Maintenance Management and Quality Evaluation of Electrical Installations in Oil and Gas Industries.

Dr. Kamalu, U. A ; Ajodo, A. A

Abstract: Maintenance management is required for the smooth and efficient running of any industrial plant so as to improve productivity. The purpose of maintenance management is to optimize the performance of productive facilities of an industry by ensuring that these facilities function regularly and efficiently. This is achieved by preventing the failure or breakdown of such facilities through planned preventive maintenance activities. This paper focuses on maintenance management system as applied to maintenance and management of electrical installations in the Nigeria Liquefied Natural Gas (NLNG). The paper also examines the quality of electrical installations as well as protection performance of the installations.

Keywords: Installation, Maintenance, Neutral Earthing Resistor, Oil and Gas Industry, Power management system, SCADA.

I. INTRODUCTION

Maintenance management is the process of overseeing maintenance resources of an industry so that the organization does not experience downtime from broken equipment or waste money on inefficient maintenance procedures. Maintenance management software programs can assist with the process. The primary objectives of maintenance management are to schedule work efficiently, control costs and ensure regulatory compliance [1]. Maintenance management is essential to the success of any oil and gas company because a poorly-organized maintenance program can bring the entire company to a halt. Maintenance managers must ensure that all maintenance tasks are conducted in compliance with local, state and federal laws as well as relevant standards and regulations.

The NLNG plant complex is grouped into 5 areas, A to E for ease of maintenance. The five maintenance teams are PMA, PMB, PMC, PMD and PME. Each team is composed of technicians, operators, planner and field engineers and they are responsible for the maintenance of all electrical equipment/ installations in their respective areas.

The purpose of maintenance is to ensure that installed equipment remains fit and perform optimally for its design purpose throughout its useful life. A successful maintenance regime is one that minimises operating cost, whilst maximising equipment availability and ensuring that installed equipment retains its designed safety integrity features.

Maintenance Management Systems are used to plan activities and prepare work orders, and be so designed as to accept feedback of results so that equipment records can be updated [1].

It is not possible to provide definitive statements regarding the interval between maintenance on equipment in all locations, as these will depend greatly on factors such as age of the equipment, environmental conditions, degree of criticality of service, timing of plant shutdowns and Manufacturer's recommendations [2]. Furthermore, the process should be one of continual feedback and fine tuning based on information on equipment condition found during the early years of any new scheme.

Reliability Centred Maintenance techniques such as the Shell-RCM process (S-RCM), and Risk Based Analysis (RBA) should be applied to optimise the amount of maintenance work carried out. Many potential problems can be avoided by the most simple of checks. As a general principle, all electrical equipment rooms and plant areas should be visited on a regular basis. Personnel should pay attention to the equipment's normal operating characteristics, i.e. load, sound, temperature, smell, vibration, etc., in order to identify oncoming problems at an early stage [2].

Where equipment is situated in remote locations and regular site visit is impracticable then computer based remote monitoring such as PMS, SCADA and ENMC can be employed.

II. RESEARCH METHODS

An in-depth case study was conducted in the NLNG liquefaction plant complex, Bonny Island,
where the author works as an electrical engineer, working on the project assets integrity management strategy (AIMS) involving As-built field verification and documentation. Site visit, observation, group discussion with maintenance planners, engineers and technicians were used to collect the primary data related to the maintenance management systems applied in the NLNG.

III. POWER MANAGEMENT SYSTEM (PMS)

The power management system (PMS) prevents blackouts and disturbances of NLNG operations, while at the same time controlling energy costs, enhances safety and mitigates both environmental and health impacts. The PMS provides an integrated set of control, supervision and management functions for power generation, distribution and supply in industrial plants. In this context, the PMS encompasses functions that are available in sub systems that are also known under alternative names, such as:

- Power Distribution Control System (PDCS)
- Load Management System (LMS)
- Electrical Network Monitoring & Control System (ENMCS)
- Electrical Control System (ECS)
- Electrical Integrated Control System (ELICS)
- Integrated Protection and Control System (IPCS)

The load sharing system operates on the running generators to equalize the power between interconnected systems and maintain the system frequency. The PMS continuously monitor the plant power against the spinning reserve power for any group of interconnected sets [1]. When the spinning reserve drops below the pre-set critical level then the system shall provide an alarm to allow operator to synchronise two split systems or to start any available non running set.

The synchronization of each single generator with the system is carried out by the turbine/generator control panels, through a local command or by remote auto-synch command from DCS. The PMS system provides the system synch across the tie breakers of each single 33kv board and the link breakers. For Plant monitoring and control, the PMS is provided with a visual display unit for graphical one line diagram, histogram, active alarm pages status info etc. [4]

Industrial plants require a stable and optimized electrical network. To achieve this goal, the PMS controls and supervises power generation and supply with proven features. The PMS also allows for a more critical design of the plants’ electrical equipment [4]. It rearranges generation, importation and loading so that the individual generators, reactors, transformers and tie-lines operate well within their specification limits. Tight integration and serial communication – with motor control centres (MCCs), protection units, governor and excitation controllers, variable speed drives and other sub-systems – reduce both wiring and maintenance costs, creating substantial savings.

IV. SCADA

A SCADA system is an industrial process automation system used to collect data from instruments and sensors located at remote sites and to transmit data at a central site for either monitoring or controlling purposes. The collected data from sensors and instruments is usually viewed on one or more SCADA host computers that are located at the central control room (CCR). Depending on the information received from the remote stations, automated or operator-driven supervisory commands can be pushed to remote station control devices, often referred to as field devices or distributed control systems (DCS).

SCADA software receives the information from programmable logic controllers (PLCs) or remote terminal units (RTUs), which in turn receive their information from sensors or inputted values entered manually. In a power system, SCADA is used to collect, analyse and monitor the data effectively, which reduces waste potential and improves the efficiency of the entire system by prompt response to changes in equipment behaviour and scheduling maintenance activities adequately [7].

With the use of Programmable Logic Controllers (PLC) hardware and some powerful bus communication links along with SCADA software and hardware in power generating stations, delivering an optimum solution for each process operation is flexible with advanced control structures. SCADA supervises several operations, including protection, controlling and monitoring. SCADA function in power generation include:

- Continuous monitoring of speed and frequency
- Supervising the status of circuit breakers, protective relays and other related safety operations
- Active and reactive power control
- Turbine protection etc.

Power distribution system deals with transmission of electric power from generating station to the loads with the use of transmission and
distribution stations. Most of public power distribution or utility companies rely on manual labour to perform the distribution tasks such as interrupting the power to loads, parameter hourly checking, and fault diagnosis. The use of SCADA in power distribution in oil and gas industry reduces the manual labour operation and its cost as well as facilitating automatic and smooth operations with minimal disruptions.

V. ELECTRICAL NETWORK MONITORING & CONTROL SYSTEM (ENMC)

Electrical network monitoring and control (ENMC) is a fully customized and user friendly integrated solution for reliable and accurate energy management. The system solution centralizes monitoring data, control, disturbance recording and data collection providing a window into the system for analysis and reporting through an integrated network of metering and protection devices across a single or multiple facility locations. It also supports a multitude of advanced system energy management functions such as load shedding, energy cost allocation, motor control and power monitoring [6]. Other functions of the ENMC include:

- Intelligent load shedding
- Control of voltage, frequency, power, MVAr/power factor
- Generator set management/dispatch
- Load start inhibits
- Load reconnection
- Transformer tap-changer control and monitoring
- Controlled load reduction (e.g. VSDs)

VI. QUALITY OF INSTALLATIONS.

Electrical installations in oil and gas industries are guided by several international standards and codes and there is strict adherence to quality and safety. Area classifications is one major consideration so that electrical equipment are not installed in zone zero of hazardous area classification except where there is no alternative for such installation in which case the equipment must be equipped with appropriate protection suitable for such hazardous area.

Several studies are carried out during FEED stage of the design before approval for construction is given. Such studies include: SAFOP, HAZOP etc. Electrical power cables are properly size for ampacity, short circuit withstand current and time as well as steady state and transient voltage drops. Environmental condition is also a factor to be considered in the selection of cables. Load balance studies are done to calculate the required power supply, transformer sizing and bus bar sizing. In addition, active, reactive power and power factor for each bus and entire system is calculated.

Another study that is necessary is the load flow study. This is the determination of all bus voltages, branch power factor, currents and power flow throughout the plant electrical system.

Stability studies are also carried out to determine both the transient performance and steady state performance of the system. Transient performance of the system and its generators is of great concern when relatively large disturbances are applied, like starting large motors, switching out loaded feeders and recovery from fault clearance.

Oil-filled power transformers are installed outdoors in a fenced-in area of the substation. The fences have minimum of two lockable gates depending on the size of the substation. Transformers are mounted on a flat concrete base and the transformer yards are filled with gravel to minimise step potential and touch potential voltages. Gravel also prevents growth of plants and weeds in the transformer yards.

All cables from transformer are laid underground and they enter the substation through a raised floor. Electrical and instrument cables run in separate trenches and load carrying cables are laid in single layer formation while non-load-carrying cables are installed either as an additional layer on top of the load-carrying cables or as a block adjacent to the load-carrying cables.

Above ground cables are supported by cable racks, trays or cable ladders all the way up to their terminations. The cable racks, trays or ladders are well bonded to the metallic equipment enclosures, junction boxes or structures where the cables are terminated. Individual cables emerging from floors or soil are usually protected against mechanical damage by means of galvanised steel pipes or rigid PVC pipes.

Plant lighting circuits are fed from dedicated lighting distribution boards installed in each substation. Conduit wiring systems are used for lighting, communications and convenience outlets in closed buildings and metallic parts of the lighting installations are properly earthed. All conduit installations are made with rigid PVC conduit and non-metallic conduit boxes. Fixed emergency lightings are installed in strategic locations in the switch rooms, control room, fire location and the main entrances and emergency exits.
VII. PROTECTION PERFORMANCE

The need to act quickly to protect circuits and equipment as well as personnel often requires protective relays to respond and trip a breaker within a few milliseconds. Circuit breakers combined with electronic protection relays bring many protections Selectivity benefits, including: coordination with upstream and downstream devices; discrimination of inrush currents; detection of low level of phase to phase and phase to earth fault currents. There are several relays used in electrical installations, some of which are given below.

A synchronism checking relay provides a contact closure when the frequency and phase of two sources are similar to within some tolerance margin. A "synch check" relay is often applied where two power systems are interconnected, such as at a switchyard connecting two power grids, or at a generator circuit breaker to ensure the generator is synchronized to the system before connecting it.

The differential protection relay responds to faults within its protected zone. The boundary of the protected zone is uniquely defined by the location of the current transformers. Time grading with other protection systems is therefore not required, allowing for tripping without additional delay. Differential protection can be used to provide protection for plants with multiple terminals and can be used to protect lines, generators, motors, transformers, and other electrical plant.

An overcurrent relay is a type of protective relay which operates when the load current exceeds a pickup value. The ANSI device number is 50 for an instantaneous over current (IOC) or a Definite Time Overcurrent (DTOC). In a typical application the over current relay is connected to a current transformer and calibrated to operate at or above a specific current level. When the relay operates, one or more contacts will operate and energize to trip (open) a circuit breaker. Protective relays can also be classified by the type of measurement they make. A protective relay may respond to the magnitude of a quantity such as voltage or current.

Neutral Earthing Resistors (NERs) are used in medium voltage AC distribution networks to limit the fault current for safety of equipment and personnel in industrial systems. In solid grounding, the system is directly grounded and only the soil resistance limits the fault current. The fault current can be very high and can damage the transformers, generators, motors, wiring and other equipment in the system. The NERs are inserted between neutral and ground in order to increase the net resistance thereby limiting the current that would flow through the neutral point of a transformer or generator in an event of earth fault. The fault current values are usually limited to a value that can be safely handled by the machine or transformer. It also needs to be high enough to be sensed by the earth fault protection relays. If the NER resistance value is too high, the fault current will be very low and will not be able to activate the earth fault protection relay during earth fault conditions. Fault current and transient over-voltage events can be costly in terms of networks availability, equipment costs and compromised safety. Interruption of electricity supply, considerably damage to equipment at the fault point, premature ageing of equipment at other points on the system and a heightened safety risk to personnel are all fault situation consequences.

In a three phase star connection, capacitances are formed with the ground. In the event of an earth fault, these capacitances may charge up by the line voltage and may cause transient overvoltage. The NER should have a value that permits a let-through current, which enables the capacitances to discharge. The installation of a Neutral Earthing Resistor in electrical networks in oil and gas industry helps to:
- Reduce the single phase fault currents for securing each equipment in MV electrical networks.
- Reduce the transient overvoltage which can occur during an earth fault, and be monitored and used to activate the earth fault relay.
- Increase protection of generators, transformers and related equipment.
- Reduced operation/maintenance costs.
- Increase safety.
- Provide simple, reliable, selective means of protection.
- Allows the use of equipment, and in particular cables with lower insulation levels than for an insulated neutral scenario.
- Reduce the step voltage
- Extend life of connected distribution equipment such as transformers
- Reduce operation and maintenance expenses.
- Improvement in network security and reduction in unplanned shutdowns.

NERs must absorb and dissipate a huge amount of energy for the duration of the fault event without exceeding temperature limitations as recommended in IEEE32. It is therefore important in the design and selection of an NER to ensure equipment and personnel safety as well as continuity of supply.

Anti-condensation space Heaters are installed to maintain the temperature of an electrical enclosure. They also provide frost protection by keeping the internal temperature of electrical enclosure above the freezing temperature. The anti-condensation space heaters prevent condensation through convection.

Condensation forms due to fluctuating temperature, even in sealed enclosures. In combination with dust and aggressive gases condensation causes corrosion which results in stray currents and arcing. Too high a temperature, or too low a temperature, can also lead to serious component failure. The safety risk is enormous and the cost of operational delays as a consequence is incalculable.

Only constant optimum climatic conditions allow components to function properly. The right climate can be attained by a temperature and moisture control system. When temperatures are too low or when temperature differences (e.g. night / day) are large, heating is required. It may also be necessary to keep components cool by controlled ventilation. The heaters are used in enclosures where condensation is to be prevented or the temperature may not fall below a minimum value. In this way corrosion is avoided and an even temperature is maintained.

VIII. Conclusion

It is very important for any organization to have a robust and effective maintenance management and repair policies to ensure optimum performance of its facilities.

A successful maintenance regime is one that minimises operating cost, whilst maximising equipment availability and ensuring that installed equipment retains its designed safety integrity features. Although, It is not possible to provide definitive statements regarding the interval between maintenance on equipment in all locations, as these will depend greatly on factors such as age of the equipment, environmental conditions, degree of criticality of service, timing of plant shutdowns and Manufacturer's recommendations, it is recommended that organizations carry out a detail study on the maintenance management needs of its facilities so as to avoid a total breakdown and stoppage of production.

References


