

Incident Summary #II-1480971-2022 (#30678) (FINAL)

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| SUPPORTING INFORMATION | Incident Date | December 10, 2022 | |
| | Location | Northern Region | |
| | Regulated industry sector | Electrical - High voltage electrical system (greater than 750V) | |
| | Impact Injury | Qty injuries | 1 |
| | | Injury description | High voltage shock with entrance and exit wounds at the elbow and wrist of one arm. Broken pelvis and impact injury to the shoulder from subsequent fall from ladder. |
| | | Injury rating | Major |
| | Damage | Damage description | N/A |
| Damage rating | | None | |
| Incident rating | Major | | |
| Incident overview | A roofer was preparing for roof drain connections near the underside of the roof in an industrial building with unlocked entrance doors. While working from a ladder, the roofer contacted an energized high voltage bus bar running near the ceiling and experienced a serious injury from the exposure to the high voltage electrical energy. | | |
| INVESTIGATION CONCLUSIONS | Site, system and components | <p>The site is a metal production facility constructed in 1956. While no longer in use for production, the roughly 12,000 square foot building where the incident occurred had an active power factor correction system for the larger site. Power factor correction is used to reduce energy consumption through adjusting the system's power factor closer to unity power typically by adding capacitance to the system.</p> <p>The power factor correction system included a three phase 13,200-volt line to line bus bar system, 7,620-volt line to ground that ran at height inside the building. There are line breakers behind locked cages in the building that connect to the bus bar system. The bus bars connect the power factor correction system with the exterior high voltage system for the site. The bus bar system is run over eleven feet high near the underside of the roof, isolating the high voltage from occupants of the building by elevation. The bus bars are supported from the buildings structural metal support beams by ceramic insulators.</p> <p>The roofing components being worked on included pipes and fittings to interconnect the existing interior metal drainpipes with new drains for the flat roof.</p> <p>When a person contacts an energized electrical component and a grounded surface, they can become part of the electrical circuit. When the circuit is high voltage, the electrical current can pass through the body with more likelihood of serious burns including where the electricity enters and exits the body as well as along the path between those points.</p> | |

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For buildings that have bare energized high voltage parts, access control methods include, administrative controls, limiting access, hazard awareness training, physical barriers, elevation by height, and signage.

The facility has a safety procedure that includes the following:

- General objective and scope to ensure that contractors are informed about and protected from risks to their safety and health while working on or near high voltage equipment on the property.
- Safety of unqualified employees
 - Unqualified employees are not permitted to enter any facility, and, to be in the vicinity of energized electrical equipment, unless authorized to be there by area supervision of the facility.
 - The area supervisor will, as they deem necessary, assign a qualified facility employee as a “safety watcher” to accompany the unqualified employee(s).
- The procedures include minimum requirements for prevention of high voltage electrical injuries to workers including those without qualification.
- Access procedures include methods intended to ensure unauthorized personnel are not being exposed to electric shock and arc flash hazards.
- The procedures preclude unauthorized personnel from access to exposed live/uninsulated conductors and entering within the arc flash boundary around high current switchgear.
- For unqualified employees to be in the vicinity of energized electrical equipment, authorization is required from facility supervision.
- Unqualified employees entering the facility shall be accompanied by a qualified facility “safety watcher” who shall ensure the safety of the visitor.

Definition of Safety watcher - A person designated to provide their undivided attention to ensure that other workers...are not put at risk as a result of special hazards in the workplace. The safety watcher shall be qualified for monitoring the work activity being performed. They shall be identified to all persons involved in the work or activity and shall have full authority to immediately stop all work or activity. The safety watcher and the persons monitored shall, be in clear sight and/or communication with each other. The person acting as safety watcher must be equipped with the necessary tools and safety equipment to render assistance, if required.

- “Unauthorized personnel” is defined as persons who have not received the specific access approval. To receive access approval, they should have completed the required electrical hazard training.
- Where it is necessary for untrained personnel (e.g., visitors) to enter controlled areas, there should be a system for communicating the hazards and escorting them with appropriately trained personnel. Contractors are to have a permit to work in controlled areas.
- The intent of this provision is to ensure that all controlled areas are clearly marked and that hazards in the controlled areas are communicated. All work performed by contract personnel should be performed under a permit system. Personnel are to be trained and authorized to enter a controlled area or escorted by a trained and authorized person.
- A system for control of access should be in place.
- There should be a system in place whereby untrained personnel are prohibited from entering controlled areas unless escorted by authorized personnel.
- All employees and contractors should be trained to recognise controlled areas that are restricted to entry by authorized persons only.

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- There should be a system in place to warn and inform all contractors of the hazards that exist within the controlled areas in which they may be required to work or visit. Such systems might include permits, inductions, and authorizations.
- All controlled areas should have appropriate signage to warn untrained and contract personnel of unauthorized entry.
- A system for training persons and authorizing them to access exposed energized conductors in excess of 1,000V should be in place.
- Site-specific high voltage access procedures should be in place.
- The limit of approach for unqualified workers to exposed 13,200-volt line to line electrical conductors and equipment is 3 meters (10 feet).
- This limit can be reduced to 1.20 meters (4 feet) if the unqualified worker is continuously directed by qualified electrical workers.
- Access to controlled areas and limits of approach for contractors:
 - Contractors and contractor employees working without direct supervision by a qualified facility employee shall observe a limit of approach of 6 meters (20 feet) to all electrical lines and apparatus unless they:
 - a) have received specific job instruction and training in the safety practices to be observed in the area,
 - b) have been instructed and know the voltage of electrical lines and apparatus adjacent to the work area and the limits of approach applicable to them,
 - c) have been instructed and know the safe limits of their movement in the work area, and
 - d) have been instructed regarding the hazards associated with the area and the work in which they are to be involved.

Work authorization numbers

- Work authorization numbers are used to inform the facility operator about work being done in areas under their control.
- Work authorization numbers are also used to document and control the entry of non-power operations personnel into those areas.
- Only qualified persons, who have received safety training for the area they are entering, may receive a work authorization number.
- Qualified personnel may receive and return a work authorization number directly from the control room operator. This may be done in person, by telephone, or by radio.
- Unqualified personnel must receive job instruction from a power operations area supervisor or other qualified representative by means of a job instruction record.
- As part of the instruction, the area supervisor or qualified representative will request a work authorization number on the person's behalf.
- When work is complete, unqualified personnel must inform the area supervisor of the equipment status. The area supervisor will ensure the work authorization number is returned to the control room operator.

The [Safety Standards Act](#) and Regulations, of BC include requirements for a field safety representative to represent the facility owner in code, technical and qualification matters.

Applicable BC electrical code high voltage rule excerpts:

- Bare conductors or live parts are allowed to run indoors where accessible only to authorized persons and isolated by elevation or by barriers.
- When isolated by elevation indoors, the required clearance from the floor for 13,200-Volt conductors when the building was constructed was ~2.29 meters (7.50 feet), and under current code is 2.90 meters (~9.51 feet).
- A permanent, legible warning notice stating "DANGER – HIGH VOLTAGE" shall be placed at service rooms or areas containing high voltage electrical equipment.

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Electrical code definitions for current BC electrical code:

“Authorized person — a **qualified** person who, in his or her duties or occupation, is obliged to approach or handle electrical equipment; or a person who, having been warned of the hazards involved, has been instructed or authorized to do so by someone having authority to give the instruction or authorization.”

“Qualified person — one familiar with the construction and operation of the apparatus and the hazards involved.”

Failure scenario(s)

In March 2022, a subcontractor mobilized for a roofing project to replace drainpipes and to seal leaks in the roof for a building. While no longer in use for production, the building still had bare energized high voltage bus bars running through part of the interior below the ceiling. The bus bars were running from the exterior high voltage plant to a power factor correction system in the building. They were energized with three-phase 7,620/13,200-volt power. This means 7,620-volts from each of the three energized lines to ground and 13,200-volts between each of the three energized lines.

In October, work was under way on the roof drain replacements and leak repairs. Snow was shoveled from areas of the roof to allow access to the existing roof drains. The roof drains were being connected through existing holes in the flat metal roof to the existing metal drainpipes below. The roofing foreman at the time planned to go inside the building to view the roof drain to drainpipe installations. The roofing foreman called the control room for access to the building after reading the high voltage and access signs at the unlocked entrance doors to the building. The building had multiple unlocked doors and one damaged door. Power operations workers attended the building and performed a walkthrough to make the foreman aware of the electrical hazards within the building. The foreman was advised that the electrical bus bars running on the third-floor ceiling at height were energized in a majority of the third floor. As the first three drains were in areas where the power was already locked out, the roofing foreman was allowed to work in those areas, although there was no interior work at height required at that point. The roofing foreman was also advised that after the first three drains, the drains beyond were in areas where the bus bars were energized. The power operations workers indicated that the roofing foreman should not work in the areas where there were energized bus bars and that power operations should be called back to lockout power to the bus bars when the drains in those areas were going to be worked on. The inside of the building was dark as it had poor lighting.

The roofing foreman and crew started setting up scaffolding in the building, which was partially installed before they left in October due to weather. In early December a new roofing foreman and roofing worker from the same contractor were arranged to be sent to site to continue the roof drains. The new foreman was advised by the control room supervisor to be cautious of ice inside the building due to the roof leaks, during a phone call over speaker phone with the contractor construction manager and the control room supervisor. The previous foreman was not aware that work had recommenced and did not speak with the new foreman about hazards of the project. The new roofing crew had identified from the rooftop that the new roof drains were not long enough to reach the existing drainpipes inside. This work included putting a tape measure down the hole within four feet of the energized bus bars below, through the round cut hole in the roof.

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In preparation for connecting the new roof drains to the existing drainpipes inside, the new roofing foreman planned to enter the building to take measurements. The measurements were needed to prepare the proper size and length of drainpipe extension materials. The building entrances had signs that indicate “DANGER NO ADMITTANCE WITHOUT PERMISSION FROM CONTROL ROOM OPERATOR” as well as “DANGER HIGH VOLTAGE”. While the previous foreman had learned of electrical hazard locations during a walkthrough of the building, they had initiated months earlier with facility power operations, the foreman in place at the time of the incident and the roofing worker were not aware of or advised that there was energized high voltage inside. With the control room supervisor warning that the entrance steps are slippery, and with daily check in and checkout with the control operations, along with the work permit and authorization number for the building in hand, the new roofing foreman and roofing worker proceeded into the building through an unlocked door. The workers had no awareness that there was energized high voltage electrical within. When entering the building, the roofers found the building was desolate, dark, and quiet. The bus bars resembled building support beams and were not easily identifiable as electrical hazards. There was some partial scaffolding in place and the roofers obtained a ladder to take measurements in the ceiling. The day before the incident one roofer entered the building to take measurements for the roofing drain. Although working in the same location involved with the incident and on a ladder near the energized bus bar, the worker did not make contact. The day of the incident, the roofing foreman entered the building again through an unlocked door. While working from a ladder, the roofing foreman’s elbow contacted a bus bar while they were measuring a pipe against the drain. The roofing foreman was exposed to a 7,620-volt shock that entered and exited through the elbow and the wrist. They stepped back and then fell from the ladder to the ground.

Facts and evidence

The roofing contractor provided a quote to the facility supervisor that was proceeded with to: *“Repair or replace any drain piping connections inside the top floor of [the] building.”*

The work both on the roof and below was less than four feet from the energized bus bars and required de-energization and lockout according to site policy.

The permit to work for the building was issued by power operations to the roofing contractor and includes an authorization number. The permit includes an item to enter transformer yards or work within 18 feet of power with a note to contact Power Ops. to maintain authorization. The permit also has electricity unchecked, power lines checked, and hazardous energy lockout unchecked as not applicable. There was no isolation officer assigned or group lockout set up, both items were stated as not applicable. The item for the contractor’s work area to be demarcated was unchecked.

Site owner report on building involved with the incident.

Building Deficiencies (recorded after the incident)

- Multiple doors unlocked.
- North person door damaged and unlockable.
- Poor lighting on third floor.

1st Roofing foreman statements (*Was foreman in October 2022, referred to as foreman #1*)

- Foreman 1 was on site in October 2022, saw the high voltage no access signage, and called the control operator to inquire.
- Foreman 1 then had a walkthrough with facility power operations (Ops) workers.

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- The power ops workers advised that on the third floor, the first three drains where the work was starting were not near energized bus bars.
- Power ops indicated that the remaining six drains were near bare energized high voltage bus bars near the ceiling and to call them to get them locked out before working near them.
- Foreman 1 was not asked to attach any lock to the lockout for the area where the first three drains were located.
- Foreman 1 found that the doors to the building were unlocked.
- The building was desolate with no facility workers in it.

“I said, do I need to call you guys (power ops workers) every time to come back in here (the building), and they said no, now that you know the hazards and we’ve done a walkthrough...you can enter and exit...at your own risk.”

- Foreman 1 stated that the hazards and job scope were not properly communicated. When someone gets pulled off the job and then someone else gets sent there two months later when everyone’s forgotten about everything about that job.

“There was never a proper pass-over of the job [between roofing crews]. I had no idea they [new roofing crew] were there.

Injured roofing foreman statements (Was foreman in December 2022, referred to as foreman #2)

- An experienced roofing foreman that was called to the site to finish the roofing job in December 2022.
- Foreman 2 had worked around basic electrical before but not high voltage.

“There’s no way in the world I would have been working up there in the ceiling... if I had any thought that there was power.”

- The new roof drains weren’t long enough so they were going to adapt the plumbing pipes.
- Foreman 2 went under the drain to get a quick measurement of the down pipe.
- Foreman 2 went up the ladder, reaching between the bus bars, to slide the new pipe up beside the existing metal drainpipe to make a mark on it to know how long to cut the new pipe.

“As I brought my arm down with the pipe in my hand, my elbow must have hit that...bus bar, it’s the first I’ve heard of what a bus bar is. And then I got that shock into my arm.”

- Foreman #2 stated being told by the control room operator the day before the incident that they were supposed to notify the control room when the work was done so the control room operators could recharge the building and not have to inspect the building.
- Foreman #2 told the control operator that they were working in or on the building.
- Foreman #2 told the control room operators that the roofers were going to have to work under the roof and make the connections with the downpipes.
- Foreman #2 was warned by the control room operator that the entrance stairs to the building were icy and to be careful.

“As far as I knew it [the power] was off, except for these caged in sections that had locks on them. I didn’t know there...was power lines running into the building.”

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“I didn’t know that [bus bars] was part of the electrical, it could have been structural...cause its aluminum Q-decking, I saw metal on metal. It could have been support beams for all I knew.”

- There was nobody from the facility in the building to discuss the electrical at any time.
- The building is basically decommissioned and is to be taken down in 2-5 years.
- The roofers had to stick a tape measure down a hole in the roof to measure in close proximity to the bus bars.

“If there was a lockout procedure then they would have to come and lock it out and we would have all been aware... We would have placed the lock; they would have placed the lock. We would have done our work and then I would have called them to turn it on. But none of us knew there was power to begin with it.”

“If you think for a second, I would have gone up beside the power and done what I was doing if I thought there was power there. I wasn’t trying to cut any corners, it’s a cost-plus job”.

Roofer co-worker statements (worked with foreman 2 in December)

- Power operations told the roofing worker to radio when going into the building and when coming out.
- The co-worker explained this radio policy was to ensure the safety of workers, such as if they did not radio back out as they were working in an abandoned building. The plant needs to know where the workers are at all times.
- Everything looked derelict to the roofing co-worker. There’s one little light on in this 12x12 foot little office. Most of the big high voltage cages were gone or locked up.
- All the big transformers were gone. There was not even a hum in there.
- The co-worker did power operations site safety orientation through a phone application the day before the incident.
- A couple years ago the co-worker did a full day in classroom orientation.
- Was not aware of what bus bars looked like.
- The day before the incident, the co-worker had been right up in the same location on a ladder measuring the pipe as where the worker was injured.

“That’s what kind of freaked me out about the whole thing...we were right there, if I would have bumped them...bus bars, I’d have got electrocuted.”

Roofing Construction Manager

- Attended an initial walkthrough in March 2022 of the building and provided a quote.

“No conversation of high voltage period [during the walkthrough].”

- There was water all over the floor and it wasn’t clear if the water was coming from the actual piping or if it was leaking around the drainpipes.

“All of our work was to pretty much be done from the outside, unless we had to make an extension with the roof drainpipe to the underside...into the existing pipe.”

- Foreman #1 was moved to another job due to rainy weather in October as the roof and roof drains can’t be pulled in the rain.
- Foreman #1 was busy with another job when the work recommenced, and a new foreman was brought in. Had a phone call on speaker with the facility control room supervisor, the new foreman and helper to arrange the new foreman and helper to review the inside of the building.

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- Had a phone call on speaker with the facility control room supervisor, the new foreman and helper to arrange the new foreman and helper to review the inside of the building.
- The control supervisor advised during the phone call to be careful because its super icy because the water's dumping into this building, that's not a heated building, so it was full of ice all the way downstairs.
- The control supervisor did not mention bus bars or high voltage during the phone call.
- The building is dark, wet, and cold.

Facility director of energy statements

- There were no electricians present in the building at the time of the incident.
- Control room operators are on site 24 hours a day, 7 days a week.

“The [injured] worker was allowed access to the building for viewing only”.

Transmission operator 1 statements

- NERC (North American electric reliability corporation) certified, without electrical red seal.
- Performed one walk through with three roofing contract workers. The walkthrough was undocumented.
- During the walkthrough, the roofing contractors stated they were still to find out about approval to do the job.
- Pointed out the energized bus bars to the workers.
- After the walkthrough, the workers were not allowed in the building.
- The roofers job included repairing roof drains and leaks.
- The roofing job inside the building involved work from a scaffold due to being over ten feet high.
- For the roofers to work in the area that was energized would require the breaker to be opened, with a key box, so electricians and the roofers' locks could be added.
- No key box was added during the walk through.
- Some entrance doors locked, and some doors didn't lock.

Transmission operator 2 statements

- Does not have electrical credentials.
- Performed a walkthrough with roofing workers in the fall of 2022. The walkthrough was undocumented.
- Told the roofing workers that before they move South to work on another drain, there is live electrical, so the facility personnel would have to reconfigure the system so it would be safe.
- The transmission operator stated they had a role to make sure the roofers were safe during the walkthrough, not to make them aware of the hazards or explain their work tasks.
- The workers were not considered authorized to go in the building based on attending the walkthrough.
- Recalls the doors to the building being unlocked in the past.

Field safety representative (FSR) statements

- Is named as the Class A FSR on the operating permit for the facility.
- Works for a company that provides contracted inspection services for the facility.
- The contracting company has an individual FSR inspector that does inspections annually at the facility.
- Access to buildings is managed by the facility health and safety or security team.
- The FSR has not reviewed and does not get involved with any access protocols or procedures for the site.

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“Access to bare live parts...that’s only by qualified people according to the code. That would be...an electrical worker or someone that’s been given authorization to access the building.”

Facility power operations supervisor statements

- An electrician by trade with 28 years working in substations and high voltage.
- NERC certified operator.
- Manages and supervises the NERC certified control room operators.
- Looks after the work authorization and procedures for the site.
- Looks after all the distributions and high voltage in the plant.
- The project to replace the roof drains went from March 2022 and was still ongoing later in the year.
- Over time, the building locks got broken and deteriorated and never got fixed.
- The roofing contractor does safe start and take five safety meetings, some of which were attended by the supervisor, power operations.
- There was a take five safety meeting between the supervisor, power operations and the four roofing contractor workers the day of the incident.
- The take five was to go over the hazards of working on the roof, more to do with working at heights.
- There were three control room operators on site the day of the incident.
- With the decommissioning going on in the building there is still live equipment in there.
- The only section of the bus that was live in the building was the line 4 East bus.
- The supervisor stated the roofing workers were not allowed to enter the building and at another time in the interview also stated the roofing workers were allowed to go in the building for viewing purposes only.
- The roofing workers had been trying to determine where any roof holes were from below to patch them, and so they can shovel the snow out of the way to find them above.

“There was fall down probably a little bit on that too. They were using PVC pipe and...the risk assessment didn’t catch that those pipes were going to be within the three feet limit of that [high voltage bus bars through the hole cut in the roof]. It’s three feet if you have a safety watch, so they didn’t consider it a risk at the time.”

- Work authorizations were used to control access to the building.
- The work authorization process is for the contractor to describe the work they’re going to be doing, then the work authorization is issued.
- The requirements for access inside the building for unqualified workers, include that the control room operators go into the building with the workers to make sure they are aware of the hazards.
- The control room operators and roofing workers had done walkthroughs of the building, pointed out the hazards.
- The supervisor stated first that the roofing contractors were not supposed to be in the building at any time, and then later stated after the workers have been made aware of the hazards, they are supposed to maintain limits of approach and let the control room operators know if they are going in the building.
- There were three different walkthroughs with people over the months prior.
- In terms of working like on their own for access even at height, the contractor would always call to go in.
- The contractor was not allowed to have ladders up on the top floor.
- If the contractor needed to do any work inside the building that requires isolation and lockdown.
- If they are going to get within the limits of approach, then they will have to contact the control room and we will do an isolation or key box for them.

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“[The] building, well at the time it should have been locked up, but it wasn’t locked up.”

- The morning of the incident the roofing contractors, in coordination with the operators, signed a permit to work and they were supposed to be only going on a roof not into the building.
- The roofing workers contact the control room by phone.
- The injured worker was new to the area and part of a new crew from the roofing contractor company.
- It was a new roofing crew, and they hadn’t requested to go in the building.
- If they called to go in, then usually we would send an operator down there.

“Unless they [roofing workers] went through a walk through and it [the high voltage bus bars] was identified to them, then they probably wouldn’t know [where the high voltage hazards are].”

“[The doors] say...call control room for access, danger high voltage. There’s a lot of signage on the doors but the doors weren’t locked and that’s a downfall.”

- There is no electrician at the building, it’s basically for storage.
- The electric safety training for the roofing workers is general, rather than for a specific building. It includes work authorization process, and the fact that if something looks like it’s not energized doesn’t mean it isn’t.
- As a result of the incident, the building is locked up tighter with three locks, fences are being installed, guarding has gone up. No one is allowed to go into the building without a control room operator or maintenance electrician escort.

“Structure and bus look a lot the same, aluminum structure and it’s all-aluminum bus and the only way you know the difference is due to the standoffs on the insulator, and that only comes through experience.”

Control room operator statements

“They’re allowed to go in and do this certain amount of work. I signed off saying I knew that they were in there so that if anything happened, we would know who was in the area.”

- The control room operator was on site the day of the incident.
- It is a restricted area according to the work authorization; the roofing workers were supposed to be just on the roof.

“I wasn’t worried about the high voltage in the top of the building that they shouldn’t have been in.”

- Had we known they were going to be in there, we could have de-energized the building.
- We’re in the process of changing everything from the old 13.2 kilovolts to 25 kilovolts. But, in the next five years, the whole building is going to be gone.
- No one was supposed to go in the building without someone being there with them.
- The control room operator is aware of three times between September and December that facility personnel had taken a group of roofing workers and showed them through that building.
- There were no facility employees in the building at the time of the incident. It was Saturday, most of the crews were gone for the weekend.

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Causes and contributing factors

The cause of the incident was that that workers were able to enter a building that had high voltage energized conductors without either de-energization of the power, direct supervision by a qualified person, or identification of the electrical hazards.

There were various contributing factors that suggested there were no electrical hazards in the building including:

- The entrance to the building was not locked.
- The daily communications from roofing foreman 2 to control operations when the roofing foreman was entering and exiting the building.
- Roofing foreman 2 received a work authorization number for the building.
- Scaffolding for inside work at height had been partially set up previous to the arrival of roofing foreman 2.
- The bus bar looked like building structure.
- The vacant building was scheduled for demolition.
- Most of the electrical switch gear had been removed.
- The low lighting levels inside the building.



Photo 1 – Roofing components including roof drains and pipes.



Photo 2 – High voltage bus bar, drainpipe, and ladder. The 7,620-volt shock occurred between one bus bar (RED) and the grounded metal drainpipe (GREEN).



Photo 3 – Entrance door to the area where the incident occurred.



Photo 4 – (RED & YELLOW DOTS) High voltage bus bars and work area. There was 13,200-volts line to line voltage present. (RED BOX) Insulator.



Photo 5 - General area of incident showing three phase high voltage bus bars (3 phase - 13,200/7620-volt) *Phase colours shown for reference only.*