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PLANT POWER QUALITY STUDY

EXECUTIVE SUMMARY

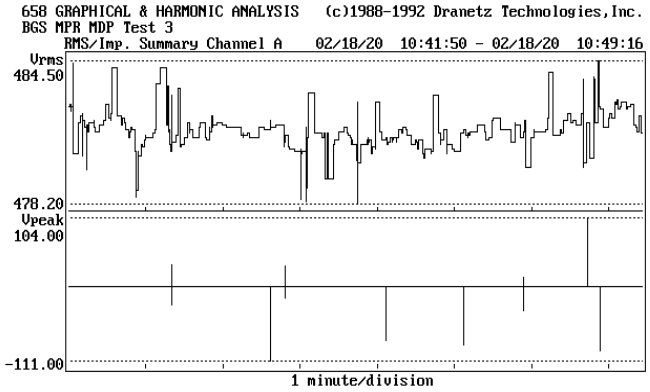
On Tuesday, February 18, 2020, I met with , Process Engineer II and , Lead Electrical Engineer from , and , Plant Manager and , Assistant Plant Manager at at 5:00 AM at the Hilton Garden Inn Hotel in . I had been contracted by to conduct a Power Quality Study of their plant electrical system.

We rode out to the plant and met in the conference room to discuss the problems the plant had been experiencing and what they wanted to monitor to investigate the causes for the problems. It was determined that almost all of the testing could be completed in the Main Electrical Power Room in the main building. I used a Dranetz Model 658 Power Quality Analyzer with a Dell computer for data storage and analysis.

Four test session were run on the Main Service Entrance / Main Distribution Panel combination in the Main Electrical Room. This is a 480Y/277 Volt, 3 Ø, 4-Wire + Ground, Wye electrical panel, with a 4000 Amp Main Bus. The Neutral and Ground are bonded at the Main Distribution Panel, but only the Ground is run with the Phase leads down line. The Neutral is not run to any of the four MCCs or to the four Power Panels. In doing this the system is converted to a simulated 480 V, 3 Ø, 3-Wire, Delta configuration. In each of the four test sessions, the continuous voltage on each Phase to Phase varied less than 2% from the nominal 480 V. This is well within acceptable levels. The four tests ran for a total time of 13 minutes and 37 seconds of recorded activity, captured 878 events and generated 3,512 charts for review.

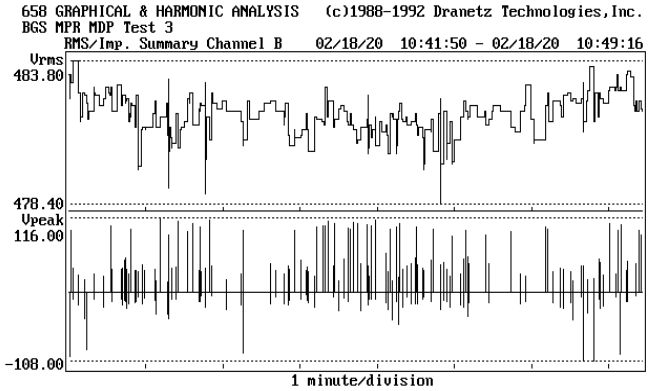
The four tests did consistently show a number of low-level, surge events coming from the Mine Power Distribution System to the facility Main Service Entrance / Main Distribution Panel, although it was not evenly distributed across the three Phase to Phase combinations. The charts below are representative of the results for all four tests.

The first chart is from Test 3 on the Phase A to Phase B, 480 V connection.



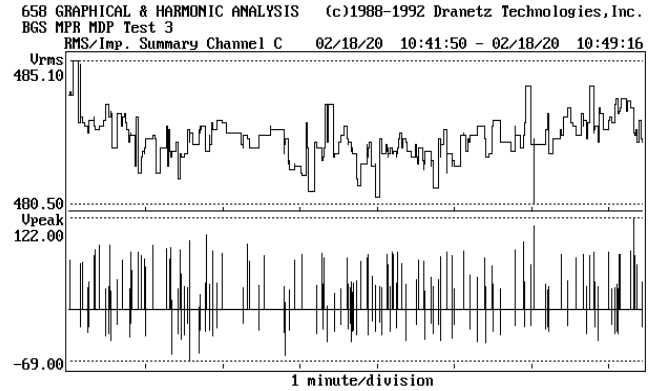
There are only a few surge events recorded, ranging from a positive 104.00 Vpeak to a negative 111.00 Vpeak.

The second chart is from Test 3 on the Phase B to Phase C, 480 V connection.



The number of surge events has jumped to well over 100 , with a maximum of a positive 116.00 Vpeak and a negative of 108.00 Vpeak.

Third chart is from Test 3 on the Phase C to Phase A, 480 V connection.



The number of surge events has grown even larger with a range of a positive 122.00 Vpeak to a negative 69.00 Vpeak.

These surge events, although low-level, are repetitive across of phase combination They are traveling down line in the system and causing cumulative damage over time as they reach point of resistance within

switchgear, MCCs, Power Panels, and equipment. This is excess, unusable voltage that gets converted to heat at the points of resistance, which over time become "hot spots" on the microscopic circuits of the processor chips, components and circuits on the printed circuit boards, lighting electronic ballasts and LED drivers, motor windings insulation, and other equipment. This activity is continuous throughout the 24 hour day, and does not stop. The difference in the number of surge events recorded between the three modes is likely attributable to unbalanced loads within the Mine Electrical Distribution System or the use of large, 1 Ø switching or electronic equipment on C Phase within the Mine Electrical Distribution System.

The four Motor Control Centers (MCCs) were tested at VFD connections, pump connections and spare breaker connections. The MCC Main Buss on all four systems displayed the same surge events observed on the Main Distribution Panel. The VFDs all had the main drive 480 V components protected by Line Reactors which were performing well in controlling the surges generated by the VFD Rectifiers from coming back onto the MCC Main Buss. But the 480 Vac to 120 Vac Step-down transformers are unprotected and subject to the surge activity on the MCC Main Buss and to any lightning or catastrophic surge events coming from the Mine Electrical Power Distribution System. By protecting the MCC with Voltage Responsive SPDs on the 1st, 4th, 7th, 10th, and 13th columns the equipment on the MCC will have second level of staged protection for the electrical and electronic equipment. The electronic control in the VFDs should be protected with a series wired SPD at the load side of the 480Vac to 120 Vac Step-down transformers. This will provide third level staged protection with electronic grade Frequency Responsive SPDs for the sensitive electronics within the drive controls.

Each of the four Power Panels in the Main Electrical Room are powering various electrical and electronic equipment. Many of the circuits are mislabeled and it was not possible to determine what was connected to several of the circuits on each Power Panel. This problem is scheduled to be corrected by the Plant Electrician with assistance from , Lead Electrical Engineer from . All the panels were relatively free of surge activity except for occasional equipment switching of larger loads. Most of the electronic loads are a significant distance from the panels, which could mean that the switch-mode power supplies in the down-line electronic equipment are creating switching surges that are staying local on the circuit at the outlets in the offices and other rooms. With the history of computer and component losses in equipment on these Power Panels the installation of an electronic grade, Frequency Responsive SPD on each panel will provide third level electronic protection from the lightning and catastrophic surge events on the Mine Electrical Distribution System, as well as internal, cumulative surge protection from the ring wave surges created by the operation of the equipment inside the facility.

Pump 602B is a 225 HP pump with a soft start in MCC 103. We tested the startup of this pump and found it produced surges ranging from 708 Vpeak positive to 743 Vpeak negative. These are potentially damaging surges over time to any equipment on the MCC. The SPDs already specified for the MCCs should alleviate this problem.

The IT/Telecom Power Panel was also tested. There were a few low-level surge events, and the panel is not protected. The servers and other electronics power from this panel have suffered numerous losses and have no protection other than a UPS which provides overvoltage, undervoltage and outage protection, but little to no surge protection. A Frequency Responsive SPD should be installed on the IT/Telecom Power Panel to provide the third level of staged protection for this very sensitive equipment.

During the testing, it was learned that the Main UPS System was malfunctioning and not providing any standby power during an outage. This was mentioned to , , and . It is to be addressed as an immediate concern.

CONCLUSIONS:

There is no surge protection within the facility at this time. There is evidence that the Mine Electrical Distribution System which is supplying power to the facility is generating it's own surge events that are contributing to the loss of equipment and downtime in the facility. Additionally, the equipment in the facility is also contributing to the surge environment. There were no significant harmonics observed on the electrical distribution system. The VFDs all have Line Reactors which are functioning properly and reducing the surge being generated by the VFD Rectifiers. The installation of a compliment of SPDs at the Main Service Entrance / Main Distribution Panel, at proper intervals on each of the four MCCs, on the load side of the VFD Step-down transformers, at each of the four Power Panels in the Main Electrical Room and on the Power Panel in the IT/Telecom room will remove the low-level, cumulative damaging surges from the facility electrical distribution system, and provide staged protection from the lightning and catastrophic surge events that have historically resulted in loss of VFDs, motors, controls and operations equipment in the recent past.

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