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POWER QUALITY STUDY

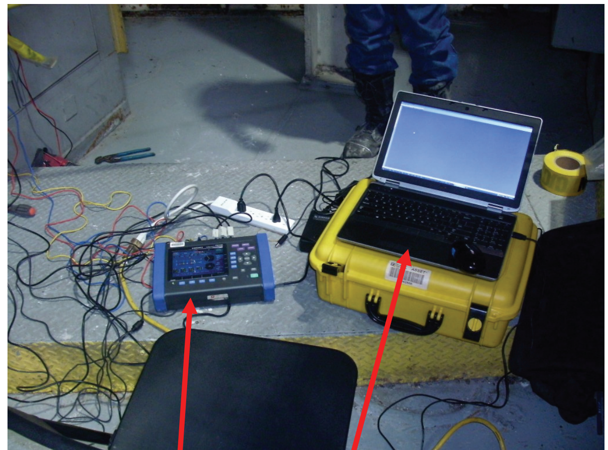
February 10, 2016, Tom Butcher from Technology Services, Surge Suppression Incorporated, joined l, North American Sales Manager – Mining & Energy from Company, Inc. We met with , Electrical Supervisor, Dragline Operations, at the mining operations office in , to conduct a power quality study of three of their mine's dragline equipment.

Dragline Marion 8200 Unit 104 was monitored. had reported that the LED lights on the dragline had been experiencing an unusual rate of failures. The purpose of the power quality study was to monitor the power on the lighting panels at the dragline for any abnormalities that might be causing the failures. Only part of the failures occurred during severe weather. Other times, the failure occurred with no severe weather observed and no other disruptive activity noted. If any problems were noted, we would try to determine whether the source of the problem was from an internal operation of the large motors and drives, or generated on the incoming power lines from the local utility or some other outside source.

We began testing at the lighting control cabinet on Dragline Marion 8200 Unit 104 at the mine.

A Hioki model PW3198 Power Quality Analyzer metered the Line side incoming power at the main disconnect switch, to monitor the power for surge activity as well as voltage and current problems. The panel was a 480 V, 3 Ø, 3-Wire, 3 Delta system. The Hioki set-up for Test 1 had Channel A monitoring the Phase A to Phase B, 480 Volt power; Channel B monitoring the Phase B to Phase C, 480 Volt power; and Channel C monitoring the Phase C to Phase A, 480 Volt power current. We were also monitoring the Phase A, Phase B, and Phase C current.

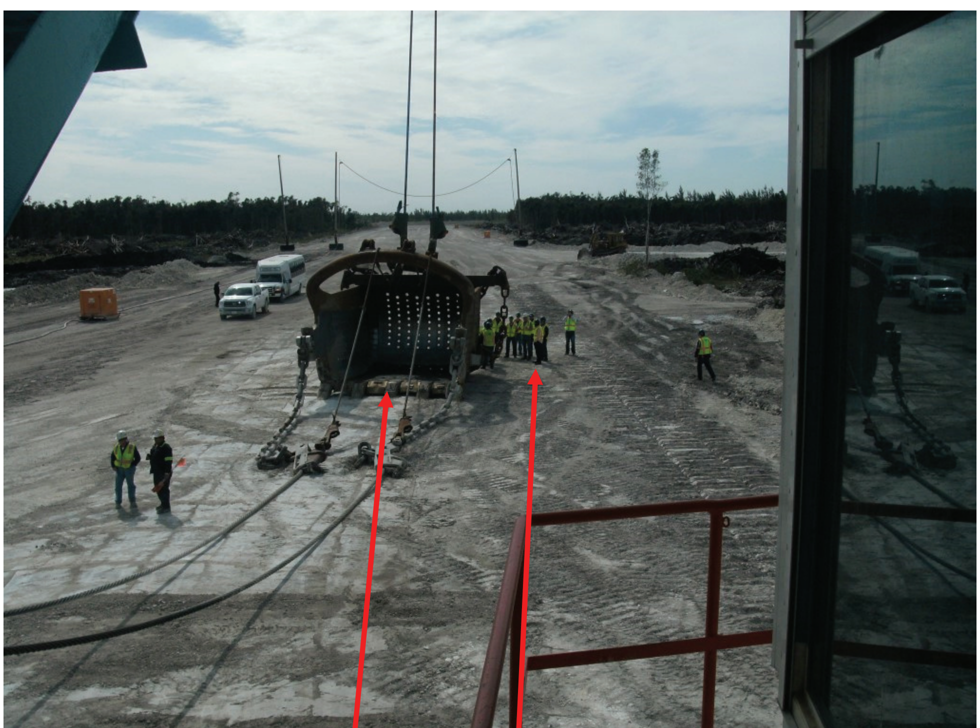
Lighting Panel



Hioki Power Quality Analyzer and Laptop

Large Crane Pulleys (note the size of the fire extinguisher)

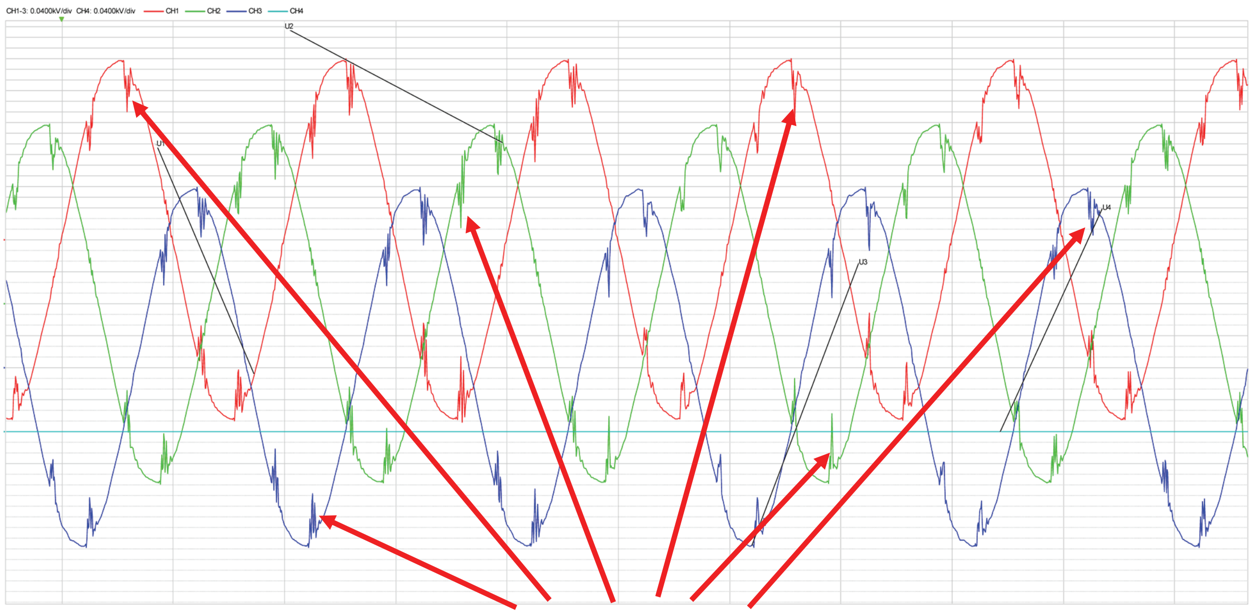
480 V motors, several hundred horsepower



Crane Bucket (note size of people standing next to bucket)

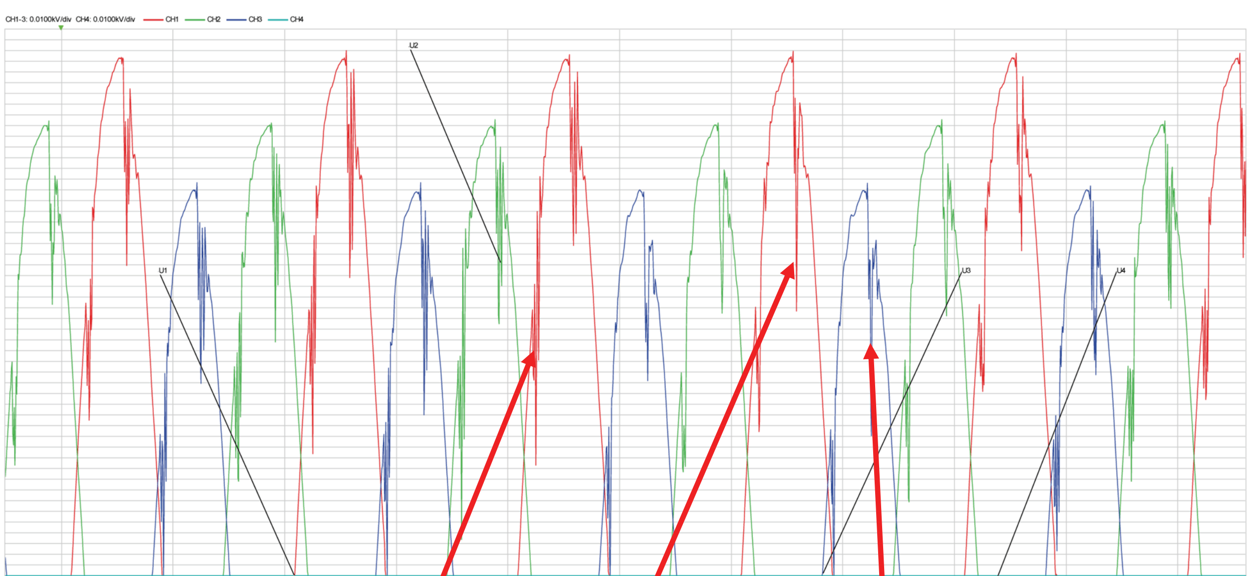
Monitoring began on Tuesday, February 10, 2016, at approximately 13:32:00 PM to 13:41:22 PM, with 114 events. The Marion 8200 Unit 104 Dragline was in full operation.

The following charts show the power during this monitoring period.



Up to 250 Vpk surges
Chart 1

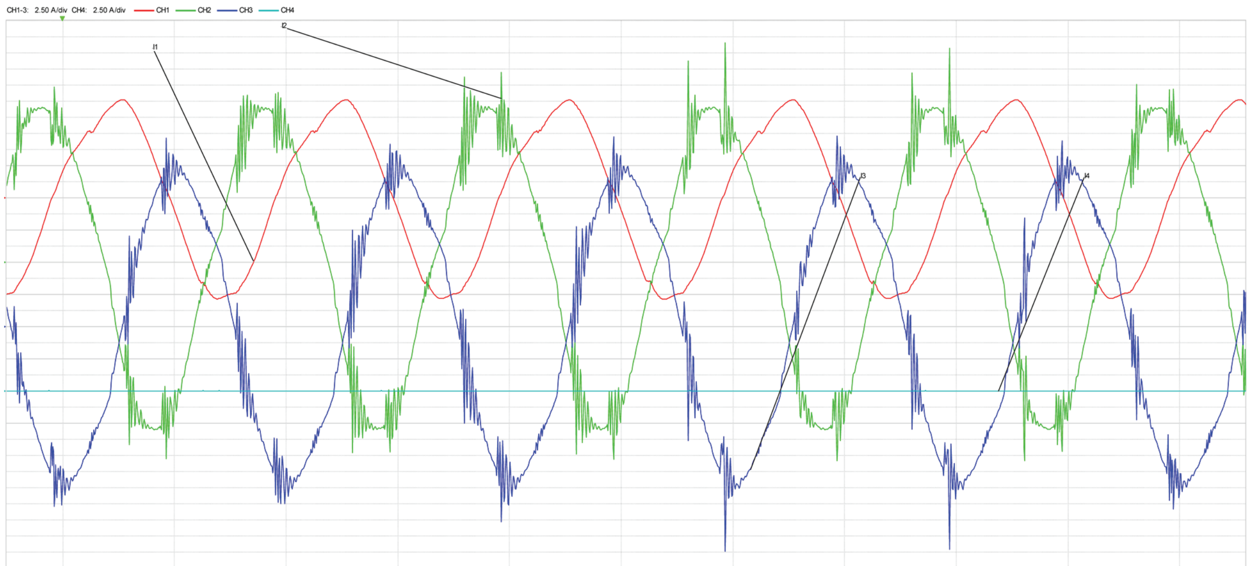
The red waveform is Phase A to Phase B voltage events near the end of the monitoring period. The green waveform is Phase B to Phase C voltage events near the end of the monitoring period. The blue waveform is the Phase C to Phase A voltage events near the end of the monitoring period. Normal voltage variations and multiple transient surge activity ranging from a positive 200+ Volts peak (V_{pk}) to a negative 200+ V_{pk}.



260 Vpk Surge 250 Vpk Surge 240 Vpk Surge

Chart 2

Chart 2 shows an expanded version of the voltage waveform with the surge activity at several points on the waveform.



Phase A in red, Phase B in green and Phase C in blue.
Chart 3

Chart 3 shows the current waveform for the same event. Phase A current is 10.6 Arms, with slight distortion and no surges. Phase B and Phase C are both 17.7 Arms, with multiple surges of 17 Apk or more, in four groups on each cycle of both phases.

The voltage surges on all three phase combinations (A to B, B to C, and C to A) are occurring several times per cycle. They are not catastrophic, but they do have the potential to cause cumulative damage over time. They are occurring four times per cycle, every cycle, equaling 864,000 times per hour. This level of surge activity will create “hot spots” within the LED drivers and lights. With the rapid repetition of the surges, the “hot spots” will never cool down and the accumulating heat will accelerate deterioration of the components, causing early failure of the drivers and lights.

A properly sized surge protective device, installed on the lighting panel with leads as short and straight as possible, will provide a path off the electrical system for these surges and remove their damaging effect on the drivers and LED lights.

RECOMMENDATIONS:

1. The Marion 8200 Unit 104 dragline at the mine exhibited surge activity at the LED lighting panels. There is no reliable surge protection at these panels with the ability to remove the impulse and ring wave surges present. The repetitive nature of the surges from the VFDs and other electronic sources within the dragline will result in cumulative damage over time to the power supplies and LED lights themselves. Because of the harsh nature of the electrical environment, and the potential for lightning activity from storms at the mine site, we would normally recommend a tiered coverage of Surge Protective Devices (SPDs) at the service entrance, distribution panels and the LED lighting panel. Since we are only working with the LED lighting panel, we would recommend a more robust SPD at that location because it will be the only SPD and not part of a coordinated system.

   The Marion 8200 Unit 14 dragline at the mine should have a CDLB3N4-D3, 480 V_{rms}, 3 Phase, 3 Wire, Delta, 60 kA per mode SPD with NEMA 4X enclosure and rotary disconnect installed on the LED lighting panel.