POWERCO

Mitigation of Arc Flash Hazards

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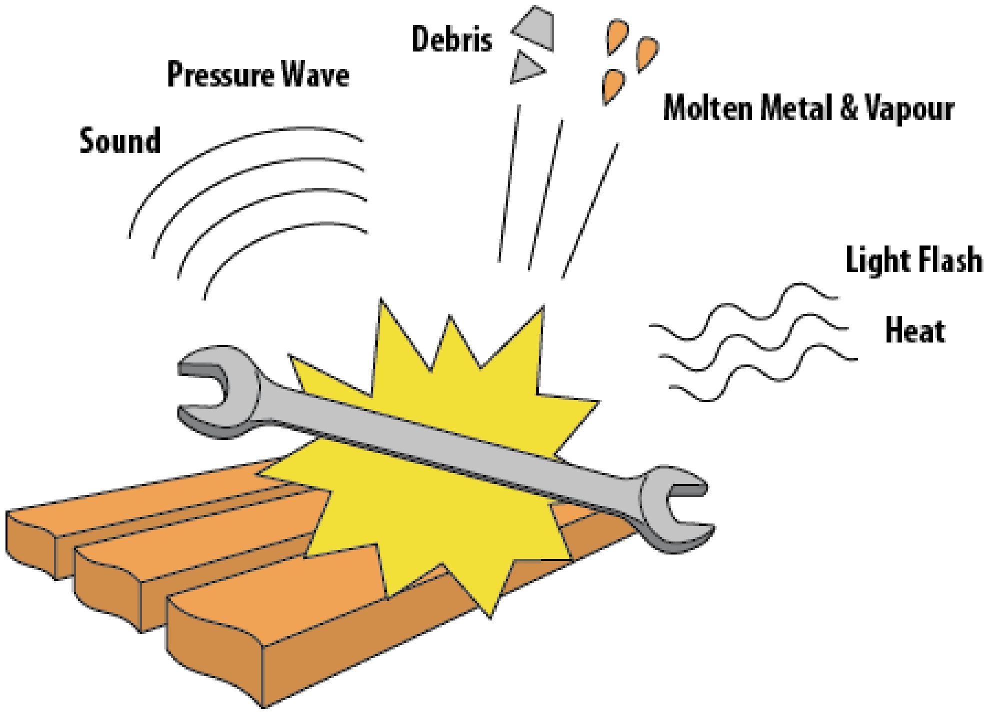
Overview

- Introduction
- Why we should address arc flash.
- How to assess arc flash.
- What can be done to mitigate arc flash.
- Future Projects.
- Conclusion.

What is an arc flash?

- An arc flash is an explosion.
- Arc flash is caused by a fault of many varieties.
- It is a hazard present with any live electrical plant.
- It can cause significant damage to plant and personnel through:
  - Heat
  - Force
  - Light
  - Sound

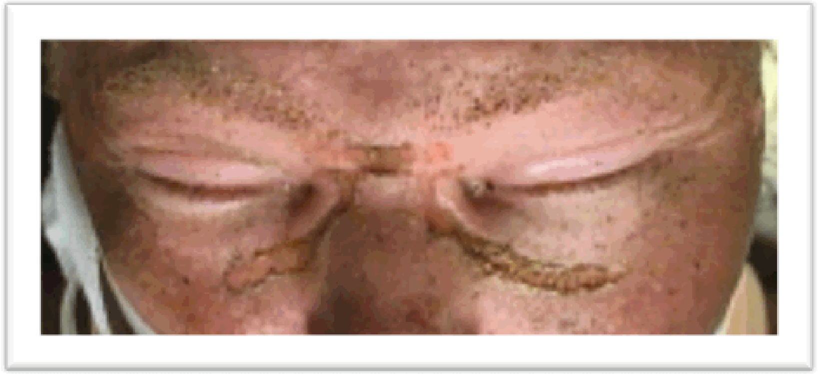


Arc flash demonstration

What are the consequences of arc flash?

What are the consequences of arc flash?

- The injuries can range from curable burns through to death.
- These images show burns to the hands and arms and temporary blinding.
- Rare for deaths but it does occur:
  - Perth, WA, 2015, two dead.
- The EEA addressed these H/S issues with Guide for the Management of Arc Flash Hazards in 2011



Determining incident energy

- IEEE 1584 Guide for Performing Arc-Flash Hazard Calculations provides techniques to determine:
  - Arc flash hazard distances.
  - Arc flash incident energies.

- The model is based on empirical data and has limitations due to this.

- The Lee method is used for voltages over 15 kV.

Determining incident energy

The process for determining incident energy is:

- Step 1: Collect the system and installation data.
- Step 2: Determine the modes of operation.
- Step 3: Determine the bolted fault currents.
- Step 4: Determine the arc fault currents. Note that these are different from the bolted fault currents.

Determining incident energy

- Step 5: Find the protective device characteristics and the duration of the arcs.
- Step 6: Document the system voltages and classes of equipment.
- Step 7: Select the working distances
- Step 8: Determine the incident energy for all equipment.
- Step 9: Determine the flash-protection boundary for all equipment.

Determining incident energy

- Arcing current formula when operating voltage is less than 1kV:
  - $\log(I_a) = K + 0.662\log(I_{bf}) + 0.0966V + 0.000526G + 0.5588V(\log(I_{bf})) - 0.00304G(\log(I_{bf}))$
- Arcing current formula when operating voltage is greater than 1kV:
  - $\log(I_a) = 0.00402 + 0.983\log(I_{bf})$
- Where:
  - Log is log base 10
  - I_a is the arcing current (kA)
  - K is -0.153 for open configurations and -0.097 for box configurations
  - I_{bf} is the bolted fault current for a three phase fault (symmetrical RMS)(kA)
  - V is the system voltage (kV)
  - G is the gap between conductors (mm), a standard table is given for voltage ranges and equipment type.

Determining incident energy

- Incident energy formulae (normalised).
  - $\log(E_n) = K_1 + K_2 + 1.081(\log(I_a)) + 0.0011G$
- Where:
  - Log is log base 10.
  - I_a is the arcing current (kA) calculated previously.
  - K_1 is -0.792 for open configurations and -0.555 for box configurations.
  - K_2 is 0 for ungrounded and high resistance grounded systems, -0.113 is for grounded systems.
  - G is the gap between conductors (mm), a standard table is given for voltage ranges and equipment type.

Determining incident energy

- Incident energy formulae (normalised).
  - $E = 4.184 C_f E_n \left(\frac{t}{0.2}\right)\left(\frac{610^x}{D^x}\right)$
- Where:
  - E is the incident energy (J/cm^2).
  - C_f is a calculation factor, 1.0 for voltages above 1kV and 1.5 for voltages at or below 1kV.
  - E_n is the incident energy normalised (for distance and time).
  - t is the arcing time (s).
  - D is the distance from the possible arc point to the person (mm).
  - X is the distance exponent, a standard table is given for various voltages and equipment types.

Determining incident energy

- Powerco developed a spreadsheet model internally to determine the incident energies.
- The first stage of arc flash assessments was at zone substations.
- 115 substations were assessed. The incident energies ranged from 0.16 – 22.36 cal/cm^2
- 27 substations exceeded the 8 cal/cm^2 limit of our standard PPE.

Mitigating incident energy

- From the IEEE equations it is apparent that there are three factors that can be controlled to influence incident energy:
  - Fault current.
  - Arcing time.
  - Distance from blast.

- Protective barrier methods include:
  - Arc rated enclosures
  - Arc venting
  - PPE

Arc rated enclosure demonstration

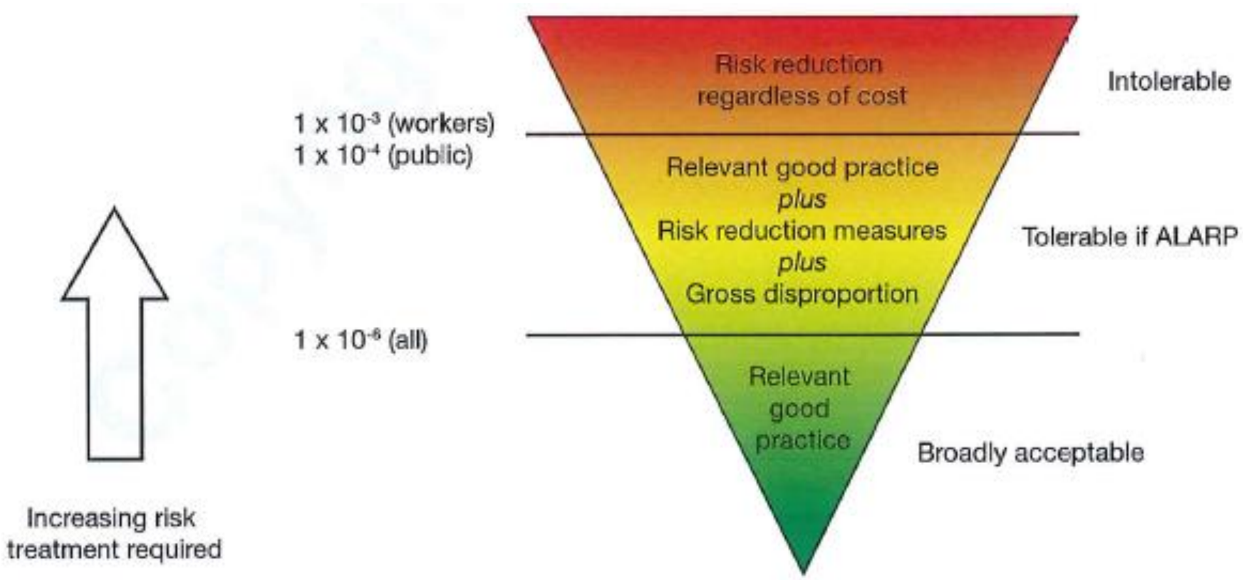
Mitigating Incident Energy

- Powerco assessed each method separately.
  - Network configuration changes
  - Protection settings
  - Replacements/retrofits
  - PPE

- Reduce incident energies to ALARP levels.

- Two primary options chosen, decrease fault levels, increase personnel distance from arc flash.

- PPE is considered the least desirable option.



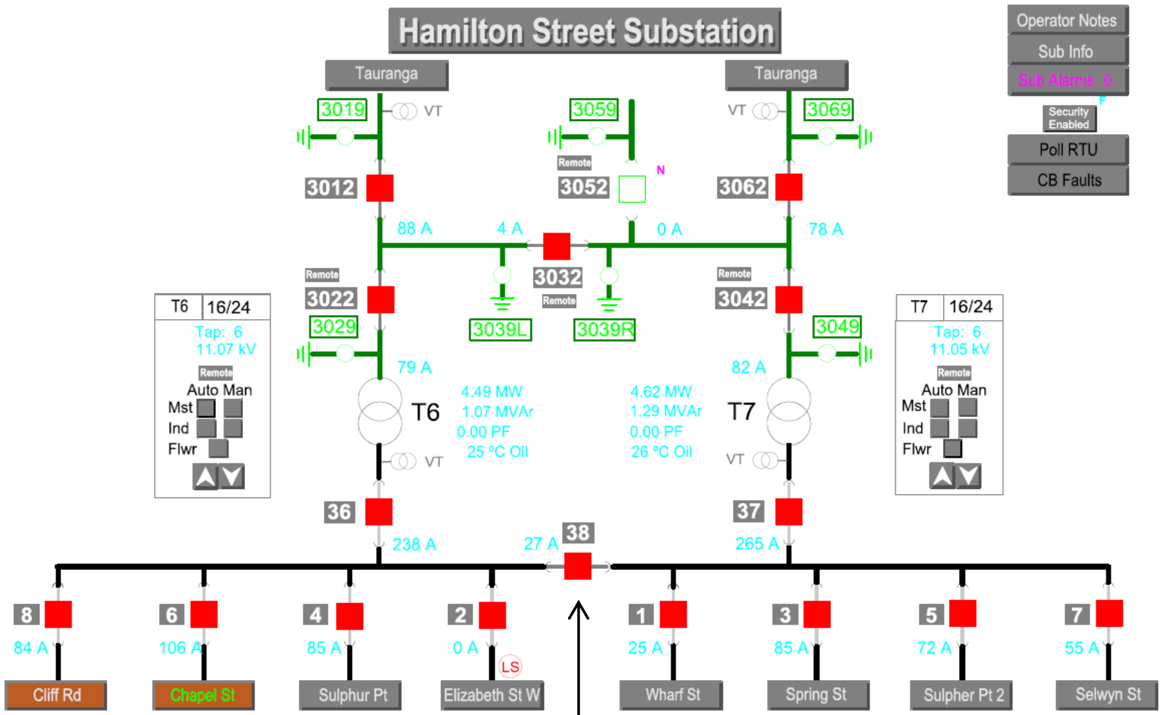
Mitigation method for operational procedures

- Powerco's primarily mitigation method was through reducing fault levels for operational procedures.

- Opening the bus coupler:
  - Reduced fault current
  - Decreased trip times

- All but 6 substations could be mitigated below 8 cal/cm^2 with this method.

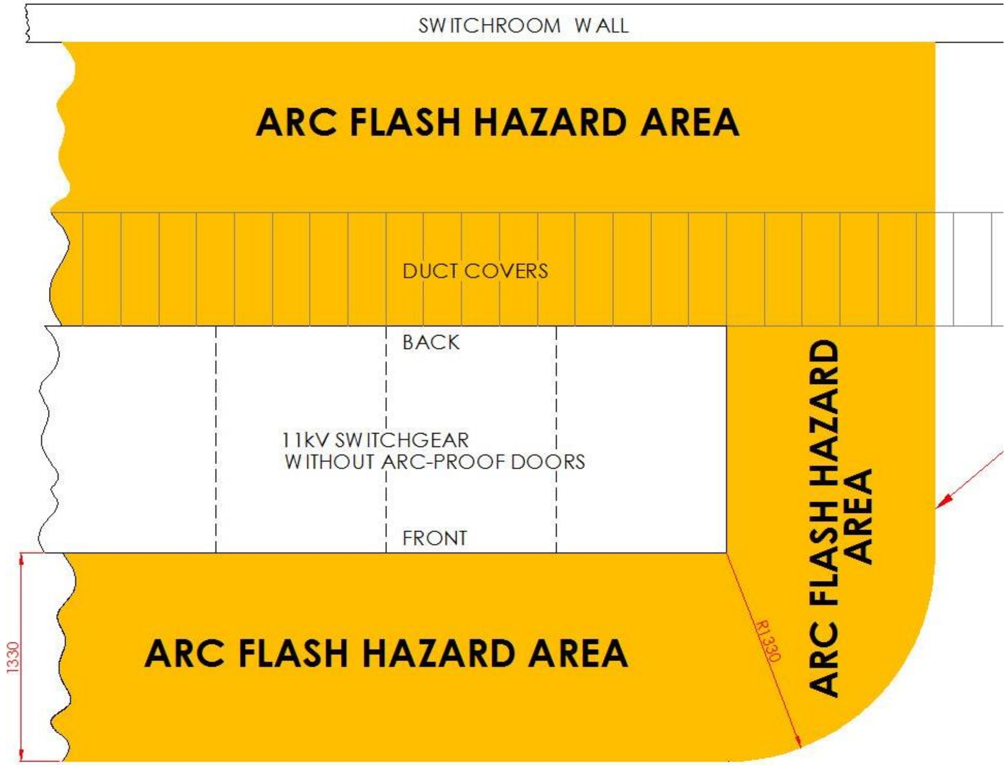
- Enhanced Cat 2 PPE required.
  Cat 3 PPE used for the 6 substations with excessive energies.



Bus coupler is opened to reduce incident energies.

Mitigation method for non-operational procedures

- Increasing distance was also used.
- Within Powerco substations a marked area on the floor indicates where the 8 cal/cm^2 and above danger zone is.
- Non operational procedures could be done without any added mitigations provided they took less than 20 minutes.
- Cat 3 PPE or switching of bus coupler required if greater than 20 minutes.
- Deemed appropriate due to low risk levels when in plant is in a quiescent state.



Future projects

- Issue distribution arc flash standard.
- Plans to reduce the hazard at the 6 substations with excessive incident energies (2 completed).
- All future installations are to have arc flash considerations.

Conclusion

- Arc flash is a dangerous hazard present in our industry.
- IEEE 1584 can be used to assess how dangerous the specific hazard is.
- Various mitigation methods are possible.
- Powerco opted for an procedural changes.
- There is still more work to be done in the arc flash space.

The End

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Any Questions?