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Three keys to achieving electrical system reliability in oil and gas processing plants

Application Note

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Electrical distribution systems must meet the needs of the facility they serve. This is especially true in oil and gas processing facilities where petroleum or natural gas is refined into useful products. The processing typically occurs through long pipes and tanks with miles of electrical wiring and all types of electrical power and control equipment.

By design, an electrical system for oil and gas processing facilities should:
- Provide for future expansion.
- Take into account the effects of non-linear loads.
- Work satisfactorily for their projected lifetime.

Large and diverse electrical systems, such as those found in oil and gas processing facilities, are prime examples of systems that must be carefully commissioned during the closeout of the construction phase, and then properly maintained throughout their life.

The three keys

Three keys to achieving electrical system reliability are:
- Thorough and well-documented acceptance testing of equipment (standard operating procedures).
- Load flow studies.
- Development of an effective electrical maintenance program.

Electrical reliability is critical in meeting process uptime needs. Only through functional (acceptance) testing, distribution system (load flow) studies, and proper maintenance can electrical systems be reasonably assured of meeting all design requirements. While specialized electrical tests are required on specific equipment, general acceptance test methods such as insulation resistance tests, thermographic surveys, and earth resistance tests are necessary to help verify proper installation of equipment. Such tests and surveys are generally done on major system components, such as motors, transformers, and cables.

Earth resistance and grounding tests are conducted on the grounding grid and associated connections. All acceptance testing is conducted on distribution system components, from unit substations down to utilization equipment.

Conduct insulation resistance testing prior to initial energization

Before the functional performance tests of systems and equipment begins, it is important to perform insulation resistance tests of cables and conductors, transformers, switchgear, motor control centers, motors, and all other such distribution system components. It is not uncommon for low resistance readings to be found as a result of insulation being scrapped off conductors during the installation phase. Wiring can be pinched in enclosure covers, a bonding jumper may be missing at a required location, or improperly landing a control wire may have created a ground fault. Finding and correcting such problems prior to initial energization of equipment can prevent an unsafe condition.

Insulation resistance testing should, as should all acceptance testing, be conducted in accordance with recognized standards, such as the "NETA Acceptance Testing Specifications" published by the International Electrical Testing Association (NETA). Choose an insulation resistance tester to meet the required voltage output levels for the equipment under test. For example, NETA recommends a minimum dc test voltage of 1,000 volts for 600 volt systems, and 2,500

Insulation resistance testing with the Fluke 1555

volts for 15 kV systems. 34,500 volt and higher rated systems, as often found in substations supplying oil and gas processing plants requires a minimum test voltage of 15,000 volts dc.

Perform earth ground testing

Proper grounding is critical for oil and gas facilities safety and operation. Grounding systems are extensive in these plants. Large amounts of steel, cable trays, process piping and the grounding system itself must be interconnected to create an equipotential plane and prevent damage if lightning were to strike. Bonding the system is also very important for the safety of personnel to prevent electric shock in the event a person comes into contact with exposed metal or electrical equipment. Lightning protection systems must also be acceptance tested. Measuring and maintaining minimum resistance to ground is absolutely necessary to effectively dissipate the large voltage surges possible at oil and gas processing facilities. Earth ground testers must be capable of performing all needed measurements. Some use only a clamp, others use stakes driven into the ground, some a combination of stakes and clamps, while others utilize only two clamps.

Both the resistivity of the earth and the connections of the distribution system to the grounding

All required earth ground tests can be performed with the Fluke 1625-2 KIT

electrodes must be initially measured during commissioning. To maintain grounding integrity, periodic testing is required during maintenance. Earth resistivity can change over time for various reasons, including changes in weather, and connections to the plant grounding grid can become damaged due to corrosive soils or loose electrical connections. A good grounding maintenance program must be implemented to maintain plant reliability and safety of personnel.

Take thermography surveys

Thermal inspections are vital for acceptance testing. Once equipment has been energized and initial function tests have been performed, systems should be operating within normal conditions. Then you can

Performing an infrared inspection with the Fluke Ti125 Industrial-Commercial Thermal Imager

Conducting an energy study with the Fluke 1735 Power Logger

capture images to be used as a baseline for comparison and future surveys. Temperature differences of 1 °C to 3 °C between similar components during similar loading conditions warrant further investigation. Expect to find loose terminals, equipment ventilation issues, and potential harmonic issues.

Generate a complete thermal inspection report as part of commissioning. Include the equipment surveyed, load conditions, any discrepancies, recommended corrective actions, and thermal images of surveyed equipment. The additional data to compare to the baseline survey results are critical in providing for future maintenance activities.

It is important to choose high quality infrared cameras for acceptance testing. One valuable feature is the ability to look at both thermographic images and the corresponding visual light photographic image of the same component. Such a feature greatly aids engineers and technicians who must find and correct problems. The same thermal imager can then be used for the normally required annual surveys for maintenance.

Conduct load flow studies

Conduct load flow studies to analyze the direction and amount of power flowing from the available sources in the plant to individual loads. Voltage and current levels, active and reactive power levels, and power factor are determined at each point in the system. In oil and gas facilities, the many large inductive loads that are present may have a negative impact on power factor. Large non-linear loads found in these facilities may adversely affect the overall quality of power causing disruption. Variable speed drives, UPS systems, and inverters are examples of such loads. An initial load flow study conducted during the commissioning phase provides baseline data to help analyze problems (this mix of equipment is sure to cause future process control problems). As the plant begins to achieve full production, load flow values will change throughout the system. Studies must continue throughout plant life to analyze data and ensure electrical system reliability and efficiency.

Conducting load flow studies requires the gathering and assembly of much data. For example, one-line diagrams, cable sizes, equipment nameplate data, and fuse and breaker data must all be obtained. While much of this data is listed in specifications and drawings, it must be verified during commissioning.

Many oil and gas facilities will have permanently installed power quality measuring equipment to assist with load flow studies. However, because of the depth to which a load flow study is conducted, the use of handheld data loggers is needed to observe specific points in the system. Handheld power quality analyzers may also serve the same function.

Schedule and conduct maintenance testing and reporting

Acceptance testing provides the baseline data for future maintenance programs. With modern maintenance software providing the ability to trend values over time, the scheduling and conducting of maintenance testing and reporting becomes even more important. Though various maintenance philosophies exist, it is the continued gathering and analyzing of data that helps minimize downtime and supports the line processes.

The best guideline for setting up and operating a complete electrical maintenance program is the "NFPA® 70B Recommended Practice for Electrical Equipment Maintenance." In addition to helping establish the administrative procedures and controls for an effective electrical maintenance program, this recommended practice also identifies various acceptance and maintenance tests in order to help staff:

- Determine the best choice between corrective maintenance or equipment replacement when equipment problems do arise.
- Determine if the system and individual components can continue to meet plant process needs.
- Chart and evaluate equipment test data over its lifetime to help predict failure modes and determine the best course of action.

Consider safety

Safety is an important consideration whether performing acceptance tests or conducting maintenance. It is important to realize that available electrical energy levels are extremely significant in oil and gas facilities, and that a failure in a transformer or switchgear can cause catastrophic results. Also, much electrical work is conducted outdoors, where workers and the test equipment they are using are subject to extremely high surge levels. To protect against large surges, all digital multimeters and similar test equipment used in acceptance and maintenance testing should be Category IV rated at a minimum of 600 volts.

Many electrical measurements in oil and gas facilities are made in Class I Hazardous (Classified) areas. Class I, or Zone 1 or 2, locations are those where flammable gases or combustible vapors may be present in sufficient quantities to produce explosive or ignitable mixtures. Electrical measurements in such areas should be made with intrinsically safe measurement devices. For example, intrinsically safe multimeters ensure that measurement and test tool operation will not produce enough thermal energy to cause an explosion.

Enjoy dividends in the future

Commissioning a new chemical process facility through proper acceptance testing pays dividends in the future through reduced maintenance costs and increased plant reliability. Insulation resistance testing, ground tests, thermal imaging, and load flow studies are all examples of what can be done to ensure the electrical system is ready to meet plant needs. In addition, they are valuable tools for providing benchmarks for the development and conduct of maintenance program activities.

Because of the complexity and the operational nature of oil and gas processing plants, the industry requires specifically designed and well-maintained electrical systems. Proper acceptance testing, maintaining up-to-date load flow studies, and developing an effective electrical maintenance program help ensure the electrical distribution system has been properly installed and will reliably meet plant needs.

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Printed in U.S.A. 7/2014 6002527A_EN