Guidance for Post-hurricane Structural Inspection of Offshore Structures

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Upstream Segment

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

Introduction

Recent hurricanes in the Gulf of Mexico have resulted in thousands of above- and below-water structural inspections of offshore structures to determine if they sustained damage. Several of the API standards for offshore structures provide guidance for such “special” inspections, but the guidance is limited and general in nature. This bulletin complements those publications and provides additional guidance specific to structural inspection following hurricanes.

The purpose of this bulletin is to provide guidance for post-hurricane, above- and below-water, structural inspections of fixed and floating structures located in the Gulf of Mexico. The goal of these special inspections is to determine if a structure sustained hurricane-induced damage that affects the safety of personnel working on the structure, the primary structural integrity of the asset, or its ability to perform the purpose for which it was intended. This document should be used in conjunction with the applicable API standards for the structure as well as any structure-specific owner/operator or regulatory requirements.

Guidance for Post-hurricane Structural Inspection of Offshore Structures

1 Scope

This document is applicable to permanent fixed and floating structures in the Gulf of Mexico. In this document, inspection refers to structural inspections only and does not include inspections of production equipment, process piping, electrical and instrumentation or other systems and components of the platform, unless noted otherwise.

Fixed structures include steel jacket or template platforms, towers and compliant towers, caissons, minimum non-jacket and special structures that are fixed to the seafloor. Design of these structures generally follows API 2A-WSD guidelines.

Floating structures include tension leg platforms (TLPs), spars, deep draft caisson vessels, semi-submersibles and any other type of floating or tethered structures. Design of these structures generally follows API 2T, API 2FPS, API 2SK, API 2RD and API 2I guidelines.

Post-hurricane structural inspections are not as comprehensive as, or supplant the need for, regular in-service inspections as may be detailed in the structure's in-service inspection plan (ISIP).

This document describes post-hurricane structural inspection of structures designed in accordance with the following API documents:

— API 2A-LRFD,

— API 2A-WSD,

— API 2FPS,

— API 2I,

— API 2RD,

— API 2SK,

— API 2T,

— API 2TD.

These structures may also be designed and operated in accordance with regulatory and classification society guidelines and these should be applied as required.

2 Acronyms

FMD	flooded member detection
GVI	general visual inspection
ISIP	in-service inspection plan
NHC	National Hurricane Center
ROV	remotely operated vehicle
TLP	tension leg platform

3 Organization of Document

This document is organized in a progressive manner such that the user starts with the early sections to determine the need for post-hurricane inspections. If inspections are required, the later sections provide specific guidance. Section 4 describes the initiators to determine the need for and the general extent of inspections that should be performed. Section 5 provides guidance for safe initial boarding of the structure as well as guidance for the above-water structure inspection. The above-water inspections also assist in establishing the need for below-water inspections. Section 6 provides guidance for below-water inspection of fixed structures. Section 7 provides guidance for below-water inspection of the external and internal structure of floating structures. Section 8 provides guidance for documentation.

4 Inspection Initiators

4.1 General

After a hurricane has passed through the Gulf of Mexico, inspection initiators determine if an offshore structure requires a special post-hurricane structural inspection. The inspection initiators are based upon the following:

— the structure's exposure to hurricane conditions; and

— indications that the structure has suffered damage, as in the case where large objects may have fallen overboard or the structure is leaning, tilted or listing.

For the purposes of this document, a hurricane event is a named tropical cyclone, as defined by the National Hurricane Center (NHC), which enters or generates in the Gulf of Mexico. The NHC is the official U.S. agency for establishing hurricanes. NHC defines a hurricane as a storm with maximum sustained 1-minute surface winds greater than or equal to 74 mph (64 kt). Surface winds are those observed to occur at the standard meteorological height of 10 m (33 ft) in an unobstructed exposure.

4.2 Assessment Process

The process for determining if a structure should be inspected following a hurricane is shown in Figure 1. This is a progressive approach based on the hurricane conditions experienced by the structure and on results from above-water inspections of the primary structure and from other damage indicators.

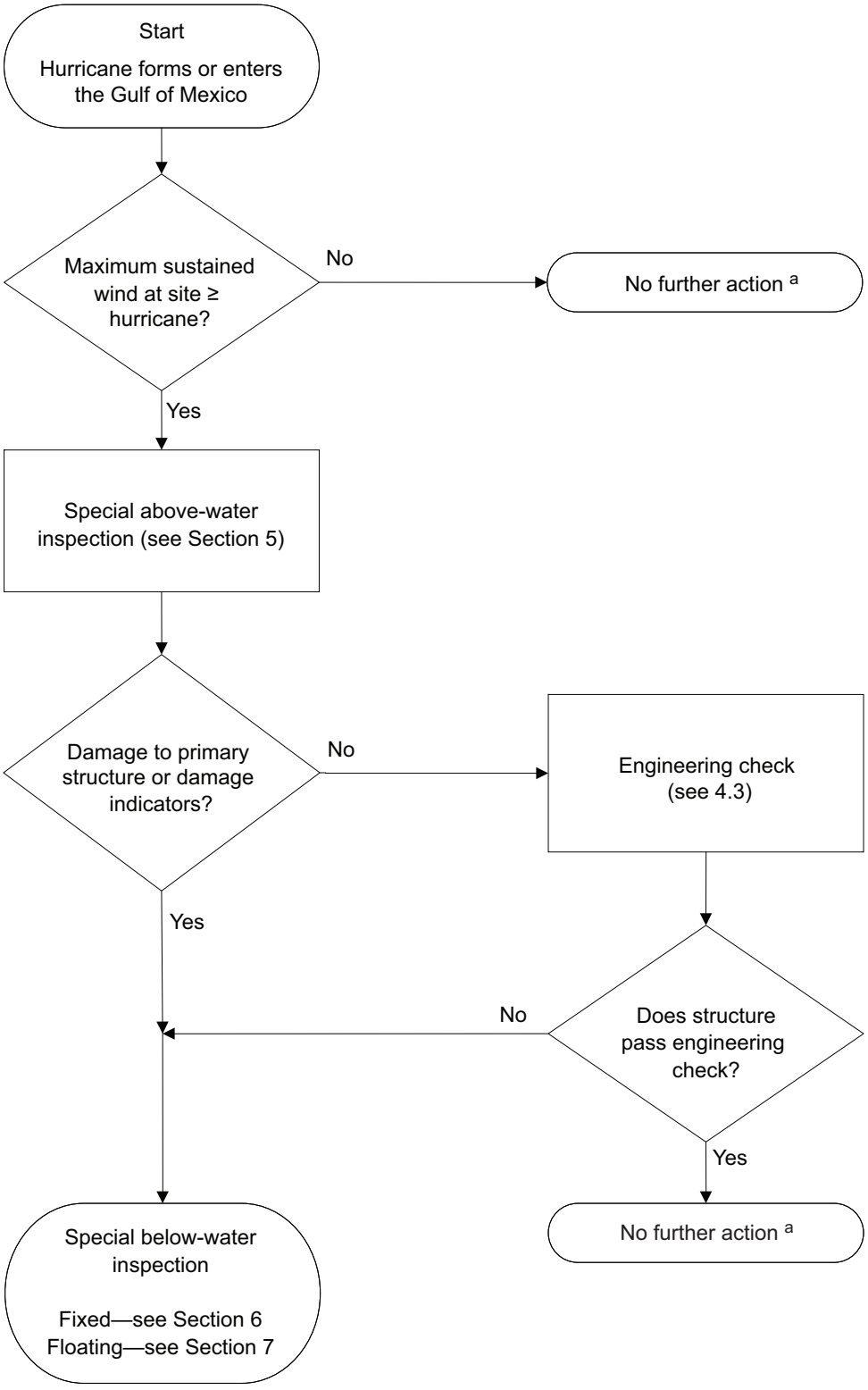
The process for a particular structure is initiated when the structure has been exposed to wind speeds equal to or greater than hurricane conditions, as defined in 4.1. The wind speed used in this determination, can be based upon any of the following:

— measured wind speeds at the structure location, using calibrated monitoring equipment demonstrated to be accurate and operating continuously throughout the duration of the hurricane;

— maximum hurricane wind speed based upon hindcast data, using generally accepted meteorological practices.

A special above-water inspection should be performed once it is determined the structure has been subjected to hurricane winds or greater. The intent of this inspection is to gain a general understanding of the condition of the structure to determine if it is safe for boarding, if above-water damage is evident and if any large objects have fallen overboard possibly damaging the structure below water. Guidance for the special above-water inspection is provided in Section 5.

An engineering check should be performed in those cases when no structural damage is apparent in order to determine whether the hurricane conditions at the site or the structure response exceeded the limits beyond which the structure may have suffered damage. This can be a simple comparison of the hurricane conditions experienced by the structure to the structure's design environmental conditions, or a more detailed engineering study intended to determine if the hurricane loads or structure motions were sufficient to cause damage. If the engineering check shows



a Unless structure-specific inspections required by owner or regulator.

Figure 1—Inspection Initiator Process for Fixed and Floating Structures

that damage is likely, then a special below-water inspection should be performed. If the engineering check indicates no structural damage is likely and no structural damage was found during the special above-water inspection, generally no further action is required, unless there are structure-specific post-hurricane inspections stipulated by owner/operator requirements, class or regulatory requirements. Guidance for the engineering check is provided in 4.3.

A special below-water inspection should be performed when the special above-water inspection finds structural damage indicating potential below-water damage, or when the results of the engineering check indicate that the structure could be damaged below-water. The scope and methods of the below-water inspection are dependent upon the findings of the special above-water inspection and/or the results of the engineering check. Guidance for the special below-water inspection for fixed and floating structures is provided in Section 6 and Section 7.

4.3 Engineering Check

4.3.1 General

The engineering check is used to determine if the hurricane may have damaged the structure and a special below-water inspection is required. There are various methods to conduct the engineering check with four methods defined in 4.3.2 to 4.3.5. Additional methods may be applicable if they can be demonstrated to accurately determine the hurricane conditions in which structural damage is expected. Typically, the engineering checks are performed in the order shown since they become increasingly more complex.

4.3.2 Metocean Condition Comparison

This is a check of the observed maximum metocean conditions during the hurricane including wind speed, wave height, current and surge compared to the structure's design environmental conditions. If all of the hurricane conditions were less than the structure's design conditions, then the structure passes the engineering check.

4.3.3 Load Comparison

4.3.3.1 General

This is a check of the environmental loads acting on the structure during the hurricane compared to the structure's design loads. The calculated environmental loads should account for direction and occurrence of extreme values of key metocean conditions during the hurricane. The method depends upon if the structure is fixed or floating.

4.3.3.2 Fixed Structures

The load comparison is typically made using the metocean base shear acting on the structure. If the structure is categorized as high consequence L-1 or A-1 according to API 2A-WSD, or if the structure is manned-evacuated, then the design load is used for the comparison. Other fixed structures can use 80 % of the base shear that causes first component failure. If the hurricane loads were less, then the structure passes the engineering check. Single unbraced caissons do not typically require an engineering check (see 5.4.5).

4.3.3.3 Floating Structures

The load comparison is typically conducted by comparing the measured structural response from motions, offsets, mooring line tensions or tendon tensions during the hurricane, where available, to the structure's design values. If the structure's response is less than the structure's design values, then the structure passes the engineering check.

4.3.4 Stress Comparison

This check involves detailed structural analysis of the fixed or floating structure applying metocean conditions equal to or greater than those observed during the hurricane to determine the component stresses in the structure. This is

typically a more detailed analysis investigation of the specific components of the structure than the engineering checks described in 4.3.2 and 4.3.3. Examples of components for fixed structures includes deck members, jacket bracing, legs, and pile foundation. Examples of components for floating structures includes deck members, hull scantlings, bulkheads, spar truss members, moorings, and pile foundation. If the hurricane-imposed stresses are less than defined by API for the type of structure, then the structure passes the engineering check.

4.3.5 Structural Natural Frequency Measurement (Applicable to Fixed Structures)

This check compares measured pre-hurricane natural frequencies of the structure with measured post-hurricane natural frequencies. The ability of this method to predict damage on a specific structure shall be established using a combination of engineering study and field measurements prior to the hurricane. If the pre-hurricane and the post-hurricane frequencies are the same, and structure mass changes have been properly accounted for, the structure passes the engineering check. If the frequencies are different, there is possible damage to the primary structure. This check is applicable to certain types of fixed structures, typically those with non-redundant framing.

4.3.6 Other Considerations

The observed maximum hurricane wind, wave, and currents at the site should be based on measured or site-specific hindcast hurricane conditions. The calculated hurricane loads should be based on actual loading measurements at the structure or calculated loads using measured or hindcast hurricane conditions.

The engineering check shall account for the configuration and condition of the structure at the time of the hurricane. The configuration accounts for the number of risers, topsides weight, presence of drilling rig, etc. at the time of the hurricane. The condition accounts for known corrosion, damage, repairs, etc. of the platform based upon the most recent inspection of the structure.

The engineering check can be performed in advance of hurricanes for some structures to determine the specific hurricane conditions expected to damage the structure. If a hurricane occurs, the owner/operator should compare the observed hurricane conditions at the structure site to the results of the engineering check to determine if a below-water inspection is required. This type of pre-planning can assist in rapid identification of the structures where below-water inspections are not necessary.

In lieu of an engineering check, the owner/operator may conduct the special below-water inspection.

4.4 Prioritizing Structures for Inspection

In the case where an owner/operator has multiple structures that have been exposed to hurricane conditions, consideration should be given to prioritizing the structures to be inspected. Candidate structures for priority treatment include:

a) structures located in an area of close proximity to the identified path of the hurricane eye wall and the peak environmental loading due to wind, wave and/or currents;

b) structures where structural problems are identified from the post-hurricane initial aircraft flyovers;

c) structures in areas prone to hurricane induced soil disturbances such as mudslides;

d) structures necessary for housing personnel needed to perform post-hurricane inspections or related repairs;

e) structures identified as possible bases for establishing aircraft logistics, including transfer points and re-fueling;

f) structures important to the restoration of oil and gas production to the field or region;

g) structures prioritized based on the engineering checks defined in 4.3.

5 Special Above-water Inspection

5.1 General

The initial step in a post-hurricane inspection is a special above-water inspection. This involves an initial surveillance to confirm if the structure is safe for boarding, a general visual inspection (GVI) of the above-water structure to identify additional safety concerns and possible structural damage, and to determine if a below-water inspection is required. The above-water inspection is generally similar for both fixed and floating structures and is therefore contained in this section. All inspections should be performed by qualified personnel. Specific additional guidance for fixed or floating structures is provided where required.

Safety and environmental concerns should be addressed prior to any structural inspection and are discussed in this section.

It is recommended that owner/operators pre-plan these inspections for their structures and have specific procedures developed prior to hurricane season.

5.2 Initial Evaluation for Boarding

Post-hurricane flyovers or close approach by boat should be used to establish the general condition of the structure and to determine if the structure has obvious damage. Access to the structure by normal means may be unsafe and may require special planning for the initial boarding party. Examples of potentially unsafe conditions include a leaning structure, structural damage to the helideck, damaged or missing boat landings, walkways and stairways, etc.

Initial boarding personnel should evaluate the life/safety hardware, egress and access features and the general conditions for access including grating, handrails, walkways, stairs, safety nets, etc. Measures should be taken to mark and isolate areas that are unsafe to enable subsequent personnel to board the facility and perform tasks in a safe manner.

5.3 Above-water GVI

5.3.1 General

The above-water GVI is focused on obvious damage to the primary structure. It is performed by a walk-through of the structure with the goal of visually identifying specific areas of damage and potential concern. If damage is detected, nondestructive testing may be used when visual inspection cannot fully determine the extent of damage. Results of the most recent pre-hurricane topsides inspection, including photos (where available), are useful in comparing pre-hurricane and post-hurricane condition of the topsides and to identify missing equipment and structure that may have fallen overboard.

5.3.2 Topside Deck Structure

GVI on topside deck structure is similar for fixed and floating structures and involves inspection of the structure from the lowest deck to the highest deck. GVI should include:

— deck framing in areas such as the drilling, process, production, utility, etc.;

— tie-downs and main deck connections for drill rigs, flare booms, quarters buildings, etc.;

— the helideck.

5.3.3 Fixed Structures

For a fixed structure, the above-water GVI should include all primary jacket structural members in the splash zone and above water, concentrating on the condition of the more critical areas such as deck legs, deck leg to pile connections, pile to jacket connections, above-water jacket members, etc. Typical structural damage to be investigated includes:

a) bent, missing or damaged structural members;

b) visual indications of overloading (i.e. bent or bowed members, severed members, cracks at pile to jacket connections, etc.);

c) dents on outboard members caused by impact from floating or fallen objects;

d) distorted or twisted beams and columns.

Much of this damage can be observed from the first elevation of a jacket structure above the waterline. From this level, the underside of the cellar deck should also be examined for beams that may be buckled or out of square due to wave impact. If edge beams exhibit indications of wave impact induced buckling or yielding, structural members should be traced back to the deck leg to check for connection integrity.

5.3.4 Floating Structures

For a floating structure, the above-water GVI is similar to that for fixed structures. The critical connections of the deck to the hull should be carefully inspected. The hull should be visually inspected from the structure and, if needed, by boat looking for dents or other damage. The underside of the topside deck should be examined for beams that may be buckled or out of square due to wave impact as described for fixed structures. For TLPs in particular, evidence of wave impact to the cellar deck can indicate exceedance of the design criteria as well as the possibility of damage to the tendon system.

Structural appurtenances vulnerable to damage from motion should be visually inspected such as the base of flare towers, crane pedestals and drilling rig connections to the deck. Hatches, doors and other openings to the hull should be inspected to confirm that they remained watertight throughout the storm and that no water entered the hull. Mooring jacks and chain stoppers should be visually inspected for indications of extreme stress or failure. The operation of critical marine systems should be verified. These systems include emergency power, ballast, bilge, firewater, and the marine monitoring system. If available, information from the marine monitoring system should be retrieved and reviewed for indications of hurricane severity and floating structure performance during the storm.

5.3.5 Appurtenances and Secondary Structural Members

Appurtenances and secondary structural members to be inspected on fixed and floating structures include:

a) boat landings and their attachment to the structure;

b) stairways, stairway connections, stair landings;

c) grating and handrails on walkways and decks;

d) hanging access decks below the cellar deck (e.g. sump tanks or well access);

e) risers, riser attachments and riser guards (clamps, bolts, isolation, etc.) including unexplained movement;

f) conductors and conductor bay framing members, centralizers and main framing joint connections located in the deck and jacket;

g) pump casings, caissons, and their associated attachments to the structure;

h) muster platforms for lifeboats;

i) draft sensor piping.

If above-water damage is detected on any appurtenance, owner/operators should proceed with additional inspection as required to determine potential damage to primary structure.

5.4 Indicators for Special Below-water Inspection

5.4.1 General

A special below-water inspection should be conducted if any of the indicators in 5.4.2 through 5.4.5 are identified. Special below-water inspections are discussed in Section 6 for fixed structures and Section 7 for floating structures.

5.4.2 Damage to the Above-water Structure

Structural damage identified by the special above-water Inspection that indicates potential below-water damage. Examples of structure damage may include buckled or cracked topside bracing members or connections, deformation of the hull structure (e.g. indication of wave slamming), bent deck girders (e.g. indication of wave in deck), and other damage that may have an impact on overall structure strength or watertight integrity. A below-water inspection is not required when damage to the above-water structure is only localized secondary bracing members or equipment/appurtenance support structure and does not appear to affect the below-water structure.

5.4.3 Large Objects Fallen Overboard

Equipment, appurtenances or structure components may have fallen overboard and potentially damaged the structure or mooring system below water. Examples of fallen objects include drill rigs, boat landings, deck structure, stairways, sump tanks, etc. The original location of the object and possible fall trajectory should be estimated to help guide the below-water inspection. For smaller fallen objects such as hand rails or grating, which are not likely to affect the below-water structure, a below-water inspection is not required.

5.4.4 Additional Damage Indicators for Floating Structures

Additional damage indicators for possible floating structure hull and mooring damage include:

— unexpected change in draft, compartment soundings (void, ballast, etc.), or bilge alarm status from before and after hurricane passage that may indicate leakage;

— unexpected change in offset, list, or trim;

— unexpected change in mooring line tensions (or tendon tensions for TLPs).

5.4.5 Single Unbraced Caissons

If the results of a special above-water inspection of a single unbraced caisson indicate that the caisson does not have any damage integral to overall structural integrity, as defined in 5.3, and the structure does not lean and/or does not have any significant post-hurricane motion, then there is typically no below-water structural damage to the caisson, and therefore no engineering checks and special below-water inspection are necessary.

5.5 Safety

Re-boarding offshore structures after hurricanes can pose challenges to the initial boarding party as the structure may have incurred structural damage or damage to onboard safety systems. Boarding personnel should be aware that landings, walkways, stairways and other access and egress facilities may have sustained damage.

Boarding parties should be provided with pre-planning guidance, as discussed in 5.7, to confirm that the structure can adequately and safely support the proposed post-hurricane operation. Minimum life safety and support capability as outlined by the governing regulatory authority or owner/operator policy should be clearly identified so boarding personnel can establish if the structure can be re-manned or requires additional inspection or safety equipment. Safety risks should be considered in advance prior to opening any internal compartment of a floating structure that could be flooded.

Following a hurricane, normal medical emergency response may be limited and alternative assistance may be necessary should an accident or sudden illness occur offshore. Frequent communication “check-ins” can help establish progress and allow shore-based support to know where crews are operating and to assure that appropriate resources are available in the event of an emergency. Long range communications, normal shore bases, marine transportation and air support are generally not available immediately following a hurricane and boarding plans should account for these potential limitations.

5.6 Environmental

Aircraft flyovers or close approach by marine craft can assist in observing the general condition of the structure and establishing if environmental issues are evident at the site. When environmental issues are observed, owner/operator and regulatory requirements apply. Boarding parties shall be made aware of the environmental issues at the location and boarding plans should include avoiding potentially hazardous materials. Special health and safety and regulatory requirements may apply while working at a site with environmental issues. Pre-planning should be developed for this contingency as discussed in 5.7.

5.7 Pre-planning

5.7.1 Initial Boarding

Pre-planning of the initial boarding of the structure should provide guidance on levels of acceptability on the conditions found for subsequent manning and work at the site with personnel safety as the highest priority. Procedures for special access or egress should be defined before inspection personnel are dispatched, including the need for special safety equipment and training to compensate for the deficiencies of a damaged platform. Clear reporting lines and specific recording and documentation instructions should be provided to the boarding team.

A pre-planned boarding/inspection checklist can establish consistent visual inspection standards and provide the inspection personnel with a well thought out and researched document to identify areas to review and report. The checklist may be structure-specific or be generalized to cover an owner/operator’s fleet. Structure-specific checklists have the advantage of covering minimum requirements and also any special features or hardware needing special attention. Items such as fuel for emergency operations and aircraft re-fueling can be included as check items and can provide critical information to ongoing recovery operations. Access and egress facilities as well as walkways and landings should be included on the checklist if personnel are expected to re-man the structure. The pre-developed checklists can be a valuable tool for personnel performing these inspections.

5.7.2 Structure-specific Post-hurricane Inspection Plans

A written plan, policy, or procedure should be developed for addressing post-hurricane inspections. Consideration should be given to the following elements, as applicable:

a) post-hurricane timing guidelines for re-boarding;

b) personnel qualifications and responsibilities including designation of qualified individuals and objective guidelines on qualification experience and training;

c) procedures for the collection of floating structure condition data at the time of pre-hurricane evacuation (e.g. ballast, draft, mooring tensions, etc.);

d) pre-assembled packages of structural and arrangement drawings and pre-hurricane photos of the structure for use by the post-hurricane inspection teams;

e) guidance for aircraft flyover or close approach by marine craft to determine possible safety, environmental and structure damage concerns;

f) boarding party guidelines including inspection guidance, requirements for special safety equipment for hazardous boarding, and checklists for life safety, access and egress issues;

g) structural integrity guidance in terms of critical support systems;

h) detailed escalation plans for addressing damage discovered and higher levels of inspections required;

i) guidance on assessment requirements relating to damage and mitigation efforts;

j) documentation methods and record retention guidance;

k) regulatory agency or classification society requirements.

6 Special Below-water Inspection of Fixed Structures

6.1 General

A special below-water inspection should be performed for a fixed structure as determined in Section 4. If adequate data are available, the engineering checks or other engineering studies can be used to focus inspections in areas most likely to be damaged. The special inspection is not intended to measure cathodic protection levels, measure marine growth, gauge anode wastage and other inspection items that are typical of an ISIP but not related to potential hurricane damage. All inspections should be performed by qualified personnel. Additional guidance for these inspections can be found in the relevant API standards for fixed structures. If damage is found, it should be documented as discussed in 8.2.

6.2 Primary Structure

The special below-water inspection is a GVI that should be conducted by divers or remotely operated vehicle (ROV) and focus on the primary structure. Experience has shown that a GVI is capable of finding damage caused by hurricanes. The GVI should inspect for evidence of:

a) environmental overload or fallen object damage (i.e. damaged members, including missing, bowed, dented or bulged members);

b) missing marine growth which may indicate possible impact loading or strain or deformation in the structure due to member or joint overload;

c) scour, seafloor instability, and other concerns at the mudline;

d) large fallen objects that may have impacted the structure;

e) damage to the cathodic protection system such as missing or loose anodes or impressed current cables;

f) damage to previous repairs.

If damage from large objects fallen overboard is suspected, the inspection should be conducted based on the trajectory of the fallen object. The jacket, risers, and appurtenances should be inspected within the estimated fall zone for indications of impact, dents or scrapes in the marine growth.

An ROV generally allows for safer access where divers may be prohibited from inspecting, such as a leaning structure. More structures can be readily inspected by ROV compared to divers because there are no delays due to diver decompression or diver saturation/de-saturation. However, damage found by ROV typically requires additional follow-up investigation by divers to determine the full extent.

If structural damage is detected, additional inspections involving progressively more detailed inspection should be performed including close visual inspection or nondestructive testing as necessary. Marine growth may have to be removed in some cases to perform the inspections.

6.3 Risers, Appurtenances, and Secondary Structure

The below-water GVI should also include visual inspection of risers, underwater appurtenances and secondary structural members to identify missing and/or damaged components. Consideration should be given to the following items.

a) Risers, riser attachments (clamps, bolts, isolation, etc.), riser freespan from the base of the structure out to the seafloor.

b) Conductors and conductor guide framing.

NOTE Conductor guide framing at the first elevation below the waterline is vulnerable to damage at the bracing connections due to the vertical action of hurricane waves.

c) Casings, caissons, and their associated attachments to the jacket.

d) Pipeline displacement in the vicinity of the base of the jacket.

7 Special Below-water Inspection of Floating Structures

7.1 General

A special below-water inspection should be performed for a floating structure as determined in Section 4. If adequate data are available, engineering checks or other engineering studies can be used to focus inspections in areas most likely to be damaged. The special inspection is not intended to measure cathodic potential, marine growth or other activities that may be required as part of an ISIP's scheduled inspections but are not related to hurricane damage. All inspections should be performed by qualified personnel. Additional guidance for scheduled inspections can be found in the relevant API standards for floating structures. If damage is found it should be documented as discussed in 8.2.

7.2 External Structure

7.2.1 General

The special below-water inspection of the external structure consists of a GVI. This should be conducted by divers or ROV and focus on identifying damage to the primary structure. As described in 5.4, there are key damage indicators that identify the need for external structure inspections. The inspections should be targeted to specific structural components based on the damage indicators. The ISIP for the floating structure may provide additional guidance to determine external structure inspection locations related to hurricane loading. The following provides guidance on types of external inspections based on the damage indicators identified during the special above-water inspection.

7.2.2 Large Fallen Objects Overboard

A GVI using ROV or divers should be conducted covering the expected fall zone for the fallen object. The fall zone should allow for the uncertainty in the trajectory of the falling object through the water column. The top and the sides of the hull, mooring fairleads and platform chain, riser porches and risers, and hull appurtenances (i.e. caissons) should be inspected within the limits of the fall zone for indications of impact, such as dents or scrapes in the marine growth, coatings, or hull steel. Production risers and pipeline/flowline risers should also be inspected below the structure in way of the object fall zone. Flowline and pipeline risers are typically left pressurized, so the GVI should note any indication of leakage (e.g. bubbles). If indications of impact are found, additional efforts, such as removal of marine growth and closer inspection including non destructive testing, may be required to evaluate the extent of the damage. If structural damage is observed on the hull exterior, interior hull compartment inspections may also be required (see 7.3).

7.2.3 Other Damage Indicators

7.2.3.1 Hull Damage Indicators

These may include an unexpected change in draft, compartment soundings (void, ballast, etc.), list or trim or bilge alarm status pre-hurricane compared to post-hurricane, and may be indicators of a possible hull breach or compromise of the internal bulkheads. If one of these indicators is observed, a GVI should be conducted on the exterior surfaces of the hull, inspecting for damage that might constitute a leak path. Within the limits of the GVI capabilities, column-to-pontoon, or similar critical joints should be inspected for possible cracks or openings or evidence of high strain such as spalling of marine growth. Soundings should be taken in all tanks. If damage to the hull is discovered, an internal structure inspection may be required as discussed in 7.3.

7.2.3.2 Mooring Damage Indicators

These may include unexpected offset after the hurricane or an unexpected change in mooring line tensions (or tendon tensions for TLPs). If one of these indicators is observed, a GVI of the mooring system should be conducted. For a structure with mooring lines, a GVI should be conducted on all mooring lines, fairleads and their foundations and piles. Guidelines for mooring system inspections can be found in API 2I. For a TLP, the GVI should include the tendon porches, tendon top connections, tendons, tendon load measurement units, fairings or strakes (if so equipped), tendon couplings and tendon bottom connector for any signs of damage or unexpected tendon movement. Flooded member detection may be used to help identify leaks in buoyant tendons. Tendon fairings should be inspected for damage and for loss of free rotation. Tendon bottom connectors should be inspected for indications of vertical or rotational movement at the pile plus intrusion of debris into the tendon receptacle.

7.2.3.3 Riser Damage Indicators

These may include observed damage to riser piping in the splash zone, evidence of excessive stresses or movement from riser instrumentation measurements, or evidence of excessive movement. Other damage indicators may apply depending on the specific type of riser arrangement. If one of these or other indicators specific to a riser system is observed, a GVI of the riser system should be conducted. The GVI should include inspection of the clamps and

attachments, connection points (flexible element, titanium stress joint, etc.), riser porches or pull tubes, the pipe suspended span in the water column and pipe in the seabed touchdown area. For direct vertical access risers, this GVI should include tensioners or buoyancy cans, keel joints (where applicable), couplings and seafloor stress joints.

7.2.3.4 Other Damage Indicators

In addition to the damage indicators in 7.2.3.1 through 7.2.3.3, engineering check results can indicate structural components or systems (e.g. mooring or risers) exposed to loading conditions in excess of their design criteria, which could cause external structure damage. In these cases, a special below-water inspection of the external structure should be conducted which focuses on these components or systems.

7.3 Internal Structure

The special below-water inspection of the internal structure (i.e. hull compartments) is a GVI focused on confirming the existence or extent of damage to the primary structure and to the hull watertight integrity. The internal inspections should be targeted to specific regions or compartments within the hull based on the damage indicators. Any of the following damage indicators may warrant inspection of internal structure:

a) the special above-water inspections or special below-water inspections of external structure indicate potential internal hull damage or loss of watertight integrity;

b) unexpected change in draft, compartment soundings (void, ballast, etc.), or bilge alarm status from before and after hurricane passage indicating possible leakage;

c) unexpected change in list or trim;

d) unexpected change in internal humidity.

If one of these indicators is observed, a GVI should be conducted within the compartments of the hull where the leak or damage is anticipated based on the damage indicator. The GVI should include the compartment watertight boundaries, watertight penetrations and any backup structure in way of external structural connections such as riser porches or mooring fairlead supports.

In addition to the above damage indicators, engineering check results may indicate that internal structural components or systems were exposed to loading conditions in excess of their design/assessment criteria which could cause internal structure damage. In these cases, an internal structure inspection should be conducted, focusing on these components or systems. The ISIP for the floating structure may provide additional guidance to determine internal structure inspection locations related to hurricane loading.

8 Documentation

8.1 Inspection Results

Documentation of the inspections should be maintained and made a part of the overall records of the structure. Documentation should include hand written records, records kept on a computer database or reports issued by third party contractors. The associated API standards for the structure type provide additional information about inspection documentation. All inspection records should meet the minimum requirements of the applicable regulatory agencies.

At a minimum, written inspection records should include the following information:

— date;

— structure identification;

— identification of person recording the information;

— area/location of inspection;

— results of GVI, nondestructive testing, flooded member detection (FMD) and other inspection methods utilized;

— findings or issues (i.e. anomalies) discovered during the inspection;

— other pertinent data.

Optional additional information that may be helpful includes:

— lease name;

— lease number;

— API categorization, e.g. L-1, L-2, A-1, A-2, etc.;

— previous inspection results;

— site-specific or special needs for the structure.

An inspection report form or database should be developed for use by inspection personnel taking into account the following considerations:

— inspection should be documented similar to normal in-service inspections;

— if damage is found, additional documentation should be collected to enable use in engineering assessment of the damage and possible repair plans;

— documentation should be in a format suitable for internal use as well as for submittal to regulators and/or classification society as required.

8.2 Damage

If significant structural damage is found, documentation detailing the location and extent (measurements) of the damage should be developed for a structural engineer to perform a proper evaluation of the damage. Detailed findings may include video, still photography, detailed inspection results such as nondestructive testing and anomaly measurements. Field notes, sketches, photos, etc. should be converted to a formal report as soon as practical to lessen the chance of losing critical data. The typical types of hurricane structural damage and the types of documentation required are as follows:

a) dents should be measured for shape, depth and location on the member, i.e. clock position, distance from ends, etc.;

b) cracks should be measured for depth and linear distance and clock position or other relevant location data;

c) bowed members should be measured for distance off centerline and location relative to member ends;

d) separations should be measured for gap distances and misalignment;

e) missing members should be noted and a search conducted for damage that may have been caused by the member failure.

As part of pre-planning activities, the owner/operator should have a procedure in place for documenting damage found. All damage should be resolved through engineering evaluation and repairs as necessary.

Bibliography

[1] API Recommended Practice 2A-LRFD, *Planning Designing and Constructing Fixed Offshore Platforms—Load and Resistance Factor Design*

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

[3] API Recommended Practice 2FPS, *Recommended Practice for Planning, Designing, and Constructing Floating Production Systems*

[4] API Recommended Practice 2I, *In-service Inspection of Mooring Hardware for Floating Drilling Units*

[5] API Recommended Practice 2RD, *Design of Risers for Floating Production Systems (FPSs) and Tension-Leg Platforms (TLPs)*

[6] API Recommended Practice 2SK, *Design and Analysis of Stationkeeping Systems for Floating Structures*

[7] API Recommended Practice 2T, *Planning, Designing and Constructing Tension Leg Platforms*

[8] API Bulletin 2TD, *Guidelines for Tie-downs on Offshore Production Facilities for Hurricane Season*

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