

Floating Systems Integrity Management

API RECOMMENDED PRACTICE 2FSIM
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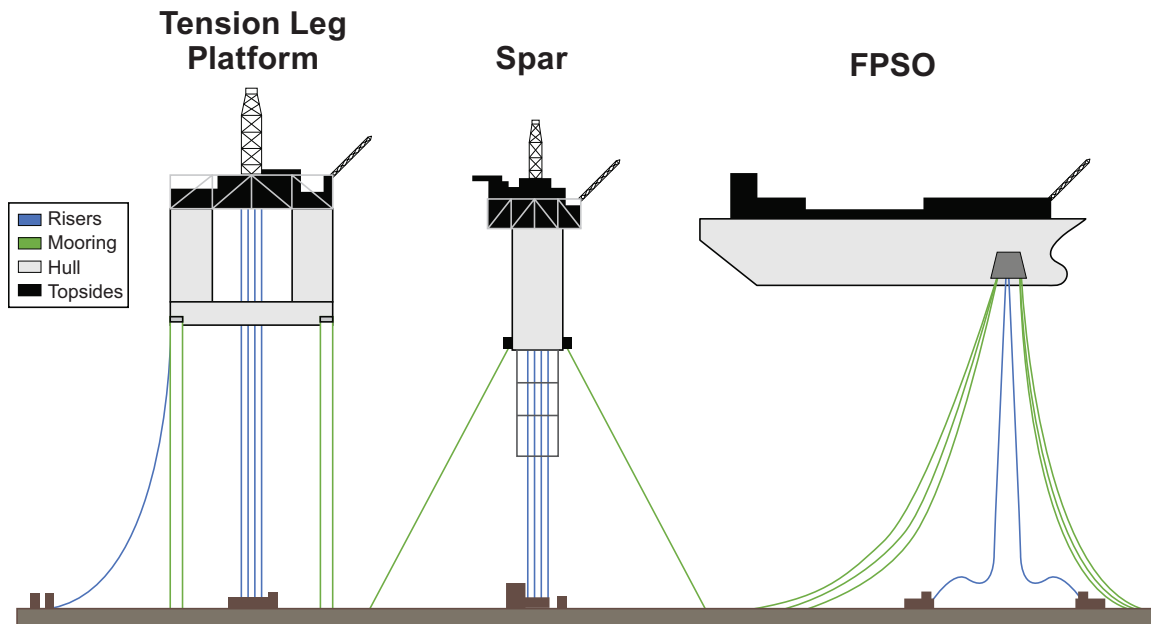
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Introduction

This recommended practice (RP) is one of three additions to API's portfolio of offshore floating structures standards that address integrity management (IM) of floating systems (API 2FSIM), mooring systems (API 2MIM), and riser systems (API 2RIM).

This RP is intended to be used by owners and engineers in the development, implementation, and delivery of a process to maintain system integrity of floating production systems (FPSs), including tension leg platforms (TLPs). The specifications, procedures, and guidance provided herein are based on internationally recognized industry standards and on global industry best practices.

API's existing suite of recommended practices such as API 2FPS, API 2T, API 2SK, API 2RD, and API 2SIM address several aspects of life cycle integrity management expectations, and the three new standards add to that suite by capturing experiences from owners, operators, integrity management specialists, recognized classification societies (RCSs), and regulators, establishing a common framework for IM for FPSs. Figure Intro 1 pictorially depicts the interfaces between the hull and mooring and risers for various types of FPSs and the IM standard that addresses the specific systems.



Physical Interfaces between API IM Standards

Implementation of effective integrity management for floating systems requires an understanding of the interfaces between the hull, mooring, and risers and how they translate to stewardship of IM activities in the field. The new standards have been developed with the objective of recognizing and identifying key interfaces, and they emphasize the criticality of a systems level approach.

By having a consistent systems level approach and by pursuing a risk-based framework to develop, evaluate, plan, and implement an integrity management program for a floating system, the user can tailor the IM program around the unique design drivers, in-service and operating conditions while conforming to the owner's organizational safety, health and environment risk management policies and regulatory requirements.

Floating Systems Integrity Management

1 Scope

This recommended practice (RP) provides guidance for floating system integrity management (FSIM) of floating production systems (FPSs), which include tension leg platforms (TLPs), used by the petroleum and natural gas industries to support drilling, production, storage, and/or offloading operations.

FPSs described in this RP are governed by local regulatory requirements and recognized classification society (RCS) rules (if classed). No specific regulatory compliance or RCS requirements are restated in this RP. The requirements of this RP do not apply to mobile offshore drilling units (MODUs) or to mobile offshore units (MOUs) used in support of construction operations. For integrity management (IM) considerations, these units are typically governed by RCS rules, and include, among others:

- floating systems intended primarily to perform drilling and/or well intervention operations even when used for extended well test operations;
- floating systems used for offshore construction operations (e.g. crane barges or pipelay barges), for temporary or permanent offshore living quarters, or for transport of equipment or products (e.g. transportation barges, cargo barges); for these, see appropriate RPs.

This RP does not address moorings or risers; these are addressed separately by API 2MIM and API 2RIM, respectively. Dynamic positioning is not covered in this RP.

The following types of floating systems are explicitly covered by this RP:

- ship-shaped floating systems and barges (monohull or otherwise);
- semisubmersibles;
- spars;
- tension leg platforms (TLPs), including tendon systems.

The following types of floating system components are included within the context of this RP:

- hull structure, including above water, below water, and internal (i.e. hull compartments) structure and corrosion protection systems (e.g., coatings, cathodic potential, etc.);
- structural systems, such as turrets, topsides structure, helidecks, flares, cranes, and process decks, and their interfaces with the hull structure;
- mooring system support structure on the hull (e.g. foundations for chain jacks, fairleads, chain stoppers, etc.)
- tendon systems, including foundations;
- marine systems, such as ballast, bilge, venting, soundings, firefighting systems, cargo systems, emergency power, propulsion, steering, sensors, alarms, and controls (vessels in transit are not included);
- permanent means of access and egress, including walkways, grating, handrails;
- structural interfaces between hull structure and riser system;

- appurtenances;
- life safety appliances.

This RP is directly applicable to oil and gas producing floating systems operating at ambient temperature, including floating liquefied natural gas (FLNG) plants, except for the aspects related to handling and storage of cryogenic liquids.

The FSIM process provided in this RP is applicable to floating systems installed at any location worldwide. However, the referenced metocean criteria has regional limitations.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API Recommended Practice 2A-WSD, *Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design*, 22nd Edition

API Recommended Practice 2EQ, *Seismic Design Procedures and Criteria for Offshore Structures*

API Recommended Practice 2MET, *Derivation of Metocean Design and Operating Conditions*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

air gap

The clearance between the highest water surface that occurs during the extreme environmental conditions and the lowest exposed structural part not designed to withstand wave impingement.

NOTE The highest water surface includes effects of tide, surge, wave crest elevation, and local diffraction/radiation effects. It does not include spray, runup, or local jets of water.

3.1.2

anomaly

An observation or finding indicating the possibility that a certain parameter could be outside an acceptable design or performance threshold.

3.1.3

appurtenances

Nonstructural attachments and any other components that interface with the hull structure.

3.1.4

assessment

A technical review process triggered by an assessment initiator (as identified during an evaluation) to demonstrate that a system or structure is fit-for-service or to determine the need for risk reduction.

3.1.5**assessment initiator**

Changes in floating system condition or operating experience, such as storms, which require an existing floating system to undergo an assessment to demonstrate fitness-for-service.

3.1.6**condition assessment**

The process of gathering information on a floating system's present condition to perform a fitness-for-service assessment.

3.1.7**decommissioning**

A process followed to plan for, and implement the removal, disposal, or offsite reuse of the floating system structure, equipment, and the associated pipelines and wells.

3.1.8**defect**

An imperfection or flaw in a component of an existing floating system.

NOTE As used in this RP, the term "defect" does not necessarily denote that the floating system is not fit-for-service.

3.1.9**design level analysis**

A fitness-for-service analysis of a floating system using linear-elastic methods with an appropriate safety margin, similar to the analysis methods used for new floating system designs

3.1.10**design life**

The time period assumed for defining various design parameters such as corrosion allowance and fatigue life.

3.1.11**evaluation**

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.

3.1.12**exposure category**

The classification used to categorize the consequence of failure based on the consideration of life safety, environmental pollution, and business disruption.

3.1.13**extreme event**

A design metocean, seismic, and/or ice condition, with a low probability of exceedance, that a floating system can be subjected to during its operational life.

3.1.14**facility system analysis**

An analysis used to demonstrate the fitness-for-service of a floating system.

NOTE The analysis can be structural, stability, stationkeeping or other analysis.

3.1.15**failure**

Insufficient strength or inadequate serviceability of a system or component to fulfill its performance requirements.

3.1.16**fitness-for-service**

A demonstration that a floating system has adequate integrity for the intended operating conditions while maintaining design functionality.

3.1.17**floating system**

A floating production system (FPS) exclusive of moorings, risers and umbilicals, but inclusive of tendons in the case of a TLP.

3.1.18**floating systems integrity management (FSIM)**

A process for demonstrating a floating system's fitness-for-service over its entire service life.

3.1.19**greenwater**

The overtopping of a deck by water causing slamming and pressure actions to structures and facilities on the deck.

3.1.20**in-service**

The condition that characterizes a floating system that has been commissioned and placed in operation.

3.1.21**inspection**

A specific visual or nondestructive examination performed for collecting data required in evaluation of an FPS's integrity.

3.1.22**integrity data**

Information on the design, condition, and operation of a floating system.

3.1.23**life extension**

The procedure of demonstrating the extension of the operational life of a floating system beyond the life specified during the original design and/or as originally permitted.

3.1.24**management of change**

A system for review and approval of changes in processes, procedures, or physical components prior to implementation of the change.

NOTE This usually includes assessment of risk, economic, and schedule implications.

3.1.25**mechanical damage**

A defect type that can include structural and mechanical fractures, permanent deformation, dents, bows, gouges, holes, and separated or severed members.

3.1.26**mitigation**

Actions taken to limit negative consequences or to reduce the likelihood of occurrence of an event or condition.

3.1.27**non-redundant component**

A component for which failure would result in complete or partial failure of the floating system.

3.1.28**operating team**

Personnel responsible for the operation of a floating system after its installation and commissioning.

NOTE The personnel may be comprised of owner personnel or contractor personnel.

3.1.29**operator**

The person, firm, corporation, or other organization employed by the owners to operate a floating system.

3.1.30**original design criteria**

Design basis and design codes used in the original floating system design.

NOTE The design criteria include reference codes, metocean conditions, analysis methods, safety factors, and original design assumptions.

3.1.31**owner**

The company or companies that own a development facility, which can be the owner on behalf of co-licensees.

3.1.32**performance criteria**

Criteria used in a fitness-for-service assessment of the floating system.

3.1.33**phantom weight**

The difference between hull displacement at current draft and the total weight determined from the daily weight report.

NOTE 1 For a TLP, phantom weight is determined from the difference between (displacement minus tendon tension) and the total weight determined from the weight report.

NOTE 2 Phantom weight reflects uncertainties in facility weight, mooring and riser vertical loads, tendon tensions as applicable and displacement calculations

3.1.34**project team**

The personnel responsible for the design, construction and installation of a new or converted floating system.

NOTE The personnel may include owner representatives, contractors and equipment vendors.

3.1.35**recognized classification society (RCS)**

Member of the international association of classification societies (IACS), with recognized and relevant competence and experience in floating systems, and with established rules and procedures for classification/certification of installations used in petroleum or natural gas activities, located at a specific site for an extended period.

3.1.36**redundancy**

The availability of alternate load paths in a floating system following the failure of one or more structural components.

NOTE This can also relate to availability of alternate equipment or systems following the failure of one or more pieces of equipment or systems.

3.1.37**redundant system**

A system for which its global capacity is maintained even when one or more of its primary system components (e.g. structural elements) have failed.

3.1.38**repair**

The work necessary to restore a deteriorated structure or system to a condition deemed fit-for-service.

3.1.39**robustness**

the ability of a floating system to withstand events that have a reasonable likelihood of occurring without being damaged to an extent that renders it unsafe or on the verge of collapse.

3.1.40**semisubmersible**

A floating system normally consisting of a deck structure supported with several widely spaced, large cross-section, supporting columns connected to submerged pontoons; and kept on-station with a conventional mooring.

3.1.41**service life**

The time period between a floating system's installation date and the anticipated end of service.

3.1.42**ship-shaped hull**

A floating system consisting of a single, continuous, buoyant hull, and having a geometry similar to that of ocean-going ships, barges, etc.

3.1.43**significant change**

A change in the condition, operation, operational exposure, or design basis of a floating system that can: (1) increase risks, (2) reduce the floating system's global capacity below the original design, or (3) expose the floating system to conditions different from the original or current service.

3.1.44**spar**

A deep-draft, small water-plane area floating structure.

3.1.45**special area**

A part of the structure identified by the designer as being of particular importance to the system integrity and safety of the system.

3.1.46**splash zone**

The area of the floating system that is intermittently wet or dry due to wave and tidal actions or change in operating draft.

3.1.47**stationkeeping system**

A system capable of limiting the excursions of a floating system within prescribed limits.

3.1.48

sudden hurricane

A hurricane that develops inside the Gulf of Mexico within a relatively short period of time.

NOTE If it develops sufficiently close to the relevant floating system, personnel evacuation and/or mooring disconnection (in case of a disconnectable floating system) cannot be assured.

3.1.49

survey

A general view, examination, or other activities performed for collecting data required in evaluation of system integrity.

3.1.50

tendon

A pretensioned stationkeeping system which connects a TLP to its subsea foundation.

NOTE Tendons are usually vertical or near-vertical hollow cylinders made of special carbon steel and are intended to always remain in tension.

3.1.51

tension leg platform (TLP)

A floating system normally consisting of a deck structure with either a single, or several widely spaced, large cross-section supporting columns connected to submerged pontoons, with a tendon system with enough stiffness and pretension to restrain vertical motions as well as provide stationkeeping.

3.2 Acronyms and Abbreviations

ACFM	alternating current field measurement
ALE	abnormal level environmental event
CG	center of gravity
CMMS	computer maintenance management system
COW	crude oil washing
CP	cathodic protection
CUI	corrosion under insulation
CVA	certified verification agent
CVI	close visual inspection
DH	dehumidification
ECI	eddy current inspection
EER	escape, evacuation, and rescue
ELE	extreme level environmental event
FLNG	floating liquefied natural gas (vessel)
FMD	flooded member detection
FMECA	failure modes, effects, and criticality analysis
FPS	floating production system
FPSO	floating production, storage, and offloading
FPU	floating production unit
FSIM	floating systems integrity management
FSO	floating storage and offloading
GM	metacentric height

NOTE The distance from the VCG to the metacentric height of a floating object.

GVI	general visual inspection
HAZID	hazard identification
HC	hydrocarbon
HSE	health, safety and environmental
HVAC	heating, ventilating, air-conditioning
IACS	international association of classification societies
ICCP	impressed current cathodic protection
IG	inert gas
IM	integrity management
IMR	inspection, maintenance, and repair
ISIP	in-service inspection plan
MCT	multiple cable transit
MIM	mooring integrity management
MODU	mobile offshore drilling unit
MOM	marine operations manual
MOU	mobile offshore unit
MPI	magnetic particle inspection
NDE	nondestructive examination
NORM	normally occurring radioactive material
P&ID	piping and instrumentation drawing
PFP	passive fire protection
POB	personnel on board
QA	quality assurance
RBA	response-based analysis
RBI	risk-based inspection
RCS	recognized classification society
RIM	riser integrity management
SAI	special areas of interest
SCIP	structural critical inspection point
SIM	system integrity management
SIMOPS	simultaneous operations
SRB	Sulphur-reducing bacteria
SURF	subsea, umbilicals, risers, and flowlines
TM	thickness measurement
TLP	tension leg platform
TTMS	tendon tension monitoring system
UTT	ultrasonic thickness testing
UWILD	underwater inspection in lieu of dry-docking
VCG	vertical center of gravity

WI	weld inspection
WSD	working stress design
WT	watertight

4 Floating Systems Integrity Management Overview

4.1 General

The purpose of integrity management (IM) is to provide a proactive process for demonstrating the integrity of an FPS throughout its life on a fitness-for-service basis. The IM process relies on collating information on the FPS, periodically evaluating the data, and using the evaluation to set a strategy for subsequent inspection and monitoring.

IM of FPS's consists of the continuous process as illustrated in Figure 1.



Figure 1—FSIM Process

IM process for an FPS should be used from installation through to decommissioning to:

- understand, communicate, and manage the in-service structural risk;
- manage the effects of deterioration, damage, changes in loading and accidental overloading;
- establish the framework for inspection planning, maintenance, and/or repair; and
- demonstrate that the FPS is fit-for-service.

Implementing an IM process for FPS's provides a means for managing the effects of mechanisms that can reduce the capacity or intended function of an FPS. The IM process is founded on risk principles and provides owners a framework for developing, implementing, and using engineering, inspection, maintenance, monitoring, and remediation activities to validate the fitness-for-service of an FPS for its intended application throughout its service life.

Approaches to dealing with IM vary depending upon field life, type of FPS and sophistication of regional infrastructure in which the FPS is located. These factors influence the philosophical approach to IM that can vary from one involving emphasis on the use of monitoring equipment to one with a preference for the extensive use of inspections. When implemented, the IM process can be used to demonstrate that the system risk to platform operations is understood, and that this IM process is being used to prevent and/or mitigate incidents that could result in safety, environmental, or economic consequences to the platform owner.

Choices are made in the design (e.g. selection of materials, design margins, condition monitoring systems, new or proven technology, robustness of design, redundancy, and fabrication/installation methods) that will influence IM activities during the operations. Implementation of an IM process can benefit from design decisions, such as providing access for inspection and maintenance. Initial IM development begins as part of the FPS design or reuse, ideally during the concept and select stages.

The IM process is used to develop an inspection and monitoring program, including scope and frequency, that can provide additional information on the condition of the FPS. The collected information can be used to understand present and emerging risks from operating the platform and can provide information for determining the ongoing strategy for mitigating emerging risks. A well-implemented IM process can provide evidence that the FPS remains fit-for-service for the operational life of the platform and through to decommissioning.

The FPS operating team responsible for implementing the FSIM strategies and maintaining the FSIM data should confirm that the FPS project team has provided the design and commissioning information/data. In addition, the FPS operating team should confirm that the project developed FSIM strategies can be implemented (i.e., tools/equipment and resources are available, regional regulations have been adhered to, and the risks are identified). Throughout the service life of the FPS, new data are collected through monitoring activities, scheduled maintenance, scheduled surveys, results of accidental events, or planned changes (e.g., modifications or additions) to the floating system. As new data are obtained, the data are subject to engineering evaluation to validate fitness-for-service. Based on the evaluation, adjustments to the strategy plans and program work scopes can be required to confirm fitness-for-service and maintain the floating system's integrity.

4.2 Risk

The owner may adopt risk-based principles for developing IM strategies that consider the present condition of an FPS, the likelihood of damage or degradation of a structural component or structural system, and the potential consequences. The consequences of failure should include the potential for loss of life, as well as undesired environmental and/or economic impacts (e.g. repairs, clean up, replacement, and deferred production).

A risk-based approach recognizes that FPSs with higher risks could warrant more frequent and more focused inspection than those with lower risk. During the development of an inspection strategy, a FPS's risk category may be used for setting survey intervals and work scopes as part of a risk-based IM strategy.

4.3 Interfaces

This RP is a companion to three other RPs within API that address integrity management:

- API 2SIM, *Structural Integrity Management of Fixed Offshore Structures*
- API 2RIM, *Integrity Management of Risers from Floating Production Systems*
- API 2MIM, *Mooring Integrity Management*

The owner is responsible for understanding and managing the interfaces between the integrity management for each of these interrelated RPs.

For requirements relating to planning, designing, and constructing new FPSs, this RP should be adhered to in combination with the latest edition of API 2FPS, or API 2T.

5 Floating System Integrity Management Process Development

5.1 General

The owner shall develop and implement an FSIM framework for managing the integrity of FPSs. Implementation of an FSIM process can benefit significantly from design decisions such as providing enough access for inspection and maintenance. Approaches to dealing with system integrity management vary depending upon field life, type of floating system, and sophistication of regional infrastructure where the floating system is located. In turn, these factors can influence the philosophical approach to the specification of an FSIM process which can vary from one emphasizing the use of monitoring equipment to one with a preference for the extensive use of inspections. Additionally, design decisions on safety factors, design margins, corrosion protection, and redundancy and system reliabilities also influence the FSIM strategy and program. Regardless, the resulting FSIM program should demonstrate the integrity of the system throughout its service life.

The initial development of an FSIM process should begin early as part of the floating system's new design or conversion, ideally during the floating system's concept and select stages. Most of the initial FSIM data, strategies and program are generated during the design by the project team and handed over to the floating system's operating team once it is constructed, installed, and commissioned onsite. Once commissioned, the effective operation of the floating system should be based on the marine operations manual (MOM), or other similar documents. The MOM is constructed using requirements from various technical disciplines generated during the design phase and is a critical first step in ensuring integrity of the system. A key design deliverable of the FSIM process (and essential component of the MOM) is the development of a floating system's in-service inspection plan (ISIP).

The project and operating teams have important roles in the initial specification and development of the FSIM process, including the identification of how the system is expected to respond and any limitations inherent in the design, whether in the form of loading limitations or environmental restrictions that apply to weather-sensitive operations. The project team in charge of the design should provide initial FSIM data, initial strategies, and program recommendations to be handed over to the operating team. The project team should have a process in place to track and manage changes to the initial design and operating philosophies through all phases of the design, construction, and installation.

The operating team should confirm that design data are comprehensive and complete and that the FSIM strategies conform to owner's risk criteria and to regional requirements. The program should be workable based on location infrastructure and capabilities. This interaction and the active participation of the operating team in the development of the FSIM program are intended to ensure that comprehensive practical FSIM deliverables are provided to the operating team.

Figure 2 shows the typical team responsibilities and deliverables that provide the foundation of the initial FSIM process.

5.2 Data

5.2.1 General

Information on the original design, fabrication, and installation, including results of structural analyses constitute the foundation of the FSIM knowledge base to be built upon over the service life of the floating system.

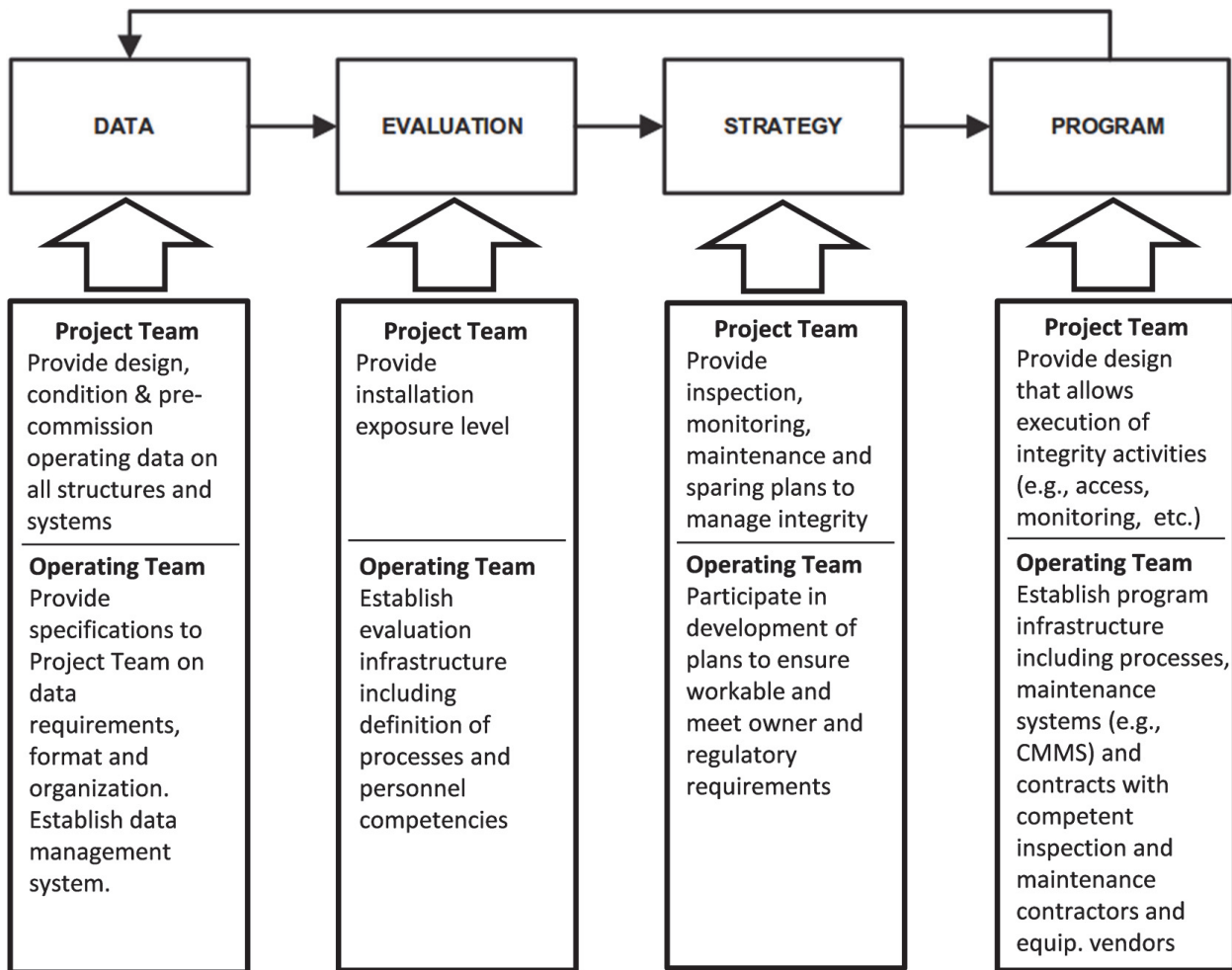


Figure 2—FSIM Process Development

FSIM data fall into four broad categories:

- engineering design data;
- condition data;
- operating data;
- changes to operating conditions and/or procedures.

At the time of the floating system's handover to the operating team, the majority of the data consist of design data.

Early in the design phase, the operating team should stipulate to the project team the design data identifications, formats, and organization, such that the data when handed over can be readily incorporated into the operating team's data management systems (i.e. database).

The owner should retain records on the design, condition, and operation data (including pre-commission operation) as a minimum for the service life of the floating system.

5.2.2 Design and Fabrication Data

The design and fabrication data constitute a broad spectrum of information. Table 1 lists some of the primary design information that should be collated on all marine systems and structures making up the floating system, preferably at the completion of the design phase.

Other design data the owner should obtain from the project team and maintain over the service life are design computer models (e.g. stability, mooring, global hull, key local systems, etc.).

Table 1—Design and Fabrication Data

Category	Data/Document
Design and fabrication	— Consolidated design criteria (e.g. metocean, geotechnical, seismic, ice, etc.) — Design analyses/reports — Drawings — Material data from fabrication and construction — Fabrication, construction, and installation inspection and QA/QC records — Marine systems equipment specification sheets — Design risk assessments — Nautical charts — Weight, center of gravity (CG), and vertical center of gravity (VCG), including initial phantom weight estimate
Operating procedures	— Marine operations manual (MOM) — Equipment operations manuals — Simultaneous operations (SIMOPS)
Strategy documents	— Inspection plans — Equipment maintenance manuals — Monitoring and sparing plans

5.2.3 Condition Data

The condition data represents the as-is condition of the floating system at the start of the service life at the site.

Condition data surveys should be performed as follows:

- *Postconstruction Survey:* This is a survey of the as-built floating system, which records the condition and arrangement of all structures and systems. This should consist of as-built drawings, a construction portfolio consisting of material and welding quality control and assurance records and photo or video records developed during construction. The weight report verification and inclining test to establish the VCG would be included in this category.
- *Postinstallation Survey:* This is the survey of the floating system confirming the as-installed condition. The survey is intended to confirm no damage has occurred during the transportation and installation activities. The survey should include above and below water structures and systems and interior spaces. The survey should include photos and video for reference during future inspection, monitoring, and maintenance activities.

- *Anomaly Register Reflecting the As-installed Condition*: This is a list of known damage or deviations in the as-installed floating system relative to the design that can affect the floating system's integrity. This should include anything from dents or alignment issues that occurred during construction to deviations in design specifications, such as the application of less robust or reduced coverage of coating systems.

Converted floating systems can have structures or hull systems that have known initial deterioration, defects, used equipment from its prior service or records of modifications (local or otherwise) to the floating system that could affect intact and damage stability. These systems can satisfy the design service life requirements, but they could have lower margins or reliability when compared to a new system. Thus, they can be more vulnerable to deterioration over the service life. This knowledge should be captured within the surveys and anomaly register, since it can influence the inspection, monitoring, maintenance, and sparing strategies.

5.2.4 Operating Data

The pre-commissioning operating data should accurately represent the operating conditions the systems were exposed to during construction and installation. These essentially represent temporary operating conditions the floating system was exposed to leading up to normal operations. Of most importance are those temporary operating conditions which would be generally considered outside of the normal operating parameters. This is particularly important if the temporary operating conditions occurred over a longer duration than originally planned, since they can influence the post-installation survey and the future FSIM strategy and program.

Typical examples of pre-commissioning operating data are as follows:

- permanent and variable loads;
- drafts;
- mooring tensions (including preinstallation conditions)/tendon pretensions tank service conditions (e.g. voids used as temporary ballast, etc.);
- equipment usage (including any adverse exposure conditions);
- environmental conditions (including storm conditions during construction, transportation, and installation).

These data should reflect the variation and duration of the conditions.

5.2.5 Data Management

Data should be maintained in a data management system (i.e. database) that enables existing information to be readily retrieved for reference during future FSIM program activities and future FSIM data to be readily added and stored.

A copy of the key integrity information should be kept onboard the floating system, in addition to a master copy kept ashore by the owner.

5.3 Evaluation

FSIM evaluation is an engineering review of integrity data, using engineering judgment, risk assessments, calculations, analysis, or other methods to identify anomalous conditions (i.e. assessment initiator) and determine whether additional detailed assessment or risk mitigation is required to demonstrate fitness-for-service.

5.4 Strategy

5.4.1 General

The FSIM strategy defines the overall inspection, monitoring, and maintenance performed over the service life to gather additional information on the FPS condition and to develop a fitness-for-service plan. The FSIM strategy plans should define the activities, work scopes, and evaluations necessary to confirm integrity. The plans reflect the overall philosophy for dealing with system integrity management, which varies depending upon the design margins, field life, types of floating system, and sophistication of local infrastructure. These factors can influence the philosophical approach, affecting the extent of future maintenance activities as well as varying the degree of reliance between inspections and monitoring activities to evaluate fitness-for-service.

For a new floating system or conversion, the overall FSIM philosophy should be developed during the preliminary design stages. Inspection, monitoring, maintenance, and sparing plans should be developed during the later detailed design stages of a new or converted floating system, ideally conducted early enough that any potential plan implementation and execution issues can be addressed within the design.

Although the FSIM program relates to the execution of the strategy during the service life, the operating team should initiate development of work processes related to the preparation and execution of the plans.

5.4.2 Interfaces

Inspection strategies can be developed as a single plan, inclusive of all structures and systems, or broken into individual plans that are organized around specific structures or systems. For example, FPSs operating within U.S. 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. The topsides structures (including process decks and framing, helidecks, flare towers, etc.) typically have their own inspection plan.

Since the overall floating system plan is typically divided into individual inspection plans and maintenance programs, the interfaces between these specific plans should be defined and any gaps in the plans identified and addressed.

Initial ISIP scope and frequency developed by the design team should be validated by the operations team. In addition, the project team should liaise with the operations team during ISIP development to ensure that the scope can be implemented.

5.4.3 Personnel Qualifications

The FSIM strategy should be developed based upon a broad base of knowledge, including design, risk, inspection, operations, etc. Thus, the developer(s) of the plans should be experienced and knowledgeable of the following:

- offshore and marine engineering specifically related to the type of floating system (or equipment) under consideration;
- offshore construction, repair, and techniques and technologies;
- deterioration, damage evaluation, and mitigation;
- risks to floating systems;
- offshore inspection, monitoring, and maintenance planning, tools, and techniques; and
- general industry-wide and historical performance of floating systems.

5.4.4 Inspection Plan(s)

5.4.4.1 General

An inspection plan should define the frequency and scope of the inspection, the tools/techniques to be used, and the deployment methods. An inspection plan shall be developed for the FPS structural and system components. The ISIP should cover the FPS service life.

The plan is intended to be a dynamic or “living” document, meaning that inspection requirements can change due to inspection results or changes to the floating system (such as significant changes in topsides weight, addition of new risers, etc.). Hence, the plan should be periodically reviewed and updated throughout the service life, based on receipt and evaluation of relevant FSIM data.

5.4.4.2 Objectives

The inspections serve as proactive measures to detect damage and deterioration and assist in evaluation of structural and marine operating system performance. The general objectives of the inspection plan(s) include:

- identify areas of corrosion;
- identify areas of coating deterioration;
- identify areas of damage due to overloading;
- identify areas of damage due to impact or abrasion;
- identify areas of fatigue damage;
- identify safety hazards (e.g. damaged handrails, missing/loose grating, etc.);
- identify missing or deteriorated markings;
- identify areas affected by marine growth, and measure its thickness;
- detect debris;
- measure cathodic protection (CP) potential;
- determine if any damage exists following a severe storm event (i.e. hurricane);
- confirm function of sensors and alarms (e.g. tank level alarms, etc.);
- confirm marine system function (e.g. pumps, propulsion, steering, etc.);
- confirm mooring equipment function (e.g. chain jacks, windlass, etc.);
- confirm mooring component departure angles and/or tensions are within acceptable ranges;
- confirm compartment boundary integrity;
- confirm weight management;
- confirm planned maintenance being performed on critical systems.

5.4.4.3 Inspection Plan Content

5.4.4.3.1 General

Inspection plans should provide the necessary requirements to confirm proper execution in the field. The plans should provide introduction or background information on the floating system, including general descriptions, key performance requirements and thresholds, unique features, and other pertinent information. This information is important since the personnel involved in the actual inspections can be unfamiliar with the specific floating system or design.

The plans should provide the overall scope of work and schedule to be performed over the service life. The process for conducting and reporting the inspections should also be included within the inspection plan. Drawings, diagrams, checklists, work-packs, and procedural lists should be included within the plans to enhance understanding of the work scope and requirements for the recording of inspection findings.

The contents of an inspection plan should include:

a) General Information:

- 1) Description of the floating system, general arrangement, location, and primary function.
- 2) Description of the structures, systems, and special features within the plans scope.
- 3) Description of structure and system special areas. This should include identified high consequence of failure and high-risk components and description of the drivers (e.g. high stress, low fatigue, etc.).
- 4) Component identification (e.g. hull compartment naming, etc.).
- 5) Description of the corrosion control systems.
- 6) Arrangement and listing of accessible and inaccessible structure or systems.

b) Inspection Procedures and Requirements:

- 1) Applicable standards, survey schedule, and work scope summary of all components within the plan.
- 2) Surveys:
 - i) Description of surveys (i.e. above water, internal, underwater) and methods (e.g. individual inspector, rope access, ROV, diver).
 - ii) Detailed scope of individual inspections and function checks (e.g. thickness gauging of structure, level alarm checks, etc.), including all identified critical structures and systems.
 - iii) Description of special area inspections.
 - iv) Anomalous condition thresholds or criteria.
- 3) Reporting and documentation requirements.
- 4) Unscheduled inspections.
- 5) Damage assessment and repair procedures.

- c) Plan review and updating.
- d) Supporting drawings, diagrams, checklists, and procedural lists.

5.4.4.3.2 Surveys

5.4.4.3.2.1 Scheduled

The inspection plan should consist of a set of scheduled survey work scopes to be performed over the service life of the floating system. Details on the general survey scope and preparation are in Section 6.

5.4.4.3.2.2 Unscheduled

The need for unscheduled surveys should be evaluated after an unexpected event (e.g. an accident) or exposure to a near-design-level event (e.g. a hurricane). The inspection plan should provide thresholds for unscheduled inspections, damage surveys, and design environmental events.

These unexpected events shall be evaluated to identify appropriate inspection requirements. The extent of structure inspected should be consistent with the severity of the event.

The methods of inspection generally fall into two categories: (1) visual inspection methods and (2) nondestructive examination methods. The inspection plan should use the following nomenclature.

- Visual methods include:
 - general visual inspection (GVI);
 - close visual inspection (CVI).
- Nondestructive methods include but are not limited to:
 - crack detection (e.g. alternating current field measurement [ACFM], eddy current inspection [ECI], magnetic particle inspection [MPI], etc.);
 - thickness measurements—ultrasonic thickness testing (UTT);
 - volumetric crack detection—ultrasonic testing (UT);
 - cathodic potential measurements (CP).

Requirements and recommendations on the inspection techniques and their purpose is in Section 6.

5.4.4.3.3 Special Areas

Attention should be paid to special areas, such as turrets, helideck supports, fatigue sensitive zones, and areas where stress raisers or “hard termination” points exist. To enhance effective transfer of knowledge relating to special areas, the project team and operating team should clearly identify these locations and provide a description why they are special (e.g. loading, strength, fatigue, limited experience, etc.), whether they are inspectable or non-inspectable and what the assumptions are for ensuring fitness-for-service (e.g. increased strength or fatigue safety factors, load monitoring, inspection activities, etc.); additionally, the project team should consider feasibility of permanent means of access to facilitate inspection. For inspectable special areas, the area should be designated either a structural critical inspection point (SCIP) or a special area of interest (SAI) and included within the inspection plan. Interfaces between major structures and assemblies usually fall into these categories (e.g. topsides-to-hull connection, turret-to-hull interface, crane pedestal, vent boom connections, etc.).

SCIPs should be identified by the FSIM framework developers based on risk, with input from design engineers and operations personnel; they are locations which have been identified from calculations (e.g. higher stresses or lower fatigue life), from the service history of the floating system, as applicable, or from similar floating systems, to be sensitive to damage that would impair the structural integrity of the floating system over the service life.

SAIs should be identified by the design engineers; they are locations where issues are either most likely to occur (i.e. initial indicator of potential structural problems) or have the greatest potential consequences if allowed to deteriorate over time. These locations satisfy associated design margins and functional requirements, and the level of inspection is typically less than for SCIPs.

5.4.4.4 Development Basis

An ISIP may be developed using a risk-based approach. A risk-based approach enables the inspection plan to be tailored around the specific features of a floating system, aligning the survey activities with the identified risks. This also helps to confirm the risks are consistent with the owner's risk tolerance, and it provides a basis for the evaluating data obtained during future inspections.

5.4.5 Monitoring Plan

Monitoring may be used in combination with an inspection plan to enhance the level and quality of data used to evaluate fitness-for-service.

The owner should have a weight management program that enables weight data (and associated location) to be retained, tracked, and managed to use for buoyancy and stability calculations and structural assessments during the service life. Monitoring programs often require specialty equipment, continuous data recording, periodic calibrations, plus specialty software and personnel to evaluate the data. Specifications should be developed that provide details on the monitoring activities (e.g. the specific activities to be performed, when they should be performed, what should be measured, who is responsible for recording, maintaining, and evaluating the data). Additionally, threshold criteria should be defined that indicate an anomalous condition that would trigger an evaluation.

Requirements and recommendations on monitoring program application and types of monitoring that can be implemented are provided in Section 6.

5.4.6 Maintenance Program

The floating system maintenance program is a component of the overall FSIM strategy, complementing the inspection and monitoring plans. Maintenance programs for floating systems should cover the marine systems (e.g. ballast, vent, fire water, etc.) as well as mooring equipment (e.g., chain jack) and corrosion control systems such as coatings and impressed current systems. Additionally, those floating systems that have hydrocarbon handling and storage systems, active propulsion, or steering for stationkeeping or disconnect, or weathervane via a turret system should include additional maintenance tasks as well as periodic function testing.

5.4.7 Sparing Plan

The need for, and quantity of spares should be considered in the development of the maintenance program to allow for timely repair response to system performance deterioration or failure. Determination of what spares are necessary should be based on risk (i.e. likelihood of occurrence, consequence of component failure, and additional risks to floating system when structure or system is not working). Lead time for procuring and manufacturing a system or associated components can also be a consideration when determining appropriate spares.

The sparing plan should list spare parts to be kept, where and how they are to be kept (e.g. onshore or on-board the floating system), and how they are to be managed (i.e. maintained in good condition).

5.4.8 Reviews and Updates

Once the FSIM strategy has been developed, the owner should periodically review the strategy and associated plans to confirm they are adequate to provide information on the integrity of the floating system based on the latest data. Updates to the plans should be made periodically and may include reduced inspections in regions that continue to show good performance, or expanded or more detailed inspection techniques in regions showing signs of initial deterioration. The plan should be updated when the latest data indicate conditions that can detrimentally affect the floating system's fitness-for-service.

As part of the FSIM strategy review, the owner should also review the effectiveness of the FSIM process elements (i.e. data, evaluation, strategy, and program). This process provides input into the overall health of FSIM process and its effectiveness to manage integrity and confirm fitness-for-service. The review should provide a gap analysis for the FSIM program implementation. The owner should identify potential issues in its FSIM process and maintain all elements over the service life of the floating system.

6 Implementation

6.1 General

This section describes the processes and activities of a functioning FSIM program implemented over the floating system's service life. This forms the primary means for the owner to manage the integrity of the floating system. As required, updates to the strategy and program are made based on the evaluation results. The updates may include changes to the inspection, maintenance or monitoring plans or implementation of repairs or modifications to structures or systems.

6.2 Scheduled Surveys and Inspection

6.2.1 General

This section provides recommendations on the typical surveys that should be included within an inspection plan. Survey frequencies, approach (e.g. continuous or periodic basis), methods (e.g. GVI, CVI, MT, etc.), and scopes are dependent on the developed inspection, monitoring, and maintenance plans for the specific floating system as provided in Section 5.

6.2.2 Topsides Structure

The primary objective of topsides structural surveys is to determine the general condition of topsides structures. Inspection frequencies and methods (e.g. GVI or CVI) should be based on component risk. Further guidance for topsides surveys and inspections is provided in API 2TOP.

General visual inspections can include:

- topside structures and coatings (e.g. process, modules, helideck, accommodations, etc.) to identify gross damage, wide-spread coating breakdown, corrosion, and/or leaks;
- inspection of walkways, ladders, stairs, and handrails to determine the condition of supports and protective barriers for personnel.

Other surveillance activities related to the marine equipment associated with topsides such as testing of fire protection systems and examination of personnel protection, rescue and escape systems, escape routes, and navigation lights should also be performed during the topsides survey.

More detailed surveys of the primary and secondary topsides structures can be performed on a defined periodic cycle or on a continuous cycle where a specified percentage of the topside structures are inspected annually, such that over a specified period all topsides structures are inspected.

Specific locations and inspection methods (e.g. GVI, CVI, etc.) should be based on the developed inspection plan. The following summarizes typical structures that should be included in the more detailed topsides survey:

- module or topsides columns and their connections to hull, including bearing systems and stools;
- module primary structures and connections to columns;
- crane pedestal and associated deck and brace connections;
- flare structure and connections to hull/topsides;
- helideck structure and connections to hull or accommodations;
- blast wall and refuge structures and connections to hull/living quarters;
- special areas (i.e. SCIPs and SAIs);
- other topsides structure and hull connections (e.g. turret tower, pipe racks, etc.).

6.2.3 Hull Structure

6.2.3.1 Internal Hull

Inspection frequencies and methods (e.g. GVI or CVI) should be based on component criticality. General visual inspections include:

- machinery spaces (i.e. permanently ventilated spaces in hull, such as pump or engine rooms), if applicable;
- tank spaces, inner shell, life-saving equipment, etc.

More detailed surveys of the internal hull structure can be performed on a defined periodic cycle or on a continuous cycle where a specified percentage of the hull compartments are inspected annually, such that over a specified period all compartments are inspected.

Specific locations and inspection methods (e.g. GVI, CVI, etc.) should be based on the developed inspection plan. The following summarizes typical structures and systems that should be included in the more detailed internal hull survey:

- special areas (i.e. SCIPs and SAIs);
- manway hatches, bolts, and coamings;
- interior walkways, stairs, and handrails;
- interior surfaces of primary load bearing structures, including hull plating, transverse and radial frames, and longitudinal and vertical stiffeners;
- internal backup structure (e.g. fairlead, riser porches, caisson supports, etc.);
- condition of coatings and anodes, as applicable;
- equipment function testing (e.g. ballast pumps, leak detection systems, etc.);
- piping, valves, and conduit and associated supports and compartment penetrations;
- pump and engine foundations.

6.2.3.2 External Hull Above Water

The external hull structure and systems above the waterline should be inspected to provide information on possible deterioration or gross damage that may have occurred that would detrimentally affect their function. The survey typically covers the above water external structures and systems including the hull, moorings attachments, and appurtenances. The method of inspection typically consists primarily of general visual and function checks, etc.

The following summarizes typical activities conducted for the above water external hull:

- hull deck exterior:
 - inspection of walkways, ladders, stairs, and handrails to confirm items provide adequate support and protective barriers to personnel;
 - inspection of hull penetrations, including hatches, manholes, vent pipes, and sounding tubes on deck and in the deck box (if applicable) to confirm watertight/weathertight integrity of hull;
 - condition of external coatings;
 - inspection of on-vessel mooring components (e.g. chain jacks, chain stoppers, mooring lines, etc.) above the waterline, if visible.
- hull outer shell (above water):
 - inspection of external hull above the waterline, looking for signs of coating deterioration, corrosion, or damage;
 - inspection of mooring system support structures;
 - inspection of hull appurtenances (e.g. hard pipes, caissons, and associated connections above the waterline on the hull exterior);
 - inspection of walkways, ladders, stairs, handrails, and boat landings to confirm items provide adequate support and protective barriers to personnel;
 - confirm hull markings (e.g. draft markings) are visible.

6.2.3.3 External Hull Below Water

Underwater surveys should be performed on the submerged areas of the hull. The surveys should cover below water structures including any SCIP's and SAI's. External marine systems components and the mooring system hull attachments or tendon system should also be included within the survey. This should include propulsion, steering and sea chests, as applicable. External hull surveys should be performed to confirm that the corrosion protection system on the external hull is functioning adequately, and to assess the extent of marine growth.

The external hull surveys may be performed on a continuous cycle where a specified percentage of the hull is inspected at a time such that all accessible structures are inspected over a specified period. The other option is to inspect the entire hull on a defined periodic cycle. Additionally, the inspection cycles may incorporate different inspection methods and techniques (e.g. general visual of entire hull with ROV at a specified interval and more detailed inspection techniques of critical locations with diver and ROV on an alternating schedule).

Specific locations and inspection methods (e.g. GVI, CVI, etc.) should be based on the developed inspection plan. The following summarizes typical structures and systems that should be included in the underwater survey:

- accessible hull exterior surfaces and appurtenances below the waterline (e.g. caissons, hard piping, and their associated external guards, clamps, and standoff supports);
- structural bracing and associated connections;
- external mooring/tendon system to hull connections (e.g. fairleads, tendon porches, etc.);
- riser and umbilical porch structures and I-tubes;
- sea chests and hull penetrations;
- special areas (i.e. SCIPs and SAIs);
- propulsion and steering, as applicable (e.g. rudder, propeller, thruster, etc.);
- corrosion protection system (e.g. coating, anode, and impressed current system);
- hull markings.

6.2.4 Marine Systems

The marine systems within the hull should be inspected and functionality should be verified during the internal survey of the compartments containing the equipment. The above-deck marine systems should be inspected during the inspection of the topsides structures. Marine systems include ballast, bilge, process equipment and piping (if within the hull), inert gas, firewater, HVAC, propulsion, steering, vents, and sounding systems.

6.2.5 On-vessel Mooring Components

The inspections to be performed during mooring surveys should be in accordance with API 2MIM and API 2I. The mooring system support structure on the hull should be inspected in conjunction with the external surveys and the topsides structure surveys.

6.2.6 Tendons

In conjunction with the underwater survey, the tendon system of TLPs should also be inspected. This should include the full length of the tendons, flex joints, connections, and piles/foundations. The components of the tendon tension monitoring system (TTMS) and any other instrumentation should also be inspected.

6.2.7 Other Structures and Systems

Other structures and systems necessary for maintaining the stationkeeping, stability, or system integrity of the floating systems should be inspected as part of the surveys (e.g. a turret system being inspected during both the above and below water inspections).

6.2.8 Default Inspection Program

6.2.8.1 General

If a risk-based inspection plan has not been developed to determine inspection locations and survey intervals, the owner shall use a default inspection program.