Effective Maintenance and Reliability Program in the Production of Crude Oil and Natural Gas

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Abstract- Maintenance and Reliability has to do with maintenance of equipment to provide optimum capabilities while at the same time keeping cost within budget. While maintenance has to do with activities involved in keeping equipment in good working condition, Reliability on the other hand has to do with the chance that a given machine will function efficiently within a specified time and set conditions. Two types of maintenance are preventive maintenance that looks at predictive or routine maintenance needed to ensure improved uptime of a piece of equipment including condition monitoring of critical piece of equipment's. Corrective maintenance has to do with repairs done on a machine that has broken down. Maintenance and reliability program in oil and gas exploration and production is an important function in ensuring that a production facility continues to produce optimally given the harsh conditions and toxicity of oil and natural gas as they go through these plants and equipment's. For this program to be effective, a structured MRP program needs to be put in place starting with planning, scheduling, execution and auditing. I have included auditing of the process, as it will help to show if the program is achieving its objectives and to achieve maintenance excellence.

A vital piece of equipment in upstream production of Crude oil and natural gas is the Flare Scrubber pumps. These pumps if not well maintained could lead to frequent plant upsets, shutdowns and deferred production and loss of revenues. Hence a well-structured MRP program is imperative. There are benefits from a well-executed maintenance and reliability program. With fluctuating and low price of crude oil in the international market, coupled with aging facilities resulting in safety considerations coupled with adverse environmental and integrity management issues, MRP will ensure organizations manage these safety and integrity concerns while achieving their business objectives.

Keywords- Maintenance, Reliability, scheduling, execution, oil, gas, excellence

1. INTRODUCTION

Crude oil Crude oil is a liquid that comes from reservoirs below the Earth's surface. Crude in the sense that the liquid is yet to be processed into finished products. Crude oil leaves the reservoir naturally when reservoir pressures are high, and when pressures are low, artificial lift using water or produced gas is injected into the reservoir to move the oil through the well head into production separators. Gas leaves the upper section of the separators through pipelines into the Liquid Knockout drums or LKO. The LKO knocks out trapped crude oil from the gas which returns back to the separators. The gas further leaves the LKO via pipelines into the flare scrubber where trapped oil is further removed from the Gas before being sent to flare. Crude oil from the separator then goes through metering before being sent via pipelines either through sub sea or land to Storage tanks to be prepared for export to buyers.

To achieve successful production of Crude oil and natural gas, several equipment's are utilized. Some of these equipment's include Crude transfer pumps that helps in transferring the produced crude from the production platforms to the storage facilities. These storage facilities could be in FSO close to the production platform or several miles onshore. Other equipment are Condensate pumps, liquid return pumps, flare scrubber pumps, Circulation pumps, Electric power generators, Electrical transformers, Electrical batteries, Heating Ventilation and Air condition (HVAC) equipment's, Control and instrumentation devices that includes Distributed

control systems (DCS), and Emergency Safety Shutdown Systems (ESSDS), Gas turbines and Compressors, Instrument air compressors among others. Without an effective Maintenance and Reliability (MRP) program, the equipment uptime of these equipment could be adversely affected which could prevent steady production and loss of revenue from the facility.

An effective maintenance and reliability program will ensure that equipment's maintenance are planned, scheduled and executed within budget. This maintenance could include periodic or pre-breakdown and corrective maintenance when the equipment has actually failed. Key Performance Indicators should be set either weekly, monthly and yearly. These KPI's should be reviewed for compliance. Furthermore, Planning meetings between planners and field locations on a weekly, monthly and quarterly basics should be encouraged such that all will be in agreement as to the planned maintenance and for operations to make available critical equipment's that are due for maintenance based on their equipment strategies.

As part of the MRP program, planned inspections on pipelines, vessels and structures by competent inspectors should be executed based on their maintenance strategies. These should include level one and two inspections for corrosion on pipelines, vessels and structures. The aim here is to know when these pieces of equipment's are decorating. When the wear and tear has gone beyond acceptable levels, arrangement should be made for their repairs or replacement. This will ensure their reliability and availability.

To ensure compliance, periodic auditing is encouraged as part of the MRP program; The aim is to ensure that inspections and PM are done as planned such that catastrophic breakdowns are prevented. This should be done both in-house and by means of external teams.

This paper will cover Oil and Gas Production, Equipment Maintenance in oil and Gas Production, Maintenance and Reliability Program, Maintenance Planning, Maintenance Scheduling, Maintenance Execution, Planned and ADHOC inspections of pipelines, structures and vessels, Auditing Maintenance Execution, Sample MRP Programs like Turbine maintenance and Flare Scrubber pumps. It will conclude with a brief discussion on equipment Rotation Strategy, Challenges of effective MRP administration and and Benefits of implementing an effective MRP

2. OIL AND GAS PRODUCTION

Crude oil Crude oil is derived from reservoirs that are below the Earth's surface. It is called crude in the sense that the liquid has not been processed into the finished products. It leaves the reservoir naturally when the reservoir pressures are high. But when pressures are low, applying of artificial lift using pressured water or produced gas is injected into the reservoir to move the oil through the wellhead into production separators. Gas leaves the upper section of the separators through pipelines into the Liquid Knockout drums or LKO. The LKO knocks out trapped crude oil from the gas which returns back to the separators. The gas further leaves the LKO via pipelines into the flare scrubber where trapped oil is further removed from the Gas before being sent to flare. Crude oil from the separator then goes through metering before being sent via pipelines either through sub sea or land to Storage tanks to be prepared for export to buyers.

As the crude oil leaves the crude outlet of the production separators through crude transfer pumps. The transfer pumps then transfer the crude through the metering skid. The metering skids has measuring equipment's that includes flow transmitters, that needs to be maintained periodically so as to ensure that the right quantity paid for is delivered to the buyers. Where the quantity of crude leaving is measured in Barrels per litter before transferred to storage tanks treated and sent for export via berth operating platforms to commercial Vessels who transfer the treated crude oil to international buyers.

Crude oil production platform. Source-Electrical engineering portal.com

Electrical power is provided by means of Generators. Large turbines power these generators due to the high power demanded to run the machines and equipment's. Some equipment's found in a typical crude oil production platform includes electric Motors, crude transfer pumps, utility pumps, electrical power transformers, circuit breakers, vessels like production separators and test separators, pneumatic and electronic transmitters, control systems, emergency safety shutdown systems and Heating ventilation and air conditioning systems. Produced gas is treated and used as source of fuel for these power generators.

Worthy to note that modern production platforms are equipped with Distributed control systems and emergency safety shutdown systems. This is needed as they help to control pressures, levels and temperatures to keep them within safe operating envelops. When these PTL goes above or below the safe operating envelops, emergency safety shutdown systems helps ensure they are shutdown to protect the equipment's, the environment and the lives of personnel working in those facilities

3. EQUIPMENT MAINTENANCE IN CRUDE OIL AND NATURAL GAS PRODUCTION

The important role-played by the above equipment's in the production of oil and natural gas, an effective maintenance program to ensure their optimum availability cannot be over emphasized. Thus, Iserman (1997) posits that maintenance is an act used in preserving physical assets in their original state while its also helps in prolonging their life cycle. (Isermann, 1997).

Maintenance could be preventive or predictive and it is aimed at applying knowledge of engineering and maintenance capabilities to ensure improved performance and reduction in their rate of failure. Furthermore, this maintenance could include periodic examination in terms of regular walk through to spot change in operating conditions, sounds or temperature, It also includes inspection programs, lubrications among others. An effective preventive maintenance program will help identify signs of equipment that is about to fail. When done regularly base on the equipment strategy of that device, it could prevent a catastrophic failure. Faults identified during preventive maintenance are resolved during corrective maintenance that needs the equipment to be shutdown in most cases. So while preventive maintenance does not require the equipment to be shutdown, corrective maintenance in most cases requires the unit to be isolated from service with the overall goal of carrying out these planned maintenance activities as the optimizing of the operating life span of the equipment.

Crude oil production platforms either offshore or onshore are filled with enormous risks, as such an effective maintenance and reliability program will ensure, efficient and reliable

process of production with benefits that includes high and quality productivity, extended or prolong life of machines, high production uptime and safety of personnel and the environment.

3.1. EFFICIENT MAINTENANCE AND RELIABILITY PROGRAM

In the oil and natural gas industry business these days, a good maintenance and reliability program cannot be over emphasized, especially with dwindling prices of oil and ageing facilities coupled with safety, environmental and integrity concerns. An effective Maintenance program helps to ensure plant availability while ensuring increased production and reduced equipment downtime (Jarrell & Bond, 2001).

However, most organizations do not have a comprehensive maintenance planning, scheduling and reliability programmes in place. They still get involved in unplanned and unscheduled jobs, thereby operating reactively to maintenance issues.

When there is no effective maintenance planning, scheduling and execution program , equipment availability and maintenance productivity will not be at the optimum . Also, it will be observed that planners in the planning unit will not be able to plan for the right number of personnel and man-hours required to execute a particular job. Equipment parts and consumables acquired in excess will all lead to high cost of maintenance to the organization.

When preventive and corrective maintenance and planned and scheduled, equipment reliability will increase. However, when preventive and corrective maintenance are poorly planned and executed, equipment reliability will be low thus leading to higher maintenance cost due to frequent breakdowns and procurement and replacement of spares. Thus a one percent increase in equipment availability could result in a ten percent reduction in cost of maintenance.

Effective reliability program also includes planned, scheduled chemical injection programs for pipelines and sump tanks. Effort should be put in place to ensure that the right dosage of chemicals is injected as scheduled. The chemical injection pumps should be included in the maintenance programs such that their maintenance planned, scheduled and executed. Defects from the preventive program should be identified, documented and addressed promptly. Poor chemical injection programs could lead to frequent pipeline rupture and tank failure that could prove costly to repair and replace. For effective maintenance and reliability program, human resource cost is one of the major important costs, that's why these personnel need to explicitly defined within the organization. These resources will include, maintenance technicians, engineers, planners, reliability engineers and first line supervisors.

Examples of preventive maintenance programs includes Instrumentation and control devices inspections, thermographic surveys or inspections, baseline vibration monitoring, Lube oil analysis, chemical injections, electrical insulation resistance tests, battery impedance tests, visual and Baroscopic inspections among others.

3.2. MAINTENANCE PLANNING

Maintenance planning is the process whereby maintenance activities are documented, resources to execute the tasks are assigned procedure or work aids for executing the tasks are identified, materials and consumables required to execute the task are identified and provided, safety considerations are also identified and mitigated or eliminated.

There are principles associated with maintenance planning. These include ensuring that the planning unit is separate from the execution unit. They could be in the same department, but has to be separate units. This is to ensure separation of duties and accountability. Other principles are that maintenance planners should focus on future tasks on equipment's, ensuring adequate equipment spares are stocked based on the planner's knowledge on such equipment

and historical data. This will ensure such critical data is shared among assets and the organization.

An important aspect of maintenance planning is the maintenance development and analysis or MDA. They are responsible for developing maintenance plans for all equipment in the plant that needs to be maintained for maximum efficiency. To be effective, they need to periodically receive input from the plants leadership on new equipment's that needs to be included in the maintenance-planning tool.Decommissioned or out of service equipment's needs to be updated or removed from maintenance plans so as not to waist valuable man-hours within the execution teams in the plants

3.3. MAINTENANCE SCHEDULING

After maintenance plans have been developed for equipment's, they need to be scheduled for execution by the field team. Basic Principles behind maintenance scheduling includes planning for the required manpower and anticipated man-hours to be used in executing a maintenance job, liaising with the field if equipment is available for maintenance, reviewing job priorities and ensure that the various maintenance crafts have the required job loading based on available manpower.

In maintenance scheduling, the maintenance planner should not work in isolation. He needs to get all stakeholders involved. These include the field maintenance and operations leadership and different craft leads involved. Other stakeholders include third parties crafts that are not resident within the facilities that have maintenance activities in the plants. The goal is to ensure that a flawless and efficient maintenance execution program that will ensure the required equipment uptime that supports optimum production.

An important tool is the maintenance-scheduling meeting to be driven and led by the maintenance planner. These meetings should be done weekly, monthly and quarterly as the need may arise. The goal is to ensure that all stakeholders are aware of the maintenance plans for the week, month, quarter and yearlong. That all equipment's will be available, and when needed spares are available. The success of any preventive maintenance relies on a well-articulated and executed maintenance-scheduling program. Emergency breakdown can be avoided or reduced when the Preventive maintenance and inspections program are done judiciously.

3.4. MAINTENANCE EXECUTION

Prior to execution of a planned corrective maintenance, it is important a work package is prepared as part of the planning process. The maintenance planner should take the lead in preparing the work package after receiving inputs from the responsible crafts to be involved in the repair.

The work package should include the approved work procedure to be used. Others are the Job safety analysis or JSA that highlights the various job steps, inherent hazards and mitigation to eliminate or reduce such identified hazards. Also included in the work package are lifting plans, consumables, energy isolation plans if needed, MSDS for chemicals that will be used, marked-up process and instrumentation, electrical and mechanical diagrams as necessary among others. It is important that the work package is prepared, reviewed, and approved before major maintenance activities are carried. The goal is to ensure that the maintenance activity is carried out safely and within approved cost.

4. MAINTENANCE EXCELLENCE

I see maintenance excellence as a process whereby maintenance be it preventive or corrective is done such that there are no sharp practices or cutting of corners. High ethical business practice must be maintained right from the planning, to the scheduling and execution stages. All planned and scheduled maintenance plans must be executed as planned. If there are business reasons why they should not be executed as planned, these must be documented and get management approval and signed off, while arrangements must be put in place to execute these deferred jobs as soon as practicable in line with the approved maintenance strategies for such piece of equipment. A word of caution is ***do not close any maintenance workorder when the job has not been done.***

5.AUDITING MAINTENANCE RELIABILITY PROGRAMS

Within the facilities, the maintenance supervisor has a weighty responsibility to ensure that all equipment have their maintenance plans in place. He takes the lead in ensuring that all stakeholders participate in reviewing drafts maintenance plans, ensure that feedbacks are sent back to the planners for effective scheduling prior to execution. The maintenance supervisor takes the lead in monitoring within the facilities that all planned maintenance jobs are executed as planned. He need to carry out sport checks during his rounds to ensure that the team is executing the jobs as per the approved procedure or job aids. He needs to ensure that the Job Safety Analysis steps are followed and each completed tasks signed off. He reviews maintenance work orders to ensure that inspection lots and observed deficiencies are entered prior to closure of work orders. The maintenance supervisor ensures that maintenance compliance Key Performance Indicators or KPI are reviewed and discussed with the workforce. Areas of commendation need to be commended while areas that need improvement needs to be discussed with the team.

In addition, to the in-house auditing done by the maintenance supervisor, other auditing done are by external auditing team that carryout maintenance auditing periodically. Findings are discussed and such identified gaps are closed. Furthermore, every production interruption or plant shutdown needs to be assigned a Root Cause Failure Analysis or PDDR. This is to ensure that causes of equipment failure are identified, lessons learnt and shared within and with the organization with the goal of preventing a future reoccurrence.

6. CHALLENGES OF EFFECTIVE MRP ADMINISTRATION AND NEW DIRECTION

There are some challenges militating against having an effective MRP Program within production organizations. These includes non documenting of failure records on equipment's, lack of management support, low training of personnel involved in maintenance planning and execution, not having maintenance plans for most equipment's in addition of having too many obsolete and out of service equipment's with maintenance plans among others. However, effective maintenance has to be planned in consonance with demands of production, such that there are reduced or minimal equipment down time and loss in production. Achieving a balance can be a challenge. Lack of maintenance can result in equipment damage, which can be costly to replace in addition to the cost of loss production. (Jarrell 2001).

To avert these challenges and achieve an effective maintenance and reliability program , it will be helpful if organizations have a full fledge reliability engineering function that helps in providing the engineering function as regards the equipment strategies of major equipment's . There should be a standards computerize maintenance management application that warehouse all maintenance planning, scheduling and other activities needed to achieve a successful maintenance and reliability program. Others are, presence of a functional planning scheduling, and maintenance Development and Analysis function and an effective maintenance audit and follow up program.

7. BENEFITS OF EFFECTIVE MRP

There are benefits to a production organization that implements an effective Maintenance and Reliability program. These benefits are:

- Increased equipment uptime
- Increased production
- Lower maintenance cost
- Low equipment damage
- Improved community relations
- Cordial business relations with business partners
- Increased equipment reliability

8. CONCLUSION

The oil and gas industry is a capital intensive industry whose operations is faced with a lot of risks as a result of its harsh operating environment and heavy machineries. Preventive and corrective maintenance activities need to be planned, scheduled prior to execution. In doing this, maintenance excellence such that these activities are done in a business ethically manned without cutting corners. On the sport assessment both from internal leadership and external team should be encouraged, while anomalies should be documented for improvement opportunities.

REFERENCES

Isermann, R. (1997). Supervision, Fault-Detection and Fault-Diagnosis Methods–An Introduction. *Control Engineering Practice*. 5(5), 639-652,

Jarrell, D.B., & Bond, L.J. (2001). Equipment Operation without Failures for Fourth Generation U.S. Reactors, SPIE, 3(3), 12.

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