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TECHNICAL PAPER

Riser and Subsea Asset Field Life Extension

D. Nashikkar, W. Mo, V. Achanta - 2H
S. Lyon - Lonestar

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Feb. 2015

RISER AND SUBSEA ASSET FIELD LIFE EXTENSION

DHAWAL NASHIKKAR
ENGINEER, 2H OFFSHORE INC.

WEIHUA MO
ENGINEERING SPECIALIST, 2H OFFSHORE INC.

VAMSEE ACHANTA
SENIOR ENGINEERING SPECIALIST, 2H OFFSHORE INC.

STEPHEN LYON
SUBSEA TEAM LEAD, LONESTAR DEEPWATER LLC.

Proceedings of the 20th Offshore Symposium, February 2015, Houston, Texas
Texas Section of the Society of Naval Architects and Marine Engineers

ABSTRACT

Many offshore floating hosts and subsea assets commissioned in the Gulf of Mexico are approaching the end of their design life. Existing fields continue to produce due to enhanced recovery while adjacent fields are considered to be tied back into aging facilities. Hence, there is motivation to extend the service life of these subsea assets beyond the original design life.

Condition assessment and life extension analysis for the assets is required to ensure safe operations during extended field life. This paper discusses the general roadmap and activities performed to provide assurance that extended operational life of riser and subsea assets will not create integrity risks.

Life extension of a typical riser system on a production platform is discussed as a case study. The case study is mainly focused on riser but can be generalized to subsea assets. The paper reviews the original designs of the assets in conjunction with the extended service requirements. Inspection and operational information from ongoing integrity management of these assets is utilized to understand the health of the existing asset. Use of actual history of loading to understand the fatigue history of the structures is discussed. The paper also includes evaluation of the impact that updated metocean and the latest code requirements have on robust extension of the asset field lives.

Keywords: Life Extension, Offshore, Subsea Structures, Risers

INTRODUCTION

Commercial development of the deep water oil and gas fields has been increasing in the recent times. New and marginal fields developed near existing facilities are considered to be tied back to existing platform and existing pipelines in order to keep the cost low until reserves are proven. The existing platforms however are reaching the end of their design lives and hence it becomes challenging to prove the integrity of the asset during the extended life.

A life extension assessment needs to be conducted to ensure that the integrity of the asset is not compromised with the extended operations under the new operating conditions. This paper discusses a generic methodology for conducting the life extension assessment of an asset while ensuring the structural integrity and compliance as per the latest codes.

The scope of the paper is to propose a general methodology for the assessment of asset life extension along with the discussion of a case study.

LIFE EXTENSION METHODOLOGY

A typical high-level life extension process consists of design review, inspection, reanalysis and structural modification as shown in Figure 1.

The life extension process is shown in greater detail in Figure 2. Life extension assessment process can be divided into the following steps:

1. Detailed Design Review
2. System Status Assessment
3. Conditional Assessment
4. Inspection plan
5. Critical Component Identification
6. Reanalysis
7. Repair
8. Replacement
9. Continued production

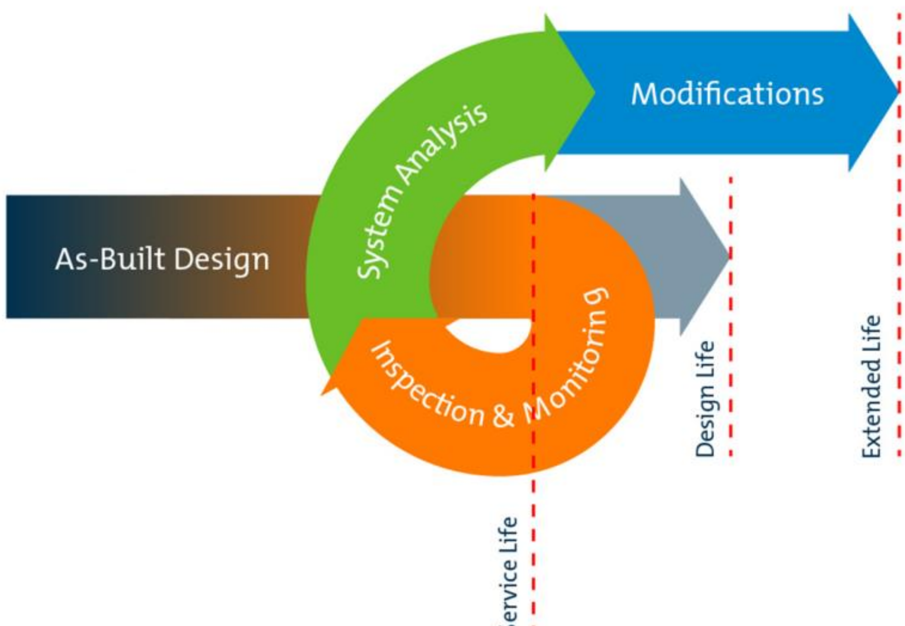

Figure 1 – Life Extension Process

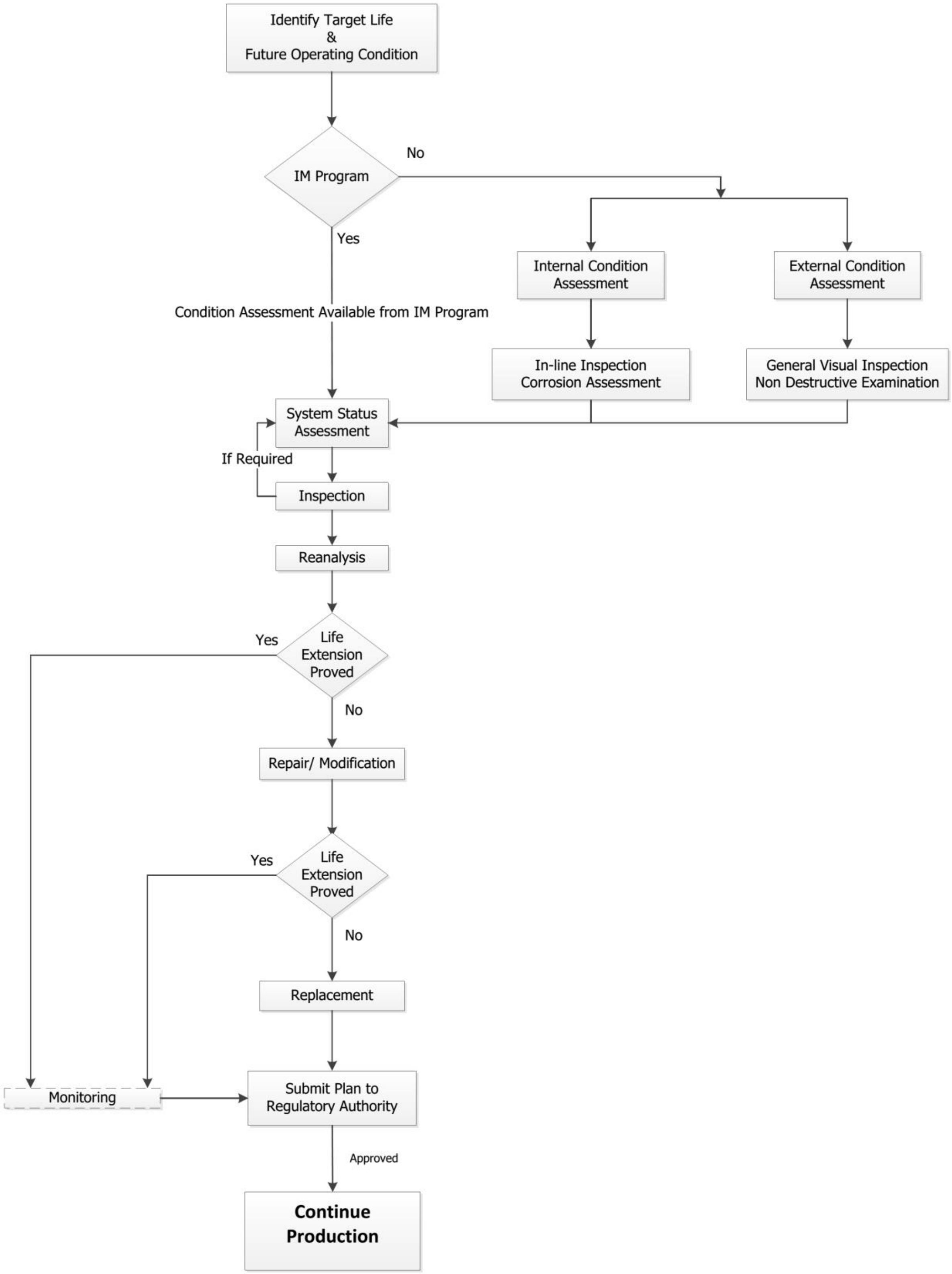

Figure 2 – Life Extension Strategy Flowchart

Design Review

Design review is conducted prior to life extension assessment of an offshore asset to confirm the relevant design parameters for all components of the offshore asset. The design data includes design parameters such as pressure, temperature, as-built wall thicknesses, corrosion allowances, manufacturing tolerances, applicable codes and standards etc. Additionally, minimum calculated fatigue lives from the design of dynamic components such as risers, flowline and jumpers need to be known before commencing the assessment.

A comprehensive review of these parameters is required from as-built drawings, manufacturer's data books and design reports for all components.

Operational and Integrity Review

Operational and integrity review is performed to assess the impact of operational conditions due to service to date. An Offshore Engineer article [2], discusses a typical integrity management process (IM Process) and their benefits, while conducting life extension assessments. The article discusses that an IM process by definition requires the periodic condition assessment of the equipment with a few examples described below:

- A Design, Fabrication, Installation and Operations (DFIO) Dossier is a compilation of all reports, drawings, and assessments completed through the life of an asset.
- Regular inspections are used as part of an IM program to periodically assess the condition of a component. Anomaly reports are typically used to document inspection or operational observations which are outside of the design intent or could degrade the components function. A risk based integrity management plan for operations to date will help predict, identify and mitigate the anomaly risks through a defined process.
- Key Performance Indicators (KPIs) round out a regular inspection program providing context on how a system is performing as compared with design. KPIs are good indicators to assess changes in operating conditions over time.
- Annual Summary Reports for an asset documents the overall condition of the asset at the end of a calendar year and any changes in overall status from the previous year.

Review of the above documents provides a comprehensive conditional assessment of a component which may be extremely valuable while conducting the life extension assessment. If IM processes are in place, significant time and effort is saved when compared to the challenge of going back and gathering details after 8-10 years in service.

Condition Assessment

Condition assessment is performed to assess the current condition of the component. This would include both internal and external condition assessments. A full scale IM process is extremely helpful as condition assessments of a component are readily available. If condition assessments are not available, external and internal condition assessments methodology are described below.

Internal Condition Assessment

The internal condition is assessed to determine whether the expected wall loss due to corrosion experienced by the riser and flowline considering actual operating parameters is in line with the original design expectations. Historical data such as corrosion analysis reports, chemical injection program details, sampling data including water chemistry, corrosion coupons, erosion rate and sand probes, flow rates, pressure and temperature data should be reviewed where available to conduct the assessment.

Historical inline inspection data can be reviewed to evaluate the amount of wall loss due to the corrosion, presence of any fatigue cracks and if the available wall thickness is sufficient to withstand the future operating pressure. If internal corrosion assessment is inconclusive for life extension, an internal condition assessment strategy should be proposed with inspection and monitoring plans as required.

External condition assessment

External condition assessment is required to be conducted to determine if any anomalous feature is present on the component and to determine that the structural integrity of the component would not be compromised during the extended operation. Historical external inspection data, riser strakes condition including marine growth, cathodic protection system status, equipment replacement/ change out history and historical anomalies should be reviewed to assess the external condition of the asset.

Critical Component Identification

Following the condition assessment, the components which would require further investigation for assessing their fitness for service during extended operations are identified. The critical components are identified by comparing the design data and the condition assessment against the future operating conditions during the extended service life.

Once a critical component has been identified, mitigation options to reduce the criticality of the component should be evaluated. These may include conducting further inspections to determine the actual physical status of the component.

Inspection

Further inspections may need to be performed to fill in the gaps for the internal and external conditional assessments. These may include in-line inspection (ILI) to evaluate the remaining wall thicknesses, general visual inspection (GVI) and close visual inspection (CVI) of the components to assist in the anomaly management.

Re-analysis

The reanalysis of the system can be conducted based on the inspection and monitoring data, the most recent environmental and operational data, and the current industry best practice. It provides a quantitative engineering evaluation of the structural integrity of the system and helps the operator make the run-repair-replace decision on pressurized equipment.

Reanalysis process can be broken down into following two steps:

- Identify Conservatism in the Design
- Component Reanalysis

Identify Conservatisms in the Design

Quite often, the equipment is designed with assumed parameters that are unknown during design phase. Design parameters including the environmental loads and operating conditions are typically unknown and hence assumed during the design phase of the project. This introduces conservatisms into the design. However if these are measured during the operating life of the asset, the reanalysis of the component can be further refined based on the measured data.

Additionally corrosion rates determined during the design process are conservative and/or corrosion defects may have been repaired. Also the anticipated operational fatigue damage experienced by the component could have been overestimated. In such scenarios, further analysis may be required using the updated environmental data and the latest software to verify the integrity of the component. Further details regarding the reanalysis are discussed in the next section.

Component Reanalysis

Once the conservatisms in the design are identified, the structural reanalysis of the critical component needs to be conducted. A typical reanalysis methodology is shown in Figure 3.

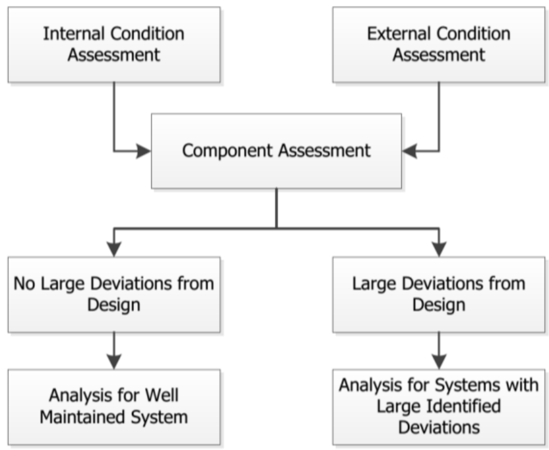

Figure 3 – Reanalysis Methodology

The reanalysis of the system can be one of or a combination of the following categories:

- Analysis for well-maintained system
- Analysis for systems with large identified deviations

Analysis for Well-maintained System

This analysis usually assumes the system to be a new build and calculates the fatigue life that will result in extension of service life beyond its design life. This reanalysis is applicable for components with acceptable maintenance and with no major historical repairs. Though very similar to the original design analysis, this reanalysis will take advantage of the advances in knowledge, technology and codes and standards since the original design analysis of the system.

The following changes in the design data or technology may initiate the necessity of re-conducting the design analysis for the system life extension assessment:

- Revised Metocean data including the seastate scatter diagram and the current profiles.
- Revised soil model based on new research or new soil tests.
- Revision to the analysis software.
- Better calibration of the analysis model based on the actual field measurement data.
- Design assumptions adopted due to insufficient information at the time of original design analysis.

- Updated international, national and company codes and standards.

It is noted that this type of analysis could also utilize as-built system data or latest system data including any modification since installation.

Analysis for Systems with Large Identified Deviations

This analysis is conducted to evaluate the system at the end of the new design life based on existing conditions. This analysis utilizes the existing condition of the system determined from the condition assessment and may also include any anomaly that is observed on the components. Updated design data and revisions to the analysis software as discussed in previous section can be also incorporated in this analysis to better predict the design loads. This type of re-analysis is often initiated when a significant deviation is identified in the current system condition against the design parameters.

For instance, the in-line inspections (ILI) of the riser and flowline pigging loop may show the presence of extensive pitting on the internal and surfaces of the pipes. In such scenarios fitness-for-service analysis is thus required to verify that at the end of the new design life, the pipe would have adequate strength and that fracture of pipe is not expected. Another example is that of a riser VIV fatigue analysis which may be required after the general visual inspection (GVI) of the riser shows a significant loss of the strakes or strake straps on the riser which can affect the VIV fatigue life of a riser.

Repair/ Modification

If life extension of a particular component is not proved after conducting further analysis, possibility of conducting some structural modification or repair should be evaluated. Structural modification for shallow water well conductors to assist in life extension [3] is an example of repair/ modification to existing components.

Replacement

Modifications of the critical component identified may not be always possible. The last option in such a scenario would be the replacement of the critical component. The replacement decision is dependent on the economics of the life extension project.

LIFE EXTENSION CASE STUDY

The life extension assessment of a field with subsea wells is discussed as a case study example. The field located in Gulf of Mexico (GoM) is service by a floater with subsea fields tied back to the platform using Steel Catenary Risers (SCR). The field consists of two Pipe-in-Pipe SCR and flowline which is near the end of service life of 15 years. The field operator is planning to recomplete one of the wells in the field which would potentially increase the shut-in tubing pressure (SITP) at the wellhead. The target extended life for the field is 30 years.

A comprehensive integrity management plan is in place for the asset located in GoM. This facilitated the assessment process as all the required design and integrity data were readily available. Integrity reports such as inspection reports, annual summary reports and key performance indicators (KPIs) were reviewed to obtain the condition assessment of the system.

Life extension assessment is conducted for the offshore field based on the methodology discussed above.

Design Review and System Status Assessment

A detailed design review of the system is conducted to determine the design specification and minimum fatigue lives of the equipment located in the field. Integrity documents from existing IM program were reviewed to identify the condition of the components. The integrity documents included annual summary reports, key performance indicator, inspection and all the anomaly reports associated with the asset. The detailed review of the asset identifies equipment with issues that do not allow extending the life of the field without some mitigation.

Components		Design Life (years)	Minimum Fatigue Life (years)	Fatigue Curve	SCF
SCR Pipe	Outer	15	20	DOE - E	1.3
	Inner	15	20	DOE - E	1.2
PIP Flowline	Outer	15	22	DOE - F2	1.5
	Inner	15	26	DOE - F2	1.6

Table 1 – Critical Component Based upon Fatigue Criteria

Based on the review process discussed above, the following activities to assist life extension assessments are identified:

1. Inspection of Pipe-in-Pipe Steel Catenary Riser (SCR)
2. Re-analysis of Pipe-in-Pipe Steel Catenary Riser (SCR)
3. Replacement of Hot Water Jumper interfacing the SCR to the Top Sides
4. Supplement of Cathodic Protection System
5. Monitoring of Flowline

Inspection of Pipe-in-Pipe SCR

External inspection data of the riser is reviewed and no significant threats are identified on the asset. However wall thickness measurement data from an In-line inspection (ILI) is not available for conducting internal assessment of the riser and the flowline. Therefore an in-line inspection is planned on the riser to measure the wall thickness and evaluate the fitness for service of the riser and the flowline.

Re-analysis of Pipe-in-Pipe SCR

Structural reanalysis of the steel catenary riser is conducted to extend the service life of the risers. The steel catenary risers located in the GoM asset are originally designed for a service life of 15 years. Based on the original design report, the minimum fatigue life of the riser is less than 30 years. In order to evaluate the possibility of extending the life of the riser beyond design life, structural re-analysis of the riser is conducted to take into account the updated software tools, analysis guidelines and design data including the following:

- Revise seastate scatter diagram based on recent hindcast data;
- Utilize comprehensive measured current profile data on the site;
- Revised vessel motions due to improved analysis processes; Usage of Shear7 v4.6 for VIV analysis;
- Updated soil model based on recent centrifuge tests;
- Structural damping for pipe-in-pipe joints based on prototype riser structural damping test;
- Vessel mean position shift due to later installation of SCRs tieback to other fields;
- A revision of the fatigue curve used for analysis. Detailed investigation and testing show that FBE coating is not compromised by the cracking in the insulation. Thus a less conservative and yet appropriate fatigue curve could be utilized for analysis.

The extended life is determined to be 3 years less than the target life. The improvement of predicted life against the predicted life during design is mainly due to the revised environmental data and the structural damping for the pipe-in-pipe riser.

General visual inspection (GVI) identifies some strake losses and significant portion of strakes with all or two third straps missing which poses a potential of further strake loss. Therefore, a refined VIV analysis is conducted considering the actual strake loss, and the analysis shows marginal fatigue life reduction with the current loss of strakes. However, the VIV fatigue damage could be significant if the strake condition deteriorates such that continuous strake coverage is missing in top section of the riser. Therefore, the repair of the missing strakes or strake straps may be necessary. The strake integrity due to failed straps is to be monitored regularly. The strakes are also recommended to be cleaned regularly to maintain VIV suppression efficiency. Illustrative example of marine growth on a riser is shown in Figure 4.

In Line Inspection (ILI) is planned but is not conducted yet. The fitness-for-service analysis is therefore pending.

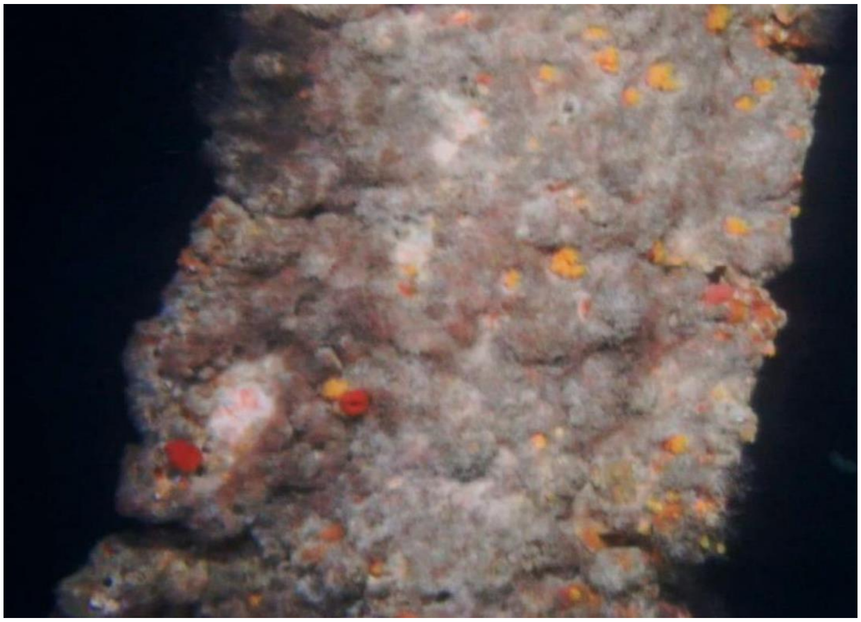

Figure 4 – Illustrative Example of Marine Growth on a Riser

Repair/ Modification

The design life of the cathodic protection system of the asset is 20 years. Hence in order to ensure adequate cathodic protection of the riser and subsea equipment, it is recommended to retrofit more anodes than necessary on any new equipment that would be installed on the asset.

A regular risk based inspection for a CP survey is also recommended to ensure that all the equipment are receiving adequate cathodic protection.

Replacement or Retrofitting

If certain components used are difficult to prove life extension but are easily replaceable, it is recommended to do so. For example, if flexible jumpers are used as fluid conduits between top sides and the riser, these are easy to be replaced than prove the extended life due to vulnerability to fatigue failures.

ISSUES EXPERIENCED

Life extension assessment process is an extensive process which involves numerous critical steps. Some of the key issues during the life extension assessment are documented below:

Design Data Availability

As discussed earlier, following 10-15 operating years, it is challenging to locate the required design documents and drawings. This process can be further complicated if the ownership of the asset changes. In such an event, not all of the documents may be transferred to the new operator or the new operator may just get a large amount of data. The review of the design documents and drawings can turn out to be unending and exhaustive process.

An effective document control process is extremely necessary during design and operations to aid in conducting life extension assessment.

Operational Data Availability

Another issue that an engineer might come across while conducting the life extension assessment is that an operator may not have properly documented the historical operational data such as fluid pressure, temperature and characteristics, environmental data measurements.

Previous operating condition including the pressure, temperature, operating environment, fluid characteristics may not be properly documented if an IM program is not in place.

Management of Change

Throughout the life of an asset, modifications were conducted on the asset which may include retrieval of some of the equipment, intervention operations and changes in the piping and pumping system. These changes may not be properly documented and hence accurate information may not be available for conducting the life extension assessment appropriately.

Updates in Code/ Regulatory Requirement

As an offshore asset is typically designed for a design life of 15-25 years, design code recommendations and regulatory requirement may be updated during the operating period of the asset. Hence any gaps between the original design and the latest code requirement should be identified.

Any additional analysis required to prove the compliance per the new code should also be conducted. ISO technical specification 12747, [8] lays down the recommended practice for pipe line life extension.

Changes in Operating Conditions

If a new field is being tied up to an existing platform the operating conditions including the pressure, temperature, fluid quality, flow rates may change/increase in comparison to what was considered in the design.

Additionally the environmental conditions may also change over time and hence the fitness of the asset needs to be proved to these new characteristics.

CONCLUSION

As more deep water fields continue to produce beyond the original design life, there is an increasing need to manage the asset integrity. Fitness of these offshore fields needs to be established for extended operating period and conditions. A developed integrity management (IM) plan will ensure that the system condition assessment is readily available at any given point of time. This will also help extensively during the life extension assessment process as the system condition is readily available.

Life extension assessment can be a very extensive, tedious and complicated process which can turn out to be exhaustive. A suitable methodology and analysis is required that would ensure extended operations without compromising the integrity of the system. This life extension methodology along with an IM plan is the key to ensuring successful and efficient asset life extension.

ACKNOWLEDGEMENTS

We would like to personally thank Mr. Basim Mekha (Cuneiform Offshore Consulting LLC) for helping the project case study referred in the paper. We would also like to thank Mr. Mark Cerkovnik and Mr. Madhu Hariharan (2H Offshore Inc.) for their guidance and support through the course of the paper.

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