Practical Aspects of Implementing Winding Condition Monitoring at KCPL

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Overview of KCPL

Great Plains Energy is headquartered in Kansas City, Missouri and is a public utility holding company of KCP&L and GMO (Greater Missouri Operations Company).
We serve approximately 826,000 customers in western Missouri and eastern Kansas and have over 6,600 MW's of generation capacity.
The principal fuel sources for electric generation are coal and nuclear fuel with the remainder provided by wind, natural gas, and oil

History of Partial Discharge and Flux Density Testing at KCP&L

Flux probes and partial discharge equipment, were installed at the LaCygne, Montrose, Iatan, and Hawthorn plants starting in 2005. The Substation Relay Department owned the test equipment and software and was responsible for the generator stator partial discharge (PD) and rotor flux density (FD) testing.
Flux Density testing could only be done while the unit was coming down for a scheduled outage normally on Friday at midnight, so scheduling issues with the Union (IBEW) was often a problem. I met with the Substation Relay crew for generator FD testing at LaCygne while the unit was coming off line for a scheduled outage and they were unable to complete the testing due to problems they encountered, so it was an unsuccessful attempt to gather data on the LaCygne unit 1 rotor.
Through communication and interaction with the Substation Relay Department, Central Engineering (the 2 Electrical Engineers) concluded that the testing was inconsistent due to scheduling problems and the data was not being analyzed because the Relay Techs had not been formally trained.
After we identified the need for training, we brought in IRIS power in July 2009 to conduct a 3-day training session, which included actual testing with our equipment at 2 of our plants and classroom theory on how to interpret the data.
Through discussions with IRIS Power, we were introduced to the RFAII-R rotor flux analyzer, and because it was capable of instant analysis of the rotor winding condition at a fixed operating load, we were sold. We received approval from Management and purchased the rotor flux analyzer in late 2009. Rotor flux analyzer training was held for the Substation Relay department and the Electrical Engineers in early 2010.
Central Engineering obtained approval from upper Management to start purchasing bus couplers, stator slot couplers, and flux probes for the plants and CT sites subsequent to our predictive maintenance presentation. We conducted an inventory at all of the plants to determine who still needed the PD and FD equipment and then established a program with the plant's approval to purchase and install the equipment during their scheduled outages.

Transition of PD and FD Testing From the Substation Relay Department to the Central Engineering Electrical Engineers

We had a manpower issue that developed in the Substation Relay group, not only due to the merger with Aquila, but because they were handling all of the maintenance, calibration and testing of the protective relays, devices, and transformers for our substations. Additionally, they performed similar tasks for generation including the highly specialized task of calibrating and testing protective relays, functional testing the lockout relays and breakers, and testing the main and auxiliary transformers at the plants. In addition to their "normal" workload for the substations and generating plants, the change in the NERC standards that required all testing to be performed and documented at regular intervals greatly added to their workload. The major problem that we encountered was that there was too much work and too few people trained to do it, so we needed a solution. Two possible solutions were contemplated: contract out the PD and FD testing for Generation or create a similar group of Relay Technicians with this specialized skill set within the Generation group. We determined that contracting the testing out would require a "union" contractor to conduct the PD and FD testing along with a KCPL union employee to go along with the contractor, so that would still not solve our dilemma. Additionally the Substation Relay Management would have to administer the testing program, which would require additional time. Secondly, we concluded that adding a parallel work group with a specific skill set would cause labor issues and be extremely inefficient.

We suggested to Management that we begin having the necessary conversations to facilitate the expansion of the Substation Relay Department to provide the manpower necessary to accomplish the critical (yet similar) work required by both the Substation and Generation areas of KCP&L. We met with the Substation Relay Department leaders in 2010 and the decision was made to continue to support the generating stations by performing the generator (BTG) and auxiliary switchgear protective relay calibration and functional testing and the GSU/Auxiliary transformer testing. However, they ruled that the generator stator partial discharge and rotor flux density testing would shift to the Electrical Engineers in Central Engineering with the assistance from the plants as needed.

Central Engineering PD and FD Testing Program

Central Engineering became the "official owner" of the PD and FD testing equipment and software following the meeting with the Substation Relay Department leadership. When we took over the testing, the first item on our agenda was to add isolation transformers to the large units with the stator slot couplers. This eliminated the potential of knocking the units off line and also created more trust with the Operators. Next, we reviewed the existing data and determined that previous PD and FD data collection was scattered in several different data bases and not stored in a central location, so we decided to create a new database and move the existing data to where the data could be accessed centrally. We contacted our representative at IRIS to ensure the software version we were using was up-to-date. It wasn't, so we installed the new versions of the PD and FD IRIS software. We recovered what PD data we could from the previous testing and sent it to IRIS Power for their analysis to ensure that we were starting with an accurate interpretation of the data. Based on the data we sent them, Iris Power prepared PD test reports for our four major coal-fired plants: LaCygne, Montrose, Hawthorn and Iatan, which we used as the basis for evaluating subsequent test data. We established the PD

and FD testing schedule for all of the plants equipped with the PD and FD equipment and began testing.
Following the PD and FD testing at each site, we prepared a formal report which provided the graphical representation of the data along with the interpretation and health of the generator stator and rotor. Plant Management and other interested parties were sent the reports for their records.

PD and FD Results vs. Budgeting Stator and Rotor Rewinds

The Electrical Engineers in Central Engineering get involved with projects during scheduled outages at the various plants. We started to notice that there were several stator and rotor rewinds that were coming due. Our generator and stator rewinds at the plants have always been budgeted out "X" number of years based on the OEM's recommendations. In one instance, we noticed that the Sibley unit 3 generator was due for a rotor rewind because the OEM said it was statistically "time", so it was budgeted accordingly. However, the flux density test results showed otherwise. We met with the Sibley Management and reviewed the FD test results with them and explained that there was no evidence of rotor shorts. We recommended that they move the rotor rewind out several years, unless the data proved otherwise over time. We explained to them that this was a generator rotor test procedure that was accepted industry-wide and endorsed by EPRI. They moved the rewind out several years, which enabled them to use the budgeted dollars on more critical projects. Based on both the PD and FD data captured for all three units at Sibley, they were able to push stator and rotor rewinds out to later years, saving them over $20 million for use on other critical capital projects.
After reviewing the data following PD testing for our Montrose unit 3, it was evident that there was a lot of noise external from the machine. We determined that a PT was going bad and it was changed out at the next scheduled outage, which saved an unexpected costly forced outage due to a PT failure.
The PD testing for LaCygne unit 2 also proved to be valuable because it verified a stator rewind was needed based on the comparison of the Qm values over time to the tables of Qm values developed by IRIS Power. The stator rewind is scheduled for the spring of 2014.

Where We Are at Today

In the past year, we have installed 7 sets of bus couplers at our CT sites and will be installing 14 additional sets at the CT sites this fall. We brought the IRIS Power expert in for the initial installation of the bus couplers at our Greenwood CT site for units 3 & 4 and our Electrician's assisted and learned how to perform the bus coupler installs.
Since then, they have installed 5 sets of bus couplers at three different sites. Following the installs, we brought IRIS Power back in to conduct the check-out and bus coupler verification.
We have installed the TF probes on our Lake Rd. 4 and Hawthorn 9 units during scheduled outages. We will be adding a TF probe to LaCygne unit 2 during their spring 2015 scheduled outage.
In 2012, we installed bus couplers on Sibley units 1 and 2 at each of their respective scheduled outages. The IRIS Power Technicians were here through the entirety of the unit 2 installation to advise the Electricians of how the install should be done and then did

their verification. During the next scheduled outage for Sibley unit 1, the Electricians did the install ahead of time and then we had the IRIS Technician out for the final verification. During the next rotor inspection for Sibley unit 3, we plan to install the stator slot couplers, which have already been purchased.
Central Engineering has realized the benefits of installing the PD and FD equipment at our generating facilities and will continue to add this equipment and monitor the health of the generator stators and rotors in order to better predict the ultimate time for scheduled maintenance.