

Accelerator Safety Workshop

Lessons Learned at C-AD Accelerators

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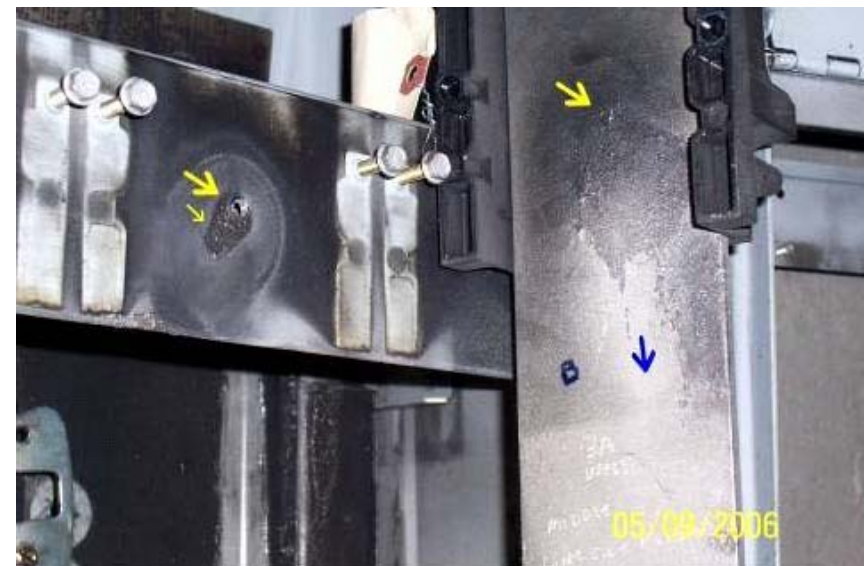
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GE Spectra Switches and Arc Flash Event

- On April 14, 2006, at Brookhaven National Laboratory (BNL), an electrical engineer was injured (first aid) by an arc flash while closing a General Electric (GE) Spectra Series 400 ampere (A) fused-disconnect switch in a 480 volt (V) electrical panel at the Relativistic Heavy Ion Collider (RHIC)
- The subsequent accident investigation listed the failure of the switch as a possible contributing cause of the arc flash. The switch being operated was destroyed together with an adjacent 400 A switch located in the same panel

GE Spectra Switches and Arc Flash Event



GE Spectra Switches and Arc Flash Event

- Cracks, broken insulating support structure, dislocated metallic clips observed
- A spare was operated approximately 4000 times during subsequent testing
 - Cracks in plastic support backing observed; almost identical to failed switches
 - During testing, screws became loose and fell out in the location of high voltage bus work
- Examined other Spectra series switches in operation
 - Switches were found to have significant structural defects
 - 32 percent of the GE switches rated at 400 amperes greater were found to have problems
 - Units rated below 400 amperes were found to have a 0.30 percent problem rate
 - In the higher rated switches, repeated switch operations cracks the backing material
- Lesson Learned: discovery of degradation of the switches over time with repeated operation prompted a general concern over the inspection and preventive maintenance program of fused disconnect switches; these switches were all replaced with a different brand switch and a routine inspection program was put into place

Melted Disconnect Switch

- On 5/10/07 at 0130, a power supply used for Booster to AGS extraction tripped. The power supply disconnect switch was found with the front panel off about 10 feet from the switch, and the plastic shield on the line side of the switch melted
- The subsequent accident investigation indicated the connection on at least one of the phases on the line side of disconnect switch caused heating from increased resistance, and the heating degraded the wire insulation and caused a phase-to-phase short

Melted Disconnect Switch



Melted Disconnect Switch

- The C-AD complex has on the order of 1000 metal-enclosed disconnect switches
- C-AD operates the facility with these switches closed for ~20 to 30 weeks per year. Literature shows an average failure rate of 5.4×10^{-8} per hour for flashover on busses. Thus, 1:1000 C-AD disconnect switches is expected to fail this way on average every 4.4 years
- Lessons Learned:
 - Begin a proactive program to periodically check electrical device panel temperatures with an infrared detector to determine potential overheating conditions
 - Develop procedure on how to react to as found temperatures on electrical device surface temperatures
 - As part of acceptance on new systems, infrared test all new connections and new systems put into service

Overheated Wire

- On Friday February 2, 2007 a technician was testing a power supply. The power supply has an output of 15 V and 300 A. Part of the testing included attaching a resistive load to the power supply and cycling the power supply at +/- 300 A rms. The resistive load consisted of a length of 2/0 AWG cable.
- Normally this test is performed over a period of ½ hour and the resistive load warms during this test
- The cable overheated and smoke alarms went off. The Fire Department used a small fire extinguisher and there were no injuries or significant equipment damage
- The subsequent accident investigation determined the 2/0 AWG cable was spliced together with a split-bolt connector and that significant overheating initiated at the connector

Overheated Wire



Overheated Wire

- Lessons Learned:
 - The use of split-bolt connectors are common throughout the complex
 - These connectors require routine inspection and maintenance since they can become loose and cause local overheating
 - When applicable use un-spliced cable or when splicing stranded cables, use permanent compression-type connectors
 - When using split-bolt connectors for splicing stranded cables, perform periodic inspection for corrosion and tightness of the connector