Incident Summary 5616104

SUPPORTING INFORMATION	Incident Date			May 16, 2017
	Location			Delta B.C.
	Regulated industry sector			High voltage electrical system greater than 750 volts
	Impact	Injury	Qty injuries	one
			Injury description	One person sustained loss of consciousness after receiving an electrical shock. The person sustained an entry burn to their right elbow and exit wounds to their right hand, top of head and left shoulder.
			Injury rating	Major
		Damage	Damage description	No damage occurred to the system
			Damage rating	None
	Incident rating			Major
	Incident overview			Workers were replacing the existing 4160 volt high voltage switch gear in a substation. While working on the inside of the equipment that was thought to be de-energized an electrician received a shock. Medical personnel responded and the electrician was transported to a medical facility.
INVESTIGATION CONCLUSIONS	Site, system and components			The site is a bulk loading facility that consists of a series of conveyers, offloading and loading equipment from rail cars to ships. Existing 4160 volt high voltage switchgear was in the process of being replaced with new modern equipment. When working in the interior of this particular piece of electrical equipment, multiple circuit breakers must be de-energized to ensure that there are no exposed energized terminals within the equipment that will pose shock and arc-flash hazards to workers. To safely operate, maintain, and work on this type of equipment, knowledge and understanding of the system components, design, and construction is required to prevent worker injuries. Adequate warning labels applied to the equipment must be placed in locations where workers will observe and follow any required safety precautions. Where owners, manufactures, and contractors are working in conjunction with one another a coordinated lockout, tag out and testing procedure must be in place to ensure that electrical equipment is de-energized prior to starting work.

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Failure scenario(s)	Workers were replacing the existing 4160 volt high voltage switch gear in a substation. Upon re energization of the electrical switch gear it was discovered that one of the pieces of electrical equipment was rotating in the reverse direction. The equipment owners electricians racked out (disconnected), isolated and locked out the high voltage circuit breaker feeding that piece of equipment that was rotating in the incorrect direction. The electrical equipment contained an integral grounding device that grounds the busses within each cubicle as an added safety feature, this feature was enabled by the owners maintenance electrician. The contractors electrician proceeded to the rear side of the equipment where the cable termination was located. The electrician tested the cable terminals that were to be worked on, but did not test all terminals within the enclosure. After completion of switching out the conductor terminations to correct the equipment rotation and while exiting the enclosure, the electrician contacted energized 4160 volt potential transformer (PT) terminals with his right arm. After receiving a shock the main circuit breaker feeding the electrical switch gear tripped within 100 milliseconds
Facts and evidence	BC Safety Authority received an incident notification of an electrical worker injured while working on high voltage electrical equipment. • Report provided by Worksafe BC indicated that the electrical equipment was not isolated, grounded and locked out prior to starting work. An interview was performed with the owner who stated that: • Aging electrical equipment located in substation 5 was replaced with new more modern equipment, (see photo 1) • The electrical equipment was being replaced in conjunction with the new equipment manufacturer, the owner, certification agency, an electrical contractor and commissioning personnel, (see photo 2) • After installing the new electrical equipment, it was discovered that electrical equipment was rotating in the wrong direction, • The equipment owner was responsible for isolating the electrical equipment by racking out the circuit breaker, • All sub-contractors were responsible for testing and ensuring circuit isolation, • Electrical sub-contractor was given verbal permission to proceed and reverse two phases within the cable termination compartment, • While working within the cable termination compartment, the individual received a phase to ground shock of 2400 volts. • Ground fault relay equipment tripped within 100 milliseconds An interview was conducted with the electrical sub-contractor who stated that:

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- Their job was to provide labor only and all voltage testing was the responsibility of the equipment owner,
- Journeyman electrician was working within the cable termination compartment when accidental contact was made between an energized potential transformer connection and ground. (see photo 8)
- Even though the circuit breaker to the cable compartment had been racked out, everyone working onsite were either unaware or failed to identify that a voltage was still present within the cable termination compartment,
- Inadequate warning notices had been provided, a warning notice had been applied to the front of the PT enclosure, but not on the back of the cable termination cabinet, (See photos 5, 6 and 7)

An interview was conducted with the individual who received the shock who stated:

- My recollection of the day is limited to about 2 hours and I don't remember very much

An interview was conducted with the equipment manufacturer who stated:

- The equipment had been built to CSA standards C22.2 number 31
- Although this was a cable termination compartment no one should have being working inside this enclosure,
- Adequate warning notices had been applied to the equipment in accordance to the CSA part 2 standard,

An interview was conducted with the equipment certification agency who stated:

- The equipment had been properly constructed to the applicable CSA part standard 2 standard, therefore their SPE 1000 label was applied,
- After the incident had occurred, the certification agency conducted a review of the equipment and confirmed the original certification of the equipment

An interview was conducted with a 3rd party high voltage commissioning contractor who stated:

- The existing neutral grounding resistor was open and that it had been replaced,
- Employee of electrical sub-contractor tested for potential voltage at the cable termination bus using a modiewark high voltage tester,
- Confirmed modiewark high voltage testing on the 4200 volt scale, but did not test within the entire cable termination enclosure,
- Could not install the grounding cables due to the lack of room within the cable termination enclosure,
- System integral grounding device had been applied. (System Integral grounding is an internal grounding system built within the equipment thereby eliminating the requirements to manually apply grounding conductors to the phase conductors. See photo 5)
- Had we known that other voltages were present we would not have conducted work in this manor

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	Causes and contributing factors	• Everyone working on the electrical equipment were either unaware or failed to identify that a voltage was still present within the cable termination compartment, • The Potential Transformers were fed from the line side of the busbars, and those terminals were continually energized and accessible within the cable termination cabinet. (see photo 6 on how to isolate PT's) The items below combined lead to a very likely chance of an electrical incident occurring, • Failure to adequately test for potential voltages within the termination cabinet, In no particular order, the following items also very likely contributed to the incident: • Poorly drawn one line diagram of the electrical equipment, • Lack of warning or signage on the cable termination enclosure door, • The cable termination cabinet was compact and confined (see photo 9), • Performing electrical work in the cable termination cabinet was only accessible by working on the floor, your body in an awkward position, • Lack of communication and knowledge of the electrical switch gear by all parties, • Lack of responsibility between the owner and electrical subcontractor. Both thought that the other party was responsible for testing the equipment to ensure it was not energized, • No one was aware or communicated that the PT's were fed from the line side of the bus bars, • Unless the main bus bars were de-energized and grounded, multiple power sources were available in the cable termination cabinet.

Photo 1,
Photo indicates the exterior view of substation number 5 where the electrical switch gear inside the building was being replaced. The photo also shows one of the two 13,800/4160 volt, 5 megawatt step down transformers that feeds the electrical distribution equipment inside the building.

Photo 2:
Overview of the newly installed 4160 volt electrical switch gear.

Photo 3:
Frontal view and location of "cell number 10, S3 Feeder" identified with the blue arrow.
Lower enclosure contains the Potential Transformers used for control circuitry (Tan arrow),
The middle enclosure (black arrow) contains the 4160 volt, high voltage circuit breaker which can be racked out so that electrical work can be safely performed on the equipment downstream from this point.

Photo 4:
Front view of the circuit breaker for cell 10, S3 Feeder,

Photo 5:
Frontal view, PT enclosure of cell 10 indicating the procedure to follow before working inside the enclosure (red arrow). Blue arrow indicates an integral grounding device that will ground the load side of the equipment without having to use the grounding cables.

Photo 6:
Close up view of the PT ‘s warning notice which identifies how to proceed prior to working inside the enclosure

Photo 7:
Rear view of cell number 10, cable termination enclosure which measures approximately 25 inches wide by 25 inches high. No warning notice indicating that an additional power source may be available if the cover has been opened or removed.
The rear side of the cabinet is where the feeder cable to the electrical equipment is terminated.

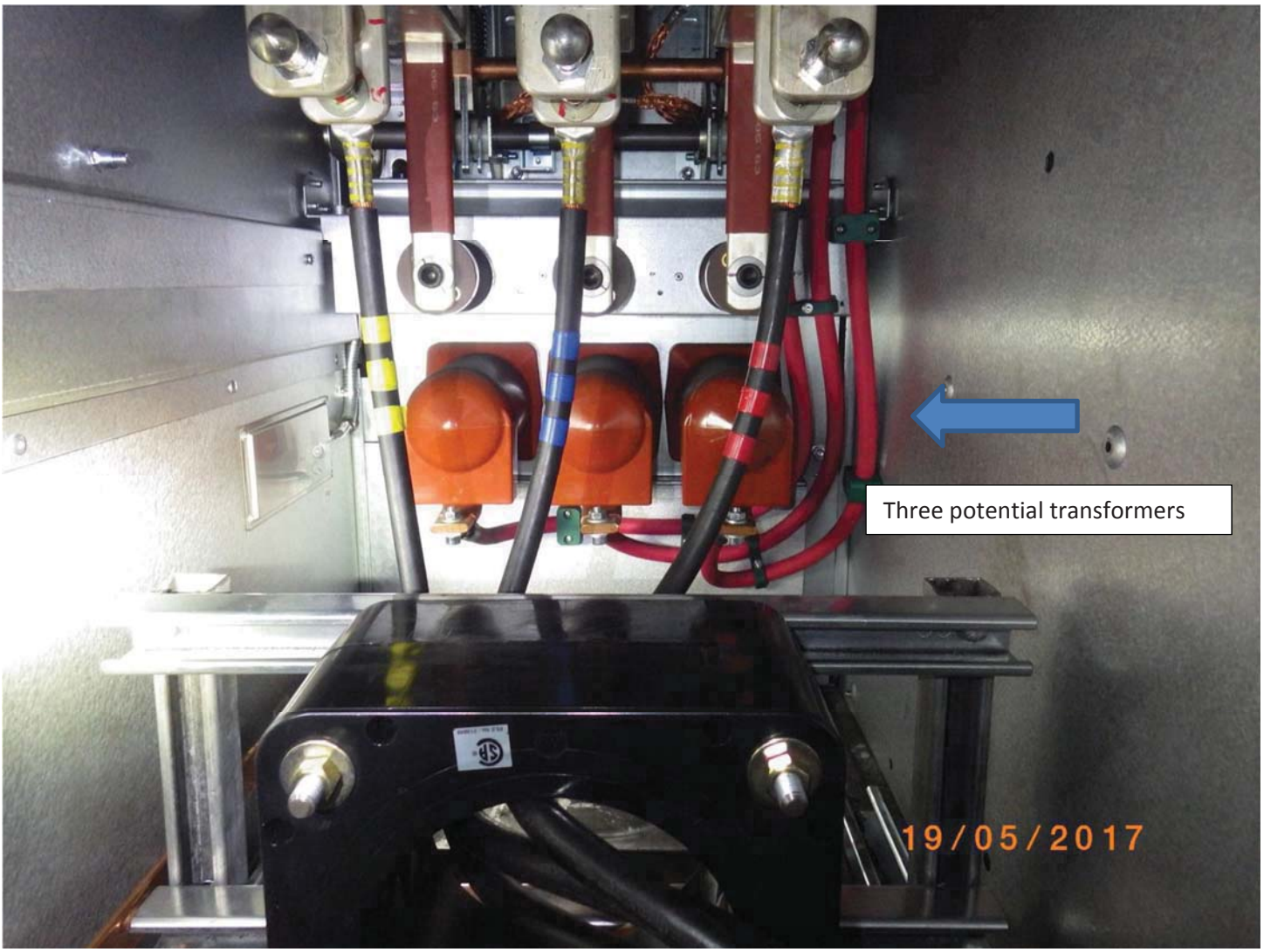

Photo 8:
Photo taken through the viewing window from the back of the electrical switch gear.

Photo identifies three potential transformers (brown items and at the back of the enclosure) that are fed from the line side of the busbars. Unless the PT's are disconnected as indicated by the warning notice on the front of the enclosure, they are continuously energized.

The 3 black conductors identified yellow, blue and red are from the load side of the circuit breaker and feed electrical energy to equipment located within the facility.

Unless you are familiar with the switch gear assemble, it is possible to work on the de energized feeder conductors, and still work in an energized cable termination enclosure.

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Photo 9:
Photo taken from the backside of the equipment.
No warning notice indicating that electrical energy is available even though the circuit breaker has been turned off and isolated.