

NRC Position on Probability of Breaching Well-Sealed MCCs of 440V or Greater

Purpose: To establish a probability of breaching a well-sealed MCC in support of FAQ 14-0009 which establishes the probability of cable damage in the overhead from well-sealed MCCs

Discussion: Fires capable of breaching a well-sealed MCC are arcing fires. Arcing fires applicable to the FAQ which this analysis supports are fires that exhibit arcing behavior, but do not exhibit the extent of energy in a high energy arcing fault (Appendix M of NUREG/CR-6850/EPRI 1011989). These fires are characterized as non high energy arcing faults in NUREG-2169/EPRI 3002002936, "Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database," December 2014.

The updated database which is a significant improvement over the existing EPRI fire events database is utilized for this analysis. The analysis is based primarily upon the database as it existed for EPRI 1025284 "The Updated Fire Events Database: Description and Content and Fire Event Classification Guidance", July 2013, with a correction cited to the event 209 severity by NUREG-2169/EPRI 3002002936, "Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database," December 2014. The updated database is a substantial improvement since substantially more plants have reported data to this database and more complete event descriptions exist than in the preceding EPRI fire events database. The more complete database leads to different conclusions on the fraction of arcing fires out of the totality of MCC fires.

The following MCC events from the updated database exhibit arcing behavior of interest and count towards arcing fires, and thus, could cause damage outside of the cabinet. The event descriptions are derived from the published database information, as well as from original sources of information collected as a part of the database development process.

- Event 144:
Severity for cabinet fire frequency: Potentially Challenging from EPRI 1025284.
Potentially Challenging in later NUREG-2169/EPRI 3002002936 (2000-2009 data).

Conclusion for MCC application: Arcing conditions such as conductive vapor, molten metal, from a fault, where conductive path was created from bus bars to metallic pan in bottom of MCC. Also, significant scorching and smoke deposits indicative of a relatively energetic event are on the inside of the MCC. If upstream breaker had not tripped, overcurrent condition would have been extended, leading to a more significant event, e.g. potential explosion. Count for arcing fire is 0.5.

Description of event: Power was lost to the valves at 1238 when the supply circuit breaker for 480 VAC motor control cubicle (MCC) 2B-53 tripped as a result of a bus to ground electrical fault. At 1244, operators dispatched to investigate the breaker trip discovered a small fire in the MCC, which they immediately extinguished. The cause of

the fire in MCC 2B-53 was determined to be a misalignment of the circuit breaker stabs that connect the 2VSF-1A circuit breaker to the bus bars that resulted in both sides of the "C" phase stab and its associated spring clip ending up on one side of the bus bar, thereby creating a high resistance connection. Subsequent starts of 2VSF-1A likely resulted in arcing which increased the resistance at the connection due to oxidation at the contact points. When an attempt to start 2VSF-1A was made on October 30, the large inrush current of the motor at the high resistance connection caused the spring clip to melt. It cannot be determined if the molten metal from the spring clip caused a fire in the bottom of the MCC which created a conductive vapor in the cabinet or if the clip simply vaporized, creating the conductive environment. Nonetheless, the result was that the conductive vapor created an arc path to ground between the bus bars and the metallic dust pan in the bottom of the MCC, resulting in significant damage to the bus bars. The upstream circuit breaker tripped immediately, terminating the over-current event. A photo of the MCC shows substantial scorching and smoke deposits on the inside of the cabinet, which is reflective of a relatively energetic arcing event.

- Event 152:
Severity for cabinet fire frequency: Potentially Challenging from EPRI 1025284.
Potentially Challenging in later NUREG-2169/EPRI 3002002936 (1990-1999 data).

Conclusion for MCC application: Count of 1 for MCC application due to door blowing open from fault. Intense heat as characterized by melting of metal and plastic in cabinet.

Description of event: On 10/23/07, a fault occurred internal to Motor Control Center (MCC) 2B-52 associated with breaker 2B-52A5 when charging pump 2P 36A was started. The fault resulted in damage to the associated vertical bus bars in the MCC and a small fire that self extinguished. Feeder load center breaker 2B-532 tripped, de-energizing MCC 2B-52. Unit 2 declared an Alert Emergency Class Declaration due to the fire and several safety related loads being electrically isolated when the feeder breaker tripped. During this event the heat from the fault caused the MCC plastic base pan and the space heater wires in the MCC to catch on fire and pressure from the fault caused the side wire way door to open exposing the adjoining wire way. A photo from the event shows the blown open door and the subsequent flash damage on the front of the MCC panel.

Additional inspection the charging pump breaker with the cubicle door open was initially performed. Initial inspection results determined that the fault did not appear to originate inside the breaker cubicle, but rather behind the cubicle in the vertical bus channel. The inspection cover below the breaker was removed and a video-scope inspection of the breaker stabs and associated vertical MCC bus bars was performed prior to disturbing the starter cubicle. These photos revealed molten metal / slag at the outer C and B phases where the stabs engaged the bus bars. All stab fingers were properly aligned with the bus bars. All 3 vertical bus bars in the MCC cubicle were found to be melted (from the bottom up) up to the first horizontal bus brace (~ 4" of bus bars melted to within ~6" of the breaker stabs). The plastic bus seal-off channel below the buses was completely melted / burned away. Visual inspection following removal of the starter

cubicle and bus safety barrier indicated questionable engagement/contact of the stab fingers on all 3 phase bus bars which is believed to be the root cause of the event.

- Event 209:
Severity for cabinet fire frequency: Not Challenging for Frequency from EPRI 1025284. Potentially Challenging in later NUREG-2169/EPRI 3002002936 (2000-2009 data). Obvious correction to potentially challenging from not challenging needed from description which cites flames, explosion, and cubicle door blown open.

Conclusion for MCC application: Count of 1 for MCC application due to explosion and door blowing open

Description of event: Incident Report Number 1-90-52. While removing Clearance 594741 on HS-P-1B places MCC pan back on bus, closed cubicle door and turned linestarter on. At the local pump controller the operator noted the green 'off' light flickering. When the control switch was placed to the "on" position a loud explosion was heard. Smoke and Flames were seen at MCC 1-12 cubicle B (located in normal switchgear room in the control building). Cubicle door had blown open, MCC had tripped and Control Room noted loss of "F" 480 volt substation. A CO2 fire extinguisher was used by the operator to extinguish the fire. MCC inspection revealed what appears to have been shorted bus-bars. Motor was cool to the touch. Both MCC supply breaker and substation feeder breaker tripped on overcurrent. It is suspected that a piece of foreign material (possibly broken stab spring) was jarred loose when contactor on MCC pan was pulled in resulting in a phase-to-phase short.

- Event 10338:
Severity for cabinet fire frequency: PC-CH for Frequency from EPRI 1025284. Potentially Challenging in later NUREG-2169/EPRI 3002002936 (2000-2009 data).

Conclusion for MCC application: Count of 1 for MCC application. Energetic event as characterized by molten metal, fumes, and parts produced, along with electrical flash and fire. Door cracked but ejected mass and signature of energetic event leads one to conclude that door likely would have blown open.

Description of event: Breaker underwent catastrophic failure. The breaker serves Steam Generator Blowdown Pump 1A (BB Pump 1A). At the time of the failure, the breaker was closed, the cabinet door was cracked open and one person was observing the motor starter relay to determine the time at which it actuated, so that current and transients could be measured by an inductive pickup installed on the pump motor power cable (located in the wiring raceway compartment adjacent to the breaker cubicle). When the pump start switch was actuated on the main control board, the breaker failed catastrophically. The breaker failure was more severe than plant personnel could recall. Electrical flash, fire, smoke, molten metal, metal fumes, metal parts, and plastic parts were produced. This was the occasion of a near-miss injury. Subsequent to extinguishing the fire, the status of the motor control center was thought to be de-energized, but was actually still energized. Live line supply leads had been blown off the breaker terminals and were hanging outside the cubicle doorway. The breaker assembly ('bucket') was pulled outward to disconnect it from the electrical bus while the bus was unknowingly still powered. This was the occasion of a second near-miss injury.

The severe injury risk and the severity of breaker failure prompted a management request for a root cause analysis that focuses on safety practices/injury prevention and the root cause/prevention of breaker failure.

- Event 20357:
Severity for cabinet fire frequency: Potentially Challenging for Frequency from EPRI 1025284. Potentially Challenging in later NUREG-2169/EPRI 3002002936 (1990-1999 data).

Conclusion for MCC application: Count of 1 for MCC application. Door open, but substantial force of explosion during maintenance activity would have blown door open if it had been closed.

Description of event: At the time of the event, a plant Control Electrician was performing an independent pre-job walkdown evaluation (i.e., non-intrusive visual inspection) of a previously identified deficiency concerning missing mounting screws from a bus cover inside the back of MCC 208. The inner bus cover is secured in place with two bottom screws. He opened the main door on the back of Cubicle 14 (the rear of the cubicle has three entrances: a hinged door in the center, and outer cover plates at the top and bottom), looked up into the upper section and observed the inside bus cover plate out of its normal position, angled away from the bus bar. In order to get a clearer look at the inner cover plate, the Control Electrician retrieved a four-foot step-ladder, removed the upper cover plate and set it on the floor. He climbed up the ladder (keeping his flashlight outside the cubicle) and looked into the upper section for about 10 seconds. He saw the inner cover plate start to shift, heard a loud explosion, and found himself standing on the floor. He was not injured. He was wearing a hard hat and safety glasses. The safety glasses aided in preventing a potential eye injury, which involved metal splatter from the resultant electrical arc. The Control Electrician contacted his Assistant General Supervisor (AGS) reporting his near miss incident and the electrical explosion at MCC 208. The AGS dispatched supervisory personnel to MCC 208 and informed the Control Room of the incident.

The 26 MCC fires in the updated database total to a MCC fire frequency of 20.5. These fires are characterized as challenging, potentially challenging, or undetermined in NUREG-2169/EPRI 3002002936, whereby challenging and potentially challenging each count as 1, and undetermined counts as 0.5 towards MCC fire frequency.

Note that the updated database documented in NUREG-2169/EPRI 3002002936 revised the source of event 10389 from electrical panel to main control board (MCB), which makes a minimal increase the fraction of arcing fires since the denominator of the fraction is slightly decreased. The EPRI database report, EPRI 1025284, has it listed as electrical panel.

Results: Taking all the above information into consideration, the fraction of MCC fires that are arcing fires = $4.5/20.5 = 0.22$. Thus the probability of breaching a well-sealed MCC from an MCC fire is 0.22.