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Application of Structured Maintenance Reliability Programme in Oil and Gas Industry - a Case Study

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APPLICATION OF STRUCTURED MAINTENANCE RELIABILITY PROGRAMME IN OIL AND GAS INDUSTRY-A CASE STUDY

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Abstract

This paper explores about the maintenance of Equipments to provide optimum capabilities at minimum/ reasonable cost in giant Oil & Gas Industry. The maintenance of an equipment is required to increase life cycle and mitigate operational risk. Maintenance activities focus on three prime factors of any equipment viz Reliability (of equipment 100%) availability(95% to 99%) and maintainability. In prevailing maintenance practices RCM (Reliability centered maintenance) is very common. Reliability and availability are crucial to the success of any project as they underlie the higher order, but less tangible, project requirements for operability and maintainability. Based on literature review and input from industrial experts, this paper discusses about a structured MRP (Maintenance Reliability programme) needs to be put in place starting from planning , scheduling, execution & auditing and also outcome of this paper establish the relationship among reliability , availability & maintainability.

Key words:

Optimum capabilities, cost, structured, scheduling, execution

1.0 Introduction

Oil and Gas industry is capital intensive organisation having heavy plant and machinery costing crores of rupees for example E&P Company (ONGC) having the plant and machinery of the cost of Rs 67000 Crores. The management of this level capital asset demands an effective and efficient equipment management system. Operation of the oil installations depends to a large extent on the maintenance of equipments. As such various maintenance management systems have been used over the years for betterment. This is evident in the fact that mostly corrective maintenance model is followed. Chances of breakdown/ failure are very high.

When analysed it is observed that main reasons of failure/ brekdown are 1) Failure due to lack of maintenance 2) Human error during maintenance 3) Unsafe maintenance practices 4) Incompetence of maintenance persons 5) Lack of communication between operator and maintenance personal

There is a common concept and belief that good maintenance results require the proper balancing of high equipment availability and reliability coupled with low maintenance cost. These two terms are not mutually exclusive. Frequent equipment failures and breakdowns cause low availability

The equipment availability & reliability, its efficiency and performance depend on its condition. To keep the equipment in operation with optimum efficiency and performance, equipment maintenance plays the key role. Maintenance activities involve periodic maintenance programme and scheduled overhauling to bring back equipment to its acceptable performance.Maintenance activities are planned and carried out are indicated by equipment manufacturer in its maintenance manuals or are worked out depending on equipment utilization and condition. In such type of industry , 30% of total manpower are busy in operation & maintenance activities.

When carried out the survey it is observed that

85% of equipment failures are directly linked to improper maintenance management strategy and Safety of equipments with recordable injury < 0.1%.

Cost reduction in Oil & Gas industry: Operators in the oil & gas industry needs to reduce their costs to remain competitive and maximum economy recovery, identifying and eliminating low value activities.

The upper stream industry has been slow to deploy new potential game changing technology including digital advances and mobile applications. There are several reasons for it :-low investment & Uncertain oil prices are main. The main objective is to identify a possible quality maintenance approach (i.e. Total Quality Maintenance) and new technology.

2.0 Brief of Oil & Gas Industry

The oil and gas industry facilities and systems are broadly defined according to their use in the oil and gas industry:
Upstream/ E& P Industry covers Exploration, Drilling, Production/ processing of Oil & Gas etc
Downstream covers Refining etc
Midstream Broadly defined as gas treatment, LNG production and regasification plants and oil and gas pipeline systems.
Petrochemical These products are chemical products where the main feedstock is hydrocarbons. Examples are plastics, fertilizer and a wide range of industrial chemicals.
In this type of industry, equipments can be classified broadly as rotary & static equipments. In the category of rotary equipments are pumps, compressors, engines, turbines etc and in the category of static are vessels, columns, heat exchangers, coolars, pipe lines etc . Out of which maintenance of equipments and facilities in upstream/ E&P Industry is little bit difficult because Equipments move from one place to another in drilling rigs and in exploration activities ,Some production platform & Sucker rod pumps are unmanned. & Equipments are scattered, installed at different locations far from one to other.

3.0 Prevailing Maintenance practices

It is not enough to purchase sophisticated equipment because of the advancement in technology, without a proper plan on how these equipment will be maintained. Basically, the effectiveness of any operational system is based largely upon the maintenance of the entire parts of the system, most especially in oil and gas industries Most industrial equipment whether simple, cheap or expensive degenerates as a result of wear, tear and ageing, except when prompt action is taken to maintain them (David, 1985). This in turn decreases the performance and reliability of the equipment and eventually increases the potential for failures. This slowly but steady regression during the operational life of equipment leads to high cost of operation, technical ageing, leading to low level and poor quality production. Maintenance is aimed at the improvement and the revival of various activities which results in increased productivity at a reduced cost (Jarrell, 2001). In order words, it increases equipment efficiency over a long period and sustains productivity. It also makes equipment condition normal. Maintenance is thus required in oil and gas industry to Place plants in serviceable condition to enable appropriate quality of work in order to boost production. Preserve the fixed assets in a satisfactory condition. Bring down the cost of lost production as a result of plant breakdowns. To ensure high rate of plant availability and reliability, constant maintenance must be done (Jarrell 2001). This maintenance must be planned in accordance with production requirements and planned so that it causes a very minimal downtime and production loss. Inadequate maintenance can result in damage, which is highly expensive not only in repairs but also in production loss (Jarrell 2001). In oil & gas industry, mostly corrective and preventive maintenance is carried out (Fig 1)

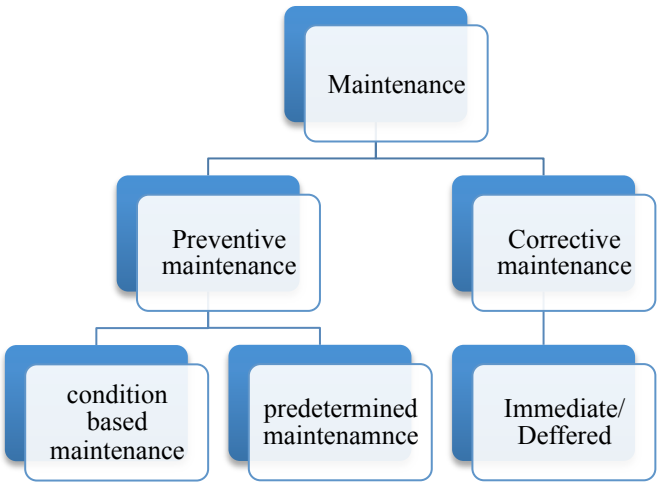

Fig 1. Various types of prevailing maintenance practices

Maintenance within the Oil and Gas industries need specialized skills in order to meet up with the challenges of extracting the "difficult oil" (Prof. G. Nwokeji, 1994). It requires customized technology and project management expertise.

4.0 TODAY'S MAINTENANCE STRATEGIES AND THEIR CHALLENGES

In the Oil and Gas Industry today, many maintenance strategies have been formulated and applied. However, all these maintenance strategies are developed to optimize the uptime of a system by choosing a suitable maintainability plan 'believed' to

enhance the availability of such system. These maintenance strategies include; Total Productive Maintenance (TPM), Business Centered Maintenance (BCM), Total Quality Maintenance (TQM), Reliability Centered maintenance (RCM) & implementation of such type maintenance is difficult. The different forms of maintenance strategies and the effects are shown in the below table 1.

Corrective maintenance " Run to failure maintenance"-due to breakdown	**Predetermined maintenance " Fix it before it breaks"-planned maintenance/ Historical maintenance/ Calendar based maintenance**	**Predictive maintenance " If it ain't broke do'nt fix it"- Condition based maintenance**
High risk of secondary failure	Machines are repaired when there are no faults	High investment costs
High production downtime	Repair often causes more harm than good	Additional skills required
High costs of spare parts	There are still unscheduled brekdown	Unexpected breakdown is reduced
Safety hazards	Fewer catastrophic failure	Equipment life is extended
Machines are not over maintained	Maintenance is performed in controlled	

Table 1 : Effects of different maintenance methodology

5.0 Structured maintenance reliability programme (SMRP)

Different maintenance strategies has been studied as described below to implement in industry. Every maintenance strategy has its Pros and Consso choosing the one you should focus on can be a challenging task.The faster flow of information, between head and maintenance team, improved response times, eliminating overtime labour costs, an easier co operation of multiple maintenance technicians on bigger maintenance tasks, are just some of the ways to reduce maintenance costs by employing a capable maintenance software.The objective is to focus on following seven principles through "maintenance monitoring" for the reliability and availability of equipments. The primary objectives is to preserve operational function of equipment and system by adhering to time bound maintenance and overhauling of equipment .Adaption of new technology and replacement of inefficient, obsolete and unreliable equipment to get competitive advantages and environmrnt protection. Corrective and predictive maintenance of equipment based on condition monitoring of the equipment and emphasises on zero delay between problem creation and manifestation, so that problem can be solved at its infancy without making it too big to be controlled.

Identification and prioritization of failure modes that can affect the function of equipment and system, emphasis on root cause analysis of the failure in all case.

Maintenanace monitoring envisages for more alignments of resources to those activities where chances of failure are more and impact is very high. It is directly related to the probability & consequences of failure. Maintenance describe the management, control, execution & quality of those activities which will reasonably assure that design levels of availability & performance of assets are achieved in order to meet final business objectives. Ehos of maintenance team is to assimilate and disseminate these guidelines to all maintenance management team across the company. Maintenance of equipment is essential to restore its functions & efficiency to design standards. Maintenance is a risk mitigation activity and failure of equipment can pervade multiple type of risks. Maintenance monitoring envisages for alignments of resources to those activities where chances of failure is more and thereafter impact is very high. Sole purpose of maintenance monitoring is to align all resources with the help of stakeholders in achieving "vision" and "mission" of the company through equipment availability beyond 95% and system availability 100%.

With this view maintenance monitoring group takes care of the following functions

- Critical equipment identificaton
- Equipment and system avalability
- Failure analysis
- Preventive maintenance programme implementation and compliance
- Holistic identification of maintenance bottlenecks and seek solutions to improve availability

Our aim is to be world class, swift, proactive, innovative and cost consciousness maintenance programme. This demands an effective and efficient management by keeping in mind Concept of life cycle management &Concept of TPM-emphasizing
SMRP is developed by improving maintenance management system consisting following factors:

5.1 Maintenance Planning and Scheduling

The last but not the least in the development of the SMRP is the maintenance planning and scheduling. This is a key strategic maintenance planning move. It is based on the principle that prior planning and preparation will improve the actual performance and execution.

Operations and maintenance – each must be thoroughly planned and organized before being actualized. By doing maintenance planning and scheduling alone, maintenance crew manning can be reduced by at least 30%. The manpower efficiency

improvement will be visible in less than three months. Another certainty is that one can use a planning and scheduling system to insure the preventative maintenance is done on time, and this will invariably lead to reduction in breakdowns within three months.

5.2 Reliability Centered Maintenance, RCM

Reliability Centered Maintenance (RCM) is the concept of developing a maintenance scheme based on the reliability of the various components of the system or product (http://www.reliability-centered-maintenance.com). "To develop an effective RCM program, knowledge of reliability and maintainability of the system and its components are required" (Moubray, 1991). The essential factors include; the MTTR (Mean Time to Repair) and failure rate (total number of failures within a given time period) of the product or system. In practice, RCM brings together principal maintenance strategies (reactive, time or interval-based, condition-based and proactive maintenance practices), rather than being applied independently. They are integrated to take advantage of their respective strengths in order to maximize facility and minimize equipment life-cycle costs (http://www.wbdg.org). RCM is a maintenance strategy that is based on consequence and cost of failure. Consequence as used here is in terms of mission (quality and quantity), safety, environment and security. There is also software that enables user to calculate the reliability information necessary to develop an effective RCM program (http://www.reliability-centered-maintenance.com). It also enables machinery stakeholders to monitor, assess, predict and generally understand the working of their physical assets (http://www.ebme.co.uk). This software analyzes the system or product. They include the following:

Failure Modes and Effects Analysis (FMEA): which determines the different ways a system can fail (http://www.reliability-centered-maintenance.com).
Fault Tree Analysis (FTA): This shows the specific steps involved in a system failure; mechanical problem or human error (http://www.cyberlink.ch).
Event Tree Analysis (ETA): This illustrates the different consequences of component or system failure (http://www.cyberlink.ch).
And so many other software are available in market. Even with all the software mentioned above, the RCM still has its challenges. These challenges include: the high cost of implementation .

5.3 Performance Based Maintenance, PBM

Performance Based Maintenance is a modern maintenance approach that ensures performance reliability. It is carried out by assessing and predicting the process or equipment performance based on data gotten from the process or equipment (Piotrowski, 2001). It involves the use of data and sensors which transcends into collation and transmitting medium to extract performance related information. From this, inference and predictions can be drawn on the system failure. Performance Based Maintenance in line, with the proactive and preventive maintenance paradigm is centred on quantifying and predicting performance degradation of a process, machine or service. Since performance degradation is a shadow of the entire system failure, it can be used to predict unacceptable system performance before it occurs. Performance Based Maintenance operates in such a way that proactive actions are taken to address the performance degradation which will eventually lead to system failure. This is done instead of taking reactive actions after the system fails because of performance degradation. This reactive action usually comes with a longer MTTR. The performance of a plant/equipment degenerates as a result of wear, tear and aging. These factors also decrease the performance reliability and increase the potential for failures and faults. This in turn will impact on the quality of products as well as productivity. Hence, in order to realize best possible quality and zero or minimal downtime, it is imperative to predict and prevent process or equipment failure.

5.4 Business centered maintenance, BCM

Core principles are "To give the operator greater authority to take charge of plant or equipmrnt (autonomous responsibility). This is developed from TPM. A profit improvement programme is the basis of this strategy. Hence the nomenclature- Business centered maintenance. The elements of this technique are early equipment management, maintenance prevention and training to all persons involved in the system to improve on their maintenance skills. It acts as watchdog for other maintenance techniques. This is because BCM depends upon other maintenance like TPM, RCM etc The difficulty is with its implementation and execution.

5.5 REPAIR POLICY

Failure will occur despite the amount of preventive maintenance that is in place. This can either be as a result of use of bad/substandard parts or incompetent maintenance personnel. Therefore, the SMRP recognizes the breakdown maintenance aspect of maintenance strategy in order to return the equipment to its original form when such equipment finally fails. This is covered under the repair policy. Repair policy invariably involves sub-contractors. Equipment is repaired immediately or later once it breaks down, and this can be in bits or a whole. Temporary replacement can also be done. For the purpose of specialized skills, the service can be outsourced to outside specialists. Sub-contracted maintenance is highly advantageous. In a situation where a

system cannot be repaired, maintenance is by outright replacement only. In oil and gas industry there is a concept of standby machines where ever it is possible.

5.6 REPLACEMENT POLICY

The SMRP equally recognizes the need to accommodate replacement policy so that equipment can be replaced whenever the need arises. Replacement problems can be grouped as either deterministic or probabilistic. For ex life of engine is fixed 15 years and life of fire fightening equipments is fixed 10 years.

5.7 Inventory Management

Maintenance of higher-than-required inventory level ties up capital. Low balance increases the risk of equipment downtime and production delays. . Present condition of equipment has to be inspected and assessed. It is essential to have records of Economical Order Quantity (EOQ) and annual consumption. All the above points have to be kept in mind for a good inventory control of spares.

5.8 CMMS (Computerized maintenance management system) / SAP SYSTEM

Computers can store information, make calculations, retrieve information and present information in formats useful to the end user . Maintenance work involves recording and manipulating data, which are amenable to computerization. CMMS has been replaced by SAP and this is uniformly applied to all installations/ rigs etc in whole organisation. This is a plethora of statistical data . Accurate statistical data and performance reports are maintained. CMMS will enable to look all things such as Maintenance work and cost ,Overall performance level of maintenance team, Which assets are costing the most and why ,Which one of location(facility is performing the best or worst & why)

5.9 DRONE INSPECTION

Around 80 – 90 % of the assets used in Oil & Gas and Petrochemical industry is static – line pipe, fittings, valves, piping, tanks, filter separators, pig launchers, distillation towers, flare stacks, well tubings, steel structures, etc. It is therefore not surprising that majority of failures or accidents in Oil & Gas assets have been reported due to damage or failure of these static equipment rather than rotating equipment. Mechanical failure of static equipment in the Oil & Gas assets can only be prevented through regular inspection and monitoring by qualified personnel as part of reliability centered maintenance (preventive plus condition based monitoring). Drone-based inspection: data acquisition services for civil structures and static / fixed assets of Oil & Gas and Petrochemical plants. These drone-based field investigations provide invaluable information to the operational and maintenance managers with following added advantages:

- Timely reporting and investigation of damage / material loss when carried out under a defined schedule.
- Enhanced personnel safety by avoiding close proximity of humans to hazardous environment and dangerous locations.
- Firsthand information by supervisor / manager without the need to visit site location.
- A cost effective alternative for route reconnaissance and aerial survey requirements.
- Provides access to inspectors for investigations without plant shutdown requirements.
- May be the only option for data acquisition under an emergency / accident situation.

5.10 Energy audit & technical audit

Energy audit and technical audit contribute to its vision of equipment life cycle management with focus on operation & maintenance of equipment and compliance to approved policies of the company. Each audit has its unique scope, coverage to collect various information from oil installation, its interpretation and result in the form of observations.

Energy audit

The scope of audit included :efficient use of energy in any form, undertake energy conservation compaign and acivities, use of waste heat recovery systems, encourage use of non conventional sources of energy, use of energy efficient equipments/ devices etc

Technical audit

Technical audit has emerged as one of the most effective tool for management to monitor the health, performance & efficiency of equipmwnts and initiate necessary action in time for corrective action

Type of observations : repair /replacement **,**safety **,**overhaul **,**preventive maintenance **,**test & inspection **,**corrosion & painting **,**housekeeping **,**documentation &others

6.0 Best maintenance practices : To be followed for reliability and reducing cost of maintenance

- Digitization and use of latest IT tools for economy and efficiecy
- Prferencing and use of SOP (Standard operating practices)
- Vedio conferencing & feedback
- Online adoption of national /international codes/ standards
- Interacive sessions: for formulation of specifications, norms, policies and guidelines

7.0 Conclusion & findings

Operation in Oil & Gas industry is of continuous nature & safety is of prime importance. In an oil installation major equipments are storage tank, heater treater, air & gas compressors, oil despatch pumps, DG set, fire pump ,trbines etc . There are many factors to consider while considering life cycle management and cost reduction in maintenance. This paper presents the key issues of maintenance, prevailing and present style of maintenance and prescribed methodology follow in justifying importance of life cycle management and cost reduction in maintenance.

7.1 Findings

The findings of equipment failure on an oil installation can be divided in two parts

Technical aspects

During data analysis it is observed that oil despatch pump failure were the highest however stand by pump is available and pump run one by one and change over takes place after every 12 hrs so further study was carried out and by applying pareto analysis it was ascertained that 75% of the defects were due to bearing failure, seal leakage & material problem.

Financial aspects

After compilation of results, financial aspect of the matter was investigated and it was found that

- cost of bearing failure in a year Rs 28000/-
- cost of seal failure in a year Rs 6.00 lakhs
- cost of material failure Rs 4.0 lakhs
- cost of other type failure Rs 2.8 lakhs

cost of pump is approximately Rs 80.00 lakhs and Rs 47.00 has been spent since commissioning in last 03 years and life of the pump is 15 year. Here maintenanance methods were reviewed & structured, focussed on online monitoring of pump parameters & immediate corrective action in case of any deviation and technicians were given special training for seal fitment. Afterthat obtained higher reliability and reduction in maintenance cost.

8.0 References

1) Aamer Hanif, Majtaba Hassan Agha (2012,Nov 6), Utilizing quality tools : A predictive Maintenance Perspective, International Journal of performability Engineering, Vol 8, issue 6 PP 699-704
2) Ethevenin Thierry Jacques Emmaneuel (2010 July ,14) Maintenance performance measurement in Oil & Gas Industry, Retrived from http://scholarbank.nus.edu.sg/handle/10635/22139
3) Eligah.Onoriode Olose (2016) , Effective Maintenance and Reliability Programme in the production of crude Oil & Natural Gas, International journal of Scientific & Engineering Research, Volume 7, issue 2, PP 1048-1056
4) Peter Okoh, Stein Haugen ,(2013), The influence of maintenance on some selected major accidents , The Italian association of Chemical Engineering, Volume 31, issue 1, PP 493-498
5) Riaz Khan, Ammeran B. Mad, Kheuril Osman and Mohd Asyraf Abd Aziz (2018, July 29) , Maintenance Management of aging Oil & Gas facilities-A case study, Retrieved from http://www.intechopen.com
6) Ravi Kumar Goyal , Dr Kapil Maheshwari (2012) , Maintenance Management Practices, International journal of awareness in Engineering Research, Volume 3, Issue 2, PP 2231-2252

7) Samual T Telford, Muhammad Ilyas Mazhar and Ian Howard, Department of Mechanical Engineering, Curtain University, Perth 6102, Australia (2011, Jan 22-24), Condition Based Maintenance in Oil & Gas Industry : An overview of Methods & Techniques, Proceeding of the International Conference on Industrial Engineering and Operations Management at Kuala Lumpar, Malasia
8) Wan Hasrunizzam wan Mahmood, Mohd Nizam Ab Rahman, Husiah Mazli, Baba Md Deors (2009) , Maintenance Management System for Upstream Operations in Oil & Gas Industry: Case Study, International journal of Industrial and Manufacturing Engineering, Volume 3, Issue 12, PP 1500-