International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 12, December-2014

Electrical Equipment Inspection Methods for the Petroleum Drilling and Extraction Facilities

Avram Lazar,
Drilling and Production Department,
Oil &Gas University of Ploiesti,
Romania,

Tudor Silviu,
Petrom S.A.

Susanu Traian Octavian,
Emirom S.A.

Stan Marius,
Mechanical Engineering Depart.,
Oil & Gas University of Ploieşti,
Romania,

Abstract:- **According to Dennis de Coster (Commissioning Electrical Critical Infrastructure - Real World Objectives), 70% - 80% of the losses suffered by the industrial systems that operate within critical environments, are due to human error. The commissioning performed in a complete manner, together with a proper maintenance and training of the operating personnel is able to minimize the losses based on human error. Considering the specific activities conducted within the drilling - extraction industry, the events that lead to loss of production, besides the special economic component implies also anextremely tough social component, namely,the loss of life with disastrous environmental effects.**

Index Terms: Commissioning, methodology, human error, drilling – extraction

1. INTRODUCTION

According to Dennis de Coster (Critical Electrical Commissioning Infrastructure - Real World Objectives), 70% - 80% of the losses suffered by the industrial systems that operate in critical environments, are due to human error. Commissioning performed in a complete manner, together with a proper maintenance and training of the operating personnel is able to minimize the losses based on the human error.

Considering the specific activities conducted in the drilling - extraction industry, the events that lead to loss of production, besides the special economic component also implies an extremely tough social component, namely the loss of human lives and disastrous environmental effects.

Commissioning performing in a fair manner leads to several objectives achievements:

- The bought equipment will operate within the specified parameters:
- When the specialists who will execute the commissioning phase are involved in the project and also in the construction phase, it must be ensured that the design and construction specifications , reflect the performance expectations of the customer;
- It is checked the way how the contractors perform the construction, in order to correspond with the customer expectations;
- It is checked the design and construction specifications and also the actual completion of the construction phase, it is ensured the project performance / the new long-term goal;
- The operating staff receives the information required for a correct operation directly from the team of specialists who performed the commissioning, having thus the guarantee of a correct interpretation of the afferent documentation and instructions.

Personal experience in the field of construction – mounting sites within the drilling - extraction projects led me to study how commissioning activity is performed both at the nationallevel and at the major oil companies operating worldwide.

In a first stage were identified methodological elements related to the most complex phase of execution of a project, which is the stage of commissioning of the equipment and electrical installations, stage considered in the modern methodology asbeing developed in 2 steps:

the initial stage of commissioning (*pre-commissioning)* and the final stage of commissioning (*commissioning*).

There have been synthesized the main methods of testing the equipment and the electrical appliances, methods that are used in the current startup technology and have been identified the main elements of the electrical systems within the drilling - extraction rigs.

Subsequently there have been investigated various commissioning tests of some equipment and electrical systems within drilling - extraction rigs with the specific methodology and standardizations for this activity - applied both in Romania and in the world - and also in the exploration and production divisions of the consecrated oil field operators: Agip, Chevron, Exxon Mobil, Shell, Total.

Following the performed researches and analyzes there were found examples of good practice, which we recommend to be implemented in a unitary manner within the process of commissioning of the local drilling - extraction projects, and a great diversity regarding the limits of applicability and acceptability of some tests, diveristy on which we will do some considerations and recommendations.

ISSN: 2278-0181
Vol. 3 Issue 12, December-2014

2. INSPECTION OF THE ELECTRICAL APPLIANCES WITHIN THE DRILLING SYSTEMS

A well drilling represents a complex of works necessary for a well execution: excavation, consolidation, investigation, productive layers probation, its architecture depending on:

- well depth (from a few tens of meters to 13,000 meters);
- Objective (geological prospecting wells, exploitation, special destination wells).

This architecture is detailed within the well drilling and casing program, which specifies the characteristics of different successive phases of drilling, among which the hole is cased (reinforced by a steel tube column).

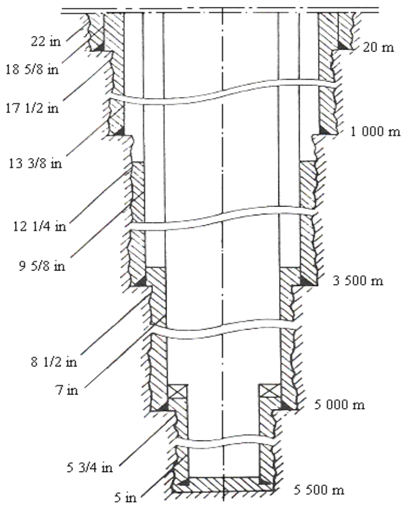

Figure 2.1. The possible architecture of a drilling process

In case of small depths, oil drilling involves two or three phases, allowing the „placement" of the following columns:

- The surface casing string - designed to arrest land surface, poorly consolidated (with its length mostly between 100 and 1000 m); it serves, inter alia, as a support for the other columns and for the facility for preventing blowouts;
- The protective column (columns) needed for isolation of layers or fluids contained within them, that are likely to impede the normal course of drilling - for example the presence of the well profile of some rocks with low stability, or the presence of some layers containing fluids with abnormal pressures (high or low);
- Extracting column - allows oil area insulation; inside it will flow down a tube for oil flow called extraction column (tubing).

Note: Before starting the actual drilling of the borehole, at its collar it is placed a so-called guiding column (onshore drilling) respectively a conductor column (offshore drilling).

The columns are cemented with a paste placed between the borehole wall and the column.

The tubes constituting the above-mentioned columns are made of high-strength steel, with a length between 9 and 14 m (the guiding column) and which are provided at the ends with special threaded. The wall thicknesses are often comprised between 5.2 and 16.1 mm, and the diameters can vary within wide limits, from 114 mm (4 ½ in) and 500 mm.

The lengths and diameters of the various phases of drilling are based on the geological information and on the results from neighboring wells (if any), taking into account the nature of the soil and fluid likely to be encountered during the drilling process.

Knowing the architecture of a drillingprocess, it permits to determine the choice of a drilling rig, the duration of the various operations, supply planning of the necessary materials, material consumption, total duration and cost of drilling.

The rotary drilling method consists in using a drilling bit (with blades, inserts, rollers or diamonds) on which acts a certain pressing force and a certain speed. The combined action of Gs pressing and of the speed allows the bits with rollers to dislodge the rock by crushing and cutting (most often), and of those with diamondsby cutting and erosion (namely, the bits with diamond inserts displaces the rock by cutting and erosion, and thosewith impregnated diamond, by erosion). The system that allows the drilling of these boreholes is called drilling rig. Most driling rigs operate in a rotary -hidraulic system: with rotary table (Fig. 2.2) or with hydraulic head driving (*top drive*).

The drilling technological process requires for driving the draw spool, the top drive and the rotary table, electric motors with mechanical characteristics that supports a rapid decline ofspeed at a speed growth, so, to present flexible features, to have a high starting torque,an increased overload capacity. There have been designed for this purpose [12] in order to drive the hoisting device, asynchronous motors with wound rotor with increased sliding feature and DC motors with artificial voltage mechanical characteristics with high slope.

Moreover, to optimize the operation of driving the hoisting device, were executed groups of diesel machines - DC generator, asynchronous motors fed by static frequency converters, DC motors, asynchronous motorsfed by static frequency converters, DC motors fed by rectifiers ordered with thyristors.

Depending on the energy generating systems used to drive the main systems of the drilling rig, the drilling wells are divided in two main groups: mechanical wells (also called thermal wells) and electrical wells.

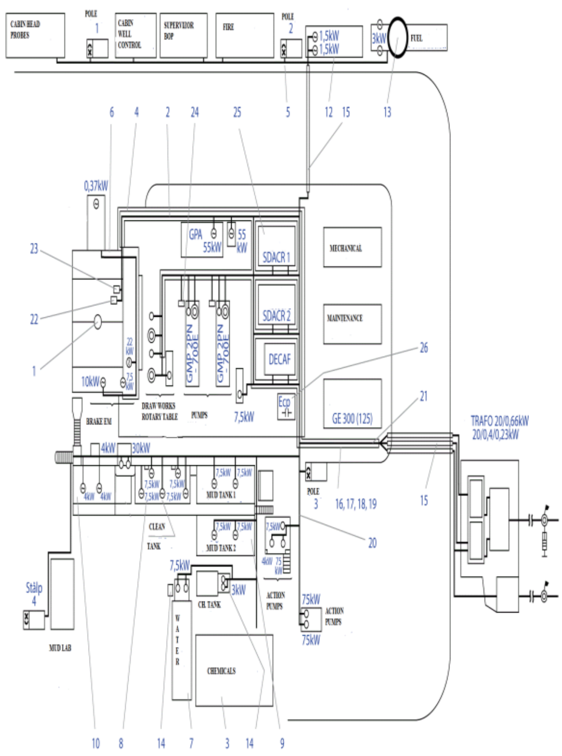

Figure 2.2. Systems and equipment layout

We present in Figure 2.2. an overview of the layout of the electrical systems within an electrical installation in a drilling wellin a hoisting device-rotary table, electrical installation for derrick;

1- shed light electric wiring;
2- chemical shed light electric wiring;
3- earthing facility;
4- exterior power-line tower;
5- general stop button (in the driller chief cabin);
6- electric wiring for water pit;
7- electric wiring for cleaning pit;
8- electric wiring for suction pit;
9- electric wiring for site pit;
10- electric wiring for the chemical pit;
11- electric wiring for the oil container;
12- electric wiring for the combined power group;
13- insulating derrick floor;
14- protection pipe;
15- cables support;
16- grid;
17- grid diversion;
18- spacer;
19- auxiliary drive cables;
20- main drive cables;
21- pedal potentiometer;
22- electric desk for chief driller;
23- local command desk for pumps;
24- SDACR, DECAF; 26- ECP (reactive power compensation installation)

3. ELECTRICAL FACILITIES INSPECTION FOR EXTRACTION SYSTEMS

In extraction systems when the hydrocarbons layer pressure does not allow the natural eruption, are used various production methods such as gas-lift, hydraulic pumping with bottom pumps (double effect pumps - *reciprocating pump*) depth pumping with pumping rods(*Subsurface Sucker Rod Pumps*) and pumping with pumps driven by bottom electric motors (*Electric Submersible Pumps ESP*).

Figure 3.1. shows a scheme of an extraction plant by depth pumping with pumping rods according to [12], Fig. 3.1:

Wherein:
1- pump;
2- grief stem;
3- tubing column;
4- beam;
5- rotary table for balancing;
6- connecting rod;
7- crank;
8- reduction gear box;
9- the electric motor system;
10- oscillating balancing mass;
11- Power cabin, CMPA type protection and command;
12- LEA 0,5 kV with STE concrete pole.

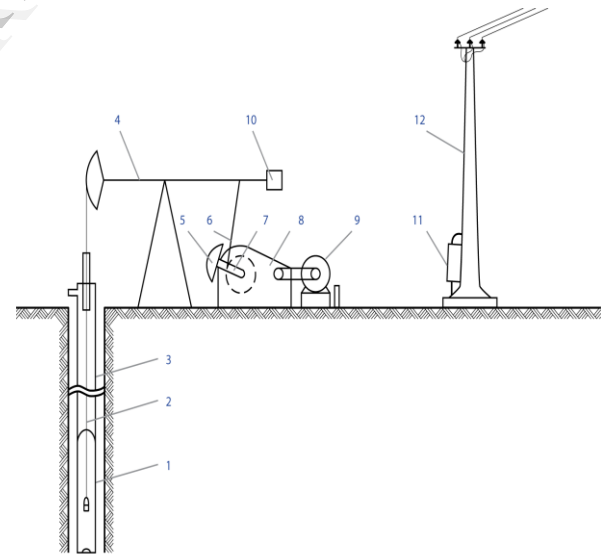

Figure 3.1 Extraction rig by beam pumping with pumping rods

The technological process of oil extraction by beam pumping with pumping rods has required the use of a short – circuit impeller induction motor, designed specifically to drive the rods pumping installations, the engine with large air gap and with a specially shaped rotor bars, engine which is characterized by:

- A high value (1.5 - 2.5) of the Mp / Mn ratio (starting time / nominal time) starting moment necessary to be able to accelerate when starting the significant rods masses, the liquid column and the system counterweight;

- A high ratio Mmax / Mn (2.3 to 3) needed to cope with large cyclic variations of each race;
- Low starting current – in order to avoid the power grid overloading when starting the machine (thus avoiding the additional costs involved by a possible intervention on power supply wire net).

4. COMMISSIONING PHASE METHODOLOGY ELEMENTS

An industrial facility commissioning is the process which provides that:

- All the systems of the respective objective (drilling systems, extraction systems, processing plants, pumping stations, collection centers, injection stations, etc.) are installed and ready for normal operation (energized) and interactive perform according to design expectations;
- These systems are effective and meet the operational requirements under the contract
- The installation process is adequately documented, including the "as built" changes respectively all the necessary documentation has been updated and given to the system operator;
- The operators were properly trained for operating the systems with maximum safety and economic efficiency conditions.

According to Total E & P [84], completing activities / completion / commissioning of a new exploration project / hydrocarbon processing "consists of a series of checks performed just before commissioning the system. The purpose of these checks is to ensure, as far as possible, that each piece of equipment / system is constructed, installed and operated according to design specifications. These checks also represent the last critical revisionof design and execution before the start-up phase. The ultimate goal is to determine a safe and undamaged object delivery. "

These commissioning checks, are structured within the engineering documentation produced by the above mentioned company for oil and gas projects (drilling and production, petrochemicals, etc.) in two phases:

- The initial commissioning phase (*pre-commissioning* - corresponding to static tests);
- The finalcommissioning phase (*commissioning* - corresponding to dynamic tests);

Subsequently commissioning phase, considered to be the last phase of "completing" the project it will move to the starting phase of the production, a phase for which the specialty literature uses the term of "Start-Up". This phase is performed by the commissioning team, together with the team that operates the industrial objective and consists of various tests of the macro system, aiming to verify if the individual systems interconnected operate and according to designed conditions (under the expected production parameters) and also under maximum safety conditions. According to Roger Kingsley quoted in [20], "when the project reached the stage of commissioning, project development costs shall be already incurred in a large extent, the climate generated by investors already being one of great waiting, impatience and sometimes of slight fear. The project will be considered in relation to the market expectations, and this often means a high sense of urgency for completion. All of this is added to a psychological stress already existing at a high level, a level that is dictated by the involved multidisciplinary engineering branches effort. „Commissioning is both a managerial task and also a technical one, imposing towards the project management a specific approach of the interconnected elements:

- Engineering team (design);
- Construction /mounting phase execution team;
- Commissioning team;
- Built project / system, at completion phase
- Involved processes.

In such instances are preferred specialized contractors for the stage of commissioning, taking into account such fairness towards the Contractors who carried out the design, namely the construction and also the high degree of specialization required by the commissioning operation. To achieve the desired results within the commissioning process are necessary the followings:

- Meticulous attention to every aspect of safety (labor safety, environment protection, security and integrity of equipment);
- Commissioning team conducted responsibly and flexible, with a well-trained and committed staff, that must be able to manage the inherent physical and psychological stress;
- An adequate involvement within the design phase and safety studies phases. The senior management stafffor the commissioning team (at least the commissioning Manager respectively, the discipline coordinator of the commissioning process) should be involved starting from the initial stage of the project, starting with the design phase and continuing with construction and installation of systems phase. Analysis made by senior management of the commissioning team, is considered of utmost importance regarding the safety issues, particularly those related to starting phases (*start-up*) and emergency interruptions (*emergency shut down*), considered critical phasesof commissioning process; in this way, their experience is shared by the design team, thus reducing the potential hazards;
- Detailed and realistic planning preparation of implementation of the effective commissioning preparations and activities; planning is also essential for a commissioning in safe conditions: a well planned startup tends to be a safe start, the regarded planning degree being dependent on the size, the complexity and the nature of the technological process; within the planning process must ensure the fact that indeed „safety comes first! „ especially for the recent events (BP accident in the Gulf of Mexico, the nuclear disaster in Fukushima) have shown us the fundamental importance of the safety of a project;

- Immediate availability from support disciplines in order to solve in due time the raised issues;
- A stable, controlledsystem, but expeditious for approval of design changes required by the commissioning team, obeying the requirements of the quality standard ISO 9001: 2008;
- A structured collaboration at senior management level among the teams for commissioning, design, construction and operation of the project.

Later, in post – commissioning phase, recording of the project changes occurred during the commissioning phase and also preservation of the obtained performance test results is vital so that the obtained values and information could be used as benchmarks within the project operation, including within the subsequent maintenance phases.
Moreover, registration of all the done works (tests, trials, modifications, etc.) within the commissioning phase for long-term, a fundamental contribution in defining new targets to improve systems performances and reduce costs.
Taking into account that the commissioning period is often the most dangerous stage of the lifecycle of a project, both commissioning client and contractor have clear obligations in ensuring the safety conditions for the staff, the environment and safety of the already in production systems.

For safety obligations fulfillment it mustbe considerred the following points:

- Attention to detail, a proper planning of all stages of commissioning, with emphasis on the security and integrity of the people, environment and equipment; a well planned startup tends to be a safe starting because it is known, the electric current "does not allow" a second mistake;
- Using a well-trained team in specific trainings with a strong technical base and with appropriate experience, technical requirements being twice towards those required for a normal operation of the system;

Preparing the commissioning team for safety domain (protection of personnel, environment and systems) is essential. All team members must know, at an appropriate level the design philosophy of the systems and how to identify the potential hazards, both for the served process (e.g. drilling process) and also in the engineering phase specific for the commissioning team specialization (e.g. electrical engineering),

- Detailed analysis of potential hazards, ensuring the protective equipment and the one for remediation;
- Appropriate investments in staff training, ensuring that the team members are properly trained and have the necessary experience to carry out specific activities.

CONCLUSIONS

Taking into account the hazard level of the tests with increased voltage, both for the staff and for the equipment, we consider that it is necessary a previous check before starting the commissioning phase, in specialized laboratories both for the protective equipment (gloves, boots , dielectric mats, etc) and also for working equipment (kits for voltage elevating,separation transformers, mobile unloaders), even if they are within the validity period in terms of insulating qualities. Also it is considered absolutely necessary that at least one member of the team that performs the tests with increased voltage (*AC Hi-pot test, DC Hi-pot test, tgδ measurement*) to have a proven experience in this kind of tests.
Testing performing with increased alternative voltage of the rotor windings should be a basic test during commissioning because only this type of voltage applies on the dielectric of insulation an electromagnetic field of the same form and structure with the real field applied during the normal operation, respectively with the real field produced in case of over voltages surges that may occur during operation.
Taking into account that the drilling - extraction generators are installed in environments with high humidity and on the other hand that these generators (especially for drilling rigs) are periodically moved to other locations we propose a test execution applying a maximum trial voltage corrected by a factor k = 0.65, so basically for a voltage lower than the imposed one on PE 116 [15].

BIBLIOGRAFHY

1. Agrawal, K.C.: Industrial Power Engineering and Applications Hnadbook,Newnes, 2001.
2. Avram, L., Susanu, T.O., Avram, S.A., Troquet, J.,:Biopiles for Hydrocarbons and Isolation for Heavy Metals, Oil & Gas University of Ploiesti Bulletin, Vol. LXIII No.3/2011, Ploiesti,2011
3. Baker, R.: A Primer of Oilwell Drilling, Petroleum Extension Service, University of Texas at Austin, 2001
4. Bradley, B.H.: Petroleum Engineer Handbook,Society of Petroleum Engineers. 1992
5. Brown, M., Rawtani, J., Patil, D.: Practical Troubleshooting of Electrical Equipments and Control Circuits, Newnes Elsevier IDC Technologies, 2005
6. Calin, S., Marcu,S.,: Relay protection of the Electrical Systems, Technical Publishing House Bucharest, 1965
7. Cserveny, I., Popescu, St., Preda, D.,: Relays protection, Measurement and Automation, Didactic and Pedagogical Publishing House Bucharest, 1970
8. DeCoster, P.D.: “Commissioning Critical Electrical Infrastructure - Real World Objectives”, paper in Electric West Conference, USA, 2008
9. Dumitrecu, I., Nestorescu, D.N., Georgescu, D., Siro, B.,: Electrical installations of the Oil Units, Technical Publishing House Bucharest, 1988
10. Earley W.M., Sargent S.J., Sheehan V.J., Caloggero M.J.,: National Fire Protection Association, National Electric Code, Quincy Massachusetts,2005
11. Fuhr, E.R.,: “Electrical Commissioning-Typical Power Equipment Problems Found in the Field”, paper in National Conference on Building Commissioning, USA 2003
12. Gill, P., : Electrical Power Equipment Maintenance and Testing Second Edition, CRC Press Taylor& Francis Group, 2009
13. Von Meyer, A.,: Electric Power Systems: A Conceptual Introduction, John Wiley & Sons, Inc., 2006
14. ***ANSI/IEEE C57.13.1,: Guide for Field Testing of Relaying Current Transformers.
15. ***ANSI/IEEE: Standard 81: IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System