# Incident Summary #II-1613228-2023 (#39797) (FINAL)

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| SUPPORTING INFORMATION | Incident Date | | October 2, 2023 |
| | Location | | Kitimat |
| | Regulated industry sector | | Electrical - Low voltage electrical system (30V to 750V) |
| | Impact – Injury | Qty injuries | 1 |
| | | Injury description | 1st and 2nd degree burns on the left wrist and hand, right wrist, and facial area. |
| | | Injury rating | Moderate |
| | Impact – Damage | Damage description | Melted conductor and breaker switch terminal due to arc flash. |
| | | Damage rating | Moderate |
| | Incident rating | | Moderate |
| | Incident overview | | An electrician at a large industrial facility, completed electrical conductor checks inside equipment in a substation. The worker accessed a breaker bucket inside the substation and shorted phase to phase on the line side of the breaker switch that was energized at 347/600V. This resulted in an electrical short, creating an arc flash which caused burns to the worker. The worker was not contacted by electricity but received medical treatment for 1st and 2nd degree burns. |
| INVESTIGATION CONCLUSIONS | Site, system and components | | The site is a large industrial facility under construction. The construction project involves several contractors and hundreds of electricians working on the site. The site has several electrical substation buildings housing electrical components, switchgear, and controls. Electricians are required to complete several safety training courses prior to working in a substation on the site including:<br>• Site orientation<br>• Arc flash and shock training.<br>• Permit to work training.<br>• Lockout awareness training.<br>• Substation awareness training.<br>• Commissioning induction training.<br><br>The electrical system providing power to an electrical motor in the field has controls and overload protection contained inside of a motor control center (MCC) in the substation. The MCC consists of metal cabinet sections containing raceways to run conductors and fixed or removable modular units to distribute power to electrical loads such as motors. Units containing circuit protection devices use a rotary operating handle (Image 3) on the door to allow operation of the disconnecting means from outside the cabinet.<br><br>Modular withdrawable units (Buckets) have a lockable, multi-position handle that controls the disconnecting means as well as a mechanical interlock, preventing the unit door from opening unless the handle is in the “off” position and the bucket from being withdrawn from the MCC unless the handle is in the “Test” position. When the handle is in the off position, the door to the MCC bucket has three, quarter turn latches that can be unlatched to open the cabinet door. The middle latch has the ability to add a lock (Image 3), which can block the latch and prevent the door from opening.<br><br>Some MCC buckets have a through door voltage indicator (Image 4) which will show lit led lights when there is voltage present inside. The indicators are used as a |

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| | supplement for establishing electrically safe work conditions and are wired to show the presence of voltage. The typical installation of an indicator is to be wired downstream of the fused safety switch or breaker. With the breaker/switch closed "on" the indicator lights would be lit identifying dangerous voltage inside, but when the breaker/switch is off, the LED lights would not be lit or indicate dangerous voltage from the energized line side conductors which may be inside the enclosure.<br><br>An electrical circuit breaker or disconnect switch typically has a line side and a load side. The line side is the electrical feed to the breaker/switch and the load side goes from the breaker/switch to the electrical load. When the breaker/switch is in the open position "off" the load side is de-energized with the line side remaining energized.<br><br>Pre-commissioning of the electrical system between an MCC and the motor includes point to point testing of the load side electrical conductors with an electrical meter. The testing confirms continuity through the electrical conductor and ensures electrical equipment is wired correctly and conductors are going to the correct terminals.<br><br>Section 2 of the CSA electrical code (2-304) requires that equipment be de-energized before work commences. The safety provisions protecting live equipment from accidental contact such as cabinets, covers, enclosures, guards, or barriers shall not be removed exposing live parts unless the task to be performed is not possible while de-energized. When work must be carried out on energized electrical equipment, the persons performing the work must be trained to understand the specific hazards and use the appropriate personal protective equipment (PPE) to protect against shock and arc flash (*https://www.technicalsafetybc.ca/regulatory-resources/regulatory-notices/information-bulletin-bc-electrical-code-section-2-requirements-de-energize-electrical*).<br><br>It is common industry workplace knowledge with qualified electricians to always "Test before touch" and assume all equipment is energized until it can be tested and verified not to be before commencing work on it.<br><br>Safety protocols on the site require electrical work to have a permit issued by the on-site permit authority before work begins. If the work is deemed "high risk", a field evaluation and walkthrough is conducted by the permit authority before approving the scope of work.<br><br>Access to the substation is monitored by the substation controller. When workers need to perform work inside the substation, they need to contact the substation controller to request access though locked doors. The substation controller is expected to review and assess activity being done in the substation to confirm personnel performing the activities understand the associated hazards. The workers then need to sign in and sign out on a form documenting the access to the substation.<br><br>When the flow of electrical current deviates from its intended path to ground or another electrical phase it produces an arc fault. When an arc fault occurs, the light and heat produced is referred to as an arc flash. The severity of the arc flash is dependant on the available voltage and current as well as the time it takes to clear the fault. An arc flash can produce temperatures in excess of 35,000ºF (19,400ºC) and vaporize metal conductors and equipment blasting molten metal and plasma outward with great force which can cause damage and injury. |
| Failure scenario(s) | The job of conducting point to point checks on electrical conductors in the substation was planned and a permit was applied for, reviewed, and discussed with the permit receiver. The scope of the job was not deemed "high-risk" and field validation and a |

walkthrough by the permit authority was not conducted when approving the scope of work.

The electricians signed into the substation but did not contact the substation controller prior to entering the area as per requirements. The substation controller was expected to review and assess activity being done in the substation to confirm personnel performing the activities understood the associated hazards.

The load side conductors in the MCC had been terminated to the breaker switch by other electrical contractors before the field wiring was complete. The rotary handle on the MCC bucket was in the off position and had several lockout locks and tags affixed to it. The breaker switch in the off position disconnected power to the load side of the breaker switch while the line side of the breaker switch was still energized with 600V. The rotary handle in the off position does not prevent the cabinet door from being opened which allowed access to energized equipment. Opening of a cabinet that contained energized 600V equipment required arc flash resistant PPE. The electrician was not wearing arc flash resistant PPE but was wearing fire retardant coveralls, a hard hat, safety glasses and gloves.

The electrician had conducted similar point to point testing several times but was not familiar with the MCC equipment. Their understanding was that when the rotary handle on the MCC bucket was locked in the off position and the lights on the through door voltage indicator were not lit, that there were not any energized components inside. They opened the MCC bucket door instead of the adjacent raceway where the tests could have been conducted without exposing energized equipment. The electrician found the load side conductors inside the MCC bucket had been terminated onto the breaker switch and they were unsure how to complete the tests with the conductors terminated that way. They inquired and sent a photo of the conductors to the work crew lead hand. The lead hand texted the photo to the foreman. The foreman responded that the tests could be conducted on the load side of the breaker switch. The lead hand informed the worker of how to conduct the tests based on the photo but did not attend the field to review and the foreman was unable to attend because he did not have the required training that would allow him to enter the substation.

The work inside the substation requires a meter to test for voltage before touching any equipment. One meter was used between the two electricians conducting the testing and it was with the electrician on the field side of the conductors. The electrician in the substation did not have a meter and did not test to verify zero energy on the equipment before touching it. The job was to use a jumper wire to short two de-energized conductors together so the electrician in the field could used the meter to identify and confirm they were correct.

They removed their protective glove on their left hand because they found it difficult using the jumper wire with the gloves on. They intended to short the conductors on the load side of the breaker switch with a small jumper wire but mistakenly shorted the conductors on the energized line side. The shorting of the two 600V 3 phase conductors created an arc flash that expelled intense heat, gasses, and molten metal particles burning the individual.

The orientation of the breaker switch was horizontal and had the line conductors on the right-hand side and the load conductors on the left-hand side. The correct location to test the load conductors was in an adjacent raceway cabinet on the right-hand side of the MCC bucket. Without testing the conductors before touching it may have been assumed the load side was on the right-hand side of the conductors when in fact it was the opposite.

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| Facts and evidence | Interview Statements:<br>A) Foreman<br>○ They had not completed the required training to allow access into the site substations.<br>○ They were unaware the workers needed to contact the substation controller before accessing the substation to do work.<br>○ When sent a picture of the open MCC bucket from the lead-hand, they responded that the point-to-point test could be conducted on the load side of the breaker.<br>○ They were aware that there was energized equipment inside the cabinets for a couple of months before the incident and had discussed it along with "Test before touch" several times with the work crew during safety meetings.<br>○ The injured electrician had been working on the crew at the site for 7 months and had 17 years experience as a journeyperson electrician.<br><br>B) Electrician<br>○ They were partnered with another electrician located at the field side of the conductors and only that electrician had a meter to test for voltage.<br>○ They did not have a meter in the substation to test the components inside the MCC bucket for storage.<br>○ They saw the locked off rotary breaker switch handle in the off position and their understanding was that there were no energized components inside and it was safe to work on. They still don't understand how the switch was off, but it was still energized.<br>○ If they had a meter they would have tested for voltage.<br>○ They had done point to point testing many times before but was not familiar with the MCC equipment.<br>○ When they went to conduct the point-to-point tests, they found the conductors terminated and marked as torqued on the breaker switch inside the MCC bucket.<br>○ They took a picture and sent to the lead hand. Who consulted with the foreman and were informed they could be the test using a jumper wire on the load side of the breaker switch terminals.<br>○ They had discussed with the work partner and lead hand while reviewing the picture and they all concluded to test the terminals on the right side of the breaker switch.<br>○ They had removed their left-hand glove because they found it difficult using the jumper wire with the glove on.<br><br>Documents<br>○ The injured worker had a valid electrical certification.<br>○ The injured worker had completed all required training to do the work they were doing inside the substation of the site.<br>○ The installation instructions for the through door voltage indicator show voltage sensing wiring to be connected downstream on the load side of fused switches or breakers. |

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| Causes and contributing factors | The electrician shorting out energized conductors on the line side of the breaker switch instead of the intended de-energized load side of the breaker switch caused the arc flash and injury.<br><br>Contributing factors to the incident include:<br>A) Lack of supervision and an incomplete understanding of the hazards in the work area:<br>○ The permit authority considering the work low-risk and not conducting a walkthrough and field validation, and the electricians not contacting the substation controller prior to entering the substation. These steps may have identified the hazardous work procedure and lack of proper equipment before the work began.<br>○ The lead hand and foreman all confirming and agreeing the testing activity should take place inside the enclosure containing energized components instead of in the de-energized raceway.<br>○ The inability of the foreman to access the substation to provide supervision due to lack of required training.<br>○ The electrician in the substation not having a meter to conduct voltage tests to confirm components were de-energized before touching.<br>○ The opening of the MCC bucket containing energized equipment without the worker donning appropriate arc flash PPE exposed the worker to an arc-flash hazard.<br><br>B) The design of the electrical system and components.<br>○ The horizontal orientation of the breaker switch with the line side conductors connecting on the right side along with inadequate identification of the system components and locations relied on workers familiarity and testing to identify the present hazards.<br>○ The through door voltage indicator not identifying line side voltage present inside the MCC bucket contributed to the workers understanding that there were no energized components inside the cabinet.<br>○ The MCC bucket door latch not being locked allowing the cabinet door to be opened with breaker switch in the locked off position while still containing energized line side equipment allowed the worker to proceed with opening the cabinet and being exposed to hazardous energized equipment. |


Image 1 – Access door into substation with warning signs.

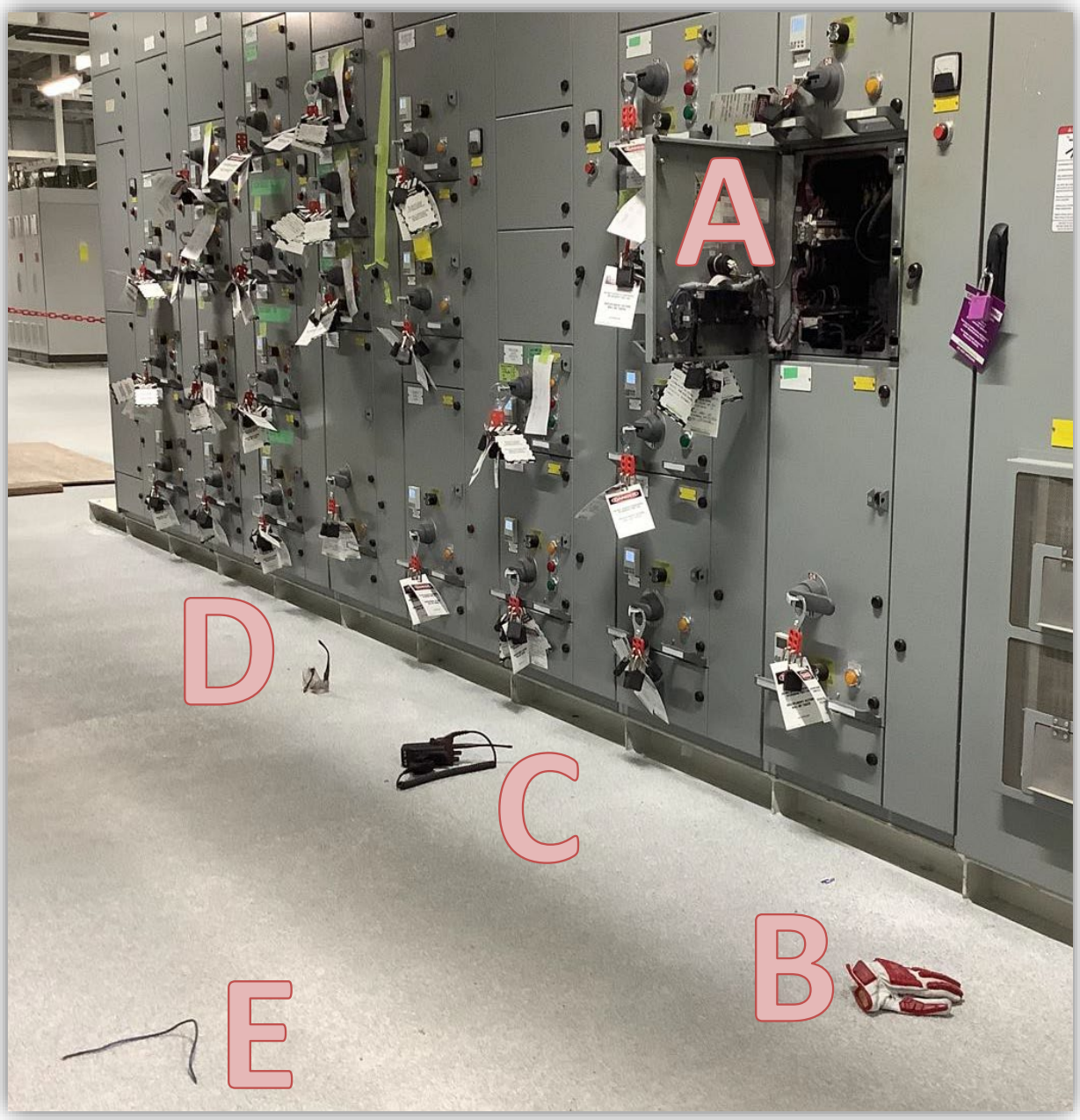


Image 2 – Substation electrical cabinets.

[**A**] The MCC bucket where the arc flash occurred.

[**B**] The left-handed glove removed by the worker before the incident.

[**C**] The handheld radio the electrician was using to communicate to the other workers.

[**D**] Safety glasses the electrician was wearing.

[**E**] The jumper wire used to short across the two energized terminals.

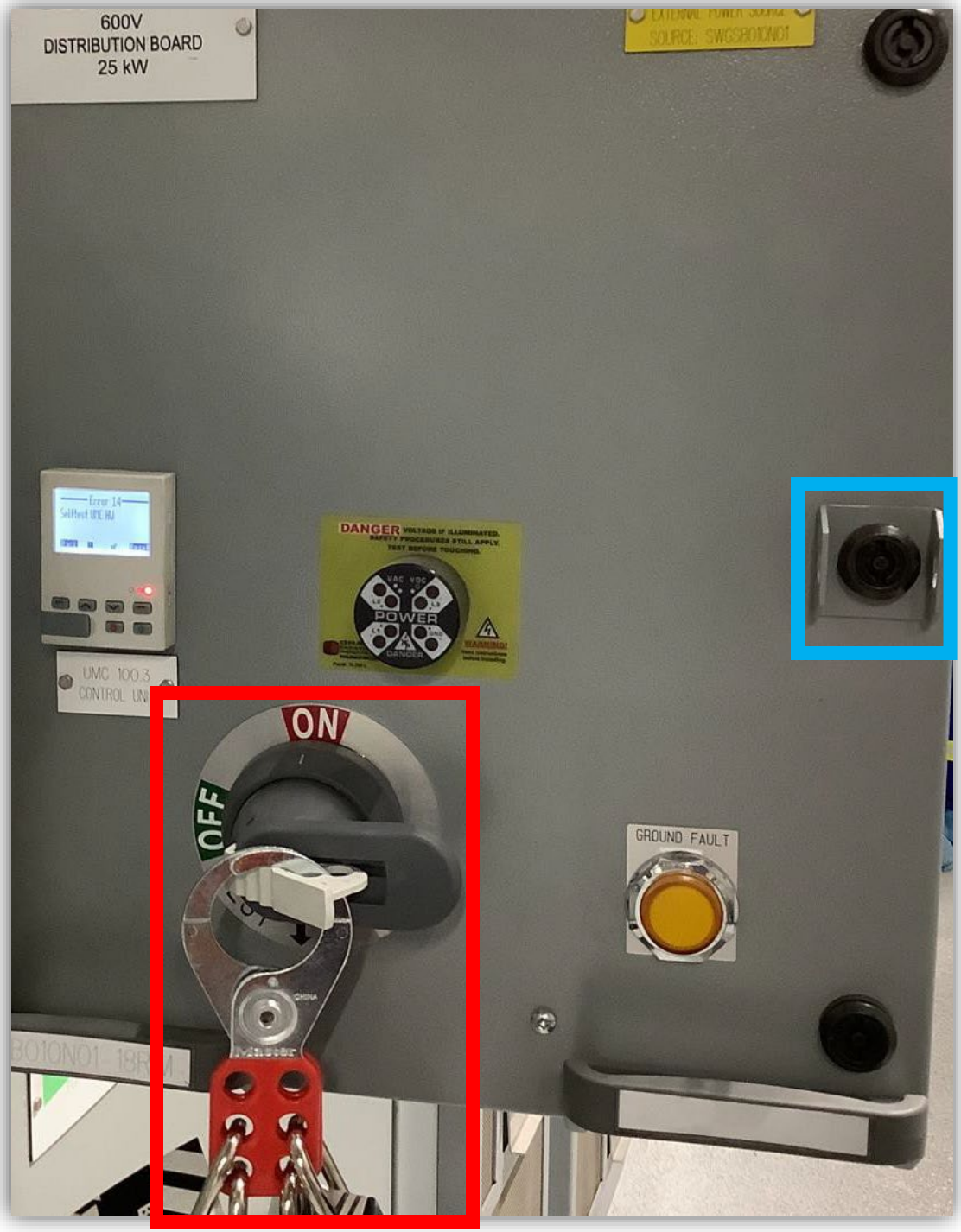


Image 3 – The MCC bucket door open. [**RED**] The lockout hasp with multiple locks affixed to the breaker switch, and rotary handle in the off position. [**BLUE**] One of three, quarter turned door latches that has a bracket allowing for a lock to prohibit opening of the door.


Image 4 – Closeup of MCC bucket door. [**BOX**] The through door voltage indicator identifying voltage on the load side of the breaker switch inside the cabinet.

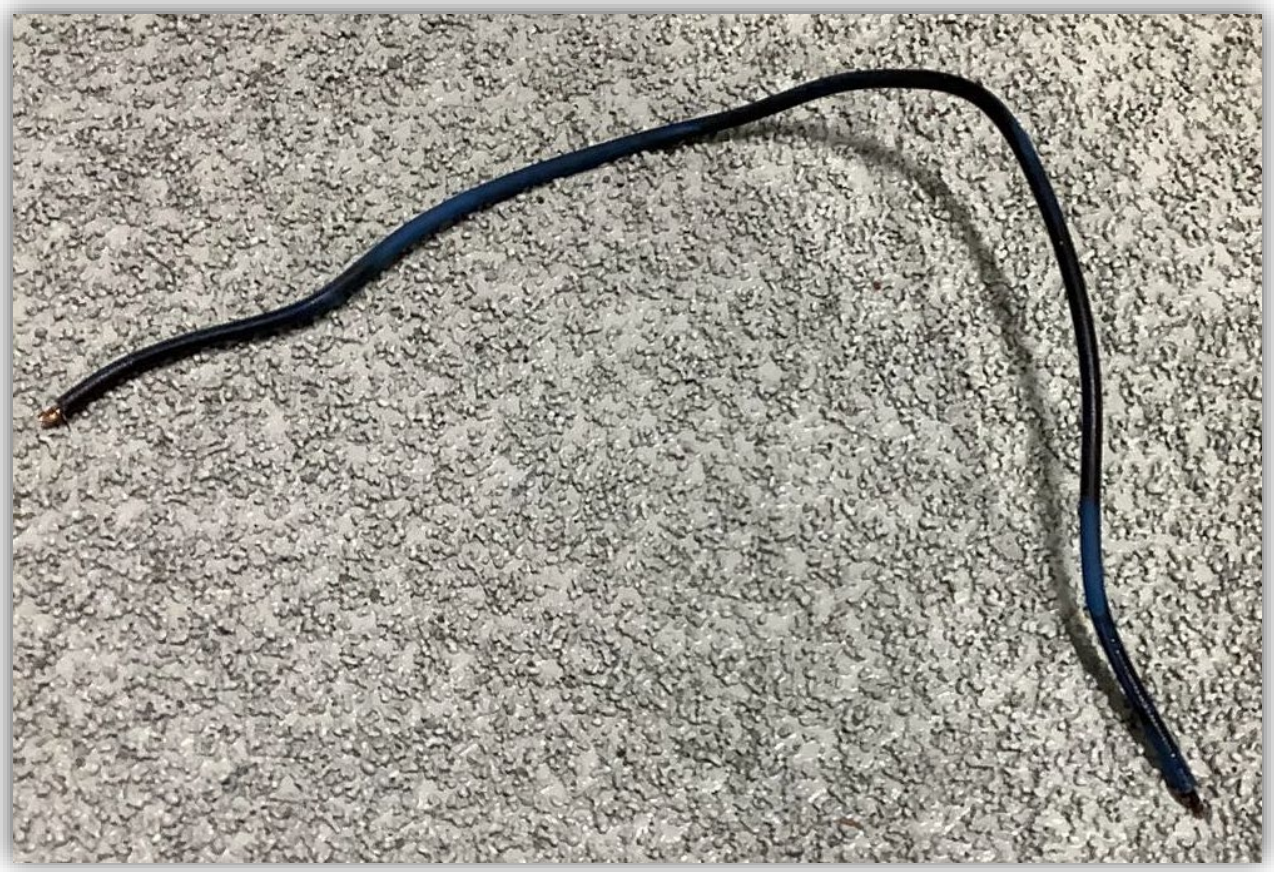

Image 5 – Closeup of the jumper wire used to short across the energized line side terminals.


Image 6 – Inside the MCC bucket showing black soot resulting from the arc flash. [**BOX**] The point-to-point testing should have taken place on the de-energized load side conductors inside the raceway to the right of the MCC bucket.

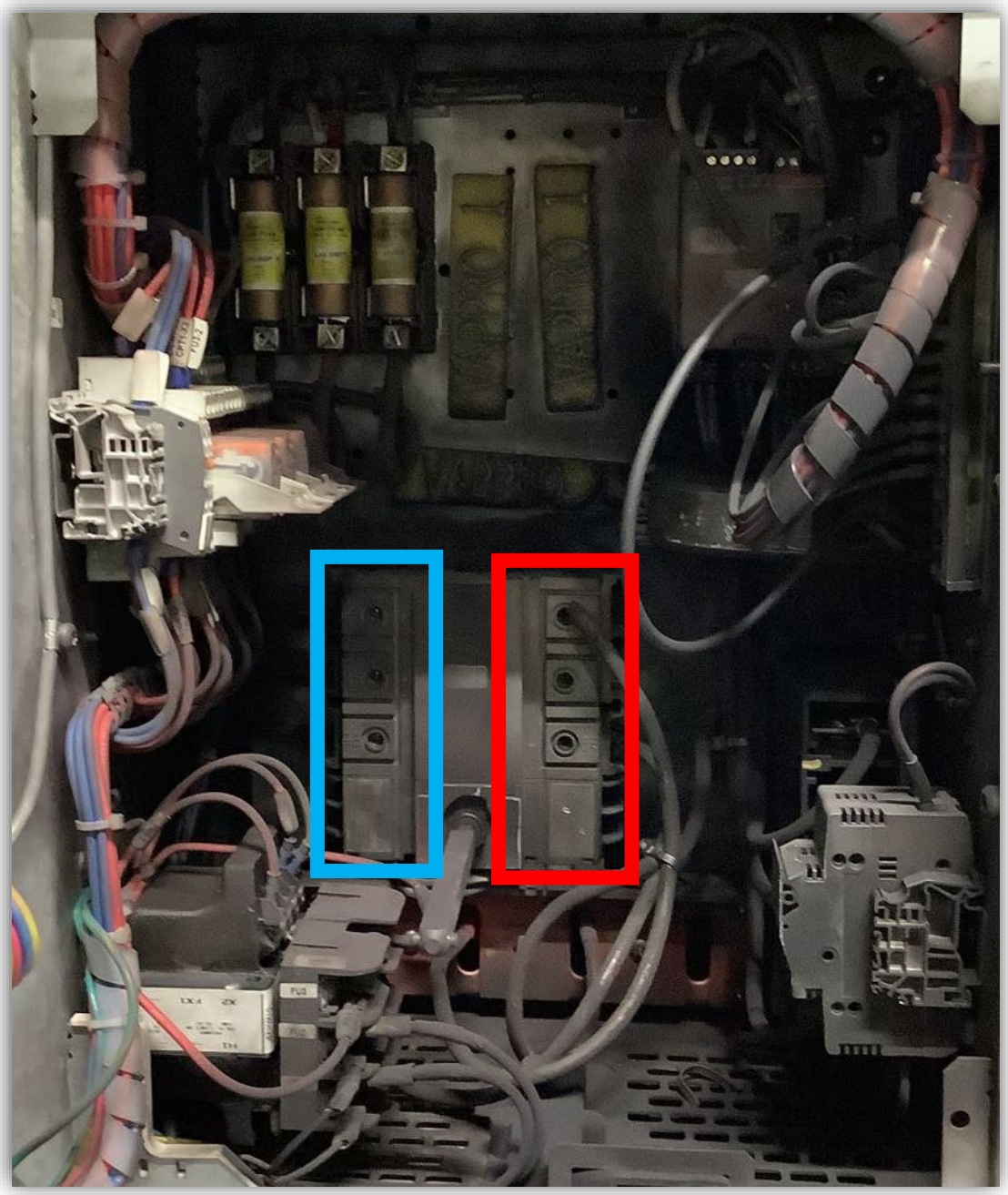

Image 7 – Inside the MCC bucket. [**LEFT**] The load side of the horizontally installed breaker switch (De-energized when breaker switch open “off”). [**RIGHT**] The line side of the horizontally installed breaker switch (Energized when breaker switch open “off”).

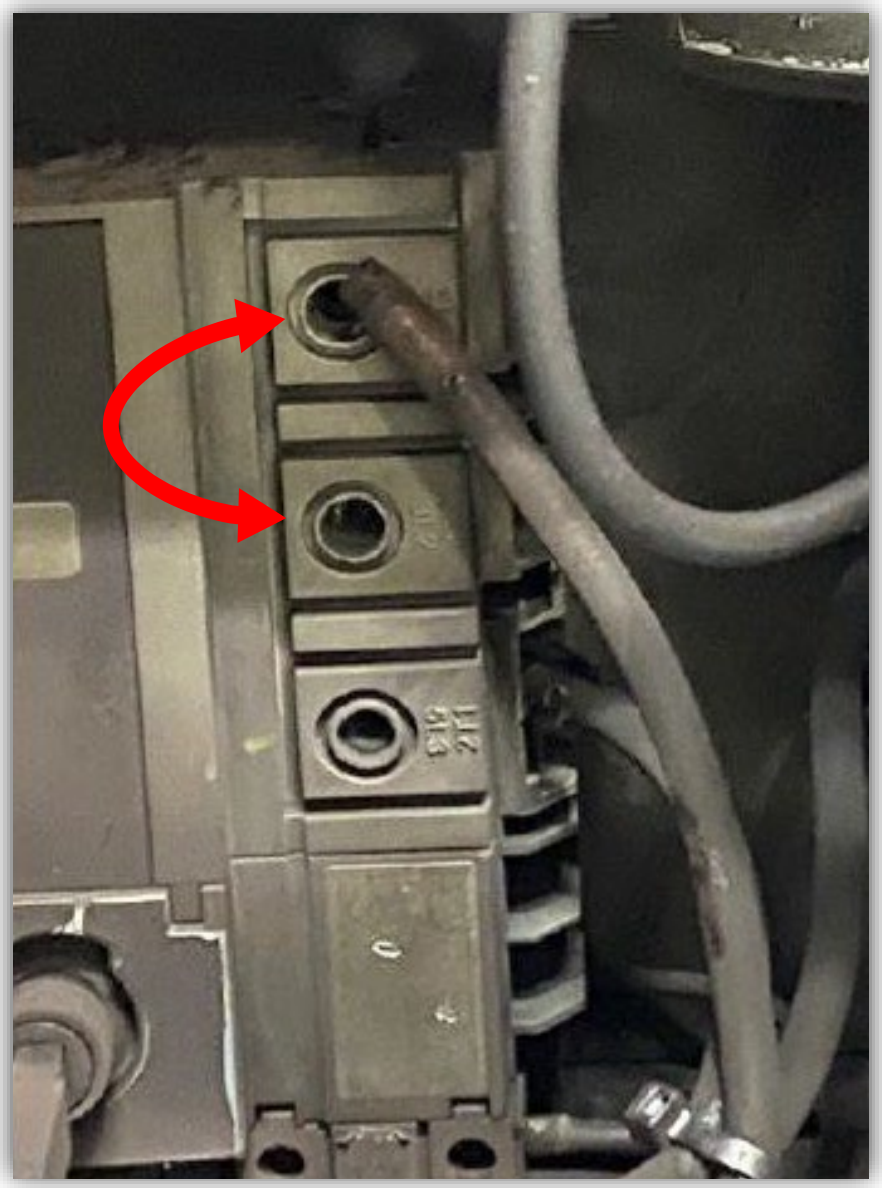

Image 8 – Closeup of line side breaker switch terminals. [**Arrow**] The energized line side terminals the electrician shorted out with the jumper wire causing an arc flash. Conductor melted and disconnected from terminal due to arc flash.