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Maintenance Management Optimization: Evaluating Manual and Automated Methods of Tracking Uptime Hours for Offshore Equipment

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ABSTRACT

Offshore oil and gas fields are among the largest contributors to global oil and gas production. The reliable functioning of these facilities relies heavily on the reliability of the process equipment. Managing and operating offshore equipment is inherently complex, requiring careful planning to ensure maximum uptime and minimal downtime. This study addresses a significant gap in knowledge by comparing the effectiveness of manual and automated methods for tracking the uptime hours of offshore equipment. Using a mixedmethods approach that incorporates quantitative and comparative data analysis, the research assesses the impact of each tracking method on equipment reliability, maintenance costs, and production efficiency. The findings indicate that both methods exhibit high level of accuracy and consistency, with minor differences, confirming the reliability of both methods. However, the study reveals that the automated tracking system, which demonstrated more significant data consistency across shifts when compared to the manual approach, offers substantial advantages, including reduced human error, improved data collection efficiency, and enhanced maintenance scheduling. These benefits, result in improved equipment reliability, lower maintenance costs, optimized maintenance management and greater production efficiency. The study recommends the use of automated logging systems, regular calibration, and maintenance of automated systems, and combining data from both approaches for cross-verification. To ensure accuracy and consistency across all equipment and shifts, it is advised that personnel involved in manual logging receive enhanced training and that logging procedures undergo continuous improvement.

INTRODUCTION

The offshore oil and gas industry is a critical component of the global energy landscape (Speight, 2014), with many countries relying on these resources to meet their energy demands. However, the maintenance and operation of offshore equipment is a complex and challenging task, requiring rigorous planning and execution to ensure optimal uptime and minimize downtime. Implementing Industry Revolution 4.0 technologies has revolutionized maintenance management in the offshore oil and gas production sector (Duque & El-Thalji, 2020). IoT sensors enable real-time monitoring of equipment parameters, facilitating predictive maintenance through data-driven algorithms that anticipate failures and optimize maintenance schedules. Advanced analytics and AI-driven systems enhance condition monitoring by detecting abnormalities early on, while remote monitoring technology allows for real-time supervision from onshore locations, enabling immediate responses to operational issues (Gilchrist, 2016). Digital twin technology creates virtual replicas for simulations and predictive maintenance, and augmented reality (AR) and virtual reality (VR) are utilized for training and troubleshooting support. The seamless integration of systems and emphasis on big data analytics improve organizational decision-making processes (Skilton & Hovsepian, 2018) and optimize maintenance strategies based on historical

data and performance analytics. Cybersecurity measures are also prioritized to protect data and operations from threats. Overall, Industry Revolution 4.0 enhances maintenance management, making it more proactive, efficient, and data-driven, ultimately improving the offshore environment reliability, safety, and operational uptime.

One of the key challenges in offshore maintenance management is the accurate tracking of uptime hours, which is essential for predicting equipment reliability, scheduling maintenance, and optimizing production. Traditionally, manual tracking methods have been used to record uptime hours, which involve relying on operator reports, maintenance logs, and manual data entry. While these methods have been effective in the past, they are prone to errors, inconsistent reporting, and time-consuming data processing. In recent years, automated tracking systems have emerged as a viable alternative to manual tracking methods. These systems use sensors, data loggers, and software to automatically collect and analyze data on equipment performance, allowing for real-time monitoring and more accurate tracking of uptime hours. Despite the potential benefits of automated tracking systems, many offshore operators still rely on manual methods due to concerns about cost, complexity, and reliability.

The lack of accurate uptime hour tracking can have significant consequences, including reduced equipment

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reliability, increased maintenance costs, and decreased production efficiency. This study aims to address this knowledge gap by comparing the effectiveness of manual and automated uptime hours tracking methods for offshore equipment using one of Nigerians' offshore oil and gas production platforms as a case study. The study will investigate the impact of each method on equipment reliability, maintenance costs, and production efficiency using a mixed-methods approach that combines quantitative and comparative data analysis. The findings of this study will provide insights into the benefits and limitations of each method and inform the development of more effective maintenance management strategies for offshore operators. By optimizing maintenance management through the use of automated tracking systems or improved manual methods, offshore operators can improve equipment reliability, reduce downtime, and increase production efficiency. This study contributes to the advancement of knowledge in the field of maintenance management by providing a comprehensive comparison of manual and automated uptime hours tracking methods for offshore equipment.

LITERATURE REVIEW

Several studies have highlighted the importance of accurate equipment uptime-hour tracking in industrial maintenance management. Manual logging automated tracking systems are utilized for this purpose, each offering distinct advantages and limitations. To fully leverage these technologies, it is crucial to understand the interconnected challenges they present (Abraha, 2011). For instance, Automated Condition Assessment systems enhance risk awareness, enable targeted remediation strategies, and improve asset management efficiency by reducing the time, cost, and labor associated with manual inspections, particularly for offshore platform topside equipment (Ferguson et al., 2022). Maintaining the reliability, integrity, and safety of aging equipment poses increasing challenges due to factors such as hardware degradation, corrosion, fatigue, and obsolescence, the complexity of managing these factors further exacerbates these challenges (Amaechi et al., 2022). In response to these issues, tools like DISTALYZER have been developed to enhance maintenance management by using machine learning to identify performance issues in distributed systems through log data analysis. This tool highlights key differences between well-performing and poorly-performing systems, requiring minimal expertise (Nagaraj et al., 2012). Similarly, the implementation of Automated Procedure Logging (APL) systems in emergency medicine has shown significant improvements in logging accuracy and completeness, greatly aiding in the assessment of residents' competencies (Seufert et al., 2011). Furthermore, IoT-based systems for preventive maintenance, as introduced by Sitompul and Rohmat (2021), allow remote access to maintenance schedules and provide timely reminders, improving the overall efficiency of preventive maintenance processes

by accounting for machine downtime, relatively, Al Dosari and Abouellail (2023) conducted a research in which they compared various methodologies and assessed the efficacy of AI-based control systems in mechanical engineering applications. The outcomes demonstrate how AI methods may be used to increase automation and precision. Field operations like those at a steam plant have also benefited from daily condition monitoring and remote data transmission to diagnostic centers, which support operational decision-making and improve maintenance practices (Russo et al., 2010). Adopting sophisticated technologies within an integrated maintenance management framework offers significant advantages in optimizing operational efficiency, enhancing maintenance practices, and effectively managing offshore oil and gas assets.

MATERIALS AND METHODS

This study methodology outlines a structured approach to researching equipment uptime hours and their management, ensuring thorough data collection, analysis, and framework development. The study commences with an overview of offshore oil and gas production plants and the specific offshore equipment under investigation. From the operation and maintenance database of the case study facility, automated and manual data loggings for five key pieces of process equipment: a gas generator, air compressor, booster pump, sewage treatment plant electric motor, and crude delivery pump were gathered, over six shifts, each lasting 28 days. The shifts began in January 2024. Variances between the manual and automated uptime data were calculated, along with percentage differences. A quantitative and comparative analysis was conducted to evaluate the accuracy, consistency, and variance between automated and manual logging. The study also assessed the advantages of the automated uptime hour logging system over the manual method and examined the impact of both logging approaches on equipment reliability, maintenance costs, and production efficiency. Graphs were employed to illustrate the trends revealed by the results and analysis. Conclusions were drawn based on these findings.

Offshore Oil and Gas Production Facility



Figure 1: Offshore production platform (European Space Agency, 2024)



An offshore oil and gas production facility is a complex system designed to extract hydrocarbons from beneath the ocean floor and transport them to onshore processing plants. These facilities are typically located in shallow or deep water and are built to withstand the harsh marine environment. They consist of several important components, such as drilling rigs, production platforms, subsea systems, pipelines, offshore cranes, living quarters, and power generation units (Fang & Duan, 2014). Drilling rigs are used to extract oil and gas from beneath the seafloor, while production platforms have pumps, compressors, and separators to process the well stream (Laik, 2018). The offshore production facility performs various essential functions, including drilling, production, processing, and transportation. During drilling, oil and gas are extracted from the seabed using specialized equipment. The production phase focuses on treating the extracted hydrocarbons to remove impurities, water and improve their quality. Processing further refines the oil and gas to meet industry standards. Finally, transportation moves the refined products from the offshore platform to onshore processing facilities through pipelines. These facilities offer several advantages, such as increased energy production, improved energy security, and significant economic benefits.

Offshore operations allow access to previously untapped sources of hydrocarbons, thereby increasing energy production and reducing reliance on imported energy. They also create job opportunities in the energy sector and generate substantial revenue for governments through taxation and royalties. However, offshore oil and gas production facilities also come with significant challenges. Environmental concerns are a top priority, with risks such as oil spills and habitat destruction. Technical challenges arise due to the need for specialized equipment and expertise to ensure efficient operation. Regular maintenance is crucial to keep the facility running, although it can be costly and time-consuming. Safety risks are also a major concern, with potential accidents and natural disasters that could result in injuries or loss of life (Ni et al., 2022). The equipment used in offshore production includes drilling rigs, wellheads, production platforms, subsea systems, pipelines, offshore cranes, and pumps. These equipment are designed to function in severe weather conditions, such as high winds, heavy rainfall, storms, and extreme temperatures. The offshore environment significantly affects equipment performance, extreme weather can cause vibrations and oscillations in equipment, leading to fatigue and accelerated wear. Corrosion is a major concern due to the highly corrosive nature of seawater, which gradually damages equipment over time. The high salt content in seawater can also lead to scaling, further impairing equipment, moreover, strong ocean currents exert intense forces on equipment, which can result in damage or failure. These harsh conditions often reduce the lifespan of offshore equipment, which necessitates more frequent maintenance and repairs (Habrekke et al., 2011).

Failures caused by exposure to extreme conditions can result in costly downtime and repairs, repairing equipment in remote offshore locations exacerbates these challenges and increases costs. Consequently, the offshore environment can compromise equipment efficiency and productivity due to corrosion, wear, and other environmental stresses (Valdez et al., 2015). To mitigate the impact of the offshore environment on equipment performance, several design and operational considerations must be taken into account. It is crucial to select materials that resist corrosion and wear for the durability of equipment components. Equipment should be designed to minimize vibrations and oscillations, thus preventing fatigue, protective coatings and enclosures can shield equipment from extreme weather conditions. Regular maintenance schedules ensure proper maintenance and servicing (Kusumawardhani et al., 2016), reducing the likelihood of failures. Additionally, condition monitoring systems can continuously assess equipment performance and detect potential issues before they become significant problems.

Case Study Offshore Oil and Gas Production Facility Equipment

These equipment are offshore oil and gas process equipment used for the production of crude oil, these equipment are continuous duty type of industrial equipment, for this study, the following equipment will be looked at, they are pipeline pump, air compressor, booster pump, gas generator and sewage treatment plant electric motor.

Pipeline Pump (PP)

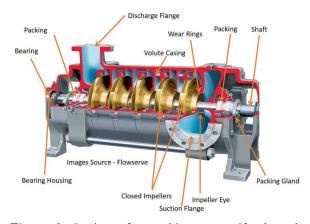


Figure 2: Section of a multistage centrifugal crude delivery pump (Hardhat Engineer, 2024)

Pipeline pumps are crucial in offshore oil production operations as they transport oil from the production platform to storage tanks or shuttle tankers. These pumps are specifically designed to handle high-pressure, high-volume oil flows and are typically used alongside pipeline transportation systems. Their main function is to increase the oil pressure so that it can be safely transported through the pipeline. Considering the harsh marine environments



in which they are installed, pipeline pumps in offshore oil production operations are designed to withstand extreme temperatures, corrosion, and vibrations. They are usually connected to the pipeline system within the production platform's processing facility. These pumps are powered by electric motors or natural gas engines and can handle flow rates of up to 100,000 barrels per day. They are engineered for continuous operation with minimal maintenance requirements to ensure reliable and efficient oil transportation. In addition to their role in oil transport, pipeline pumps also play a critical role in maintaining the pipeline system's integrity. They help prevent corrosion and erosion by keeping the pipeline filled with oil and also aid in removing any accumulated sediment or debris. Moreso, these pumps can be used to extract residual oil from the pipeline, which can generate additional revenue for oil producers.

Industrial Air Compressor (IAC)



Figure 3: Sullair LS air compressor pictorial (Sullair, 2021)

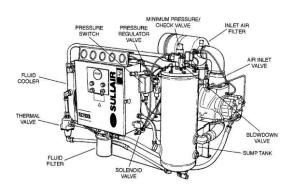


Figure 4: Sullair LS air compressor schematic diagram (Sullair, 2023)

In offshore oil production operations, industrial air compressors play a vital role in supporting the various equipment and systems required to extract, process, and transport oil. Air compressors are used to generate compressed air, which is used as a power source for various applications, such as driving pneumatic tools, powering pneumatic cylinders, and operating pneumatic control systems. In offshore oil production, air compressors are typically used to power pneumatic tools and equipment

used in drilling, completion, and maintenance operations. The air compressors used in offshore oil production operations are typically large, high-pressure units that are designed to operate in harsh marine environments. These units are usually fuelled by electricity or natural gas, and are capable of producing high-pressure air up to 1000 psi (6900 kPa). The compressed air is then distributed throughout the platform through a network of pipes and hoses, where it is used to power pneumatic tools and equipment. For example, pneumatic drilling tools, such as rotary drill bits and drill collars, are powered by compressed air, which allows for efficient drilling operations. In addition to powering pneumatic tools and equipment, air compressors also play a critical role in supporting safety and emergency systems on offshore oil production platforms. For example, compressed air is often used to power emergency lighting systems, lifeboats, and other safety equipment. Furthermore, air compressors can also be used to support maintenance and repair operations on the platform, such as powering pneumatic tools used in welding and fabrication.

Booster Pump (BP)



Figure 5: Process booster pump (GOTESCO, 2020)

A booster pump is an essential component in offshore oil production. Its purpose is to increase the pressure of fluids like oil or water. These pumps are designed to be centrifugal, operating at high speeds and pressures to transfer energy from the motor to the fluid. Booster pumps can handle pressures ranging from 500 to 5,000 psi (34 to 345 bar), making them suitable for various applications. They are also built to handle large flow rates, typically measured in thousands of barrels per day (BPD), and have a robust construction to withstand harsh offshore environments. In offshore oil production, booster pumps are primarily used to increase the pressure of crude oil and transport it through pipelines to the pipeline pump. They are also utilized in water injection systems to enhance oil recovery by increasing the pressure of injected water into underground reservoirs to maintain reservoir pressure. Additionally, booster pumps can be employed in gas compression systems to increase the pressure of natural gas for transportation or injection into underground reservoirs. The advantages of booster pumps include increased efficiency, flexibility,



and reliability, making them a key component in many offshore oil production operations.

Booster pumps also present some challenges. Regular maintenance is necessary to ensure optimal operation, which can be costly, as they are exposed to corrosive fluids and environments, leading to premature wear and failure. Furthermore, booster pumps are typically installed in small spaces on offshore platforms, which can limit their maintenance.

To mitigate these challenges, engineers and operators must carefully design and operate booster pumps to ensure reliable and efficient operation. Regulations and standards play a crucial role in ensuring the safe and efficient operation of booster pumps. The American Petroleum Institute (API) has developed standards for centrifugal pumps and positive displacement pumps, while the American Society of Mechanical Engineers (ASME) has developed standards for gas transmission and distribution piping systems. Additionally, the Occupational Safety and Health Administration (OSHA) regulates the installation, operation, and maintenance of booster pumps to ensure worker safety. By understanding these regulations and standards, engineers and operators can ensure that booster pumps operate reliably and efficiently, maximizing oil recovery and minimizing downtime.

Gas Generator (GG)



Figure 6: Gas generator (CAT, 2024)

In offshore oil production operations, the gas generator plays a vital role in powering the equipment and systems needed to extract, process, and transport oil. This type of power generation equipment converts natural gas into electrical energy, which then provides the electrical energy needs of the offshore platform. By utilizing the natural gas produced alongside the oil instead of wasting it through flaring or venting, the operation reduces its environmental impact while also obtaining a reliable and cost-effective power source. The gas generator is typically connected to a high-voltage alternating current (HVAC) system that distributes electricity to various loads on the platform. These loads include pumps, compressors, and generators that power oil production, gas processing, utility systems, and life support systems. The gas generator provides power to the oil production system, which lifts the oil from the wellhead to the processing facility, as well as the

gas processing unit, which separates the natural gas from the oil and prepares it for transportation. Additionally, the gas generator powers the platform's utility systems, such as lighting, communication systems, and life support systems. In emergencies or power outages, the gas generator serves as a backup power source to ensure a continuous supply of electricity to the platform. It is designed to operate alongside other power sources, such as diesel generators or grid power, to ensure a reliable and redundant power supply.



Figure 7: Sewage treatment plant blower motor (REDFOX Environmental Services, 2014)

Sewage Treatment Plant Blower Motor (STPBM)

Sewage treatment plants rely on electric motors to operate various equipment, such as pumps, blowers, and aerators. These motors are specifically designed to handle the harsh conditions of wastewater treatment. Three-phase induction motors are commonly used in sewage treatment plants due to their ability to produce high torque, resistance to corrosion, and ability to withstand exposure to water and corrosive substances. In certain areas of the plant where flammable gases or high temperatures may be present, explosion-proof and high-temperature designs are necessary. The motors play a critical role in various processes, including handling wastewater flow, aerobic treatment, and chemical mixing. Motors drive the pumps that handle wastewater flow, while blowers and aerators supply air for aerobic treatment processes. Additionally, motors are used to drive mixers that blend wastewater and chemicals. The reliability and efficiency of these motors are vital for the smooth operation of the sewage treatment plant, and regular maintenance is necessary to prevent downtime and equipment failure. However, maintaining and operating sewage treatment plant motors can be challenging. While corrosion-resistant materials and waterproof designs can help extend the lifespan of the motor, regular cleaning and maintenance are still required to prevent damage. Furthermore, the electrical system supplying power to the motor must be reliable and free of faults to avoid downtime and equipment failure. Compliance with industry standards and regulations, such as API 14C, NFPA 70, IEEE 802, and ASME B30, is also essential for ensuring safe and efficient operation.



Hour Meter



Figure 8: Electronic - digital hour meter (ALTRONIC, 2024)



Figure 9: Mechanical hour meter (TAS, 2024)

An hour meter is a device that measures the operating time of engines, machines, or equipment. It functions as a timer, recording the total hours of operation to accurately track maintenance intervals, fuel consumption, and overall performance. Two basic types of hour meters: mechanical and electronic. Mechanical hour meters use gears and dials, whereas electronic (digital hour meters) display time in a digital format. Electronic hour meters utilize microprocessors to measure and display time on a digital screen. One of the key features of hour meters is their ability to record total hours of operation precisely. This ensures that maintenance is scheduled accurately, guaranteeing proper servicing and maintenance of equipment. Additionally, hour meters can monitor fuel consumption, allowing operators to optimize usage and reduce costs. They also assess performance, identifying areas for improvement in engines, machines, or equipment. Hour meters offer several advantages. They improve maintenance scheduling, reducing downtime and increasing productivity by ensuring proper equipment maintenance. They enhance efficiency by accurately tracking operating hours and optimizing fuel consumption and performance. Furthermore, hour meters help reduce costs by identifying areas where maintenance can be optimized. Lastly, they enhance safety by minimizing the risk of equipment failure. Hour meters are commonly used in various applications, including industrial equipment such as pumps, generators, and compressors; vehicles such as cars, trucks, and motorcycles; construction equipment such as excavators, cranes, and bulldozers; and agricultural equipment such as tractors, plows, and harvesters.

Manual Uptime Hours Log

Manual uptime log hours are derived through systematic recording and summation of equipment operational times by on-site operators or technicians. This process begins with daily recording, where operators record the start and stop times of equipment operation during their shifts. They note the exact hours and minutes when the equipment is turned on and off or experiences an emergency shutdown, ensuring continuous logs for equipment that runs continuously or for extended periods across multiple shifts. At the end of each shift, the operator calculates the total operational hours, this summation process continues until the end of the six shifts. By summing up all shift logs for the sixth shift, if GG1 1 ran for a total of 2016 hours, this becomes the sixth shift total. To ensure accuracy, operators must ensure proper handover between shifts to maintain continuity in logging. Supervisors or engineers periodically verify manual logs against operational records or automated systems. Additionally, maintaining duplicate logs or electronic backups helps prevent data loss. Accurate manual logs serve as a backup in case of automated system failures, it also helps verify and validate automated system data, and are necessary for audits, inspections, and compliance with industry standards. Ensuring accuracy in manual logging is critical for effective equipment management and maintenance scheduling.

Automated Uptime Hours Log

The integration of advanced digital technologies in the Industrial Revolution 4.0 has had a significant impact on the development of automated uptime-hours tracking systems. In the era of smart manufacturing, where the Internet of Things (IoT), cyber-physical systems, and big data analytics play a central role, these tracking systems have become essential for monitoring and managing the operational hours of machinery. By leveraging IoT sensors, these systems continuously collect real-time data on equipment usage, automatically recording uptime hours without the need for manual input. This data is then processed and analyzed to optimize maintenance schedules, predict potential failures, and improve overall equipment efficiency. By aligning with the principles of Industry 4.0, automated run hours tracking systems enhance operational transparency, reduce human error, and contribute to the predictive maintenance strategies that are fundamental to today's smart factories.

Devices can connect to the Internet using the Internet of Things technology to share data and communicate with other devices (Lamoj, 2024). Automated system uptime hours are derived through continuous monitoring and recording by sensors and software integrated into the equipment. These sensors are typically part of a larger control and monitoring system, such as a SCADA (Supervisory Control and Data Acquisition) system. They collect real-time data, continuously logging the equipment's operational status. Each time the equipment is started or stopped, the system logs a timestamp,



ensuring a precise recording of the duration for which the equipment was operational. The system calculates the run hours incrementally by subtracting the start timestamp from the stop timestamp and summing these intervals over the desired period.

The collected data is securely sent to a centralized database or cloud storage for storage. This centralized storage allows for easy access to data for analysis and reporting, ensuring data is not lost. The system automatically aggregates the uptime hours over specified intervals, such as daily, by shifts, or monthly. This eliminates the need for manual summation and reduces the risk of errors. Regular calibration of sensors is essential to maintain accuracy, as it ensures they provide precise readings. Periodic system checks and maintenance prevent drift and errors in data logging. Additionally, automated systems can include algorithms to detect anomalies or inconsistencies in the data, prompting further investigation if needed. Automated systems offer several advantages, including precision, efficiency, real-time monitoring, and seamless integration with other maintenance management software. They provide accurate uptime hour measurements, reducing human error and saving time and effort in recording and calculation. Continuous monitoring allows for immediate detection of operational issues, enhancing maintenance planning. Regular calibration and system checks are essential to maintain the reliability of these automated systems..

Percentage Difference

Percentage difference is a method used to measure the difference between two values, expressed as a percentage of one of the values, typically the average of the two. It is commonly used to compare the accuracy of different measurement systems, such as automated and manual tracking systems, by showing how much they differ relative to each other. To calculate the percentage difference between automated uptime hour tracking and

manual uptime hour tracking, you first find the absolute difference (D) between the two recorded values for each shift. Then, you divide this difference by the average of the two values and multiply by 100 to convert it into a percentage. The percentage difference can be mathematically expressed as:

% Difference =
$$D/Ave \times 100\%$$
 (1)

The percentage difference displayed in this case represents the relative error or variation between the two systems. A small percentage difference signifies that the manual and automated systems are closely aligned, whereas a larger percentage difference indicates a more substantial discrepancy. In situations where precision is of utmost importance, such as when monitoring uptime hours for maintenance planning, a high percentage difference may indicate potential issues with the reliability of the manual system or, less frequently, errors in the automated system that require attention.

Shift Period, Parameters, and Variables

In this operational setup, the shift period follows a 28/28day work cycle. During this cycle, equipment operates on a rotating schedule to ensure continuous productivity and allow for routine maintenance. Specifically, the equipment runs for seven consecutive days, followed by seven days offline for routine checks and maintenance. During this maintenance period, a second unit, previously idle or redundant takes over operations for the next seven days. This alternating schedule ensures that each equipment has 14 days of uptime within the 28-day cycle. By implementing this rotation, the operational load is evenly distributed between the two units, reducing wear and tear on individual equipment and ensuring uninterrupted production. This strategy maximizes equipment efficiency, reliability, and minimizes the risk of unexpected downtime by providing dedicated maintenance and recovery periods for each unit before resuming operations.

Table 1: Parameters and variables

Shift work period (days)	Year	Shift maximum obtainable uptime hours, hrs		Equipment uptime per shift (days)	Status of hou meter and sensor	
28	2024	336	0	14	Not verified	

RESULTS AND DISCUSSION

Pipeline Pump A

Initially, both systems recorded the same run hours of 336 in the first shift. However, starting from the second shift, the automated system consistently recorded slightly higher uptime hours than the manual system. The differences started at 2 hours in the second shift, increased to 5 hours

by the third shift, and reached the highest discrepancy of 9 hours in the fourth shift. Although the difference narrowed to 4 hours in the fifth shift, it increased again to 8 hours in the sixth shift. This pattern suggests that the automated system may be more precise or sensitive, while the growing differences in some shifts could indicate potential inaccuracies in the manual logging process.

Table 2: Manual and automated uptime hours calculations for PP A

Shifts	Shift period	Manual Log, hrs., a		Difference, D, hrs., a-b	Average, ave. (a+b)/2	% Difference, D/Ave x 100
1	Jan 1- Jan 28	336	336	0	0	0.00



2	Jan 29 - Feb 25	668.85	670.85	2	669.85	0.30
3	Feb 26 - Mar 24	1001.85	1006.85	5	1004.35	0.50
4	Mar 25 -Apr 21	1351.85	1342.85	9	1347.35	0.68
5	Apr 22 - May 19	1674.85	1678.85	4	1676.85	0.23
6	May 20 - Jun 16	2006.85	2014.85	8	2010.85	0.40

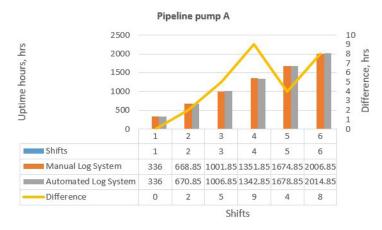


Figure 10: Manual and automated methods result illustrations for PP A

Air Compressor

In Shift 1, both systems recorded 336 uptime hours, showing no difference. In Shift 2, the manual system logged 676 hours, slightly higher than the automated system's 672 hours, resulting in a 4-hour discrepancy. A similar 4-hour difference was observed in Shift 3, with the manual system recording 1010 hours compared to the automated system's 1006 hours. However, in Shift 4, both systems recorded identical uptime hours of 1341,

indicating no difference. In Shift 5, both systems again recorded the same 1680 hours. Finally, in Shift 6, the manual system logged 2021 hours, slightly higher than the automated system's 2016 hours, resulting in a 5-hour difference. Overall, the differences between the two systems are minimal, with the largest discrepancy being just 5 hours in Shift 6. This suggests that both systems are generally consistent in their recording, although slight variations occur in certain shifts.

Table 3: Manual and automated uptime hours calculations for IAC

Shifts	Shift period	Manual Log, hrs., a	Automated log, hrs., b	Difference, D, hrs., a-b	Average, ave. (a+b)/2	% Difference, D/Ave x 100
1	Jan 1- Jan 28	336	336	0	336	0.00
2	Jan 29 - Feb 25	676	672	4	674	0.60
3	Feb 26 - Mar 24	1010	1006	4	1008	0.40
4	Mar 25 -Apr 21	1341	1344	3	1342.5	0.22
5	Apr 22 - May 19	1680	1680	0	1680	0.00
6	May 20 - Jun 16	2021	2016	5	2018.5	0.25

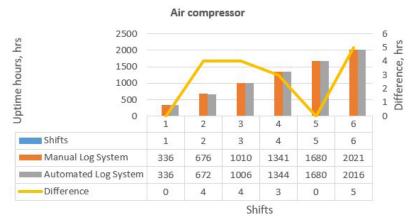


Figure 11: Manual and automated methods result illustrations for IAC



Gas Generator 1

The data indicates that in Shift 1, there is a minimal difference between the two systems, with the manual system recording 337 hours and the automated system recording 336 hours, resulting in a 1-hour difference. In Shift 2, the manual system logged 676 hours, slightly higher than the automated system's 672 hours, showing a 4-hour difference. As we move to Shift 3, the gap widens, with the manual system recording 999 hours compared

to the automated system's 1006 hours, resulting in a 7-hour difference In Shift 4, the manual system logs 1336 hours, while the automated system reports 1344 hours, leading to an 8-hour discrepancy—the largest observed difference in the data. Shifts 5 and 6 show a reversal, where the manual system reports 1670 and 2009 hours respectively, compared to the automated system's 1677 and 2013 hours, leading to differences of 7 hours in Shift 5 and 4 hours in Shift 6.

Table 4: Manual and automated uptime hours calculations for GG 1

Shifts	Shift period	Manual Log, hrs., a	Automated log, hrs., b	Difference, D, hrs., a-b	Average, ave. (a+b)/2	% Difference, D/Ave x 100
1	Jan 1- Jan 28	337	336	1	336.5	0.30
2	Jan 29 - Feb 25	676	672	4	674	0.59
3	Feb 26 - Mar 24	999	1006	7	1002.5	0.70
4	Mar 25 -Apr 21	1336	1344	8	1340	0.60
5	Apr 22 - May 19	1670	1677	7	1673.5	0.42
6	May 20 - Jun 16	2009	2013	4	2011	0.20

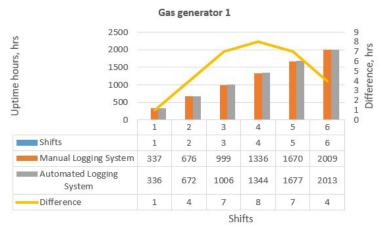


Figure 12: Manual and automated methods result illustrations for GG 1

Booster Pump B

In Shift 1, both systems recorded 336 hours, however, there were noticeable uptime hour variations in Shift 2, the manual system recorded 679 hours, which was slightly higher than the 672 hours recorded by the automated system, resulting in a 7-hour difference. In Shift 3, the manual system recorded 1,001 hours compared to 1,006 hours recorded by the automated system, resulting in a 5-hour difference. Shift 4 followed a similar pattern,

with the manual system recording 1,350 hours and the automated system recording 1,344 hours, creating a 6-hour difference. The largest discrepancy occurred in Shift 5, where the manual system recorded 1,689 hours, which was 9 hours more than the 1,680 hours recorded by the automated system. Finally, in Shift 6, the difference narrowed again, with the Manual Logging System recording 2,009.22 hours and the automated system recording 2,012.22 hours, resulting in a 3-hour difference.

Table 5: Manual and automated uptime hours calculations for BP B

Shifts	Shift period	Manual Log, hrs., a	Automated log, hrs., b	Difference, D, hrs., a-b	Average, ave. (a+b)/2	% Difference, D/Ave x 100
1	Jan 1- Jan 28	336	336	0	336	0.00
2	Jan 29 - Feb 25	679	672	7	675.5	1.04
3	Feb 26 - Mar 24	1001	1006	5	1003.5	0.50
4	Mar 25 -Apr 21	1350	1344	6	1347	0.46
5	Apr 22 - May 19	1689	1680	9	1684.5	0.53
6	May 20 - Jun 16	2009.22	2012.22	3	2010.72	0.12

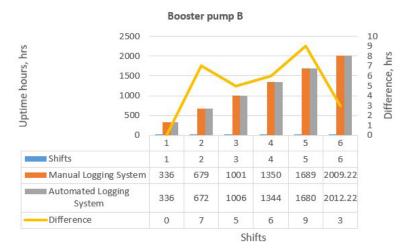


Figure 13: Manual and automated methods result illustrations for BP B

Sewage Treatment Plant Motor Blower B

The analysis shows that in Shift 1, both systems had an uptime of 336 hours, indicating perfect alignment. However, in Shift 2, the automated system recorded 672 hours, which was 3 hours more than the manual system. This difference could be attributed to minor delays or rounding discrepancies in manual recording. In Shift 3, there was a larger discrepancy of 8 hours, with the automated system recording 1006 hours compared to the manual system's 998 hours. This suggests the possibility

of manual logging errors. Shift 4 continued this trend, with the automated system recording 1,344 hours, 4 hours more than the manual system. Interestingly, in Shift 5, the manual system recorded 1,688 hours, which was 8 hours more than the automated system, reversing the previous pattern. This inconsistency, especially during peak usage periods, may require further investigation. Finally, in Shift 6, the automated system recorded 2,016 hours, 7 hours more than the manual system, continuing the pattern of minor discrepancies.

Table 6: Manual and automated uptime hours calculations for STPBM B

Shifts	Shift period	Manual Log, hrs., a	Automated log, hrs., b	Difference, D, hrs., a-b	Average, ave. (a+b)/2	% Difference, D/Ave x 100
1	Jan 1- Jan 28	336	336	0	336	0.00
2	Jan 29 - Feb 25	669	672	3	670.5	0.45
3	Feb 26 - Mar 24	998	1006	8	1002	0.80
4	Mar 25 -Apr 21	1340	1344	4	1342	0.30
5	Apr 22 - May 19	1688	1680	8	1674	0.48
6	May 20 - Jun 16	2009	2016	7	2,012.5	0.35

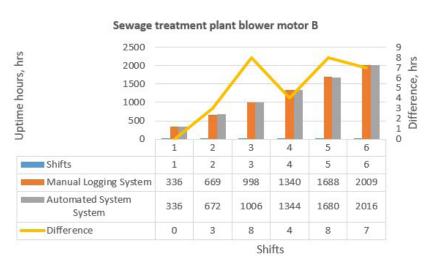


Figure 14: Manual and automated methods result illustrations for STPBM B



Comparative Analysis of Accuracy, Consistency and Variance of Automated and Manual Loggings

The comparative analysis of manual and automated logging systems across various equipment—PP A, IAC, GG 1, BP B, and STPBM—reveals important insights into their accuracy, consistency, and variance. The differences between manual and automated logs are minimal, typically ranging between 0 to 9 hours per shift period, with percentage differences consistently below 1%. This indicates a high level of accuracy for both systems. For example, PP A shows percentage differences ranging from 0.00% to 0.68%, while the IAC's differences range from 0.00% to 0.60%. Similar trends are observed across other equipment, with GG 1, BP B, and the STPBM B showing low percentage differences, peaking at 1.04% in the case of BP B. The automated system demonstrates a high degree of consistency, as reflected in the small deviations from manual logging. For instance, the IAC consistently shows a maximum difference of only 4 hours across all shifts, maintaining low percentage differences. The STPBM exhibits similar consistency, with differences ranging from 0 to 8 hours and percentage differences from 0.00% to 0.80%. Despite the overall minimal variance, there are slight increases during longer operational periods, particularly noticeable in Pipeline Pump A, during shifts 3, 4, and 6, where the differences reached 5, 9, and 8 hours respectively.

Equipment-specific observations indicate that while the differences between manual and automated logs are small, they vary slightly depending on the equipment and shift duration. For example, BP B shows the highest percentage difference of 1.04% during the second shift, indicating a slightly higher variance compared to other equipment. However, these differences remain within an acceptable range, confirming the reliability of the automated logging system. Overall, the analysis concludes that both manual and automated systems exhibit good level of accuracy and consistency, with the automated system providing a more reliable alternative to manual logging. The consistency of uptime log hours across all equipment and shifts suggest that the automated system is effective for monitoring equipment uptime hours, with the added benefits of reducing human error and increasing efficiency in data collection.

Advantages of Automated Uptime Logging System over Manual Method

Automated logging systems offer several advantages over traditional manual uptime-hour logging, despite the latter being considered reliable and accurate. One significant benefit is the improved accuracy and consistency provided by automated systems. Human errors, like forgetting to log hours or entering incorrect data, are eliminated, resulting in more reliable information for maintenance decisions. This ensures that data remains consistent and accurate across all operations. Automated logging systems offer real-time data access in addition to accuracy, which is essential for contemporary

maintenance management. Instantaneous monitoring of equipment performance and usage by maintenance teams facilitates more efficient maintenance planning and allows for speedier, more informed decisionmaking. With this real-time capabilities, the likelihood of equipment failures and unplanned downtime is greatly reduced, supporting a proactive maintenance strategy. The smooth integration of automated systems with other maintenance management platforms, including enterprise resource planning (ERP) or computerised maintenance management systems (CMMS) is another important benefit. Effective resource planning and allocation is made simpler for organizations by this integration, which streamlines data administration and analysis. The ability to consolidate data from multiple sources enhances the overall maintenance strategy and execution.

Automated logging systems also excel in efficiency. Without the need for manual data entry, these systems save valuable time and effort for maintenance personnel, boosting productivity and reducing labor costs, thereby making the maintenance process more cost-effective. Additionally, many automated systems are equipped with features that provide alerts and notifications when critical thresholds are reached or when abnormalities in equipment usage are detected. These features enable maintenance teams to respond proactively to potential issues, preventing equipment failures and reducing downtime, thereby maintaining optimal operational efficiency. The capability to store and analyze historical data is another significant benefit of automated logging systems. Over time, these systems collect extensive data that can be used for trend analysis and predictive maintenance. By analyzing historical performance patterns, organizations can gain a deeper understanding of equipment lifecycles, develop maintenance strategies that extend asset life, and reduce costs. Moreover, automated logging systems maintain a detailed audit trail of all data changes and accesses, which is essential for regulatory compliance and audits. This level of transparency and accountability enhances the reliability of the maintenance process, ensuring that all activities can be traced and verified.

Automated logging systems, especially those with remote monitoring capabilities, allow maintenance teams to manage equipment performance from anywhere. This is particularly beneficial for organizations with scattered assets. These systems outperform manual logging in terms of accuracy, efficiency, data integration, and proactive maintenance, making them indispensable for contemporary maintenance practices. In summary, automated systems greatly enhance asset management and operational performance.

Impact of Automated and Manual Uptime Hour Tracking on Equipment Reliability, Maintenance Costs, and Production Efficiency

The use of manual and automated methods for tracking uptime hours of offshore equipment has a significant



impact on equipment reliability, maintenance costs, and production efficiency. When manual tracking methods are used, errors and inconsistencies in data collection and reporting can result in inaccurate assessments of equipment reliability, leading to excessive or inadequate maintenance. This, in turn, can lead to inefficient allocation of maintenance resources, decreased equipment reliability, and higher maintenance costs. Additionally, manual tracking may fail to account for subtle changes in equipment behavior, causing missed opportunities for proactive maintenance. In contrast, automated tracking methods allow for real-time data collection and analysis, enabling accurate and timely monitoring of equipment performance. This facilitates proactive maintenance, reducing downtime and enhancing equipment reliability. Moreover, the impact of manual and automated tracking methods on maintenance costs is significant. Manual tracking methods can result in inefficient allocation of maintenance resources, leading to unnecessary or ineffective repairs. Inaccurate data collection and reporting can also lead to incorrect prioritization of maintenance tasks, resulting in unnecessary expenses. Conversely, automated tracking methods allow for optimized maintenance scheduling, minimizing the need for unnecessary or reactive repairs. Automated tracking can also identify opportunities for cost savings through optimized allocation of maintenance resources, providing insights into maintenance costs and identifying areas for improvement.

Lastly, the use of manual and automated tracking methods has a considerable impact on production efficiency. Manual tracking methods can lead to inaccurate production scheduling, resulting in reduced production efficiency. Inefficient allocation of maintenance resources can also cause reduced production efficiency due to unplanned downtime. On the other hand, automated tracking methods enable accurate production scheduling and optimization, reducing the risk of production losses caused by equipment failure or downtime. Automated tracking can also identify opportunities for production optimization through real-time monitoring of equipment performance, providing insights into production efficiency and identifying areas for improvement. The use of automated uptime hours tracking methods can improve equipment reliability, reduce maintenance costs, and increase production efficiency, making it a valuable tool for offshore operators.

CONCLUSION

This study aimed to address a significant knowledge gap by comparing manual and automated methods for tracking the uptime hours of five critical offshore equipment. It also examined the impact of each method on equipment reliability, maintenance costs, and production efficiency, using a mixed-methods approach that combined quantitative and comparative data analysis.

The study found that both manual and automated

systems are effective in monitoring equipment uptime hours. However, the automated system is considered more reliable because it minimizes human error, improves efficiency, and provides consistent data logging across different work shifts of the case study's operation. This was evident in the results of the study analysis. Also, when compared to manual method, automated logging allows for access to real-time data, seamless integration with other maintenance management platforms like CMMS or ERP, and enables maintenance teams to monitor equipment uptime hours from remote locations, making it beneficial for companies with dispersed assets.

The study demonstrates the significant benefits that organizations derive when implementing automated logging systems in offshore operations. These systems enhance accuracy, enable proactive maintenance, reduce costs, and improve production efficiency. Additionally, they offer greater operational transparency and support data-driven decision-making. as a result, organizations can achieve more reliable, efficient, and sustainable operations in the challenging offshore environment.

RECOMMENDATIONS

Organizations Should

Implement Automated Logging Systems to Track Equipment Uptime Hours

Automated systems offer numerous benefits over manual methods, such as reducing human error, providing realtime data, and ensuring accurate tracking of equipment uptime.

Maintain Calibration of Hour Meters and Sensors for Reliable Automated Uptime Data Logging

Regular calibration and maintenance of hour meters and sensors are essential to uphold the accuracy and reliability of automated logging systems.

Strengthen the Manual Logging System and Provide Personnel Training to Reduce Errors

Though automated systems are on the rise, manual logging remains relevant in many operations. Enhancing manual logging processes and offering comprehensive training to staff members can help minimize errors, ensuring manual logs are as precise as possible.

Establish a Procedure to Regularly Compare Data from Both Tracking Systems to Detect Discrepancies Promptly

Developing a systematic approach to comparing data from manual and automated systems aids in early identification of inconsistencies or errors. This practice boosts data accuracy and includes a fail-safe in the tracking process, ensuring swift resolution of any discrepancies.

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REFERENCES

- Abraha, H. H. (2011). Optimization of maintenance performance for offshore production facilities (Master's thesis). University of Stavanger, Norway.
- Al Dosari, F. H. M., & Abouellail, S. I. A. D. (2023). Artificial Intelligence (AI) techniques for intelligent control systems in mechanical engineering. *American Journal of Smart Technology and Solutions*, 2(2), 55-64.
- ALTRONIC. (2024). *DH-100A digital hour meter*. Altronic. https://altronic-llc.com/dh-100a
- Amaechi, C. V., Reda, A., Kgosiemang, I. M., Ja'e, I. A., Oyetunji, A. K., Olukolajo, M. A., & Igwe, I. B. (2022). Guidelines on asset management of offshore facilities for monitoring, sustainable maintenance, and safety practices. Sensors, 22(19), 7270.
- CAT. (2024). *Gas generator engines*. https://www.cat.com/en_US/products/new/power-systems/electric-power/gas-generator-sets.html
- Duque, S. E., & El-Thalji, I. (2020). Intelligent maintenance maturity of offshore oil and gas platforms: A customized assessment model complying with Industry 4.0 vision. In Engineering assets and public infrastructures in the age of digitalization: Proceedings of the 13th World Congress on Engineering Asset Management (pp. 653-663). Springer International Publishing.
- European Space Agency. (2013). Offshore platform. ESA. https://www.esa.int/Offshore_platform
- Fang, H., & Duan, M. (2014). Offshore operation facilities: Equipment and procedures. Gulf Professional Publishing.
- Ferguson, E. L., Castillo, M., Kazzaz, A., & Dunner, T. F. (2022, October). Case study on the impacts of an automated condition assessment system deployed across offshore production facilities. In *Abu Dhabi International Petroleum Exhibition and Conference* (p. D022S163R003). Society of Petroleum Engineers.
- Gilchrist, A. (2016). *Industry 4.0: The industrial Internet of Things.* Apress.
- GOTESCO. (2020). Vertical inline multistage pumps ESv series. https://gotesco.com/product/vertical-in-line-multistage-pumps-e-sv-series-goulds/
- Håbrekke, S., Hokstad, P., & Ersdal, G. (2011). Ageing and life extension for safety systems on offshore facilities.
- Hardhat Engineer. (2024). Centrifugal pump diagram. https://hardhatengineer.com/centrifugal-pump-diagram/
- Kusumawardhani, M., Kumar, R., & Tore, M. (2016). Asset integrity management: offshore installations challenges. *Journal of Quality in Maintenance Engineering*, 22(3), 238-251.
- Laik, S. (2018). Offshore petroleum drilling and

- production. CRC Press.
- Lamoj, M. (2024). Smart field technologies in petroleum engineering (control and monitoring). *American Journal of Energy and Natural Resources*, 3(1), 41-50.
- McCullouch, B. G. (1997). Automating field data collection in maintenance operations. *Joint Transportation Research Program*, 342.
- Nagaraj, K., Killian, C., & Neville, J. (2012). Structured comparative analysis of systems logs to diagnose performance problems. In 9th USENIX Symposium on Networked Systems Design and Implementation (NSDI 12) (pp. 353-366).
- Ni, S., Tang, Y., Wang, G., Yang, L., Lei, B., & Zhang, Z. (2022). Risk identification and quantitative assessment method of offshore platform equipment. *Energy Reports*, 8, 7219-7229.
- REDFOX Environmental Services. (2014). Marine sewage unit. Redfox Environmental | Marine Sewage Treatment Units | Wastewater Treatment |
- Russo, A., Forte, A., Paci, M., Rossi, M., D'Ercole, M., Olivieri, T., & van Graefschepe, M. (2010, October). Operating experience on the first MS5002E unit to exceed 16,000 running hours at Yara Sluiskil, Netherlands. In *Turbo Expo: Power for Land, Sea, and Air* (Vol. 44007, pp. 649-656).
- Seufert, T. S., Mitchell, P. M., Wilcox, A. R., Rubin-Smith,
 J. E., White, L. F., McCabe, K. K., & Schneider, J.
 I. (2011). An automated procedure logging system improves resident documentation compliance.
 Academic Emergency Medicine, 18, S54-S58.
- Sitompul, E., & Rohmat, A. (2021). IoT-based running time monitoring system for machine preventive maintenance scheduling. *ELKHA: Jurnal Teknik Elektro*, 13(1), 33-40.
- Skilton, M., & Hovsepian, F. (2018). *The 4th industrial revolution*. Springer Nature
- Speight, J. G. (2014). Handbook of offshore oil and gas operations. Elsevier.
- Sullair. (2023). Sullair LS-10 series air compressor: Features, options and specifications. https://bidadoomedia.s3.amazonaws.com/sullair ls10 series.pdf
- Sullair. (2024). Sullair LS 10-30 manuals. Description;
 Introduction; Description Of Components; Sullair
 Compressor Unit, Functional Description Sullair
 LS-10 25HP Operators Manual And Parts Lists [Page 11] | ManualsLib
- TAS. (2024). *Gauges (VDO hourgauges)*. https://vdogauges.co.za/vdohourmetergauges.html
- Valdez, B., Schorr, M., & Bastidas, J. M. (2015). The natural gas industry: Equipment, materials, and corrosion. *Corrosion Reviews*, *33*(3-4), 175-185.