The structural inspection work engineering essay

Subsea integrity management (SIM) is a continuous process throughout the lifecycle of subsea/offshore facilities. As a requirement for the effective implementation of the Company's Integrity Management (IM) program, Remotely Operated Vehicle (ROV) underwater inspection work shall be carried out on subsea structures and pipelines. The purpose of this Scope of Work document is to define the scope of inspection, equipment types, personnel role and competence, and quality of work for the Contractor.

The Company requires the underwater inspection services operated from a Remotely Operated Vehicle (ROV) support vessel equipped with Work and Observation ROVs and other ancillary equipments. The Contractor shall supply all resources necessary to perform the Work. This shall include without limitation the vessel required to perform the Work, the ROVs, all necessary certification, personnel, equipment, machinery, consumables, materials, logistics, tools, spare parts, management, engineering, and other services required to effectively carry out the Work. Contractor shall ensure all his employees conform to all Company HSE standards.

Structural Inspection Work

4. 1 Objective and Methodology

The purpose of this inspection is to assess the integrity of the jacket structure and other structural components attached to the jacket. This shall be achieved by the ROV visually inspecting all jacket structural members, connections, clamps and other fitting. The inspection shall be performed in conjunction with continuous CP measurements on all structural members surveyed and irregularities recorded. Data from this Inspection Survey would be utilized by Company to assess the deterioration rate of the condition of the structure and the corrective actions required.

4. 2 Scope of Work

The scope of inspection shall cover the following jacket segments and other structural components:

Jacket members in splash zone.

All horizontal, vertical, diagonal structural members.

CP measurement of all structural members.

Installed Galvanic anodes

Structural clamps and connections.

Mud mat and leg pile scour.

4. 3 Inspection Deliverables

The inspection shall establish and report the following details:

Major or minor structural damage such as dents, cracks, flooded members, buckle, weld defects, gouges etc.

Thickness and nature of marine growth on jackets and shall carry out immediate work to remove growth.

Impact damage from dropped objects, coating damage, loose members.

Condition of Mud mat and pile scour (check for settlement, stability)

Performance of the CP and anode wastage.

Condition of riser, umbilical and structural clamps and other structural connections.

Flooded member detection

5. 0 Pipeline inspection work

5. 1 Objective and Methodology

The purpose of this inspection is to assess the integrity of the pipeline and identify any potential threat to it. This shall be achieved by the ROV moving above and along the pipeline, inspecting visually and recording of pipeline system irregularities using underwater video cameras. At the same time, continuous cathodic potential measurements shall be taken, measurement of the burial depth, free spans etc. Data obtained would be utilized by Company to assess the deterioration rate of the external condition of the pipelines and the corrective actions required. The survey shall be performed for the entire pipeline lengths.

5. 2 Scope of work

The scope of inspection shall cover the following pipeline segments and other subsea facilities:

Pipeline riser in the splash zone and below splash zone.

Riser Clamps in splash zone and in submerged zone.

Umbilical carrying electrical, hydraulic and fibre optic cables.

Submarine pipelines fittings such as flanges, spools, supports, induction bends etc.

Subsea structures components (pipeline end terminal, valves, instruments etc)

5. 3 Inspection deliverables

The inspection shall establish and report the following details:

Major or minor pipe damage.

Pipeline settlement/displacement along the entire length.

Pipeline exposure and burial depth.

Identification of where upheaval buckling or excessive lateral buckling occurs.

Identification of where excessive free spans occur including length, height and end support conditions.

Assessment of pipeline and riser expansion loops, support and protection.

Assessment of sea bed scour and sand wave movement affecting pipeline integrity.

Assessment of physical condition & evidence of damage to pipeline external attachments such as valves, flanges, induction bends, end termination etc.

Assessment of the performance of the CP.

6. 0 ROV Requirements

The ROV shall have capability to work in all depths and under weather conditions normally experienced in the location of the Company assets. IMCA Code of practice for safe and efficient operation of ROV's is classified below as:

Class I – Pure Observation

Class II – Observation with payload option

Class III – Work class vehicle

Class IV – Towed or bottom crawling vehicles.

Class V – Prototype or development vehicle.

Class I, II and III shall be utilized. ROV's shall have sufficient thrust and controllability to permit positioning at any required orientation to the structure and pipeline without their performance being affected by action of the sea current or wave. ROV shall be of high power rating. As a minimum, the Contractor's ROV shall have the following equipments and specification:

Pay Load Capacity – should be sufficient to perform the activities indicated in Sections 4. 2 and 5. 2

Flotation module and tethering capability

Propulsion System – thrusters should be capable of producing speed to drive the payload capacity.

Lighting – should be adequate to conduct all the operational sequences.

Camera – ROV should be equipped high quality video camera (monochrome and coloured) that can record, transmit and take pictures.

Handling system and controller

Manipulators

Launching and recovery system – “ A” frame and winch system

ROV console, umbilical and power cables

Topside PC based control with diagnostic monitoring system.

Telescopic boom showing both sides of pipeline

Special tools – metal cleaning and cutting wheel, air grit blasting system, water jet system and hydraulic steel brush, Ultrasonic test, Magnetic particle test etc

Sensors for temperature, leak detection, trench profile, pipe burial, cathodic potential, marine growth and acoustic measurements.

Spare and tool kits

ROV operation and procedure manuals

7. 0 Personnel Requirements

7. 1 Personnel type

The following personnel shall be required for the work:

ROV supervisor

ROV pilot

ROV maintenance technician

Data recorder

Surface support personnel

7. 2 General qualification

Contractor shall supply fully qualified and experienced personnel to undertake the inspection Work. All personnel shall have experience in the field of subsea inspection for jacket structures and pipelines. They shall be computer literate with adequate skills to produce electronic reports, input to databases and have good communication skills. Personnel shall be familiar with the main oil and gas industry codes and standards in general use, including all relevant CSWIP codes and standards and shall comply with HSE procedures. All personnel shall possess current and valid offshore medical/visual fitness and offshore survival certificate.

7. 3 Personnel role and qualifications

The personnel job functions and minimum qualification are highlighted below:

7. 3. 1 ROV/Inspection supervisor

Role

The ROV supervisor shall be responsible for, but not limited to the following:

Integrating all the required ROV functions with topside support activities which are associated with planned operations.

Shall be familiar with the structures and pipelines to be inspected.

Shall determine how operations are accomplished, their means of documentation, and the actions of those personnel required to assist operations.

Shall work closely with the Inspection/Data Recorders to ensure an efficient inspection operation.

Shall be responsible for the overall safety of the ROV operations including coordination of vessel activities.

Shall be competent in piloting the ROV and carry out basic checks and maintenance on the vehicle.

Shall ensure that the ROV is maintained in good working condition.

Qualification

Shall possess the following minimum qualification:

Desirable degree in engineering (mechanical, electrical, electronic) or its equivalent.

Shall possess evidence of ROV related trainings.

Shall possess good leadership, interpersonal, capacity to work under pressure, result oriented skills.

7. 3. 2 Remote Visual Inspection (RVI) Inspector

Role

Shall be responsible for, but not limited to the following:

Shall be able to perform specific calibrations, interpret test results and make final evaluations.

Shall carryout subsea qualifications for minor or major defects, CP, FMD and other NDT.

Shall prepare subsea inspection reports complete with structural sketches

Shall report to ROV/Inspection supervisor.

Qualification

Hold a qualification in a relevant engineering or science subject, HNC or above.

Current CSWIP 3. 4. u or other relevant CSWIP certification or equivalent.

Shall have offshore experience in supporting ROV structural/pipeline inspection, corrosion monitoring, underwater NDT, FMD and data processing.

7. 3. 3 ROV Pilot/technician

Role

The ROV pilot/technician shall be knowledgeable in both piloting and maintenance of the ROV. His role shall include the following:

Shall be responsible for the actual flying and control of the ROV.

Shall work with the data recorder.

Shall be responsible for the maintenance of the ROV including pre-dive and post-dive maintenance checkout of ROV components

Shall report to ROV/Inspection supervisor.

Qualification

Shall possess the following minimum qualification:

Engineering degree, trade apprenticeship or college education in mechanical, electrical, electronic or hydraulics.

Shall possess proven track record in operating, maintaining and repair of ROV.

Shall be skilled at solving problems and troubleshooting, open minded, work under pressure, team player and result oriented.

7. 3. 4 Data Recorder

Role

The Data recorder shall be responsible for the following:

Shall be responsible with the management of information acquisition and recording during ROV operations.

Shall work with the ROV pilot to obtain required information.

Shall be responsible for keeping records of structural and pipeline drawings, inspection data, photographs and all video documentation.

Shall report to ROV/Inspection supervisor.

Qualification

Shall possess the following minimum qualification:

Trade apprenticeship or college education in mechanical, electrical, electronic or hydraulics.

Shall possess proven track record in subsea inspection work and recording of inspection results.

Shall be knowledgeable in identifying and classifying and different damage types.

Reference

API RP 1111 – Recommended Practice for the Design, Construction, Operation and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design)

CSWIP-DIV-13-04 Registration Scheme for Underwater (Diver) Inspectors – Grade 3. 1U, 3. 2U, ROV Inspectors (3. 3U) and Underwater Inspection Controllers (3. 4U)

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IMCA R 002 rev 2 – May 2009 Entry Level Requirements and Basic Introductory Course Outline for New Remotely Operated Vehicle (ROV) Personnel

IMCA R 004 – Code of Practice for the Safe and Efficient Operation of Remotely Operated Vehicle

ISO 13628 – 8: 2002 Petroleum and Natural Gas Industries – Design and Operation of Subsea Production Systems – Part 8: Remotely Operated Vehicle (ROV) Interfaces on Subsea Production Systems

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Question 10

More than a quarter of the North Sea oil & gas production pipeline network were first commissioned in 1960's and 70's. Other 23% was built during the 80's. These pipelines were originally designed to operate around 20 years. Identify the key threats to the integrity of a pipeline in later life.

1. 0 Introduction

Generally, pipeline whether onshore or offshore is still the most cost effective and relatively safest way of transporting oil and gas from production field to users. Most of the offshore pipelines in the North Sea are well past their originally design life of 20 years. Some are even over thirty to forty years. Some of these pipelines may be required to operate for more years beyond their design life as the North Sea continues to supply oil and gas. Identifying the threats to the integrity of a pipeline in later life is paramount in designing an effective Pipeline Integrity Management (PIM) system.

2. 0 Threats to the Integrity of Pipeline in Later Life

Some of the key threats to the integrity of a pipeline in later life are discussed below using section 2. 2 of ASME B31. 8S – 2004: Managing System Integrity of Gas Pipeline as a guide.

2. 1 External Corrosion

External corrosion is a common phenomenon in offshore pipeline. This result due to the galvanic cell formed on the pipe surface. The seawater acts as the electrolyte, while anodic and cathodic areas are formed on the pipe surface. The steel pipe wall also acts as the conductor for electrons. The cathodic areas with high oxygen absorption receive electrons from the anodic areas and this causes metal loss at the anodic region. The pipe is usually coated with materials such as asphalt, fusion-bonded epoxy, polyethylene, polypropylene etc to isolate the pipeline steel from seawater and soil. This provides a sort of resistance between the anodic and cathodic areas on the pipe surface. A cathodic protection system using sacrificial anode or impressed current is also installed to complement the coating system.

As pipeline ages the pipeline surface coating breaks down gradually and allows oxygen to the bare metal pipe causing metal loss. The cathodic protection system is usually put in place to make up for coating defects and degradation over time. As the coating wears out more cathodic current is needed and this reduces the effectiveness of the cathodic protection system. If the degradation of the coating and cathodic protection is not mitigated the pipeline metal surface is exposed and corrodes quickly, therefore constant monitoring of coating and CP system is required.

Internal Corrosion

Corrosion on the internal wall of a pipeline occurs when the pipe wall is exposed to water and contaminants such as oxygen, carbon dioxides, sulphides and chlorides present in the pipe fluid. The operating conditions of the pipe can further lead to the concentration of these corrosive elements; internal corrosion process is determined by the service of the pipeline. For example sweet and sour corrosion is caused by the presence of dissolved carbon dioxide and hydrogen sulphide in the fluids respectively.

Activities of some micro-organisms living on the internal wall of pipes may influence corrosion this is known as Microbiologically Influenced Corrosion (MIC). Some of these micro organisms are capable of producing metal dissolving products such as organic acids which are detrimental to the pipe metal surface by accelerating corrosion.

Stress Corrosion Cracking (SCC)

Stress corrosion cracking occurs as a result of combined actions of stresses in the pipe metal and the presence of a corrosive environment. It could occur internally or externally in the pipe. The stresses are either produced from operational cyclic loads or residual stresses introduced during manufacturing or installation. The corrosive environment is the seawater or it could be in the presence of a specific chemical such as hydrogen sulphide present in the pipe fluid. The more the pipe is exposed to these agents of SCC the higher the probability of failure. Palmer and King (2008, pp 95) stated that the cracking starts at pits and crevices, and they gave two hypotheses to explain the propagation of cracking. The first hypothesis is that if the pit is over a certain depth, there is stress amplification. This causes a plastic yield at the crack tip and this progressively damage the oxide film and there is a severe anodic dissolution at the crack top. The second hypothesis relates to brittleness of the material at the crack tip due to hydrogen concentration and this leads to material failure. An effective CP of the system can help reduce the effect of SCC.

Manufacturing Related Defects

Pipe manufacture refers to how the pipe pieces are made in the mill. Pipe defects may occur at the melting, forming or heat treatment of steel such as microstructure anomalies, non metallic inclusions, surface decarburization and segregation amongst other. It may also occur by improper storage that can lead to surface defects such as corrosion, cracks, grooves and scabs or during subsequent processing. API Specification 5L provides standards for pipe suitable for use in conveying gas, water and oil in both the oil and natural gas industry. Pipe could be seamless or welded. Seamless pipes are manufactured by hot working steel to form a tubular product without a welded seam. If necessary, the hot worked tubular product may be subsequently cold finished to produce the desired shape, dimensions, and properties.

Seam welded pipes are manufactured by joining the sheets together by using filler or non filler metal and seams are formed on the pipe. Example of seam pipe formed by using filler metals are continuous, electrical and laser welding. Non filler metal methods such as submerged arc welding (SAW) and gas metal arc welding (GMAW) are also used. Defects may arise during the joining of the pipe sheets resulting to weak seam lines, leakages, cracks etc. These defects should be eliminated when proof test is carried out on the pipe in the mill. Section 7. 8 of API specification 5L gives limit of acceptable defects, which sets the standard for detection during manufacture of pipes. The likelihood of failure of pipes in service to fail as a result of these manufacturing defects increases as the pipe ages.

Fabrication/Construction Related Defects

These are defects introduced into the pipeline during fabrication, construction or installation. It may occur during transportation, handling or welding of the pipe on site. They mostly result into mechanical damage such as dents, gouges, bends, buckle, broken pipe, defective fabrication weld and girth weld defects (causes cracks, burns and undercut). Critical defects could be detected using radiographic test, ultrasonic testing or hydro testing of the pipeline. If these defects are not eliminated as the pipe ages they propagate and eventually lead to failure of the pipeline. Residual stresses introduced during fabrication and construction of the pipeline contributes to SCC which also leads to pipeline failure.

Equipment Failure

Equipment failure is the failure of the pipeline ancillary facilities such as valves, pumps, compressors, pig traps, meters, regulators etc. Some of these facilities wear out with time. For example failure of pressure and relief valves can cause pipeline rupture and explosion. Vibration as a result of poorly installed pump or compressor leads to cyclic loading on pipe flange connections and with time this cause fatigue and eventual cracking or fracture of the pipe.

Third Party Damage

Over the lifespan of a pipeline, third party interference is very common. This could be accidental or intentional (vandalism). The consequence of third party interference causing pipeline damage is at times catastrophic. Impact damage on pipeline could occur due to dropped object from platform or ship impact on risers. Anchor drag during construction and supply boat activity, trawl board/net drag could also seriously damage the pipeline in later life. External coating of the pipe if damaged causes accelerated corrosion and a potential for future fail (delayed failure mode) or direct cut into the pipe thereby causing leaks and in some cases explosions (immediate failure). Pipeline could also be vandalised by economic saboteurs and terrorist, and this usually lead to environmental problems, loss of life and property.

Incorrect Operational Procedures

This threat is caused by incorrect operating procedures or failure to adhere to procedures. There are time when pipe leakages are reported and due to poor communication and bureaucratic procedures such leakages are left unattended to on time. Abnormal or inconsistent operating conditions of the pipe can lead to the concentration of corrosive elements in pipe causing internal corrosion or formation of hydrates, wax deposition and erosion problems. Inconsistent past pipeline incidents reporting, data collection and management leads to data duplication, accuracy differences or data loss. This has a huge negative effect on the pipeline integrity management programme as insufficient, inaccurate or non availability of data results in deficient integrity management.

Weather Related and Outside Forces

Submarine pipeline which is very common in the North Sea have been subjected to cyclic loads from sea waves, vortex induced vibrations and thermal stress over the years and these could result into fracture. Earth movement causing natural hazards in form of earthquake, mudslides, faults, soil liquefactions, storms amongst others has high likelihood of occurrence with time and these poses threat to the integrity of pipelines.

Reference

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Question 9

Prepare a list of questions and information requirements that you could present to an asset owner who is in need of a sacrificial anode retrofit for a subsea pipeline.

1. 0 Introduction

Sacrificial anode retrofit on subsea pipeline is usually required by asset owners to maintain the integrity of their pipeline. It involves the installation of sacrificial anodes to replace or augment the depleted cathodic protection (CP) system in place. The reasons for retrofitting a subsea pipeline CP may be due to the following:

To maintain the integrity of the pipeline when the original CP system is inadequate or depleted.

To increase the service life of the pipeline so that it can serve way beyond its design life.

When there is a coating damage to the pipeline.

2. 0 Information Required for Sacrificial Anode Retrofit for a Subsea Pipeline

The following questions must be answered and the information obtained is used to effectively design a sacrificial anode retrofit for the subsea pipeline.

Location of pipeline

Where is the pipe located?

Where are the termination points?

How far is it from platform or shore?

Is there any pipeline route survey drawings or alignment sheets?

Pipe properties

What material is the pipe made of?

Is it seam welded or seamless?

What is the strength of the pipe?

What is the outside and internal diameter?

What is the pipe wall thickness?

What is the pipe length?

Subsea environment

What is the depth of seawater?

What is the seawater temperature at seabed?

What is the velocity of seawater at seabed?

What is the concentration of dissolved oxygen at seabed?

What is the concentration of dissolved salt at seabed?

What is the PH of the Seawater at seabed?

What is the electrical resistivity of seawater at seabed?

What is the soil resistivity of the seabed?

How is the seabed topography/terrain?

What is the burial status of the pipeline?

How does soil erosion affect the pipeline?

Has there been any incidence of ground movement, for example mudslides, earthquake, subsidence etc?

Has there been any adverse weather related problems, for example storms, hurricane, Tsunami etc?

External coating assessment

Does the pipeline have any external anti corrosion coating?

If yes,

What material is it made of?

What is the thickness?

Does it have any defect?

How effect is it?

Is there any thermal insulation?

If yes,

What material is it made of?

What is the thickness?

Is it damaged in any place?

Is there concrete coating?

If yes,

What is the strength?

What is the thickness?

Is it damage in any place?

To what extent does it cover the pipeline

Are there any other types of coatings? Please specify.

Assessment of Existing CP system

How is the Present CP system performing?

What is the range of current output of existing anodes?

What is the pipeline current density demand/requirement?

What is the potential level in the pipeline?

Pipeline fittings and connections

What is the condition of the flanges?

What is the condition of the bends?

What is the condition of the valves?

What is the condition of the tees?

What is the condition of the expansion loops?

What is the condition of the riser connection?

What is the condition of the tie in spools?

Are there any other fittings? Please specify.

Operating procedures

Can the CP operating and maintenance data be provided?

Was there any deviation from specification/procedures?

Is the electrical power system put in place always available?

Was there any record of accident on the CP system?

Does the operating procedure comply with Company’s HSE procedures?

Does the operating procedure comply with legislation?

How are other CP systems performing in the area?