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Lifting Structural Assessment of a Working Basket Installed on a Hydraulic Workover Unit (EHR 340K)

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Abstract

The Hydraulic Workover Unit (HWU) is a critical piece of equipment in the oil and gas industry, widely used for well maintenance operations. One of the main components of the HWU is the working basket, which serves as a designated workspace for personnel and must be transported through a lifting process prior to installation on an offshore platform. Lifting operations involve significant risks and therefore require thorough technical analysis to ensure structural safety and reliability. This study aims to analyze the structural behavior of the working basket of the HWU EHR 340K during lifting operations. The analysis was conducted using SACS software. The results indicate that all structural members satisfy the unity check requirements with values less than one, and that the sling forces remain within the allowable capacity limits. Consequently, the proposed lifting configuration is considered safe and suitable for implementation in the lifting process of the HWU working basket.

Kata Kunci: Hydraulic Workover Unit; Lifting Analysis; SACS Software; Sling Force; Structural Analysis.

1. INTRODUCTION

The oil and gas industry remains one of the most critical sectors supporting national and global energy demand [1]. The sustainability of this industry is strongly dependent on the reliability and safety of production facilities and supporting equipment employed throughout the operational lifecycle, from exploration to production and maintenance [2]. As production fields mature, the frequency of well intervention and maintenance activities increases, thereby elevating the importance of specialized equipment capable of supporting safe and efficient operations [3].

One of the key systems widely utilized in oil and gas well operation and maintenance is the Hydraulic Workover Unit (HWU). The HWU is a heavy-duty mechanical system designed to perform workover operations such as well maintenance, repair, tubing handling, and component replacement without dismantling the primary drilling rig. This capability significantly reduces operational downtime and costs compared to conventional workover methods. Previous studies have highlighted the effectiveness of HWUs in improving operational efficiency and safety during well intervention activities [4, 5].

Among the various HWU models currently in operation, the HWU EHR 340K is commonly employed in offshore and onshore fields due to its high lifting capacity and operational flexibility. At present, the HWU EHR 340K is undergoing maintenance at the fabrication facility of PT Elnusa Tbk, a national energy service company providing comprehensive services in oil and gas equipment operation, maintenance, and engineering. Upon completion of the maintenance process, the unit is scheduled to be redeployed for operational use in the Offshore North West Java (ONWJ) area, which is characterized by intensive offshore production activities and strict safety requirements [6].

A critical component of the HWU is the working basket, which serves as the primary workspace for personnel during operational, inspection, and maintenance activities. The working basket accommodates workers, tools, and operational equipment, making its structural integrity essential for ensuring occupational safety. During maintenance and transportation stages, the working basket must be dismantled floor by floor, and the separated structural modules are relocated using lifting operations. These lifting activities represent a high-risk phase in the lifecycle of the equipment due to the potential for instability, excessive stress, or improper load distribution.

Lifting operations are defined as the process of raising or lowering structures using mechanical lifting devices such as cranes, hoists, or winches. Inadequate engineering design or improper lifting configuration can result in structural overstress, excessive deformation, or even catastrophic failure, posing serious risks to personnel safety and equipment integrity. Consequently, lifting operations for offshore structures must be supported by rigorous structural analysis to ensure that stresses, sling forces, and stability criteria remain within acceptable limits throughout the lifting process [7-9].

In response to these challenges, this study presents a comprehensive structural assessment of the working basket lifting operation for the HWU EHR 340K. The analysis is conducted using the Structural Analysis Computer System (SACS), a widely recognized software package for offshore structural analysis [10-12]. The study evaluates structural responses during lifting, including unity check ratios and sling forces, in accordance with relevant offshore design standards. The findings are expected to provide valuable insights into the safety and reliability of the proposed lifting configuration and contribute to improved engineering practices for lifting operations in the oil and gas industry.

2. METHOD

The study begins with a comprehensive literature review to establish the theoretical background and engineering practices related to lifting operations, structural integrity, and safety assessment of Hydraulic Workover Units (HWUs). This stage is followed by the formulation of the problem statement and research objectives, which focus on evaluating the structural performance of the HWU working basket during lifting operations. Subsequently, data preparation is conducted using detailed structural information and the collection of technical data required for structural modeling, including member grouping, component descriptions, material types, and main specifications of the HWU. The structural components are classified into member groups such as flanges, gin poles, basket elements, pipes, tong arms, and workover tower elements, with materials represented by tubular sections, hollow sections, plates, box sections, and wide flanges. Key physical parameters, including tare weight, payload, maximum gross mass, and overall dimensions, are defined as input data for the numerical model. The flowchart can be seen in Figure 1.

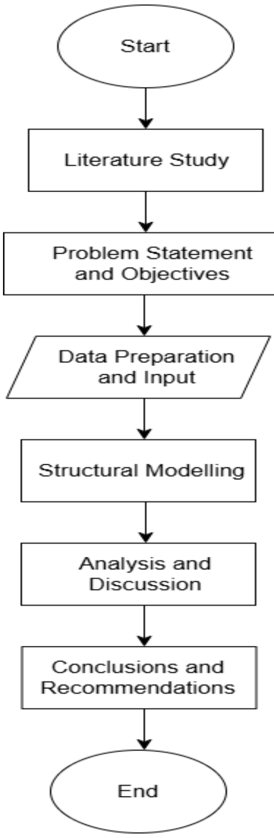


Figure 1. Flowchart

Following data preparation, a three-dimensional structural model of the HWU is developed to simulate the lifting configuration. The structural lifting analysis was performed using SACS (Structural Analysis Computer System) software, which is widely applied in offshore and oil and gas structural engineering. The model incorporates material properties, geometric characteristics, and boundary conditions consistent with actual lifting scenarios (Table 1). Structural analysis is then performed to evaluate internal forces, stresses, and load distribution within the members under lifting loads, including the effects of self-weight and payload (Table 2).

Table 1. Structural Data of the HWU

No	Member Group	Description	Material
1	FLG	Flange	Tubular
2	G	Gin Pole	Tubular
3	J01	Basket	Rectangular Hollow Section
4	J05	Basket	Square Hollow Section
5	J10	Basket	Plate
6	PIP	Pipe	Tubular
7	PN2	BOP	Tubular
8	T1	Tong Arm	Wide Flange
9	T2	Tong Arm	Box
10	T3	Tong Arm	Tubular
11	WOT	Workover Tower	Box
12	WR	Wire	Tubular

Table 2. Main Specifications of the HWU

No	Specification	Value
1	TARE	2.400 kg
2	PAYLOAD	1.935 kg
3	MGM	3.400 kg
4	DIMENSION (L x W x H)	3.720 x 3.950 x 1.415

Table 3. Load Case for In-Place Analysis

No	Load Case	Description
1	GP	Gin Pole Dead Load
2	JA	Jacket Assembly
3	LL	Live Load
4	RT	Rotary Table
5	TA	Tong Arm
6	101	Wind 0 degree
7	102	Wind 45 degree
8	103	Wind 90 degree
9	104	Wind 135 degree
10	105	Wind 180 degree
11	106	Wind 225 degree
12	107	Wind 270 degree
13	108	Wind 315 degree
14	109	Blowout Preventer

Table 3 presents the load cases applied in the in-place analysis of the HWU structure, consisting of dead loads from the main components, live load, and environmental loads in the form of wind loads from eight directions All load cases were subsequently combined into several load combinations using appropriate load factors in accordance with API RP 2A-WSD to evaluate the structural strength and stability of the HWU under normal operating conditions.

For the lifting analysis, only one load combination was considered, namely Load Combination 1000, which consists of dead load and wind load. This load combination is multiplied by a load factor of 1.2 to represent a more conservative lifting condition and to account for possible uncertainties during the lifting operation. During the lifting analysis, all boundary conditions used in the in-place condition were removed. Working basket was modeled as a free system and supported only by the lifting slings connected to the crane hook.

Consequently, the restraint of the structure during the lifting operation was represented solely by the tensile forces in the slings. In this analysis, one load case was considered, namely a load combination of 1000 with an applied load factor of 1.2. This factor was used to account for additional safety considerations during the lifting operation, ensuring that the structural response was evaluated under a more conservative loading condition.
The 3-D model can be seen in Figure 2. The model explicitly includes the main structural components, namely the gin pole, working basket, tong arm, hydraulic jack, and blowout preventer (BOP), each idealized according to its functional role and structural characteristics. Frame and beam elements are used to model primary load-bearing members, such as the gin pole and tong arm. The working basket is represented using a combination of frame and plate elements to capture both global stiffness and local load transfer. The hydraulic jack is incorporated as a vertical load-transferring element, and the BOP is modeled as a concentrated mass acting at the lower end of the structure. This modeling strategy ensures that the geometry, connectivity, and load paths realistically reflect the physical system during lifting.
The lifting configuration is simulated by applying appropriate boundary conditions, sling connections, and load cases corresponding to self-weight, payload, and equipment masses. Lifting points are defined at designated nodes on the working basket and structural frame, where sling forces are introduced to replicate crane-assisted lifting. The analysis considers the combined effects of gravity loads and lifting-induced forces to evaluate internal stresses, member forces, and global structural stability. The structural response is assessed through parameters such as axial forces, bending moments, and unity check ratios to verify compliance with allowable limits. This methodological approach enables the identification of critical members and load concentrations during lifting, providing a robust basis for evaluating the safety and reliability of the HWU structural system. The analytical results are assessed through unity check ratios (Figure 4) and structural response parameters to ensure compliance with acceptable design limits. Finally, the analysis outcomes are interpreted and discussed to identify critical structural components and potential risk areas during lifting, leading to conclusions and recommendations aimed at enhancing safety, reliability, and engineering practices for HWU lifting operations.

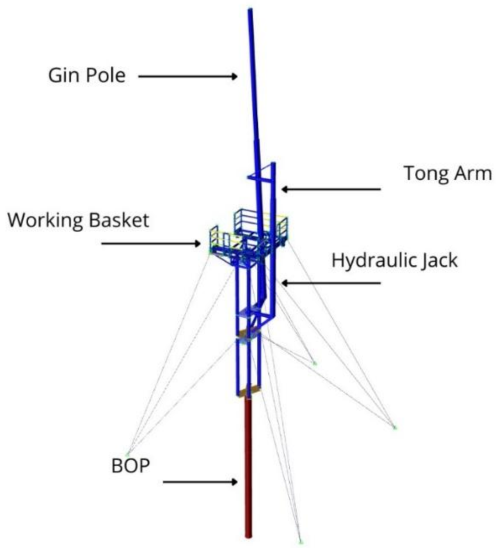


Figure 2. Structural Model of the HWU

In addition to the applied load combinations, the lifting condition is treated as a temporary load case in accordance with API RP 2A-WSD, where appropriate load factors are applied to account for uncertainties during lifting operations. Although dynamic effects such as crane motion and environmental disturbances are not explicitly modeled, a conservative load factor of 1.2 is adopted to implicitly account for potential dynamic amplification during lifting.

3. RESULT AND DISCUSSION

In this study, the lifting condition is classified as a temporary load case, where a slightly higher tolerance is generally acceptable due to its short duration. However, all evaluated members remain well below the allowable limit, indicating a conservative design with sufficient structural capacity.

3.1. In-Place Analysis

In-place analysis is a static structural analysis performed to evaluate the serviceability and load-carrying capacity of the structure under applied operational loads. The primary outputs of the in-place analysis are the allowable stress ratios and joint punching shear, which are presented in the form of unity checks. The unity check represents the ratio between the actual stress induced by applied loads and the allowable stress capacity of the structural material. The results of the analysis are expressed through member unity checks and joint unity checks, as summarized in Table 3.

Table 4. Unity Check Result

Member Group	Description	Utilization Ratio	Remark
FLG	Flange	0.28	OK
G	Gin Pole	0.13	OK
J01	Basket	0.21	OK
J05	Basket	0.26	OK
J10	Basket	0.16	OK
PIP	Pipe	0.09	OK
PN2	BOP	0.32	OK
T1	Tong Arm	0.17	OK
T2	Tong Arm	0.15	OK
T3	Tong Arm	0.22	OK
WOT	Workover Tower	0.41	OK

Among all structural components, the Workover Tower (WOT) exhibits the highest utilization ratio of 0.41. This is attributed to its role as a primary load-bearing element that transfers significant loads from upper structural components to the base. Despite having the highest value, the utilization ratio remains well below the allowable limit, indicating that the structure still possesses a substantial safety margin.

According to API RP 2A-WSD, the maximum allowable unity check under operational conditions is 1.0. Structural members with unity check values exceeding this criterion are considered to have failed the design requirements. The analysis results indicate that all structural members exhibit unity check values less than 1.0, thereby satisfying the API RP 2A-WSD requirements. This confirms that the structural capacity is sufficient to resist the applied loads with an adequate safety margin, as the actual stresses remain below the allowable limits. In this study, the lifting condition is classified as a temporary load case, where a slightly higher tolerance is generally acceptable due to its short duration. However, all evaluated members remain well below the allowable limit, indicating a conservative design with sufficient structural capacity.

3.2. Lifting Analysis

The lifting analysis conducted in this practical work focuses exclusively on the working basket, while other structural components included in the overall model are excluded from the analysis. The working basket is lifted using a single-hook configuration without a spreader bar. Key parameters required for lifting analysis include the center of gravity (COG), lifting points, hook point location, and sling angles (Benjamin, 2019).

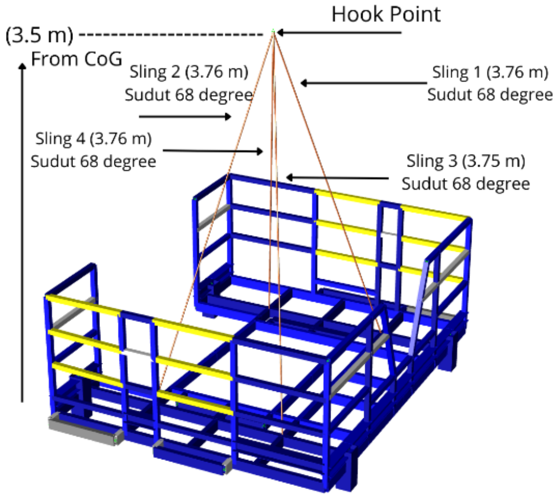


Figure 3. Working Basket Model

Figure 3 illustrates the structural model of the working basket developed using SACS software, which serves as the basis for the lifting analysis.

Table 5. *Centre Of Gravity*

Structural Weight (kg)	*Centre Of Gravity (m)*	
	X	Y
2.400	1.39	0

Table 6. Hook Point Coordinates

No	Sling Member	Hook Point Coordinates		
		X (m)	Y (m)	Z (m)
1	100-0031 WR	-1.39	0	3.5
2	082-0031 WR	-1.39	0	3.5
3	057-0031 WR	-1.39	0	3.5
4	055-0031 WR	-1.39	0	3.5

The Table 5 above presents the hook point coordinates for each sling member used during the lifting operation. All hook points are located at X = −1.39 m, Y = 0 m, and Z = 3.5 m, and are positioned vertically above the center of gravity of the structure to ensure lifting stability.

Table 7. Sling Angles

No	Sling Member	Sling Length (m)	Angle (°)
1	100-0031 WR	3.76	68°
2	082-0031 WR	3.76	68°
3	057-0031 WR	3.75	68°
4	055-0031 WR	3.76	68°

The sling length used in the lifting configuration is approximately 3.76 m, with a sling angle of 68°. This angle is within the safe operating range, as it exceeds the minimum recommended angle of 60°, thereby reducing the risk of excessive tensile stress in the sling during lifting operations. The single-hook lifting configuration adopted in this study represents a practical and commonly used lifting arrangement in offshore operations, particularly when lifting modular components such as working baskets. This configuration is selected to reflect actual field practice, where simplicity, operational efficiency, and crane availability often govern lifting strategies. The vertical alignment of the hook point above the center of gravity ensures stability and minimizes rotational effects during lifting.

Table 8. Sling Material Properties

Sling Type	Section Type	OD (cm)	WT (cm)	E (kN/cm2)	G (kN/cm2)	Fy (kN/cm2)
Wire Rope	Tubular	2.2	0.693	20000	7722	24.5

The sling material used in the lifting operation is wire rope, modeled as a tubular section with an outer diameter of 2.2 cm and a wall thickness of 0.693 cm.

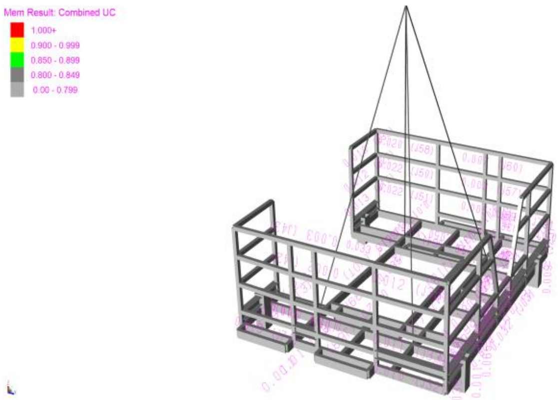
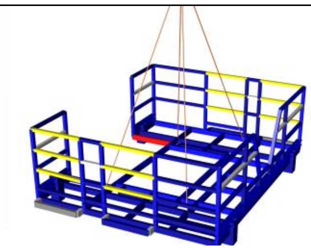
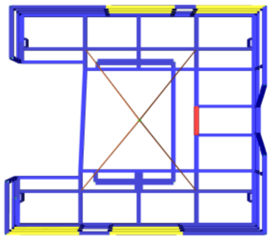
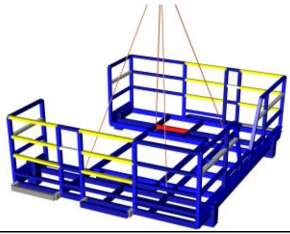


Figure 4. Unity Check Results

Table 9. Maximum Unity Check Values

Member Group	Utilization Ratio	Remark	Structural Member
J01	0.33	OK	
J05	0.050	OK	
J10	0.47	OK	

The lifting analysis results indicate that the structural model satisfies the unity check criteria specified in API RP 2A-WSD, as all structural members exhibit unity ratios less than 1.0. This confirms that the structure remains within safe stress limits under lifting loads and is therefore suitable for the lifting operation.

Tabel 10. *Sling Force*

Member Group	Force (X) kN
WR	2.8466
WR	3.3515
WR	1.5008
WR	-0.1710

Table 9 presents the forces acting on each sling during the lifting process. The Force (X) values represent the horizontal tensile force components acting along the X-axis on the slings. Negative sling force indicates that the corresponding sling is not effectively carrying tensile load. This condition is mainly caused by its proximity to the load application point, which leads to an uneven load distribution among the slings and results in a local unloading or compressive response in that sling. The presence of a negative sling force value does not indicate that the sling is subjected to compressive forces, as wire ropes are incapable of carrying compression. Instead, this result reflects a minor load redistribution effect within the structural system, where one sling becomes effectively unloaded due to geometric configuration and proximity to the center of gravity. This condition is commonly observed in numerical simulations and can also be influenced by modeling tolerances and idealization assumptions. Therefore, the negative value should be interpreted as an indication of negligible load contribution rather than a physical compression condition. Overall, the structural analysis demonstrates that the working basket system maintains adequate safety margins under both in-place and lifting conditions. The unity check values significantly below unity indicate that the structure operates within a safe stress range, providing confidence in the reliability of the lifting configuration.

4. CONCLUSION

The methodology and analysis approach presented in this study can serve as a reference framework for similar lifting assessments of offshore equipment. By integrating structural modeling, load evaluation, and code compliance checks, this approach provides a systematic procedure for ensuring lifting safety and structural reliability in practical engineering applications.

Based on the results of the analyses conducted, the following conclusions can be drawn:

1. The lifting analysis results indicate that the sling forces acting along the X-axis are 2.8466 kN, 3.3515 kN, and 1.5008 kN, while the fourth sling exhibits a negative force value of −0.1710 kN. These values indicate that the primary lifting load is predominantly distributed along the X-axis during the lifting operation.
2. The analysis results demonstrate that all structural members satisfy the unity check requirements with values less than 1.0 in accordance with the API RP 2A-WSD standard. This confirms that structural strength and stability are sufficient and that the structure is safe to support the lifting process.

From a practical perspective, the results of this study highlight the importance of proper lifting configuration design, accurate determination of the center of gravity, and careful evaluation of sling forces to ensure safe lifting operations. The findings also emphasize that numerical analysis tools such as SACS can provide reliable support for decision-making in offshore lifting planning. Future work is recommended to incorporate dynamic lifting effects and real-time monitoring to further enhance operational safety and structural performance.

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