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INTEGRITY AND RISK ASSESSMENT OF OFFSHORE JACKET STRUCTURES

INTEGRITET I PROCENA RIZIKA MORSKE NOSEĆE KONSTRUKCIJE

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Keywords
- offshore jacket structures
- underwater inspection
- structural integrity and risk assessment
- RBI (risk-based inspection)

Ključne reči
- morske noseće konstrukcije
- podvodna inspekcija
- procena integriteta i rizika konstrukcije
- rizikom bazirana inspekcija (RBI)

Abstract

There are the common steel platforms which can be of the eight legged type, or of lightweight four-legged variety. There are also jack-up rigs which are mobile, and tension leg platforms (TLP) which float. With steel fixed platforms the jacket supports the superstructure which contains all necessary facilities. The jacket is built in a fabrication yard and if it is a large six or eight-legged jacket designed to support full production facilities, it may well have modified legs designed as floats, or additional ballast tanks may be installed, so that it can be floated out to the site.

Rezime

Postoje uobičajene čelične platforme, koje mogu biti tipa sa osam nogu ili mogu biti lagane četvoronožne. Postoje i dizalice, koje su mobilne, i platforme sa zategnutim nogama (TLP), koje lebde. Sa čeličnim fiksnim platformama, noseća konstrukcija podržava nadgradnju, koja sadrži neophodne objekte. Noseća konstrukcija je napravljena u fabrici i ako je velika sa šest ili osam nogu, projektovana je da podrži pune proizvodne kapacitete, a može imati modifikovane noge dizajnirane kao plovke, ili se mogu instalirati dodatni balastni rezervoari, tako da može da pluta.

INTRODUCTION

Steel fixed platforms have the jacket to support the superstructure that contains all the necessary facilities, /1/. The jacket is a welded tubular space frame consisting of vertical or battered legs supported by a lateral bracing system. The jacket is built in a fabrication yard and if it is a large six- or eight-legged jacket designed to support full production facilities, it may well have modified legs designed as floats, or additional ballast tanks may be installed so that it can be floated out to the site.

Smaller steel structures, designed and built as a result of advances made in materials, and for a better understanding of the imposed on offshore structures, some different design concepts are given.

Both of these types of platforms are sometimes referred to as steel piled structures because the jacket is piled into the seabed. Once it is in the upright position, with piles either driven through the legs or positioned around the main legs and driven through pile sleeves, so-called skirt piles.

The production platforms are the most massive installations, and they may be of steel or concrete construction, steel being the most prevalent, Fig. 1. Figure 2 shows the view of an offshore jacket after production in a shipyard.

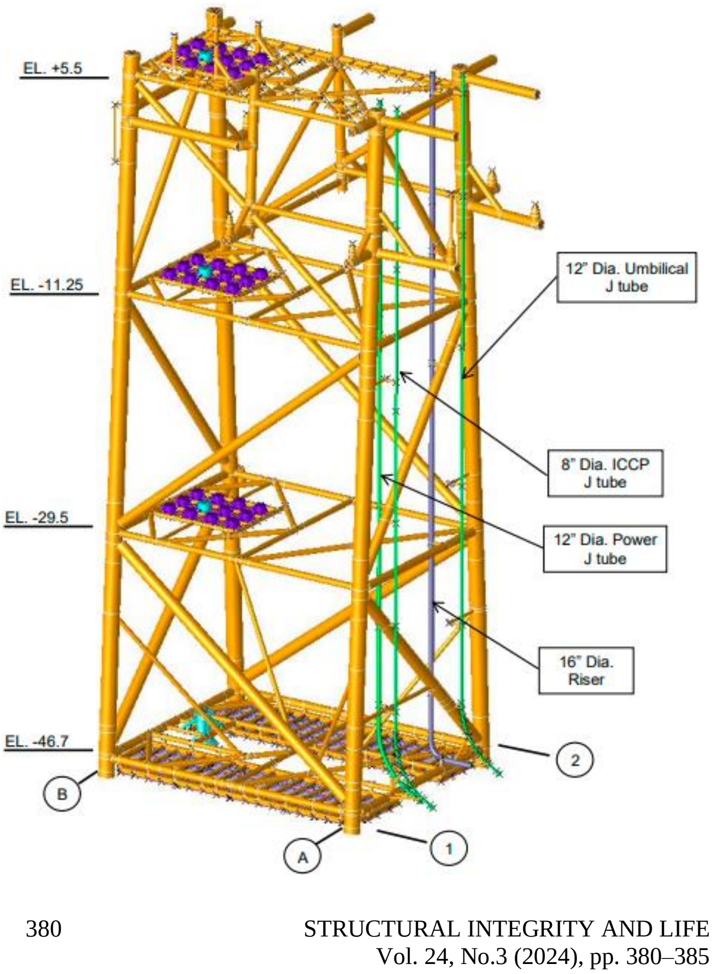

Figure 1. Isometric view of jacket.

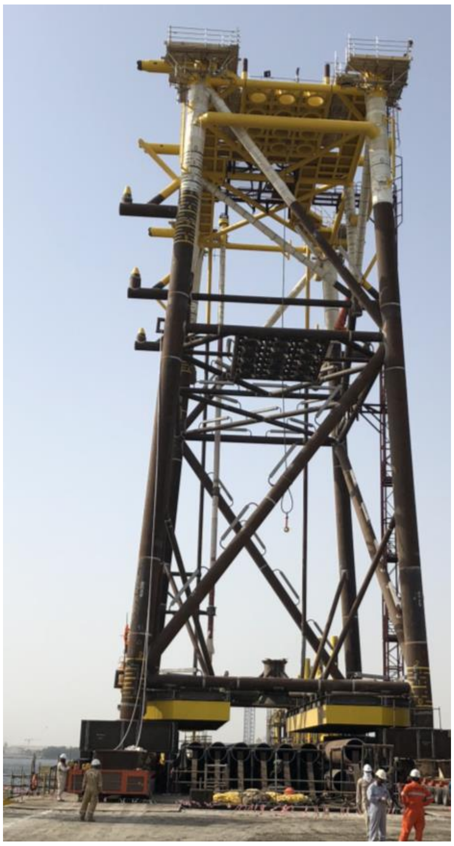

Figure 2. View of jacket after shipyard production.

OFFSHORE JACKET STRUCTURES

The basic parts of offshore jacket are shown in Fig. 3.

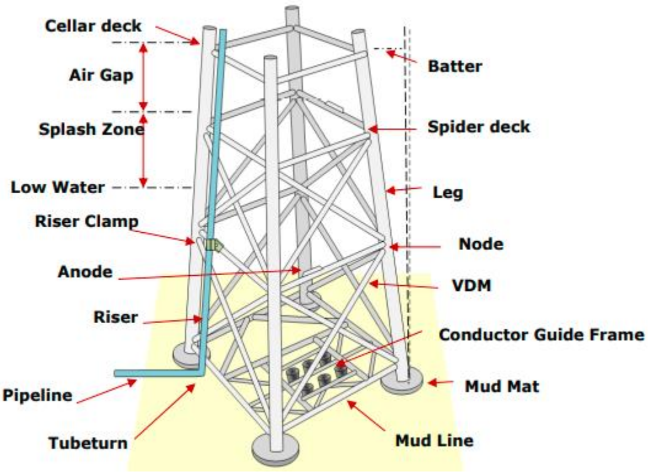

Figure 3. Offshore jacket structures-basic parts, /2/.

For further analysis, the four-legged jacket structure suited for the water depth of 50 m, as shown in Fig. 3, comprises the following:
– a three bays jacket with
– horizontal braces
– 4-legged jacket with true batter in north and south rows
– grouted jacket leg with 4 numbers of 42” piles driven through the legs
– 16” oil riser
– two-sided boat landings: full length east boatlanding with extension on the southside and half-length west boatlanding
– J-tube, power J-tube and umbilical J-tube
– mudmats
– sacrificial anodes for 25 years.
– barge bumpers on the north and west sides
– tide gauges and mooring bollards.

INSTALLATION METHOD OF JACKET

The jacket, Figs 1-3, is planned to be horizontally transported from fabrication yard to the offshore installation location and to be single hook lifted with a minimum sling angle of 60° with the horizontal. It will be lifted using four slings connected to the main hook of the crane at one end and to the trunnions at row 2 (EL -11.25 m and EL -29.50 m) on the jacket legs at the other end. To verify the jacket structural elements, the FFS analysis was performed. Figure 4 shows the boundary conditions for lifting that have been obtained wit FFS analysis. Figure 5 shows the boundary condition of the Noble Denton Case.

Figure 6 shows the global axis system during jacket lifting. During the installation of the jacket there are four trunnions, Fig. 7. Stages of the installation of the jacket from offshore jobs are shown in Figs. 8 and 9.

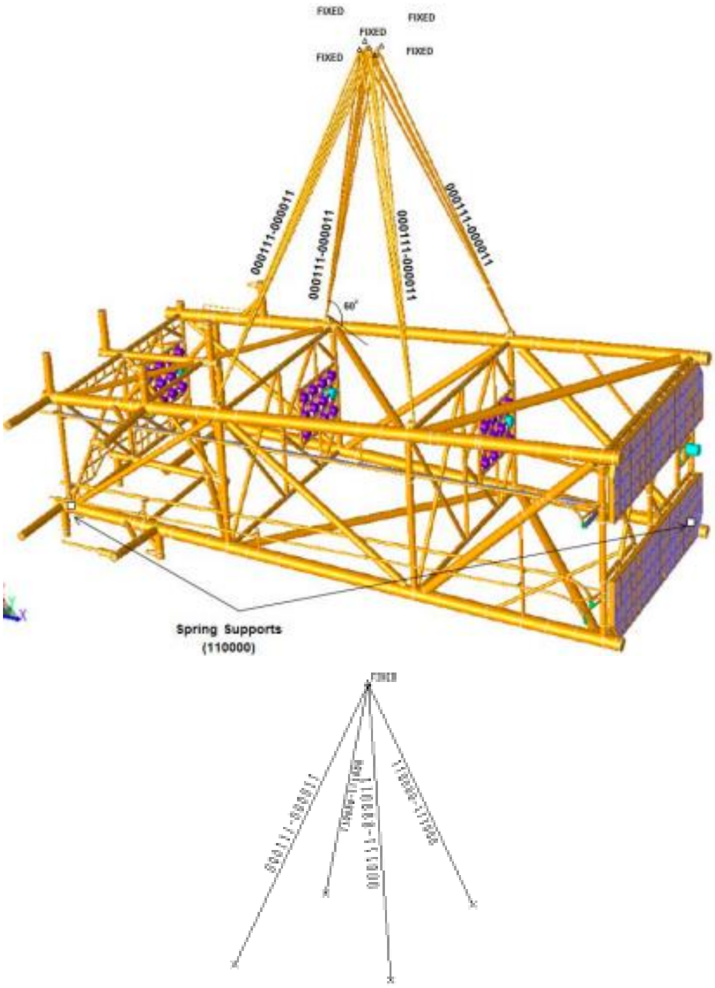

Figure 4. Jacket lifting - boundary condition.

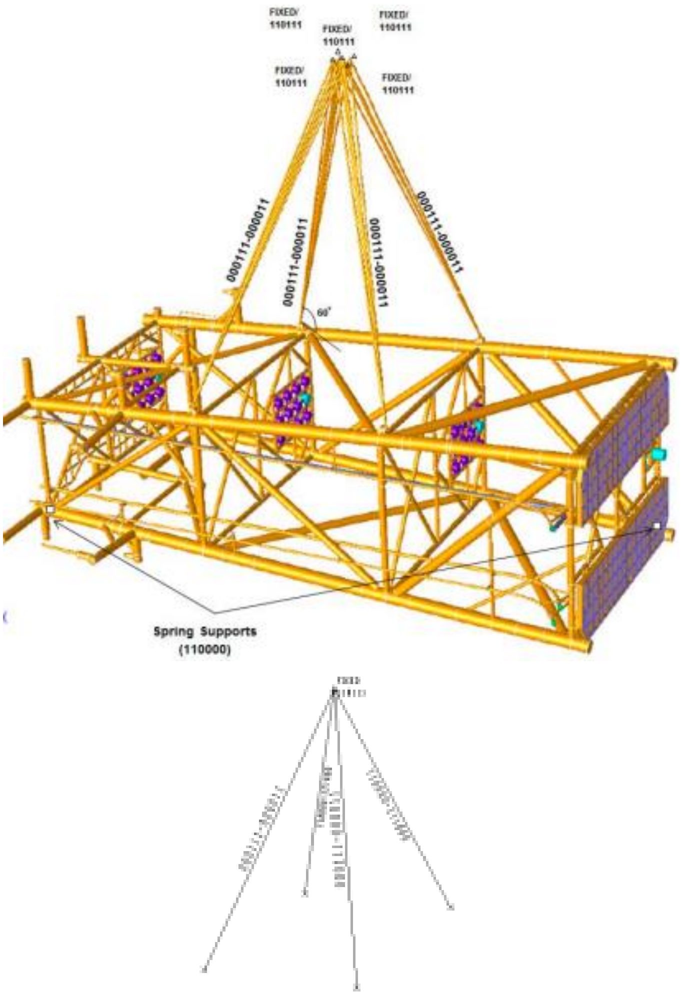

Figure 5. Jacket lifting - boundary condition Noble Denton case.

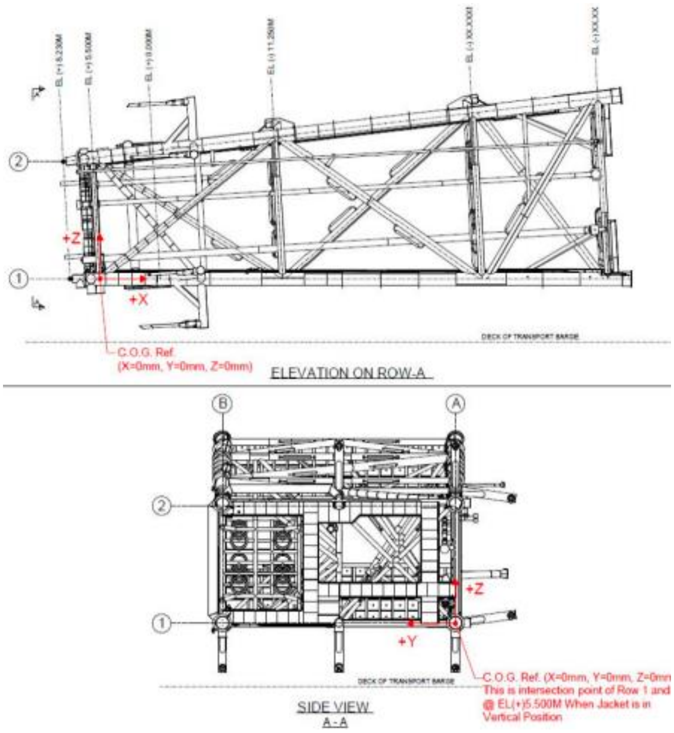

Figure 6. Jacket installation - global axis system.

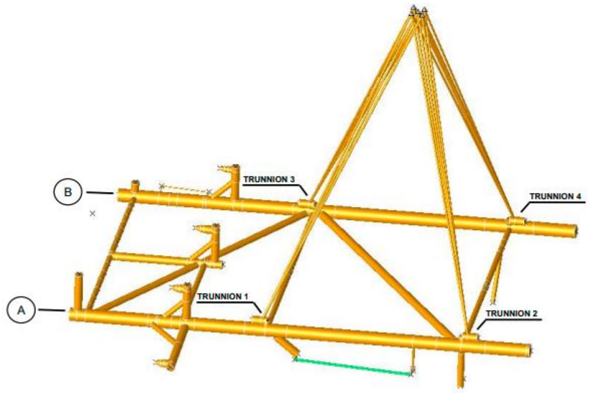

Figure 7. Jacket lifting - Trunnions.

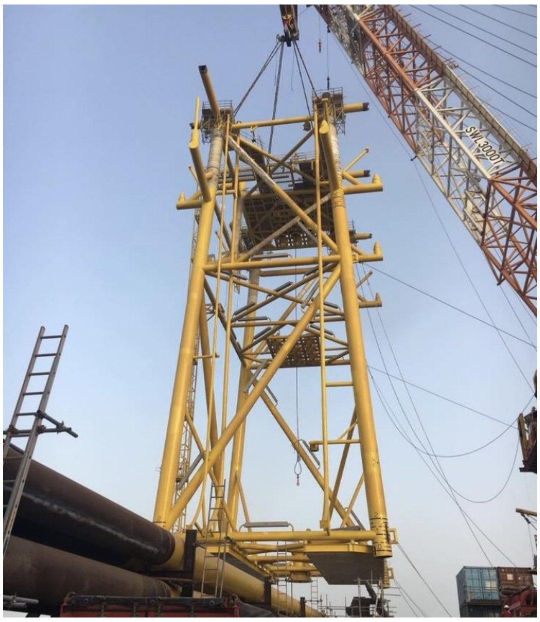

Figure 8. Offshore installation of jacket-lifting.

Figure 9. Offshore jacket after completed installation.

UNDERWATER INSPECTION OF JACKET

The obvious way to conduct an underwater inspection is by using a diver, Fig. 10.

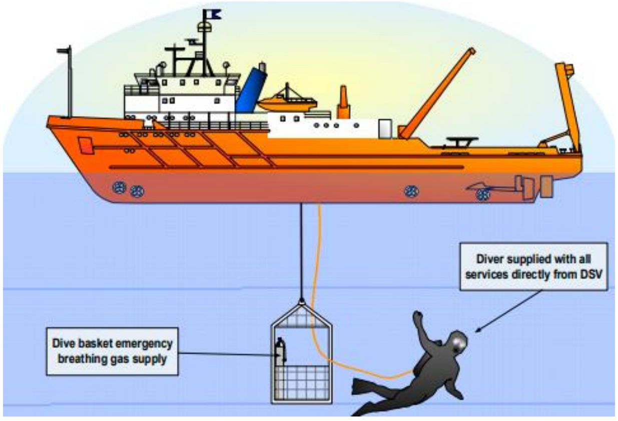

Figure 10. Underwater inspection by diver deployed from a basket, /1/.

Before starting each underwater inspection, it is very important to make an orientation and an inspection plan, as shown in Fig. 11, the oil jacket inspection schedule.

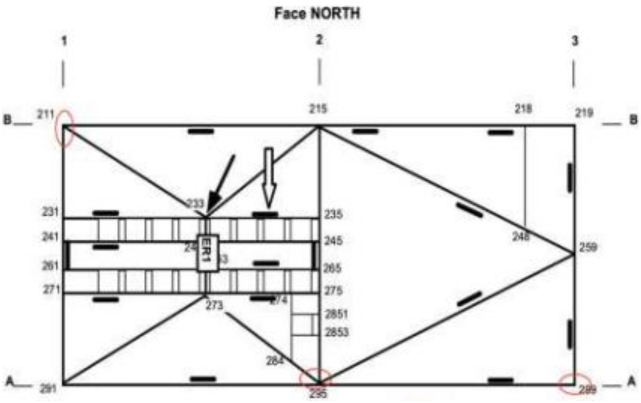

Figure 11. Underwater jacket inspection plan.

The most important underwater inspection on this jacket is ET (eddy current) inspection of welds and critical places, as shown in Figs. 12 and 13.

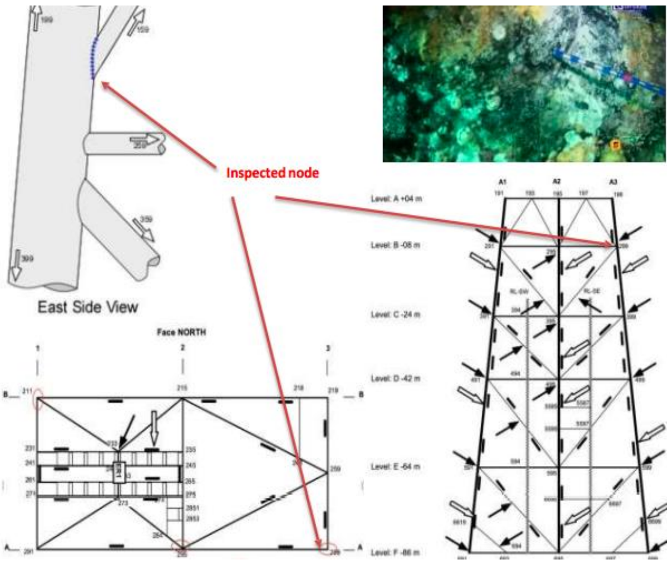

Figure 12. Underwater inspection of welds of the jacket.

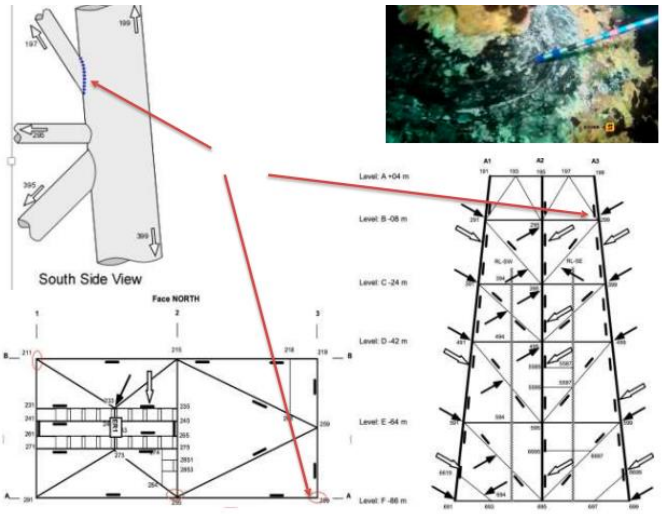

Figure 13. Underwater inspection of welds and HAZ of jacket.

Figure 14 shows some findings of underwater inspection of jacket based on the performed structural analysis for the described jacket, Fig. 1, after which the installation of the jacket was performed and described, and finally underwater inspection is presented. Based on the integrity analysis for fixed platforms, Fig. 15, and the risk matrix, Fig. 16, an assessment of the risk analysis on the structural integrity of our oil jacket is provided.

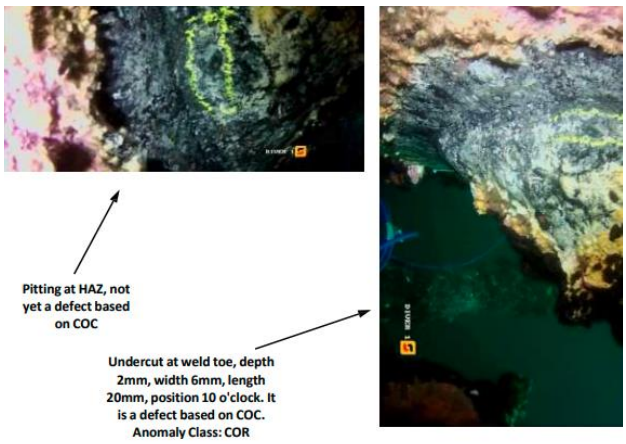

Figure 14. Underwater inspection of welds with ET.

Structural integrity management of fixed offshore structures

Here, a particular fixed offshore jacket structure is selected to demonstrate the structural integrity analysis based on the steps shown in Fig. 15. The key points in this procedure are defined in /3, 4/, according to common structural integrity and risk assessment methods, described in /5-9/, including the risk matrix, Fig. 16. Results are shown in Tables 1-4, whereas the level of the jacket risk is shown in Fig. 17, obtained using the estimated probability (cat. 2) and consequence (cat. 5). Afterwards, the structural integrity analysis for the described jacket is completed, its installation and underwater inspection is performed.

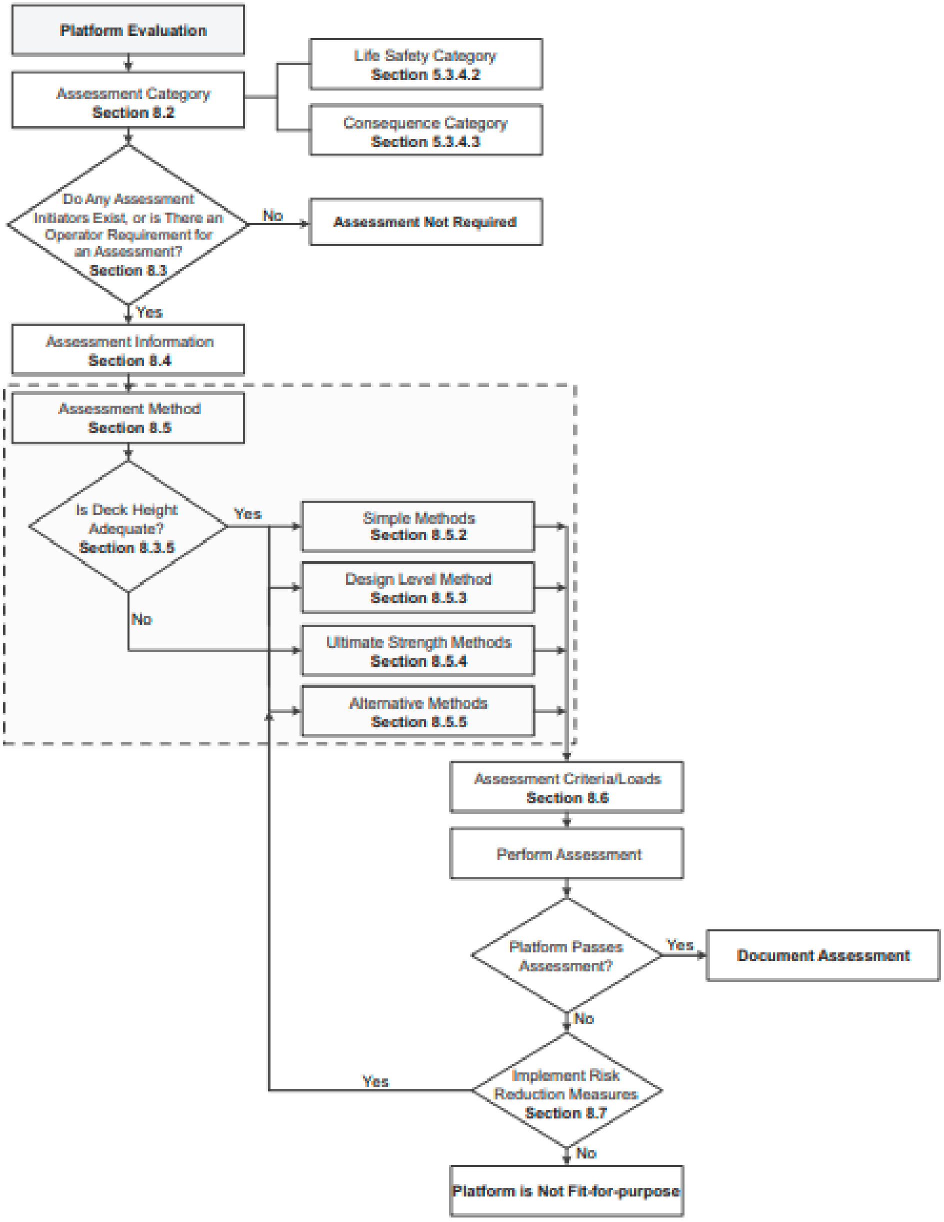

Figure 15. Process of structural integrity assessment of jacket structure.

Risk		Consequence category				
		A	B	C	D	E
Probability category	5	Medium	Medium high	Medium high	High	Very high
	4	Medium	Medium	Medium high	High	High
	3	Low	Medium	Medium	Medium high	Medium High
	2	Low	Low	Medium	Medium	Medium high
	1	Very low	Low	Medium	Medium	Medium

Figure 16. The risk matrix.

Table 1. Risk assessment procedures.

Step	Action	Action Details
1.	Data review: historical information and inspection results	Ensure the availability of data
2.	Evaluation: platform categorization	Categorizing platforms in one field according to the type, function, and configuration of the platforms to select most critical platforms
3.	Evaluation: risk categorization	Generate the rank of risk by product of exposure category and likelihood of failure
4.	Evaluation: damage evaluation	Damage evaluation is performed to platform(s) with highest risk ranking
5.	Evaluation: fitness-for-purpose	The fitness-for-purpose assessment is performed by simplified method
6.	Decision	The conclusion for service life extension and its inspection strategy

Table 2. Data availability checklist

Number	Data Category	Data Request	Jacket
1.	Design history	As-built drawings	Y
		Design analysis reports	
		Equipment list	
2.	Fabrication history	Fabrication report	Y
3.	Installation history	Installation report	Y
4.	Operational history	Accident report	Y
5.	Above water inspection report	NDT Reports	Y
6.	Underwater inspection report	NDT Reports	Y

Y = data available; N = data unavailable

Table 3. Codes standard and recommended practices related to structural integrity assessment of structures.

Codes, Standards or Recommended Practices	Chapter or Section
API RP2SIM	Section 07: Structural assessment process
NORSOK Standard N-006	Section 06: Assessment principles for existing structures

Table 4. Exposure category based on platform function.

Function	Life safety	Consequences of failure	Exposure category
Installation	Manned-non-evacuated	(D) High	E
Processing	Manned-non-evacuated	(D) High	E
Inspection	Manned-non-evacuated	(D) High	E
Structure	Unmanned	(C) Medium	C

Table 5. The risk matrix - the jacket.

Risk		Consequence category				
		A	B	C	D	E
Probability category	5					
	4					FIXED JACKET
	3					
	2					
	1					

CONCLUSIONS

The installation and underwater inspection of oil jacket justification lies in the fact that structural integrity of every contraction in oil and gas industry must be followed in every stage during working life. This has been confirmed by underwater NDT examination and numerical calculation of oil jacket structure. Most dangerous observed defects that one can expect are through-thickness cracks.

The risk assessment procedure is proposed to assess the structural integrity of the offshore jacket. Since the conclusion states that the offshore jacket has a high risk, finite element analysis needs to be conducted to evaluate the stress state and fatigue performances by modelling the members in accordance with the results of survey and inspection. In parallel, the scoring method will be prepared to perform the quantitative assessment.

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