoring data
- Repairs and maintenance logs
- Engineering and analysis results associated with any repairs
- Associated Class or Regulatory reports (e.g., the Survey Status Report)

### 2.2.3 Operating History

The operating history provides information on operational service and environmental conditions the facility has been exposed to through its operating life. Being exposed to conditions and operations that deviate from the specified design conditions can have a significant influence on a system's life (i.e., increase or decrease a system's life) relative to the original design life. Typical operating documentation includes the following, when available:

- Facility modifications
- Operational service conditions
- Environmental conditions
- Management of change documents

### 2.3 Qualitative Assessment

The individual system qualitative assessments are the foundation on which the life extension plan and associated assessment activities are built. An efficient means of systematically assessing the collected data is in a workshop format with a multidisciplinary team consisting of Operations personnel, subject matter experts (SMEs) and others with knowledge of the individual systems. The qualitative assessment can be conducted by other methods, provided adequate input is obtained from the appropriate personnel with intimate knowledge of the operation and current condition of the FPS. This assessment provides a means to review the collected data, obtain an understanding of the state of the facility, define the longevity drivers and make a preliminary identification of the activities required to address the longevity drivers. Some of the drivers that can influence the longevity of a system or the ability to demonstrate the systems fitness for future service include:

- Design longevity drivers
  - Design fatigue lives
  - Design strength / corrosion margins
  - Corrosion protection system design
  - Obsolescence
  - Lost / limited design data
- Condition longevity drivers
  - Condition of corrosion protection systems
  - Condition of structures and equipment (e.g., corrosion)
  - Limited condition data
- Operations longevity drivers
  - Metocean / loading conditions
  - Weight and stability conditions
  - Tank service conditions
  - Equipment usage

The identified activities to address the longevity drivers may be part of the life extension plan required to demonstrate life extension, as well as future integrity activities (e.g., corrosion protection renewals, equipment replacements, etc.) that may need later in the facility's life extension (i.e., after the approvals).

### 2.4 Life Extension Plan

Table 2 describes the typical deliverables from the review and assessment that form the operator's life extension plan. Note that most of the deliverables described below will be for internal use by the operator. However, they will enable the operator to begin the interaction with the BSEE with a clear understanding of the life extension team (operator representatives, 3rd party contractors and CVA) and the planned activities.

*Table 2 - Life Extension Plan Items*

| | |
|---|---|
| Life Extension Basis | This should define the desired life extension duration, planned future operations, any anticipated production changes, drilling, facility modifications or additions. Additionally, it should include the FPS' original design particulars (e.g., number of TTRs, risers, drilling capabilities, POB, etc.), original standards used for design as well as the ownership history. |
| Life Extension Plan | This should define the intended plan to demonstrate fitness for the proposed life extension. This should include the following<br>• Planned activities and deliverables, such as inspections and analyses, that will be conducted by the operator or operator's contractors<br>• Identified 3rd party contractors conducting the activities<br>• Nominated CVA(s) for the individual systems<br>• Overall schedule for the individual activities, submittals to CVA and the desired completion of CVA reviews and submittals to BSEE<br>• Life extension team points of contact, project organization roles and responsibilities |
| Draft Analysis and Inspection Details | For each of the identified activities in the life extension plan, the operator, with the assistance of 3rd party contractors as required, should define detailed work scopes. The details of these work scopes will need to be presented and agreed upon with the CVA(s). Examples of the type of details that need to be defined for analysis and inspection activities include<br>• Analysis - objectives, scope, methods, assumptions, criteria and industry references<br>• Inspection - objectives, scope and methods<br>Note that, as the plan is executed, some revisions to the plan may occur due to results from analyses and inspections. |

## 2.5 Initial Regulatory Interaction

### 2.5.1 Kick-Off Meeting

It is good practice for the operator to have a life extension plan kick-off meeting with BSEE to begin the life extension process. The meeting provides a forum for the operator to introduce their life extension point of contact as well as the planned team make up. The operator should be prepared to discuss their general plan, DVP and schedule that will be in the life extension request application submittal. The operator's nominated CVA for each of the systems should be presented, and the operator should also confirm the points of contacts at BSEEs different departments. It is important to be clear when requesting a kick-off meeting that all three branches of BSEE should be represented, if needed.

During the Kick-off meeting discussions or any follow up meetings with the different departments, the operator should work to ensure mutual agreement with BSEE on the proposed life extension plan activities (e.g., engineering reviews, inspection or analysis) and CVA activities (e.g., reviews or analysis) such that there are no surprises during the course of the project. For example, the operator should ensure mutual agreement on any system where the CVA may be required to conduct additional independent analysis.

### 2.5.2 Application Submittal

Applications are submitted via the BSEE TIMS Web epermit system. The applications may be sent to other BSEE departments for internal review (typically TAS will review the TTRs). The operator only submits applications for the parts for which they are the designated operator. If life extension for an export pipeline riser or a third-party tie back pipeline riser is desired, then those designated operators will have to submit the applications, not the primary facility operator. A CVA must be nominated and approved for all life extension projects.

A typical application will have the following sections:

- Introduction
- History of the Facility
- Summary of Life Extension Basis
- Methodology for Life Extension Assessment
- Alternative Compliance Requests
- Project Schedule
- CVA Review Scope and Qualifications
- References
- Common Acronyms

### 2.5.3 Alternate Compliance

For Life Extension, typical alternate compliance requests are related to using an Industry Standard in lieu of the standard referenced in BSEE regulations in 30 CFR 250.198. This includes using a later edition of a standard than the edition listed in the CFR. 30 CFR 250.141 describes requirements and approvals for alternative compliance requests. The alternate compliance request should be submitted with the Life Extension application in the epermit system, or can be a stand-alone request in the epermit system but then it needs to be linked back to the life extension submittal. The alternate compliance request has to summarize the differences between the incorporated standard and the proposed standard to be utilized and the operator needs to state that using the proposed standard will provide a degree of protection, safety and performance that is equal to or better than what would be achieved by compliance with the incorporated standard.

If additional industry standards are being used as guidance for life extension, but are not being used in lieu of any of the incorporated standards, these standards should be identified along with a confirmation that they are additional to and not being substituted for the requirements in the incorporated standards. For example, API RP 2MIM [3], 1st Edition incorporates the integrity management recommendation in API RP 2I, 3rd Edition [5] and API RP 2SK, 3rd Edition [6], but expands on the integrity management requirements in those incorporated documents.

# 3 Typical System Assessments and Submittals

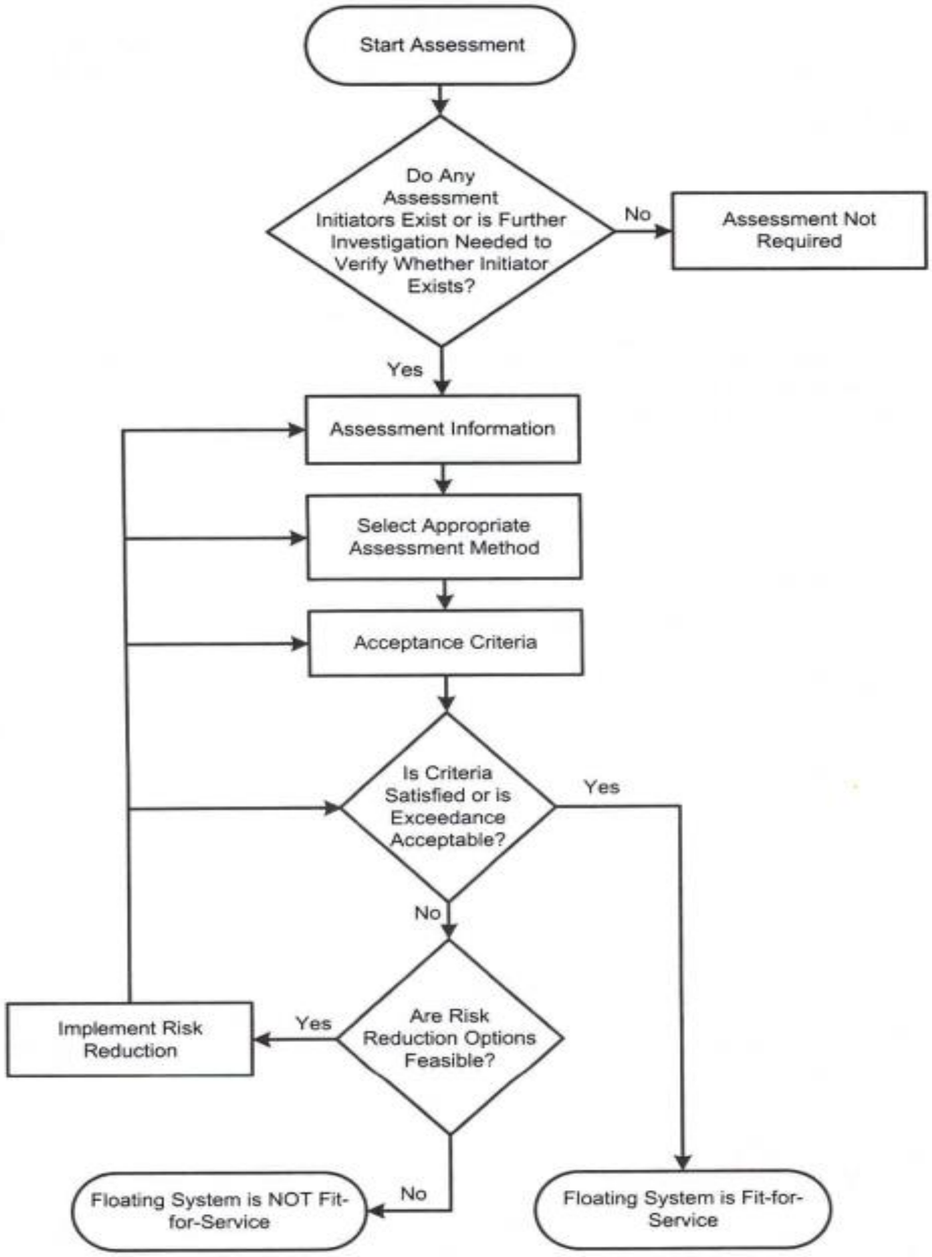
Life extension is a “trigger” to assess and update a facility’s integrity management program. Within API RP 2FSIM [2], RP 2MIM [3] and RP 2RIM [4] life extension triggers an assessment of the design and current operations and condition of a facility to determine if additional integrity management activities are warranted to demonstrate and achieve service life beyond the current, approved service life.
It is important to note that assessment for life extension is not simply reanalysis of the entire facility and/or all of its associated systems. It should consist of a progressive assessment process of the systems using one or more of the following activities:

- Reviews of existing design, operating and condition information,
- Engineering evaluations (e.g., comparisons to original design and current industry standards, risk-based assessments, etc.),
- Life extension inspections, and/or
- Facility System analysis (e.g., strength analysis, fatigue analysis, etc.)

Section 8.5 of RP 2FSIM [2] describes the progressive assessment process and methods to demonstrate fitness-for-service for individual systems (e.g., hull, mooring, etc.), as shown in flowchart provided in Figure 2. The typical deliverables developed will be dependent on the assessment method that is used. For example, a review of the original or prior design analysis, current condition and operating data may demonstrate a system’s fitness for future life extension service without the need for additional life extension inspections or system analysis. In this case, the deliverable will be a report documenting the review process, reference materials and the engineering basis for the conclusion. For systems where, additional life extension inspections or system analysis is required, the deliverables should include the inspection or analysis methods and results that form the basis of the conclusions.

This section describes typical assessments and submittals that may be warranted as part of the life extension process to demonstrate fitness for future service and to support decisions related to future integrity activities.

*Figure 2 - Typical Assessment Process for Individual Systems [2]*




## 3.1 Assessments Based on Load Changes

Load changes that exceed the original design or most recent analysis on a system can trigger the need for system analysis as part of the assessment process. The two most common load changes that can trigger the need for systems analysis are increased metocean loads and increased facility weight and vertical center of gravity, although topsides additions that increase the windage area may be a factor for stability if significant enough.

### 3.1.1 Metocean

For life extension, the operator should determine whether the metocean criteria used as the basis of the most recent facility system analysis (e.g., original design analysis or most recent reanalysis) represent the current metocean conditions. Significant increases in metocean loads can trigger the need for facility system analysis. API RP 2FSIM stipulates, "if the floating system is added to or altered such that the new combined environmental and operational loading is more than 5% beyond the original design loads and VCG limits, an assessment shall be performed." [2] This can also include loading on the deck from greenwater or loading on the topside due to negative air gap.

There are two approaches that may be taken to determine whether the metocean criteria used in previous analyses (i.e., original design analysis or analysis conducted while facility was in service) is current.

1. The operator can determine if there are any significant changes by commissioning a new site specific metocean study to determine the wind, wave and currents for the storm and eddy / loop current conditions. These results can be compared to the metocean used during the most recent facility system analyses to determine if there are any significant changes.
2. Alternatively, if site specific metocean updates have been conducted in the past, they can be considered to be representative of site conditions, if there have been no observed severe storm or eddy/loop current conditions in the region that would indicate the need for another revision. The operator may then use this metocean criteria to compare against that used in the most recent facility system analyses to confirm no significant changes.

This assessment will define the environmental criteria used in any facility systems analysis that may be required as part of the life extension assessment.

### 3.1.2 Weight and Stability

Lightship changes on the FPS should be tracked over the facility's life. For the life extension assessment, the aggregate sum of lightship changes categorized as non-exempt weight should be reviewed and assessed against USCG MTN 04-95 [7]. If the sum of the absolute values of all non-exempt lightship weight changes (both additions and removals) exceeds 2% of the currently approved total lightship value or the lateral center of gravity (TCG or LCG) of the lightship weight shifts by more than 1% of the hull's main dimension in the corresponding direction, a deadweight survey may be required as per USCG MTN 04-95. In addition, it should be verified that the operational VCG remains below the Max KG Curve, and that for TLPs the tendon tension remains within their specified operating envelopes.

The phantom weight should be calculated by taking the difference between the displacement value obtained from the measured draft and the displacement value calculated from the monitored and logged weights (variable loads, recorded lightship, mooring and hang-off structure tension loads, and ballast loads) to confirm this is not a significant percentage of the lightship.

API 2FSIM also stipulates, "if the floating system's stability parameters (e.g., weight, center of gravity, center of buoyancy, down flooding points, etc.) are more than 5% beyond the values used in the original intact or damage stability design, the floating system shall be assessed."

If the facility is Classed, the operator should also consult the Class requirements related to weight and stability changes.

## 3.2 System Life Extension Activities

This section describes system assessment and life extension inspection activities operators may conduct as part of a facility life extension. Note that the specific activities conducted by an operator can vary significantly based on the identified longevity drivers. Some factors that can influence the extent of system assessments and inspections include:

- Significant changes in metocean criteria or facility weight/wind area (i.e. stability and loading)
- Original design margins and safety factors
- Limited original facility design information (e.g., analysis, drawings, etc.)
- Limited inspection data
- Future plans (e.g., new additions or modifications, etc.).

The following subsections provide guidance on the types of longevity drivers typically identified with each system and the possible activities (i.e., assessments or inspections) that may be required to demonstrate fitness for future service.

### 3.2.1 Hull

Table 3 summarizes some of the typically identified longevity drivers for the hull and the potential life extension activities that may be required to demonstrate fitness for future service. It should be noted that the results from the conducted life extension activities may trigger additional activities. For example, structural analysis may identify new areas that warrant additional life extension inspections. In these cases, the final submittal results may be developed in an iterative manner. This is highlighted within Figure 1 by the two-way arrow between System Analysis and System Life Extension Inspections. RP 2FSIM [2] provides guidance on the hull assessment processes.

For the hull, Table 3 has a longevity driver associated with marine systems in addition structural longevity drivers. Marine systems are intended to cover ballast water, bilge, vents, soundings, fire water and any other piping systems within the hull.

*Table 3 - Typical Longevity Drivers and Potential Life Extension Activities for a HULL*

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Design Analysis | Analysis Information | Available complete set of existing (most recent) analysis | None | Limited or missing existing analysis results (i.e., original or previous reanalysis) may require hydrodynamic (i.e. global performance) and structural analyses of the hull. |
| | | Limited existing analysis | Analysis | |
| Condition | Inspection Information | Complete condition data set covering all of the hull (structure and corrosion protection systems) | None | Limited or missing inspection results on the overall condition of the hull may require additional life extension inspection campaigns to supplement the lack of condition information. Typically, if the ISIP inspections are up to date, include representative thickness measurements (or positive coating condition data where there is little breakdown) and are well documented, additional life extension inspections are typically only needed on a few identified locations where some additional data is needed to confirm the local condition. |
| | | Limited overall condition data set or limited condition data on a few identified locations (structure or corrosion protection systems) | Inspection | |

| **Typical Longevity Drivers** | | **Engineering Review and Qualitative Assessment Results** | **Potential Life Extension Activities** | **Comments** |
|---|---|---|---|---|
| Strength | Metocean | No significant change or lower load magnitude | None / Evaluation | Significant changes in metocean loads compared to those used for existing analysis results (i.e., original or most recent reanalysis) may require hydrodynamic (i.e. global performance) and structural analyses of the hull. |
| | | Significant change in load magnitude | Analysis | |
| | Corrosion | No or less than anticipated material loss | Evaluation | • Even with less than predicted corrosion (as defined in the basis of design) observed on the hull, rate estimates from prior inspections should be used to forecast future material loss to determine if future mitigation (e.g., coating) may be required to achieve the desired target life.<br>• If material loss is following original predictions or worse, a similar evaluation should be conducted to determine mitigation (e.g., coatings, repairs, etc.). Local structural analysis may also be used to determine actual allowable corrosion margins.<br>• For both result scenarios, additional life extension inspections may be needed to supplement existing prior inspection data. This will depend on the quality and extent of prior inspections. |
| | | Observed material loss at predicted rates or higher | Evaluation / Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Strength | Corrosion Protection | Good corrosion protection systems | Evaluation | • Even with good corrosion protection observed on the hull, anode wastage and coating breakdown estimates should be made based on prior inspections to forecast future effectiveness to determine if future mitigation (e.g., anode retrofits or coatings) may be required to achieve the desired target life.<br>• If deterioration observed, a similar evaluation should be conducted to determine mitigation (e.g., coatings, repairs, etc.). Local structural analysis may also be used to determine actual allowable corrosion margins.<br>• For both result scenarios, additional life extension inspections may be needed to supplement existing prior inspection data. This will depend on the quality and extent of prior inspections. |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| | | Deteriorated corrosion protection system (e.g., anode depletion, coating breakdown) | Evaluation / Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Fatigue | Metocean | No significant change or lower cyclic load exposure | None / Evaluation | • Even if the there is no significant change, it is important that the review of the metocean cyclic load exposure is clearly documented.<br>• Additionally, in some cases revised metocean cyclic load exposure may be lower than what was used in previous fatigue analysis. This information may be useful in demonstrating increased fatigue safety factors.<br>• Significant changes in metocean cyclic loading compared to metocean used for existing analysis results (i.e., original or most recent reanalysis) may require hydrodynamic (i.e. global performance) and structural analyses of the hull using updated site specific metocean. |
| | | Significant increase in cyclic load exposure | Analysis | |
| | Motions Monitoring | No significant change or lower cyclic load exposure | None / Evaluation | • Even if the there is no significant change, it is important that the review of the metocean cyclic load exposure is clearly documented.<br>• Additionally, in some cases actual measured cyclic load exposure may be lower than what was used in previous fatigue analysis. This information may be useful in demonstrating increased fatigue safety factors.<br>• Significant increases in observed cyclic loading compared to assumptions used for existing analysis results (i.e., original or previous reanalysis) may require hydrodynamic (i.e. global performance) and structural analyses of the hull using the latest motions data or updated site specific metocean.<br>• Where fatigue margins are lower than original design requirements, enhanced analysis techniques and inspections may be required to justify the fatigue performance of the critical connections. |
| | | Significant increase in cyclic load exposure | Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Fatigue | Fatigue Life | Safety factors for extended life satisfy industry guidance | None | • Even if the fatigue safety factors satisfy industry guidance, it is important that the review of the hull fatigue is clearly documented.<br>• If fatigue safety factors are lower than industry guidance for the structural criticality and inspectability, additional life extension inspection and/or analysis may be required to demonstrate fitness for future service. In some cases, connections may have originally been categorized as uninspectable, requiring higher fatigue safety factors, but if improved inspection techniques now allow these components to be seen, lower safety factors can be justified. |
| | | Safety factors for extended life lower than industry guidance | Inspection / Analysis | |
| | Condition Data | Complete condition data set covering all of the fatigue sensitive locations in the hull | None | • Limited or missing inspection results on the overall condition of the hull may require additional life extension inspection campaigns to supplement the lack of condition information. Typically if the ISIP inspections are up to date, include close visual or NDE of critical connections and are well documented, additional life extension inspections are typically only needed on a few identified locations where some additional data is needed to confirm the condition. |
| | | Limited overall condition data set or limited condition data on a few identified locations | Inspection | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Marine Systems | Corrosion | No substantial material loss | Evaluation | • Even with no substantial corrosion observed, rate estimates from prior inspections should be used to forecast future material loss to determine if future mitigation (e.g., coating, spool repairs, etc.) may be required to achieve the desired target life.<br>• If substantial material loss, a similar evaluation should be conducted to determine mitigation (e.g., coatings, repairs, etc.).<br>• For both result scenarios, additional life extension inspections may be needed to supplement existing inspection data. This will depend on the quality and extent of prior inspections. |
| | | Observed substantial material loss | Evaluation / Analysis | |
| | Condition Data | Complete condition data set covering the marine system piping (piping and corrosion protection systems) | None | • Limited or missing inspection results on the overall condition of the hull may require additional life extension inspection campaigns to supplement the lack of condition information. Typically, if the ISIP inspections are up to date, include representative thickness measurements (or positive coating condition data where there is little breakdown) and are well documented, additional life extension inspections are typically only needed on a few identified locations where some additional data is needed to confirm the local condition. |
| | | Limited overall condition data set or limited condition data covering the marine system piping (piping and corrosion protection systems) | Inspection | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Lightship | Lightship | No significant change | None | • Even with no significant change, it is important that the review of the lightship weight is clearly documented.<br>• If there is a substantial change, a deadweight survey may be required to validate the current lightship weight and centers.<br>• It is important to keep good records of lightship changes as VCG can only be validated numerically (incline tests are not feasible when moored on station) and significant penalties may be applied to the VCG value if the logged and measured lightship values do not correspond within acceptable limits for total weight and lateral CGs |
| | | Significant change | Deadweight survey | |
| | Phantom weight | Small phantom weight | None | • Even with no significant change, it is important that the review of the phantom weight is clearly documented.<br>• If there is a substantial change, a deadweight survey may be required. |
| | | Large phantom weight | Deadweight survey | |
| Stability | Stability Parameters | No significant change | None | • Even with no significant change, it is important that the review of the lightship and phantom weights, centers of gravity (LCG, TCG and VCG), wind areas, down flooding points, maximum KG curves is clearly documented.<br>• If there is a substantial change, a weight survey may be required and/or a hull stability analysis. |
| | | Significant change | Deadweight survey / Analysis | |

### 3.2.2 Topside Structure

The longevity drivers associated with design analysis, strength, fatigue, lightship and stability, and associated life extension activities for the topside structure will be similar to those described for the hull. RP 2FSIM [2] and API RP 2TOP [8] provides guidance on the topside structure assessment processes.

### 3.2.3 Mooring

Table 4 summarizes some of the typically identified longevity drivers for a mooring system and the potential life extension activities that may be required to demonstrate fitness for future service. A mooring system (also referred to as a station keeping system) is made up of off-vessel components (e.g., chain, steel wire rope, fiber rope, clump weight, buoy, winch, windlass, chain jack, stopper, triplates, H Links, shackles, fairlead, anchor, etc.) and on-vessel components (e.g., chain jacks, chain stoppers, hawse pipes, fairleads, etc.) that permanently moor or anchor the FPS. RP 2MIM [3] provides guidance on the mooring assessment processes.

Similar to the hull, results from the conducted life extension activities may trigger additional activities as highlighted within Figure 1 by the two-way arrow between System Analysis and System Life Extension Inspections.

*Table 4 - Typical Longevity Drivers and Potential Life Extension Activities for a MOORING SYSTEM*

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Design Analysis | Analysis Information | Available complete set of existing (most recent) analysis | None | Limited or missing existing analysis results (i.e., original or previous reanalysis) may require hydrodynamic (i.e. global performance) and mooring system analysis. |
| | | Limited existing analysis | Analysis | |
| Condition | Inspection Data | Complete condition data set covering mooring system (components and corrosion protection, if present) | None | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| | | Limited overall condition data set or limited condition data on some mooring components (structure or corrosion protection, if present) | Inspection / Data from other similar mooring systems | • Limited or missing inspection results on the overall condition of the mooring system may require additional life extension inspection campaigns although data from other similar mooring systems may supplement the lack of condition information.<br>• Typically, if the ISIP inspections are up to date and well documented and include representative chain diameter measurements at locations known to be more susceptible to corrosion or wear (or positive coating condition data where there is little breakdown), additional life extension inspections are typically only needed at a few locations (e.g., near the mooring line touch down region) where some additional data is needed to confirm the condition.<br>• Some regions of a mooring system may be uninspectable (e.g., region of mooring line on or in the seabed and the anchorage below the seabed). For these components, inspection data near these regions (e.g., measurements of components near the seabed) or from other similar mooring systems (e.g., experience from other FPS' operating in the Gulf of Mexico) may be used to estimate the condition. |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Strength | Metocean / FPS Position Requirements | No significant change or lower load magnitude or position requirements | None / Evaluation | • Significant changes in metocean loads or in the FPS position requirements compared to those used for existing analysis results (i.e., original or most recent reanalysis) may require hydrodynamic (i.e. global performance) and mooring strength analysis.<br>• Changes to FPS storm position requirements can be driven by riser strength or fatigue management. This highlights the potential interaction between the riser systems and the mooring system. |
| | | Significant change in load magnitude or position requirements | Analysis | |
| | Corrosion / Wear | No or less than anticipated material loss | Evaluation | • Even with less than predicted corrosion (as defined in the basis of design) or wear observed on mooring components, rate estimates from prior inspections should be used to forecast future material loss to confirm the component will have adequate strength to achieve the desired target life.<br>• If material loss is following original predictions or worse, a similar evaluation should be conducted to determine whether mitigation (e.g., chain section replacement) may be required before reaching the desired target life. Mooring strength analysis may also be used to determine actual allowable corrosion/wear margins. This may include more intensive analysis including modelling of the actual corrosion (i.e. 3D models from inspection results) combined with advanced FEA techniques.<br>• For both result scenarios, additional life extension inspections may be needed to supplement existing prior inspection data. This will depend on the quality and extent of prior inspections. |
| | | Observed material loss at predicted rates or higher | Evaluation / Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Strength | Corrosion Protection | Good corrosion protection systems | Evaluation | • Even with good corrosion protection observed for the on-vessel (e.g., chain jack/stopper and fairleads) or off-vessel (e.g., connectors, top of pile anchor, wire rope end termination, etc.) components, anode wastage and coating breakdown (if component corrosion protection relies on coatings), forecast future effectiveness based on prior inspections to determine if future mitigation (e.g., anode retrofits) may be required to achieve the desired target life.<br>• If deterioration is observed, a similar evaluation should be conducted to determine mitigation (e.g., anode renewal, component replacement, etc.). Mooring strength analysis and/or detailed component assessments may also be used to determine actual allowable corrosion margins.<br>• For both result scenarios, additional life extension inspections may be needed to supplement existing prior inspection data. This will depend on the quality and extent of prior inspections. |
| | | Deteriorated corrosion protection system (e.g., anode depletion, coating breakdown if present) | Evaluation / Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Fatigue | Metocean / FPS Position Requirements | No significant change or lower cyclic load exposure or position requirements | None / Evaluation | • Even if the there is no significant change, it is important that the review of the metocean cyclic load exposure is clearly documented.<br>• Additionally, in some cases revised metocean cyclic load exposure may be lower than what was used in previous fatigue analysis. This information may be useful in demonstrating increased fatigue safety factors.<br>• Significant changes in metocean cyclic loading or FPS position requirements compared to existing analysis results (i.e., original or most recent reanalysis) may require hydrodynamic (i.e. global performance) and mooring system analysis using the latest site specific metocean and/or FPS position requirements.<br>• Changes to FPS storm position requirements can be driven by riser strength or fatigue management. This highlights the potential interaction between the riser systems and the mooring system.<br>• Where fatigue margins are lower than original design requirements, enhanced analysis techniques and inspections may be required to justify the fatigue performance of the critical components. |
| | | Significant increase in cyclic load exposure or position requirements | Analysis | |
| Fatigue | FPS Motions / Mooring Tension Monitoring | No significant change or lower cyclic load exposure | None / Evaluation | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| | | Significant increase in cyclic load exposure | Analysis | • Even if the there is no significant change, it is important that the review of the metocean cyclic load exposure is clearly documented.<br>• Additionally, in some cases actual measured cyclic load exposure may be lower than what was used in previous fatigue analysis. This information may be useful in demonstrating increased fatigue safety factors.<br>• Significant increases in observed cyclic loading compared to assumptions used for existing analysis results (i.e., original or previous reanalysis) may require hydrodynamic (i.e. global performance) and structural analyses of the mooring system using the latest motions data, tension monitoring data or updated site specific metocean. |
| | Fatigue Life | Safety factors for extended life satisfy industry guidance | None | • Even if the fatigue safety factors satisfy industry guidance, it is important that the review of the mooring system fatigue is clearly documented.<br>• If fatigue safety factors are lower than industry guidance for the structural criticality and inspectability, additional life extension inspection and/or analysis may be required to demonstrate fitness for future service. In some cases, mooring components may have originally been categorized as uninspectable, requiring higher fatigue safety factors, but if improved inspection techniques now allow these components to be seen, lower safety factors can be justified. |
| | | Safety factors for extended life lower than industry guidance | Inspection / Analysis | |

### 3.2.4 Riser Systems

This section describes some of the typically identified longevity drivers for riser systems and the potential life extension activities that may be required to demonstrate fitness for future service. Riser systems are tubulars used for the transport of fluids between the sea floor and the FPS. Functions of a riser system may include well intervention, production, injection and export of produced fluids. A riser is typically part of a larger subsea system extending from a wellhead, tree, manifold, template or other structures on the seabed, to a boarding valve or pig trap on the FPS's topsides [6].

For this document, the riser consists of the dynamic portion of the riser system, as described within API RP 2RIM [4], with the top boundary that is somewhere at or above the point where it transfers load to the hull structure, and a lower boundary where it transfers load into a foundation, which could be a wellhead, pipeline or subsea structure. For risers structurally connected to the platform below the topsides, hull piping structurally clamped to the hull up to a boarding valve or pig launcher at the topsides is also included as part of the riser system for life extension assessments.

As noted in the previous sections, results from the conducted life extension activities may trigger additional activities as highlighted within Figure 1 by the two-way arrow between System Analysis and System Life Extension Inspections.

Table 5 summarizes some of the typically identified longevity drivers for riser systems, and the potential life extension activities that may be required to demonstrate fitness for future service. This table applies in general to all types of risers – top-tensioned, steel catenary, flexible, or umbilical gas lift risers. Some specific considerations for each type of riser are summarized below.

#### *3.2.4.1 Top Tensioned Risers (TTR)*

Top-tensioned risers are typically supported by either a group of hydraulically actuated cylinders, anchored to the topsides deck structure. However, other means of controlling top tension include elastomeric supports and buoyancy cans. The details of the supporting structure should be included in all assessments. Refer to Section 3.2.1 for structural considerations.

Note that most top-tensioned risers are well risers that provide direct vertical access to a wellhead on the seabed with well control on a tree at the top of the riser, hence the common alternative descriptions of "dry tree risers" or "direct vertical access risers". These are casing risers in that the riser provides the structural support for other well as a continuation of the well casing. The contents of the well production are contained within well tubing inside the riser. There is also typically a second casing between the riser and the well tubing (a.k.a dual casing risers). Only the external casing is considered in the structural integrity of the riser. Integrity management and life extension of the internal casing and well tubing, which do not carry the dynamic loads of the riser, are subject to separate regulatory requirements than addressed in this document. The annulus between the riser and the inner casing is typically pressurized with nitrogen to prevent internal corrosion. Monitoring the annulus pressure and contents is an important means of assuring the integrity of the interior of the riser.

Other top-tensioned risers may be connected to pipelines or subsea flowlines through a structural foundation that supports the dynamic loads of the riser at the seabed, allowing the pipeline or flowline to be unaffected by dynamics. These top-tensioned risers have more in common with steel catenary risers in that the interior is directly exposed to potentially corrosive production fluids and should be treated as such in integrity management and life extension assessments.

Top-tensioned riser systems include riser pipe, as well as numerous other forged components, including threaded connectors on each joint, stress joints (top and bottom), tie-back connectors (bottom), tensioner joints (top) and the tensioner system itself. They may also include buoyancy modules, wet insulation, and VIV suppression devices. All of these components are integral to the riser system and equally critical to its integrity, and should be considered in all stages of the life extension process.

#### *3.2.4.2 Steel Catenary Risers (SCR)*

A steel catenary riser is a direct extension of a pipeline or subsea flowline that transitions from horizontal at the seabed to nearly vertical (typically 5-15 degrees from vertical) at the FPS, through a natural catenary shape based on the weight and material properties of the pipe. There is no mechanical tensioner system involved, and there is no internal well tubing or casing.

The structural support on the FPS is made through a stress joint or flexible joint suspended from the hull or deck. In some cases, a pull tube is used to act as a stress joint, and other schemes may be used. In some instances, a subsea structure may be used to anchor the catenary some distance from touch-down. Steel catenary risers may include VIV suppression, wet insulation, or pipe-in-pipe insulation. All of these components are integral to the riser system and should be considered in all stages of the life extension process.

#### *3.2.4.3 Other Hydrocarbon Transporting Riser Systems*

Other riser systems that transport hydrocarbons, including flexible riser systems or gas lift umbilicals, will have similar longevity drivers as those described for SCRs. For such systems, the original manufacturer should be directly involved in the life extension process, including qualitative and quantitative assessments. Refer to API RP 17B [9] for integrity management and life extension guidance for flexible pipe, and consult the manufacturer of the flexible pipe. Additionally, components integral to the performance of these riser systems such as stress joints, bend stiffeners, buoyancy, VIV suppression, insulation or anchor systems, should be included as part of the riser life extension assessment process.

*Table 5 - Typical Longevity Drivers and Potential Life Extension Activities for RISER SYSTEMS*

| **Typical Longevity Drivers** | | **Engineering Review and Qualitative Assessment Results** | **Potential Life Extension Activities** | **Comments** |
|---|---|---|---|---|
| Design Analysis | Analysis Information | Available complete set of existing analysis | None | Limited or missing existing analysis results (i.e., original or previous reanalysis) may require hydrodynamic analysis of the FPS (i.e. global performance) and riser system analysis. |
| | | Limited existing analysis | Analysis | |
| Condition | Inspection and Monitoring Data | Complete condition data set covering riser system (internal and external) | None | • Limited or missing inspection and/or monitoring data on the overall condition of the system may require additional life extension inspection campaigns, monitoring data collection although data from other components that have similar internal operating conditions (e.g., downstream piping) may be used to supplement the limited condition information.<br>• Some regions of a riser system may be uninspectable (e.g., exterior in way of air cans or hull guide structures). For the exterior regions, the condition of the riser near the uninspectable region provides insight into the condition of the uninspectable region.<br>• For the interior of well risers (i.e. casing risers) the condition may be inferred from monitoring the annulus pressure and contents.<br>• For the interior of pipeline risers, the condition may be inferred by condition information upstream (e.g., well and fluid composition monitoring) or downstream (e.g., pipe corrosion coupons, topside pipe inspections and fluid composition monitoring) of the riser systems. |
| | | Limited overall condition data set or limited condition data | Inspection / Monitoring / Data from other components or similar risers | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Strength | Metocean / FPS Position Requirements | No significant change or lower load magnitude or position requirements | None / Evaluation | • Significant changes in metocean loads or in the FPS position requirements or FPS global performance characteristics compared to those used for existing analysis results (i.e., original or most recent reanalysis) may require hydrodynamic (i.e. global performance) and riser strength analysis.<br>• In addition to the riser strength, the analysis should also confirm the riser downstroke and upstroke relative to the riser stops, and the strength of the structural support for the tensioner system.<br>• Changes to FPS storm position requirements can be driven by the TTRs or other riser system (e.g., SCRs) strength or fatigue management. This highlights the potential interaction between the various riser systems as well as the mooring system.<br>• Riser top-tension changes due to changes in metocean conditions or to improve VIV performance may also affect riser dynamics and will require additional analysis. |
| | | Significant change in load magnitude or position requirements | Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Strength | Corrosion / Wear | No or less than anticipated material loss | Evaluation | • Corrosion / wear includes both the exterior and the interior of the riser pipe.<br>• Even with no substantial corrosion or wear observed, rate estimates from prior inspections and/or monitoring should be used to forecast future material loss to confirm the riser will have adequate strength to achieve the desired target life.<br>• If substantial material loss, a similar evaluation should be conducted to determine whether mitigation (e.g., cathodic protection, reduce corrosivity of internal fluids, etc.) may be required as part of a plan to achieve the desired targe life. Strength analysis may also be used to determine actual allowable corrosion/wear margins.<br>• For both result scenarios, additional life extension inspections and/or monitoring may be needed to supplement existing prior data. This will depend on the quality and extent of prior inspection and monitoring data. |
| | | Observed material loss at predicted rates or higher | Evaluation / Analysis | |
| Strength | Corrosion Protection | Good corrosion protection systems | Evaluation | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| | | Deteriorated corrosion protection system (e.g., exterior anode depletion, exterior coating breakdown, ineffective internal corrosion inhibitor program) | Evaluation / Analysis | • Even with good corrosion protection, estimates should be made based on prior inspection and/or monitoring results to forecast future effectiveness to determine if future mitigation may be required to achieve the desired target life.<br>• If deterioration is observed, a similar evaluation should be conducted to determine mitigation (e.g., coating above water and in the splash zone, external anodes, internal corrosion inhibitor, annulus gas, etc.). Strength analysis may also be used to determine actual allowable corrosion margins.<br>• For both result scenarios, additional life extension inspections of the exterior and/or additional monitoring may be needed to supplement existing data. This will depend on the quality and extent of prior inspections and/or monitoring program. |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Fatigue | Metocean / FPS Position Requirements | No significant change or lower cyclic load exposure or position requirements | None / Evaluation | • Even if the there is no significant change, it is important that the review of the metocean cyclic load exposure is clearly documented.<br>• Additionally, in some cases revised metocean cyclic load exposure may be lower than what was used in previous fatigue analysis. This information may be useful in demonstrating increased fatigue safety factors.<br>• Significant changes in metocean cyclic loading or FPS position requirements compared to existing analysis results (i.e., original or most recent reanalysis) may require hydrodynamic (i.e. global performance) and riser analysis using the latest site specific metocean and/or FPS position requirements.<br>• Changes to FPS storm position requirements can be driven by riser strength or fatigue management. This highlights the potential interaction between the different riser systems as well as the mooring system. |
| | | Significant increase in cyclic load exposure or position requirements | Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Fatigue | FPS Motions / Riser Tension Monitoring | No significant change or lower cyclic load exposure | None / Evaluation | • Even if the there is no significant change, it is important that the review of the metocean cyclic load exposure is clearly documented.<br>• Additionally, in some cases actual measured cyclic load exposure may be lower than what was used in previous fatigue analysis. This information may be useful in demonstrating increased fatigue safety factors.<br>• Significant increases in observed cyclic loading compared to assumptions used for existing analysis results (i.e., original or previous reanalysis) may require hydrodynamic (i.e. global performance) and riser system analysis using the latest motions data, tension monitoring data or updated site specific metocean. |
| | | Significant increase in cyclic load exposure | Analysis | |

| Typical Longevity Drivers | | Engineering Review and Qualitative Assessment Results | Potential Life Extension Activities | Comments |
|---|---|---|---|---|
| Fatigue | Fatigue Life | Safety factors for extended life satisfy industry guidance | None | • Even if the fatigue safety factors satisfy industry guidance, it is important that the review of the mooring system fatigue is clearly documented.<br>• If fatigue safety factors are lower than industry guidance for the structural criticality and inspectability, additional life extension inspection and/or analysis may be required to demonstrate fitness for future service. In some cases, mooring components may have originally been categorized as uninspectable, requiring higher fatigue safety factors, but with inspections lower safety factors can be justified. |
| | | Safety factors for extended life lower than industry guidance | Inspection / Analysis | |

### 3.3 System Life Extension Submittals

This section describes typical life extension submittals that may be required for review and approval by the CVA and BSEE. The specific number of life extension submittal documents will be contingent on the identified longevity drivers and associated activities determined to demonstrate the fitness for future service.

Table 6 summarizes the typical life extension submittals that may be required as well as the BSEE group that will be responsible for the regulatory review and approval. Note that the Life Extension Structural Analysis descriptions provided within the table for different system may include various types of analyses, for example, corrosion analysis or fracture mechanic analysis (e.g., failure assessment diagram).

*Table 6 - Typical Life Extension Submittals*

| System | Submittal | Min. Required | May Be Required | Description | BSEE Group |
|---|---|---|---|---|---|
| Metocean | Evaluation of Metocean Criteria | **X** | | Engineering review of the metocean used for the prior system analyses to determine the need for a new site specific metocean study. Since metocean criteria will influence loading on all systems, this submittal is required to provide the basis for the loading on the systems. Note: If it is determined the development of new metocean criteria is required, the results of the engineering review can be described in the new site specific metocean submittal. In this case, the development and submittal of engineering review would not be required. | OSTS, TAS & PS |
| | New Site Specific Metocean Criteria | | **X** | The development of the new metocean may be required if the engineering review determined increases in metocean loading. Since metocean criteria will influence loading on all systems, this submittal may need to be provided with analysis conducted on the systems. | OSTS, TAS & PS |
| Lightship / Stability | Review of Lightship Weight Changes and Stability | **X** | | Engineering review of weight, center of gravity, and any other potential changes to the FPS weight or stability and any associated longevity drivers. | OSTS |
| | Deadweight Survey | | **X** | This survey may be required if the engineering review identified significant changes in weight or center of gravity. | OSTS |
| | Stability Analysis | | **X** | This analysis may be required if the engineering review or deadweight survey identified significant changes in weight, center of gravity or down flooding points. | OSTS |

| System | Submittal | Min. Required | May Be Required | Description | BSEE Group |
|---|---|---|---|---|---|
| | | | | | |
| Hull | Evaluation of Hull Structure and Marine Systems | X | | Engineering review of design (including prior structural analysis results or significant changes in the lightship), condition (including corrosion protection systems) and operating exposure (including any FPS motion monitoring) of the structure and marine systems and any associated longevity drivers. | OSTS |
| | Life Extension Inspections | | X | Life extension inspection report(s) covering locations identified within the engineering review or structural analysis. Reports may include external hull above the water, internal hull or below water inspection results. | OSTS |
| | Hydrodynamic Analysis | | X | This analysis may be required if updates in the global performance is required for the hull, topside structure, mooring or risers. | OSTS |
| | Life Extension Structural Analysis (Strength & Fatigue) | | X | Life extension analysis report(s) covering locations identified within the engineering review or the life extension inspections. Reports may include global structural analysis and/or local analysis of connection details or identified degraded structure. | OSTS |
| Topside Structure | Evaluation of Topside Structure | X | | Engineering review of design (including prior structural analysis results or significant changes in the lightship), condition (including coating conditions) and operating exposure (including any FPS motion monitoring) of the structure and any associated longevity drivers. | OSTS |
| | Life Extension Inspections | | X | Life extension inspection report(s) covering locations identified within the engineering review or structural analysis. | OSTS |
| | Life Extension Structural Analysis (Strength & Fatigue) | | X | Life extension analysis report(s) covering locations identified within the engineering review or the life extension inspections. Reports may include global | OSTS |

| System | Submittal | Min. Required | May Be Required | Description | BSEE Group |
|---|---|---|---|---|---|
| | | | | structural analysis and/or local analysis of connection details or identified degraded structure. | |
| Mooring | Evaluation of Mooring System | X | | Engineering review of design (including prior structural analysis results), condition (including corrosion protection systems if applicable) and operating exposure (including any FPS motion monitoring or FPS position changes) of the system and any identified longevity drivers. This may include statements on component life from OEMs. | OSTS |
| | Life Extension Inspections | | X | Life extension inspection report(s) covering locations identified within the engineering review or structural analysis. | OSTS |
| | Life Extension Structural Analysis (Strength & Fatigue) | | X | Life extension analysis report(s) covering locations identified within the engineering review or the life extension inspections. Reports may include global structural analysis and/or local analysis of components or identified degraded components. | OSTS |
| Riser Systems | Evaluation of Riser System | X | | Engineering review of design (including prior structural analysis results), condition (including corrosion protection and monitoring) and operating exposure (including any FPS motion monitoring, FPS position changes and fluid composition) of the system and any identified longevity drivers. This may include statements on component life from OEMs. | TAS or PS |
| | Life Extension Inspections and/or Monitoring | | X | Life extension inspection report(s) covering locations identified within the engineering review or structural analysis. | TAS or PS |

| System | Submittal | Min. Required | May Be Required | Description | BSEE Group |
|---|---|---|---|---|---|
| | Life Extension Structural Analysis (Strength & Fatigue) | | **X** | Life extension analysis report(s) covering locations identified within the engineering review or the life extension inspections / monitoring. Reports may include global structural analysis and/or local analysis of components or identified degraded components. | TAS or PS |

## 3.4 Operation Document Updates

This section provides a description of potential updates to the FPS operating documents that may be required as part of the life extension assessment process. The two key operating documents that are required to be up to date and onboard the FPS are the In-Service Inspection Plan (ISIP) and the Marine Operations Manual (MOM). Typical updates conducted on this document for life extension are described in the following subsections.

If these operation documents are updated as part of the life extension, the revised document should be submitted to the CVA for review and approval. Once the documents have been approved by the CVA, the documents and an accompanying CVA report should be submitted to BSEE for their review and approval. Note for updates to the operation regulatory document updates (i.e., ISIP and MOM), the operator should inform the USCG and make the documents available, if requested.

### 3.4.1 In-Service Inspection Plan (ISIP)

FPS's operating within United States waters are required to have an ISIP that covers the hull structure (including attachments and appurtenances), marine systems (including vents, ballast systems, propulsion, steering, etc.) and mooring systems [2]. The ISIP will define the planned inspection activities (survey schedule and scope) for the approved operating service life of the FPS. For life extension, the ISIP should be updated to include the scheduled inspection activities for the additional approved years of operating service. The life extension assessment work (i.e., engineering reviews, will form the basis for the ISIP revision. RP 2FSIM [2] and RP 2MIM [3] provide guidance on the development and content of hull and mooring ISIPs.

### 3.4.2 Marine Operations Manual (MOM)

Similar to the ISIP, a MOM is required to be onboard the FPS. The MOM defines the design, the operations and the operating parameters of the various systems that comprise the FPS. Any changes to the design, operation, and operating parameters that have been approved by BSEE and/or the Class Society, if applicable, as part of the life extension should be included within a revised MOM. Additionally, the FPS operations should be informed of the specific MOM revisions, reason for the changes and their influence on the FPS operations.

# 4 Lessons Learned

The following describes some lessons learned from experience on previous life extension projects.

1) Start the Initial "Qualitative" Life Extension Assessment Process Early - As shown in Table 1, the process for determining if a life extension plan is economically viable and technically feasible can take the owner considerable time. In addition to this, the sooner the owner determines their desire to pursue a life extension during the service life of the facility, the sooner the facility's integrity management program can be aligned to support that decision. This may include ensuring activities such as maintenance of corrosion protection systems are adjusted so that the facility can achieve the desired life extension. If integrity management activities are allowed to fall behind in the later service years, a substantial maintenance backlog can build up. This can tie up offshore resources and prevent other works required to achieve the life extension (see POB concerns in number 7 below). Hence, the earlier the owner knows they plan to extend the service life, the smaller will be the adjustments and increases to offshore integrity management activities (e.g., fabric maintenance) needed to align to that objective. This will increase the likelihood of successfully achieving the desired life extension.

2) Conduct the "Qualitative" Assessment Process Before Getting into Detailed Analyses - There is often a tendency with life extension projects to immediately jump into detailed analysis prior to conducting any of the initial review or initial qualitative assessment process shown in Figure 1. Analysis is important and often required to demonstrate the fitness of certain systems. However, starting analysis without a detailed review of the facility's actual condition or an understanding of the longevity drivers and operating constraints can result in misplaced resources focusing on systems and structures that may have limited impact on achieving the desired life extension. As a result, it is recommended prior to starting any detailed analysis that, at a minimum, a comprehensive data gathering and review be conducted and documented. This initial work is typically not an extensive effort, but it will ensure that any analyses conducted will be focused on the critical structures or systems, at the appropriate level of detail.

3) Ensure There are Appropriate Maintenance Strategies in Place to Achieve the Life Extension - Maintenance programs should be pragmatic and proactive to prevent a backlog of activities from occurring at the end of the facility's original service life. This issue has been observed more often when a contractor is operating the facility on behalf of the facility owner, and there are no incentives in the commercial terms of the operator's contract to maintain the structure above the bare minimum requirements. This minimum maintenance strategy can precipitate the need for substantial work at the end of the facility's original service life to enable the life extension when the operator's contract is complete. To prevent this from occurring, owners may renegotiate the contract to address these issues, or simply take over operation.

4) Ensure Multi-discipline Team Involvement in the Qualitive Assessment, Life extension Inspection Planning and Analysis Process - Input from all disciplines is important to obtain a comprehensive understanding of the condition and relative risk levels between systems, required repairs and renewals and overall level of effort to maintain the facility in the future. This information is key to obtaining realistic life extension execution costs and understanding of the overall risks.

5) Longer Life Extension Durations Can Be Costly to Achieve – As the duration of life extension increases, the cost increase is typically not linear, as the likelihood for system replacements will be greater. For example, mooring line corrosion forecasts based on prior inspections may predict fitness for 10-15 more years, but for 20-25 more years, line replacements may be required. Additionally, for some period, topsides equipment can be maintained with normal practices, but there may come a time when substantial renewals or replacements may be required offshore at a level of cost that can diminish the economic viability of life extension.

6) Factors that Can Influence the Level of Life Extension Effort - Below are some examples of factors that can influence the identified longevity drivers and associated amount of work (e.g., engineering assessment, inspection, repair, etc.) that may be required to demonstrate a facility is fit for service beyond its original service life.

   a. Missing original facility design information (e.g., analysis, drawings, etc.) - Lack of information on the facility's design makes it difficult to demonstrate the fitness of the facility or forecast the influence of degradation (e.g., corrosion or fatigue) on a system. This lack of information often requires the regeneration of the design information (e.g., structural analysis).
   b. Original design margins and safety factors - Where facilities or systems were built with margins and safety factors above industry or Class minimum requirements, the level of inspection or analysis effort may be less when compared to facilities that were designed strictly to minimum requirements. This is especially the case at locations where the metocean loads have increased over time.

   c. Quality of Owner's Fabric Maintenance Program - A facility that is well maintained (i.e., has a low backlog of coating maintenance, machinery maintenance, etc.) will be more likely to demonstrate the ability to operate beyond the facility's original service life without the major campaigns to address backlogged maintenance that can significantly tie up resources and POB. In some cases, owners have had to consider major shutdowns, maintenance campaigns and even the use of accommodations vessels to address the backlog of maintenance activities.

   d. Future plans (e.g., new additions or modifications, etc.) - Additions or major modifications planned as part of the life extension (e.g., new production tie-backs, new topside process equipment, etc.) that were not part of the original design basis will typically increase the assessment effort in order to demonstrate the fitness for future service. Additions can also increase the life extension inspection requirements, since greater resolution will be needed on the current condition of the existing systems where the additions or modifications will tie into them.

7) Importance of Assessing Future POB Requirements - The life extension assessment may identify additional future integrity management activities (e.g., increased future schedule inspections, coating renewals, system replacements, etc.) that will be required. These additional activities will typically require additional offshore resources and associated POB. Since POB restrictions are common, it is important that the operator investigates the future POB requirements as part of the life extension assessment process. This will ensure that offshore activities that are technically feasible are also feasible from an execution viewpoint.

8) Ensure the Independence of the CVA - The CVA's role is to independently review documentation (e.g., inspection results, design documents, reviews, assessment, analysis, testing, etc.) submitted by the owner and the owner's 3rd party contractors to demonstrate fitness for service beyond the original service life. The CVA is a company (e.g., engineering consultancy firm, Class Society or engineering design company) with expertise on a specific system (i.e., hull, mooring, risers, TTRs) contracted by the owner to submit an independent recommendation to BSEE based on their review of the provided information. Independence issues have arisen when the company in the CVA role also develops supporting information on behalf of the owner (essentially acting as one of the owners 3rd party contractors). In this case, the CVA is now reviewing and making recommendations based on their own work products, which can be (or give the appearance of) a conflict of interest.

9) System Analysis and Life extension Inspections Can Influence Each Other - It is important to highlight that analysis and life extension inspection activities for the different systems (See the blue box in Figure 1) may be interdependent and require an iterative process to reach a final conclusion. For example, the analysis review or updates may identify locations requiring life extension inspections, or the life extension inspections may identify areas that warrant additional analysis to confirm fitness for future service.

## 5 References

1. Assessment and Decision-Making Framework, DeepStar Phase XII, Project: 12401 - Continued Service Guidance for Aging Floating Infrastructure, Nov 2015.
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4. API Recommended Practice 2RIM, Riser Integrity Management, First Edition, Sep 2019.
5. API Recommended Practice 2I, In-service Inspection of Mooring Hardware for Floating Structures, 3rd Edition, Apr 2008.
6. API Recommended Practice 2SK, Design and Analysis of Stationkeeping Systems for Floating Structures, 3rd Edition, Oct 2005.
7. Marine Safety Center Technical Note 04-95, CH-2, 16710/Lightship Change, February 11, 2016.
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9. API Recommended Practice 17B, Recommended Practice for Flexible Pipe, Fifth Edition, May 2014.