Development of Work Breakdown Structure Corrective and Preventive Maintenance Activities to Preserve Facility Reliability and Optimize Oil and Gas Production That Excess the Design Life to Maintain Reliability

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Abstract: Asset maintenance is an activity aimed at ensuring the functional continuity of a production system so that the system can be expected to produce output as expected. The maintenance system can be interpreted as a shadow of the production system, maintenance might be more intensive when the production system is operating at very high capacity.Production losses such as unplanned shutdowns, pipe leaks, equipment damage and delayed drilling activities due to equipment unpreparedness are highly undesirable. A number of maintenance strategies for existing wells are expected to minimise production losses in an effort to meet oil and gas production targets.Determining the most appropriate asset maintenance strategy is a complex and important maintenance management process. Verifying and measuring the effectiveness of asset maintenance strategies is a significant challenge for asset maintenance. In addition, asset maintenance management achieves minimum asset life cycle costs with the right process optimisation steps. It is therefore very important to create a clear and structured maintenance programme that can lead to system stability or asset maintenance for the smooth and safe operation of production facilities. By creating implementation standards based on the Work Breakdown System, it is expected that all existing maintenance elements will be covered, thereby reducing the risk of asset damage.

Keywords: WBS, corrective, preventive, maintenance, reliability, optimize production.

I. Introduction

Selecting the most appropriate asset maintenance strategy is a complex and important process in maintenance management. Evaluating and measuring the efficiency of asset maintenance strategies is a major challenge for asset maintenance(Peinado Gonzalo et al., 2022a). In addition, asset maintenance management achieves minimum asset life cycle costs through appropriate process optimisation measures. Maintenance is defined as the actions required to maintain or restore the function of a product to a specified operating condition in order to achieve its maximum useful life.

Based on data from SKK Migas (Indonesian Government Institution that manages upstream oil and gas business activities), the regulator of oil and gas operations, as of May 2023 Indonesia had 635 platforms, consisting of 512 platforms still in operation, 116 platforms not in operation and 7 platforms that have been dismantled. This data indicates that more than 280 platforms are over 30 years old or have exceeded their design life.

In recent decades, maintenance activities have grown as an effective part of a company's competitiveness. Therefore, it is very important to create a clear and structured maintenance programme that can lead to system stability or asset maintenance for the sustainability and safety of running production facilities.

Work Breakdown Structure is a process of breaking down deliverables and project work into smaller, more manageable components. By creating implementation standards based on Work

Breakdown Structure, it is expected that all existing maintenance elements will be covered, thereby reducing the risk of asset damage. The study was carried out at a production facility for the upstream oil industry. Cost-benefit analysis of alternative maintenance methods to be applied in a condition-based maintenance strategy(Afangide et al., 2018a). This alternative consists of a choice of equipment condition monitoring systems with different costs and benefits. The impact on total annual maintenance costs is then compared with a time-based maintenance strategy.

II. Research objectives

This research is expected to provide benefits and added value to:

1. Provide an appropriate and integrated maintenance methodology system for oil and gas industry.
2. Provide additional literature for further research on asset management, especially WBS-based maintenance and care methods.
3. The development of WBS standards is carried out with asset maintenance and care using corrective and preventive methods.
4. Development of WBS standards is carried out with asset maintenance and repair using corrective and preventive methods.
5. Create and develop WBS based maintenance and repair system guidelines. Optimise maintenance work by making improvements to critical tasks.
6. Creation and development of maintenance and care guidelines applied to structural and piping work on offshore platforms.

III. Literature review

3.1 Work Breakdown Structure

WBS is a hierarchical grouping method that is used for detailing by breaking down each work process into more detail, with the intention of making it easier to achieve the required objectives and deliverables, so that they are easier to manage. This process is carried out once or at predetermined points in the project. The inputs, tools and techniques and outputs of this process illustrate the data flow diagram of the process.

In the offshore platform structure refer to API 2A-WSD Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design, the components have a characteristic hierarchy, forming structural elements designed to channel loads in a characteristic way. The design of this structure is a guarantee of the stability of the structural system. The construction system is the way in which the building structure is implemented (strength issues, connections per element/part that are connected in detail). The building structure system is designed and constructed to safely support and transfer the force and load of equipment, gravity and lateral loads to the ground without exceeding the allowable load or that which can be supported by the parts of the structure system itself.

Referring to the offshore specific oil and gas industry standard API RP 14E (Design and Installation of Offshore Production Platform Piping System), specific differences in pipe types are divided into several classifications based on the function and shape of the pipe. This classification is simplified according to the pipe category

3.2 Corrective maintenance

When a failure occurs, maintenance is considered to restore the asset to a fully operational condition. It is therefore necessary to plan a maintenance strategy, a corrective method, based on the basic condition (condition based) of an asset when the condition of the asset requires repair due to functional failure or poor condition of an asset so that immediate repair is required(Li et al., 2020a).

3.3 Preventive maintenance

Preventive maintenance can reduce the possibility of asset damage by considering the performance of the machine or equipment and the life of components due to unplanned maintenance. However, one of the challenges of this maintenance strategy is the selection of the optimal time interval to perform maintenance and service activities(Wijaya et al., 2020a). Optimal preventive maintenance must be planned taking into account various influencing factors such as the capital cost of maintenance and the benefits to the business.

3.4 Predictive maintenance

Predictive maintenance predicts the failure or

malfunction of an asset before it occurs. This helps industries to plan maintenance before it is detected and to prevent small failures from causing a chain of failures(Nordal & El-Thalji, 2021a). The priority of predictive maintenance over traditional maintenance strategies is the potential to eliminate failures, extend equipment life, save on failure-related costs and repair time, and significantly improve operational safety.

3.5 Guideline for maintenance work in offshore platform

An efficient maintenance strategy helps to keep assets operating as close as possible to their peak performance, which can be attributed to the reliability factor. This should be considered as a top priority in the asset management of process plants. The purpose of this study is to identify the WBS variables, maintenance methods, work activities, technical specifications and implementation guidelines for the maintenance and care of offshore platforms. Once these variables are known, the implementation guidelines for the maintenance and care of offshore platform structural and piping components will be standardised based on the work breakdown structure(Aryaningrum et al., 2018a).

IV. Methodology

In order to achieve relevant and expected research results, an appropriate strategy is needed. There are three factors that need to be considered when determining the research strategy:

1. The type of question (research question) that will be used in the research.

2. The degree of control researchers have over the behavioural events being studied.

The chosen instrument uses data archives and questionnaires or surveys to obtain the form of WBS offshore platform components. In data collection, questionnaires will be given to respondents according to the requirements, namely having a background or work related to policies, regulations, procedures and guidelines for the maintenance and care of offshore platforms in Indonesia. The selected respondents have more than 10 years of working experience.

This research utilises descriptive research with qualitative approach to answer the research objectives. Data collections are exploited using archive analysis along with literature study, hereinafter consultation with expert were conducted to validate the collected data.

The number of experts or specialists required is three to five individuals with a minimum of 15 years of experience in the oil and gas industry or academics and a minimum education equivalent to bachelor degree. The validation process is then conducted through expert responses on whether or not they agree that variable inquired is the appropriate part to compile a WBS for maintenance and care work.

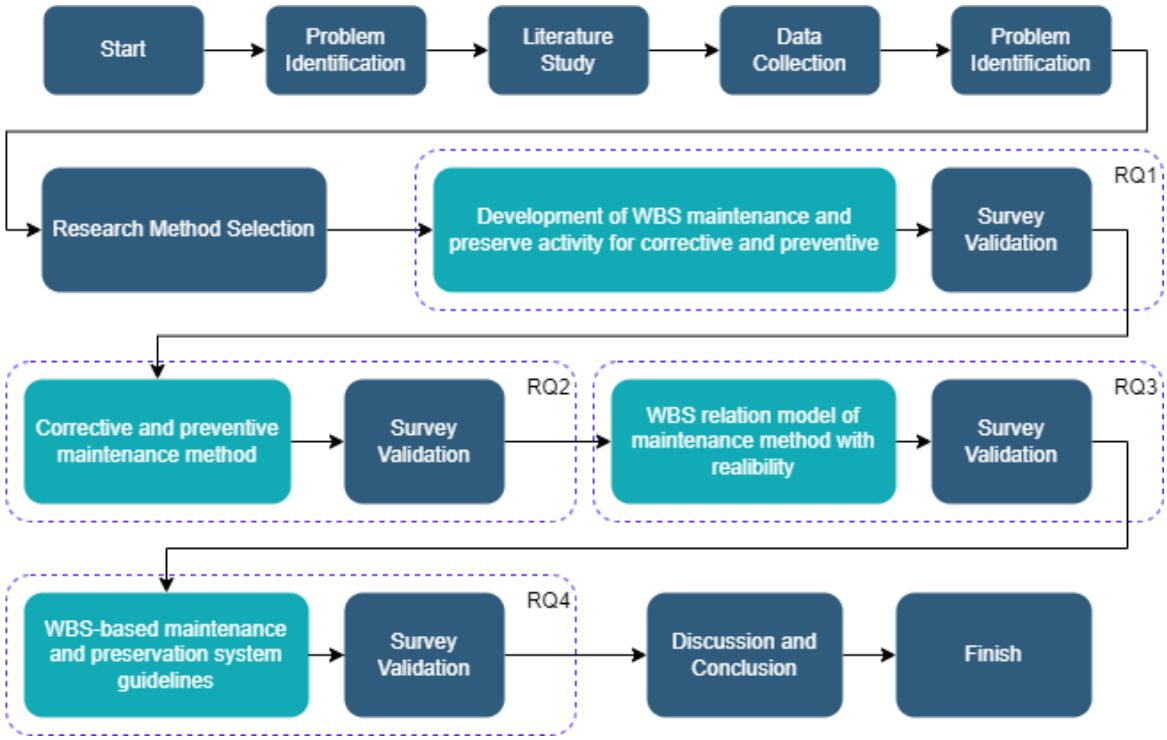

Fig. 1. The research flow.

V. Result and discussion

The result of this research is following:

In order to answer Research Question 1 (RQ1), Identification of Work Section and Sub-Work Section Component of Offshore Platform Jacket Structure and Piping, detailed part to be assessed in the Work Breakdown Structure diagram below was carried out.

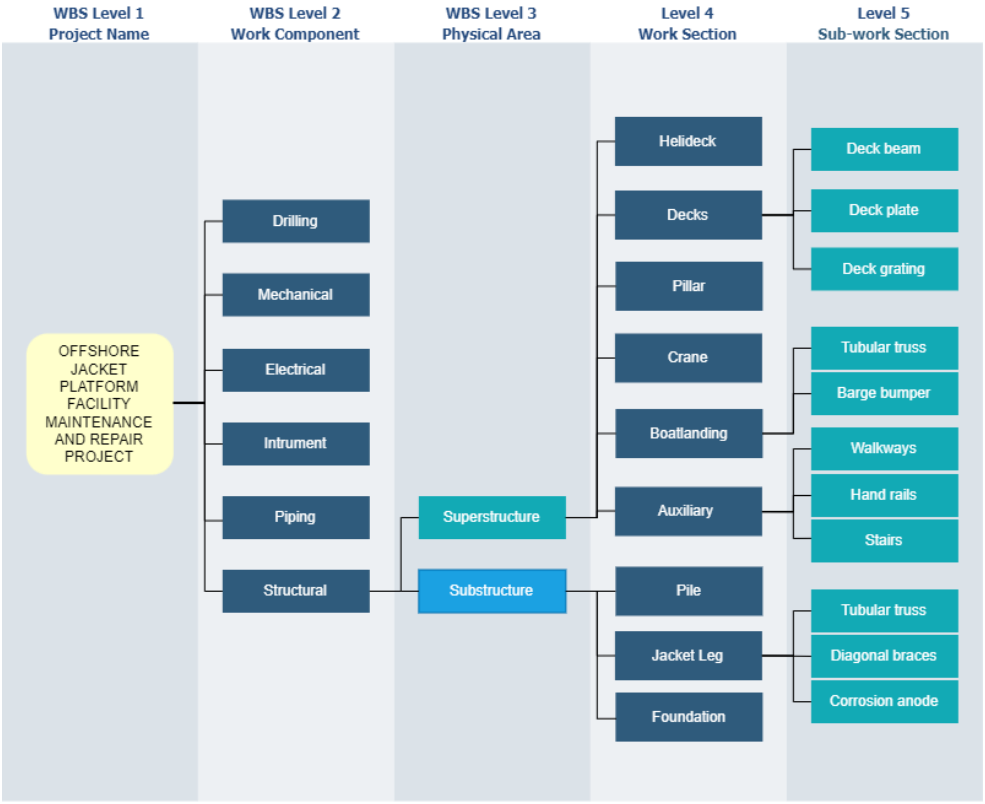

Fig. 2. Work breakdown structure (WBS) diagram of structural component.

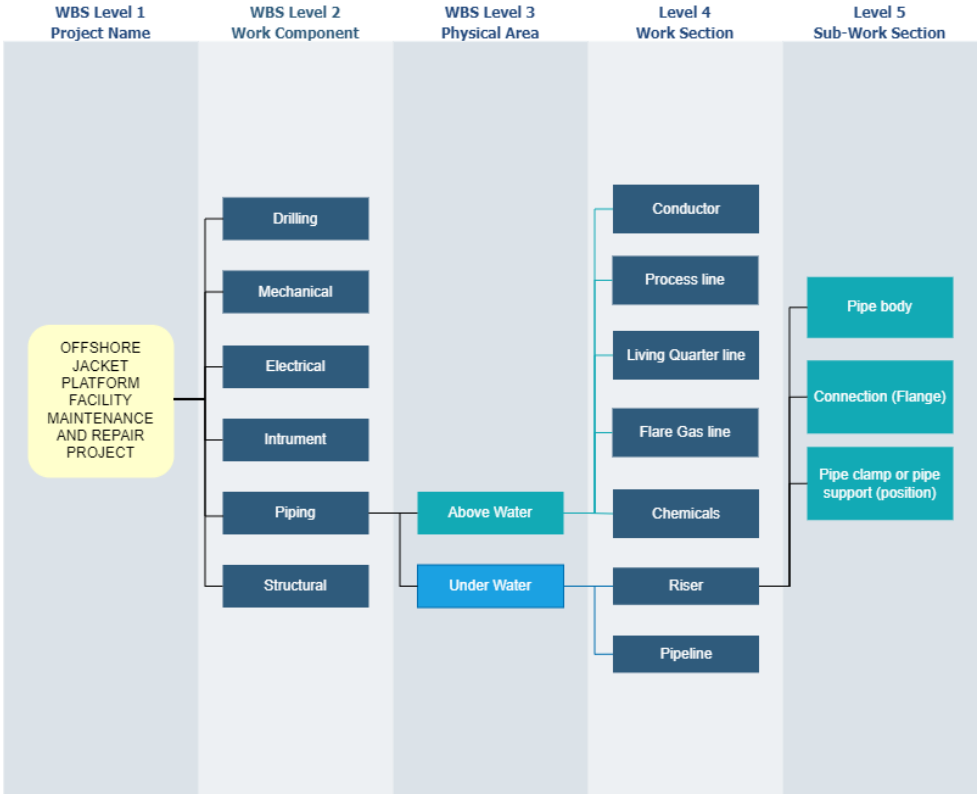

Fig. 3. Work breakdown structure (WBS) diagram of piping component.

WBS Level 1 describes the project name, the offshore jacket platform facilities maintenance and repair project. WBS Level 2 describes the work component embedded on the Offshore Jacket

Platform to support operations. WBS Level 3 describes physical area, above or below water, this area classifies equipment, supplies, experts who will intervene in the area. WBS Level 4 describes work section, this area describes the different functions of the supporting parts of an offshore jacket platform facility process. WBS level 5 sub-work area describes the smallest part of a component of a supporting facility operation.
After collecting all the information relating to the supporting components of the structure and pipework, it is broken down according to all the associated work.

To answer Research Question 2 (RQ2), the identification of the work section and sub-work section components of the offshore platform jacket structure and piping was carried out to identify the detailed parts to be assessed.

The next WBS intersects in the maintenance and repair work of corrective and preventive structural and piping components on the offshore platform jacket, which is called the maintenance method, maintenance aspect, work package and activity, which is validated by experts in work variables, activities, implementation requirements and resources whether they are appropriate and can be applied according to the literature study for structural and piping work. At this stage, the WBS has been reduced to the methodology of the literature study activity and analysis of previous project archives. The data validated at this stage are the Method, Maintenance Method (WBS level 6), Maintenance Aspect (WBS level 7), Work Package (WBS level 8) and Activity (WBS level 9).

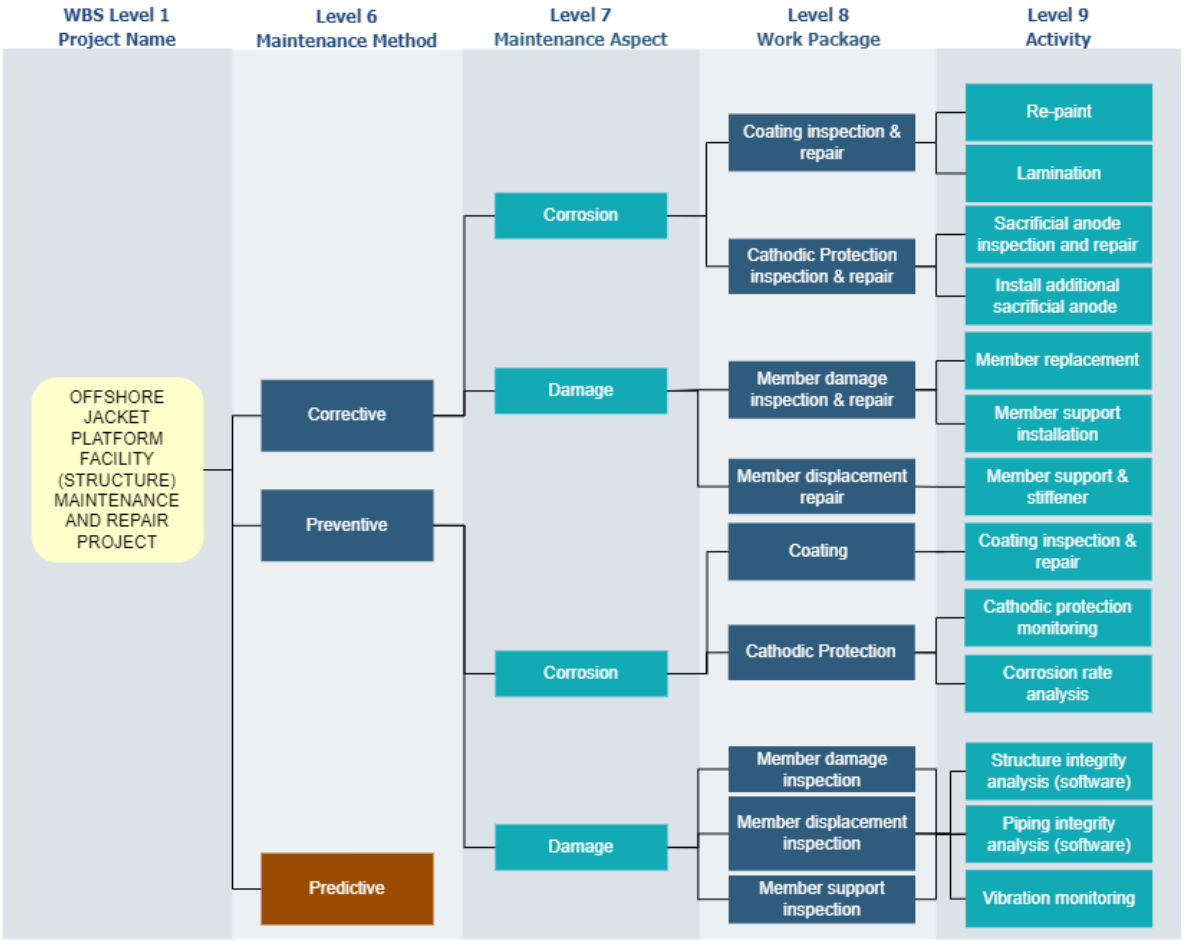

Fig. 4. Work breakdown structure (WBS) maintenance diagram of structure component.

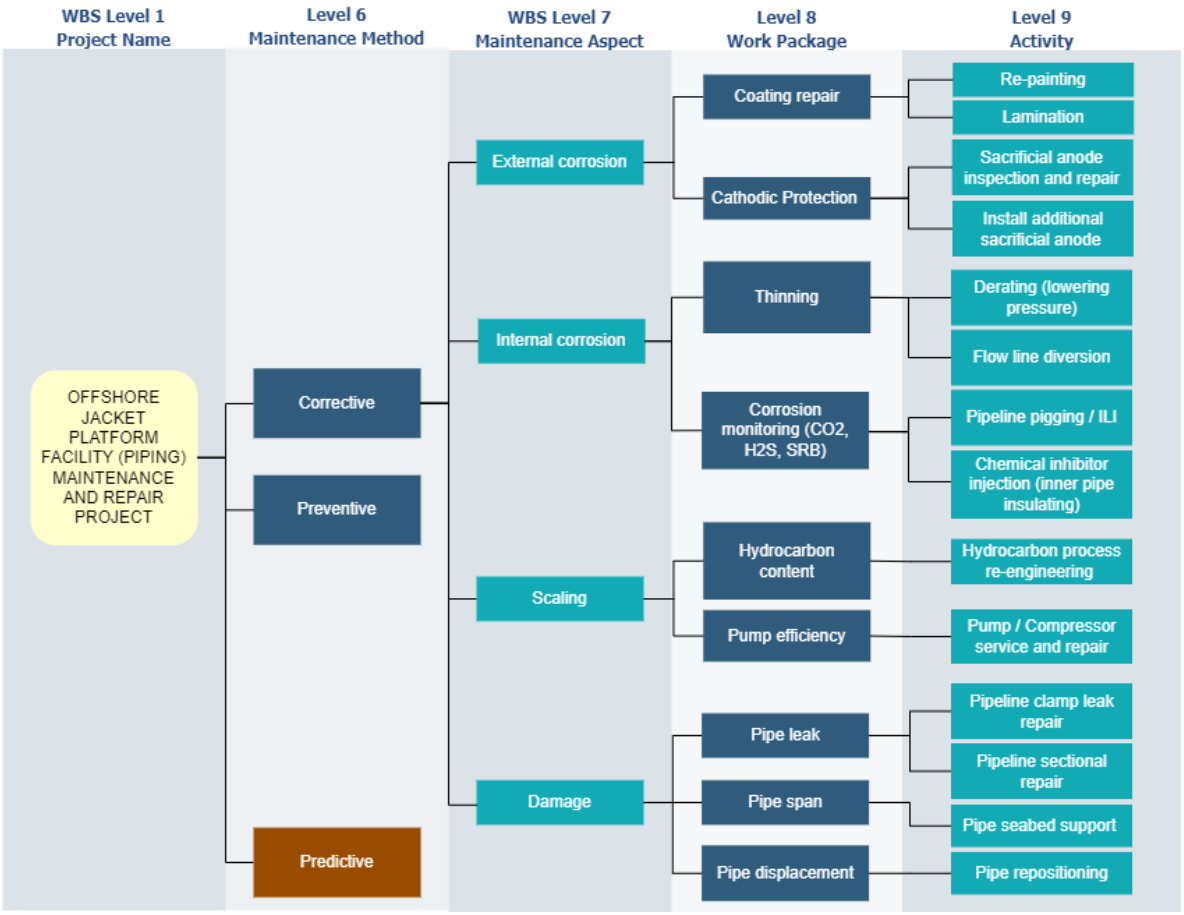

Fig. 5. Work breakdown structure (WBS) corrective maintenance diagram of piping component.

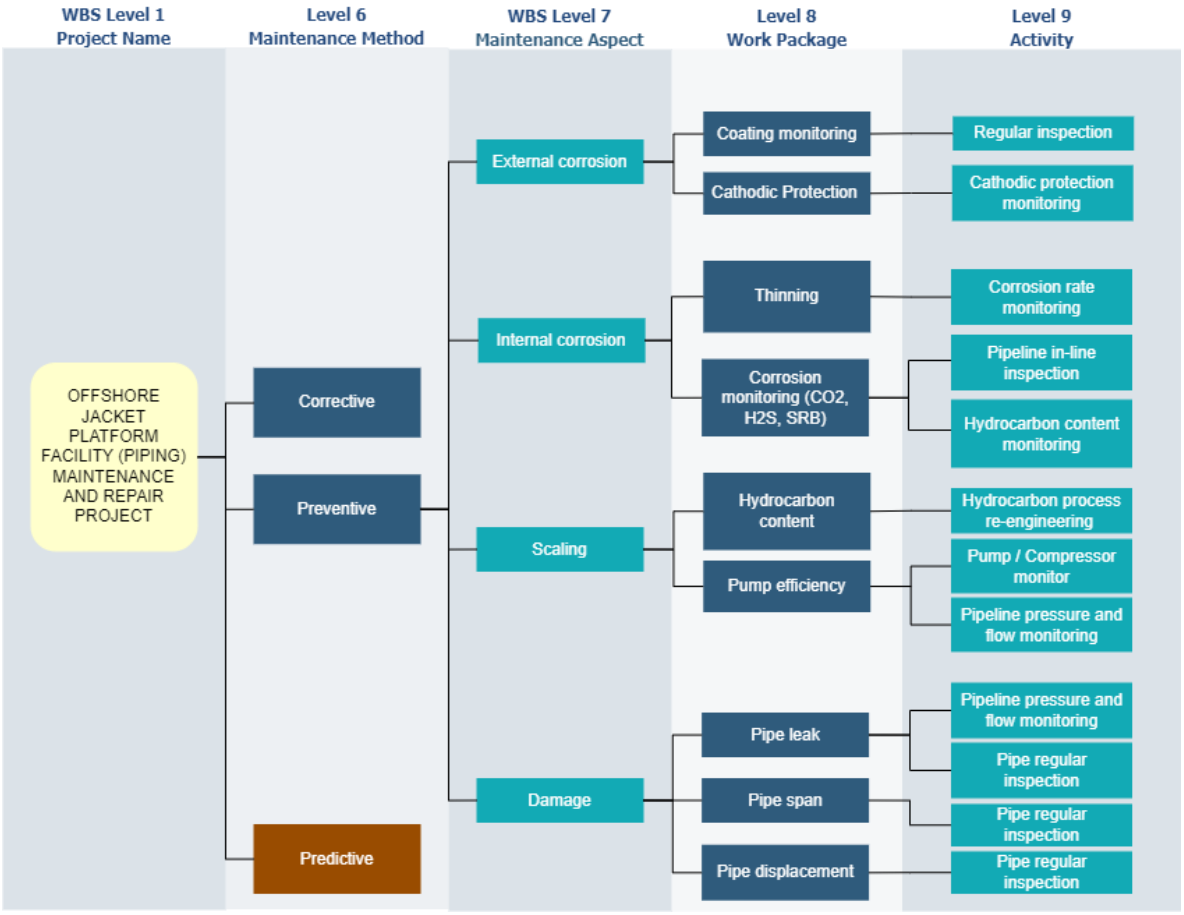

Fig. 6. Work breakdown structure (WBS) preventive maintenance diagram of structure component.

The relationship between the WBS of preventive and corrective maintenance of structural and piping components to maintain the reliability of offshore platforms can be seen from the following matrix.By using descriptive analysis, where the resource person provides an answer as to whether the type and package of maintenance work up to alternative designs/methods are appropriate for the maintenance and care of offshore platform production facilities. If it is not appropriate, a revision will be made in the form of changes, additions or reductions.

Data collection of offshore platform structure construction work which is mostly obtained from the American Petroleum Institute Recommended Practice 2A WSD Planning, Designing, and Constructing Fixed Offshore Platforms reference standard and oil and gas construction journals. As well as for piping components, most of them are obtained from Project Management in The Oil and Gas Industry. Massachusetts: John Wiley & Sons (El-Reedy, 2016) and ASME and ISO oil and gas piping industry standards.

To respond to Research Question 3 (RQ3), identification of the relationship between WBS preventive and corrective maintenance work on structural components and piping to maintain the reliability of offshore platforms.

Table 1: Matrix of relation diagram between WBS preventive and corrective of structure component

	WBS Level 5	Kode	X1.1.1.1	X1.1.1.2	X1.1.1.3	X1.1.2.1	X1.1.2.2	X1.1.2.3	X1.1.3.1	X1.1.3.2	X1.1.4.1	X1.1.4.2	X1.1.5.1	X1.1.5.2	X1.1.6.1	X1.1.6.2	X1.1.6.3	X1.2.7	X1.2.8.1	X1.2.8.2	X1.2.8.3	X1.2.9.1	X1.2.9.2
		Detail	Deck Beam	Deck Plate	Deck Grating	Deck Beam	Deck Plate	Deck Grating	Main Pillar	Stiffener	Crane Support	Crane Stiffener	Tubular truss	Barge bumper	Walkways	Hand Rails	Stairs	Pile connection	Tubular truss	Diagonal Braces	Corrosion Anode	Mudmat	Skirt Plate
WBS Level 9 (Aktivitas)																							
Kode	**Detail**																						
X3.1.1.1	Re-paint																						
X3.1.1.2	Lamination																						
X3.1.2.1	Sacrificial anode inspection and repair																						
X3.1.2.2	Install additional sacrificial anode																						
X3.2.1.1	Member replacement																						
X3.2.1.2	Member support installation																						
X3.2.2.1	Member support & stiffener																						
X4.1.1.1	Coating inspection & repair																						
X4.1.2	Cathodic protection monitoring																						
X4.1.3	Corrosion rate analysis																						
X4.2.1.1	Structure integrity analysis (software)																						
X4.2.1.2	Piping integrity analysis (software)																						
X4.2.1.3	Vibration monitoring																						
X4.2.2.1	Structure integrity analysis (software)																						
X4.2.2.2	Piping integrity analysis (software)																						
X4.2.2.3	Vibration monitoring																						
X4.2.3.1	Structure integrity analysis (software)																						
X4.2.3.2	Piping integrity analysis (software)																						
X4.2.3.3	Vibration monitoring																						

Table 2: Matrix of relation diagram between WBS preventive and corrective of piping component

	WBS Level 5	Kode	X2.1.1.1	X2.1.1.2	X2.1.1.3	X2.1.2.1	X2.1.2.2	X2.1.2.3	X2.1.3.1	X2.1.3.2	X2.1.3.3	X2.1.4.1	X2.1.4.2	X2.1.4.3	X2.1.5.1	X2.1.5.2	X2.1.5.3	X2.2.1.1	X2.2.1.2	X2.2.1.3	X2.2.2.1	X2.2.2.2
		Detail	Pipe Body	Connection	Pipe Support	Pipe Body	Connection	Pipe Support	Pipe Body	Connection	Pipe Support	Pipe Body	Connection	Pipe Support	Pipe Body	Connection	Pipe Support	Pipe Body	Connection	Pipe Support	Pipe Body	Connection
WBS Level 9 (Aktivitas)																						
Kode	Detail																					
X5.1.1.1	Re-paint																					
X5.1.1.2	Lamination																					
X5.1.2.1	Sacrificial anode inspection and repair																					
X5.1.2.2	Install additional sacrificial anode																					
X5.2.1.1	Derating (lowering pressure)																					
X5.2.1.2	Flow line diversion																					
X5.2.2.1	Pipeline pigging / ILI																					
X5.2.2.2	Chemical inhibitor injection (inner pipe insulating)																					
X5.3.1.1	Hydrocarbon process re-engineering																					
X5.3.2.1	Pump / Compressor service and repair																					
X5.4.1.1	Pipeline clamp leak repair																					
X5.4.1.2	Pipeline sectional repair																					
X5.4.2.1	Pipe seabed support																					
X5.4.3.1	Pipe repositioning																					
X6.1.1.1	Regular inspection																					
X6.1.2.1	Cathodic protection monitoring																					
X6.2.1.1	Corrosion rate monitoring																					
X6.2.2.1	Pipeline in-line inspection																					
X6.2.2.2	Hydrocarbon content monitoring																					
X6.3.1.1	Hydrocarbon process re-engineering																					
X6.3.2.1	Pump / Compressor service and repair																					
X6.3.2.2	Pipeline pressure and flow monitoring																					
X6.4.1.1	Pipeline pressure and flow monitoring																					
X6.4.1.2	Pipe regular inspection																					
X6.4.2.1	Pipe regular inspection																					
X6.4.3.1	Pipe regular inspection																					

In order to answer Research Question 4 (RQ4), Identification of WBS-based maintenance guidelines to maintain the reliability of maintenance and care of structural components and piping on offshore platforms. Validated content data are guidelines and procedures for preventive maintenance work on structural components and piping of offshore platforms to improve the reliability of maintenance and care through corrective and preventive methods.

Guidelines and work procedures for structural components and piping on offshore platforms to improve the reliability of maintenance and care through corrective and preventive methods.

Table 3: Maintenance guidelines and work procedures implementation (piping)

GENERAL INFORMATION

WBS	LEVEL 2	PIPING	Unit Tag No : 10B2R
WBS	LEVEL 3	TOP SIDE / ABOVE WATER	No Required : (Note iv)
WBS	LEVEL 4	PROCESS LINE	Serial No :
WBS	LEVEL 5	BODY PIPE	PO No :

TECHNICAL DATA

Project Design Code	ASME B 31.4 or B 31.8 or SNI 3473 or SNI 3474	
Pipe Design Code	API 5L or ISO 3183 or ISO 15590-1	
Company Design Specification	Specification for Line Pipe	
	Specification for Inducion Bend	
Service Content	3 PHASE LINE	
Design Temperature (°F)	200	deg F
	1000	psig
Pipe Bend Nominal Diameter Size	12	inch
Wall Thickness	0.5	inch
Pipe Bend Type	Pipe Bend 90 degree (5D) 5 x Diameter bend radius	
Quantity	1	ea
Pipe Bend Design Life	20	years
Year Installed	1997 (24)	years
Coating	5/32" D&W	
Pigging Record	3-Sep-20	
Corrosion Monitoring	CO2: 1% (ppCO2: 1.1 psig), H2S: 1 ppm (ppH2S: 0.00 psig) & No sampling for SRB (Jan 2022)	
Leak History	No	
Certification	Valid until 23 April 2025	
Pigability	Yes	

PROPOSED LOCATION SCHEMATIC

Remarks :
(i) Painting system B1 (System for Submerged Zone) in accordance to company sspecification..
(ii) Thinning : The wall thick, of a finished bend shall be no less than 90% of the pipe wall thickness from which the bend was performed
(iii) Out of roughness : in order to pass the specified sizing of cleaning pig (foam pig) of sphere then pipe bend diameter (in pipe body after forming) shall not be reduced at any point by more than 2.5% of nominal diameter.
(iv) Cathodic Protection Calculation
(v) Pipe integrity report

VI. Conclusion

The preparation and development of WBS for maintenance and care activities is the key to maintaining the reliability of offshore production facilities, especially those that have passed their design age, where there is an increasing potential for asset failure. The preparation and development of a WBS can be a reference in determining the scope of the project, the compilation of work packages, work activities and resource requirements both at the design and implementation stages.

WBS development by incorporating all preventive and corrective actions into additional activities to form integrated guidelines or standard operating procedures.

This study discusses the object of offshore platform production assets, so that further research can be carried out for other production objects.

To determine the relationship between the preparation of WBS, this study uses expert validation analysis methods and archival analysis. Therefore, further research is needed to conduct relationship analysis using other methods.

The work breakdown structure (WBS) standard that has been prepared is expected to continue to be updated in accordance with the development of work methods and technology, then in further research, the development of WBS standard applications can be carried out using information technology systems.

Acknowledgments

This research has been supported by the Project Management Program, Civil Engineering University of Indonesia to provide support in completing this research.

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