Switchgear and Circuit Breakers Failures and Case Studies

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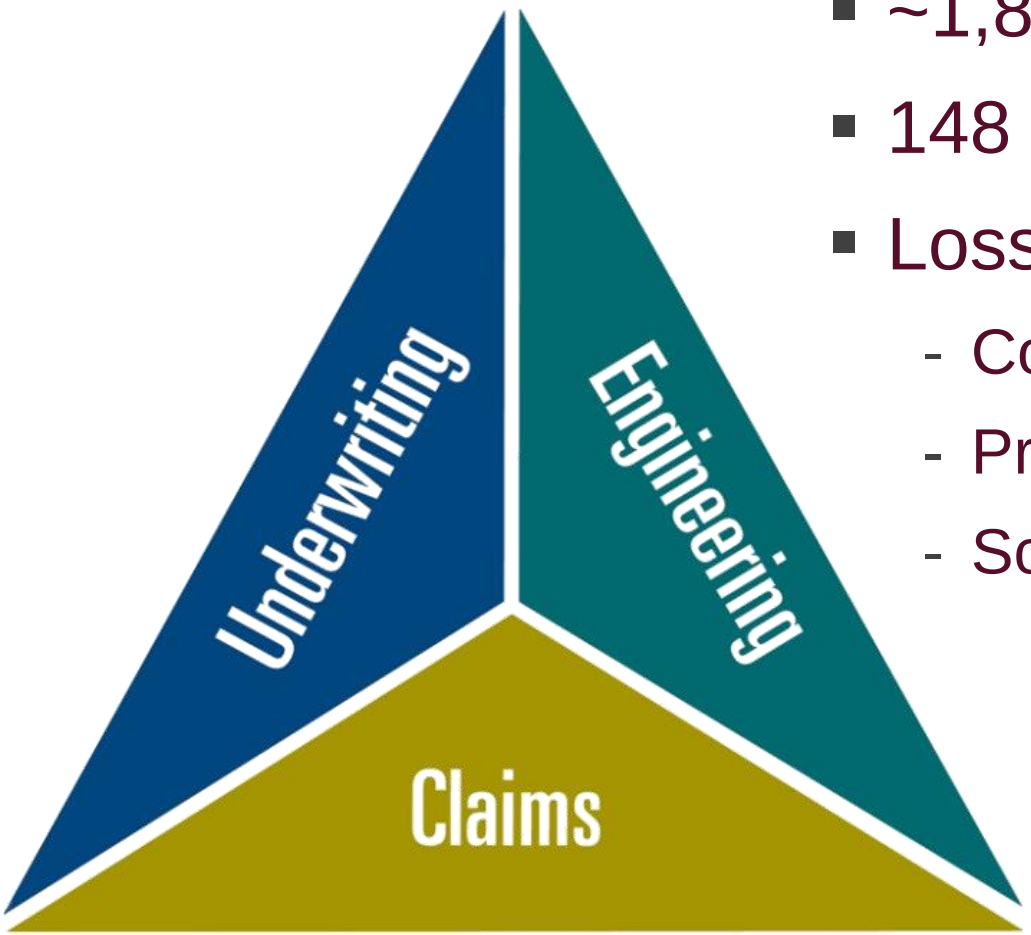
180 years of expertise

Mutuality

Single focus

- commercial property

FM Global-Engineering



- ~1,800 engineers
- 148 countries
- Loss Prevention Solutions
  - Consistent
  - Practical and cost effective
  - Scientific proven

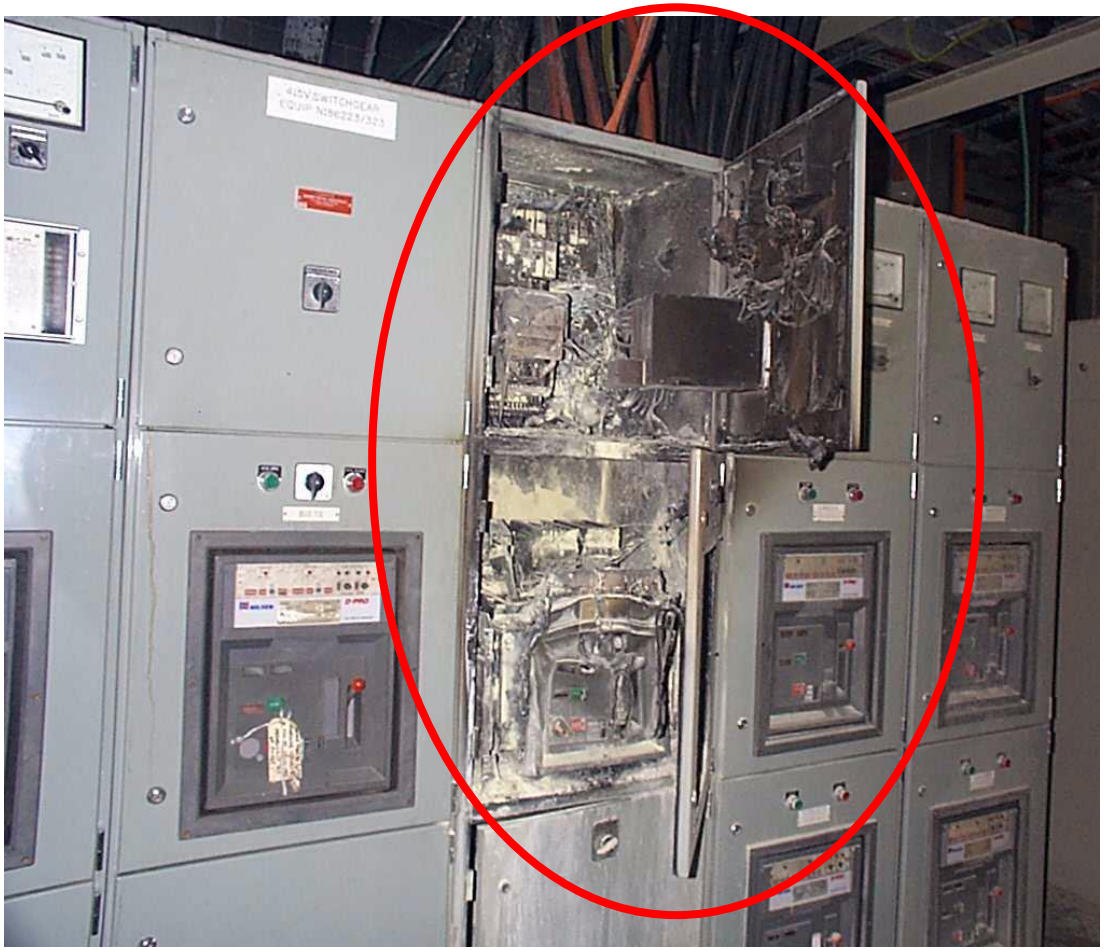
Switchgear and Circuit Breaker Failure

What can happen?

Switchgear/circuit breakers fail to operate with severe consequences

Switchgear and Circuit Breaker Failure

What can happen -



Switchgear and Circuit Breaker Failure

What can happen -

Switchgear and Circuit Breaker Failure

What can happen – worst case

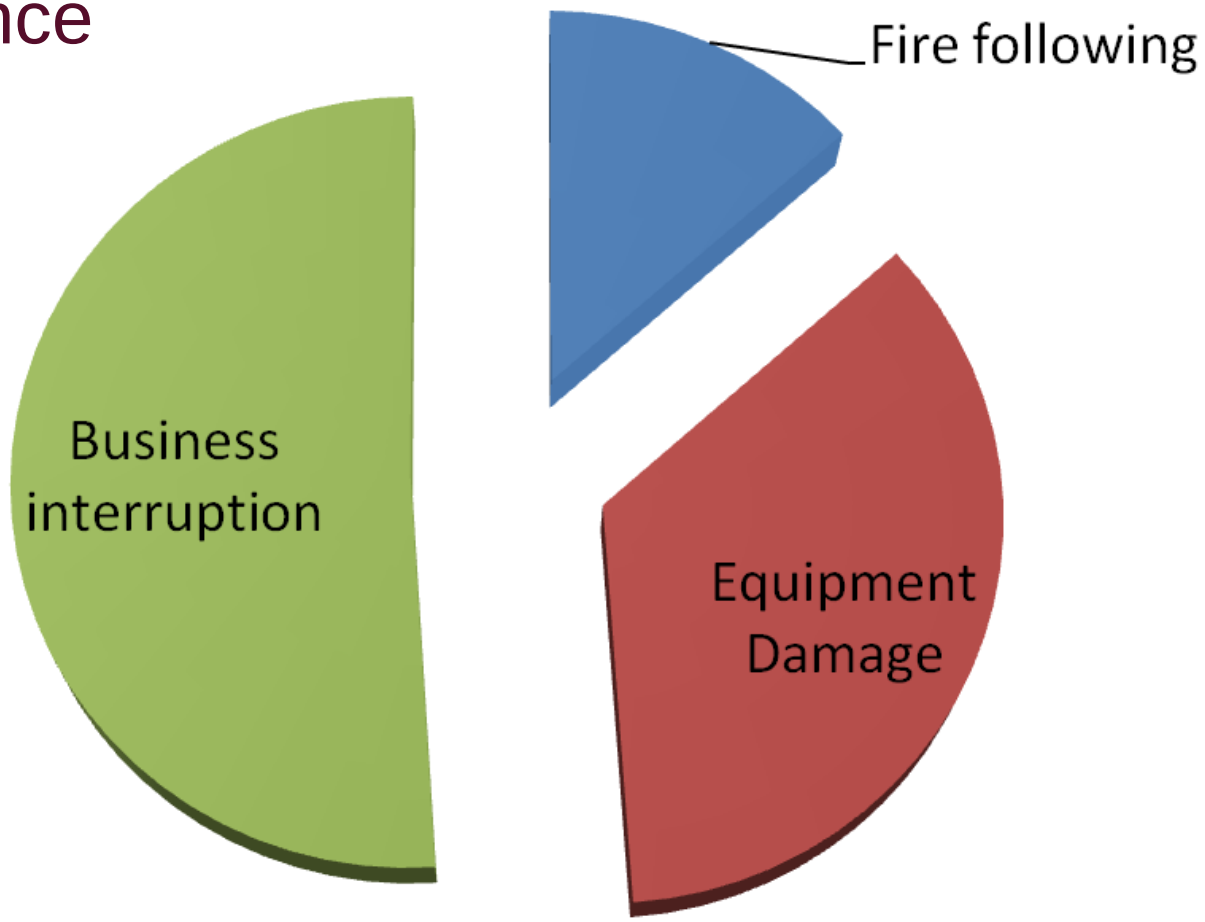
Switchgear and Circuit Breaker Failure

Beyond the loss of the CBs and Switchgear

- Ignition source
- Catastrophic failure of controlled equipment
- Business Interruption

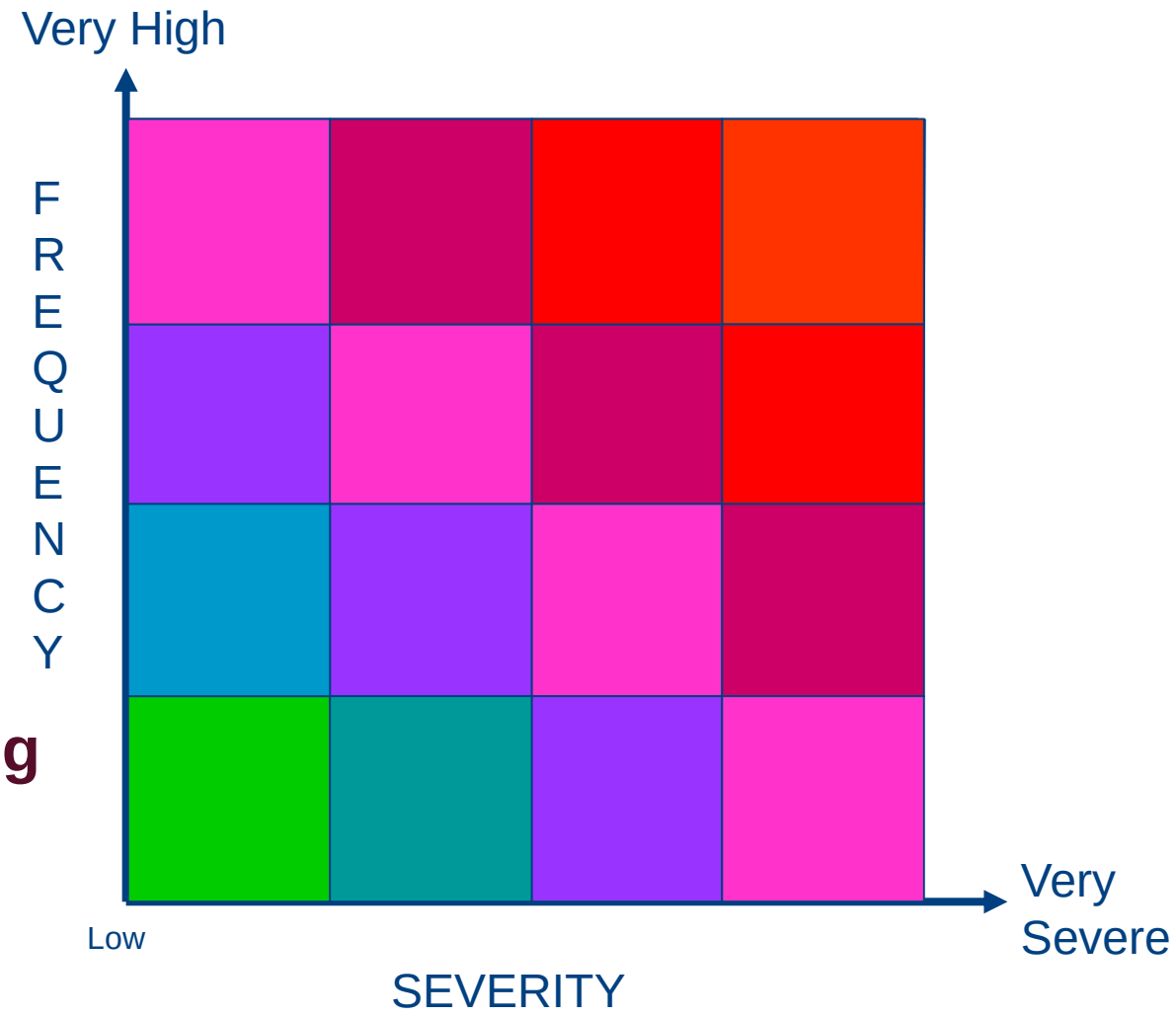
Switchgear and Circuit Breaker Failure

FM experience



Risk Factors

- **Environment**
- **Operating conditions**
- **Age/history**
- **Maintenance**
- **Operator training**

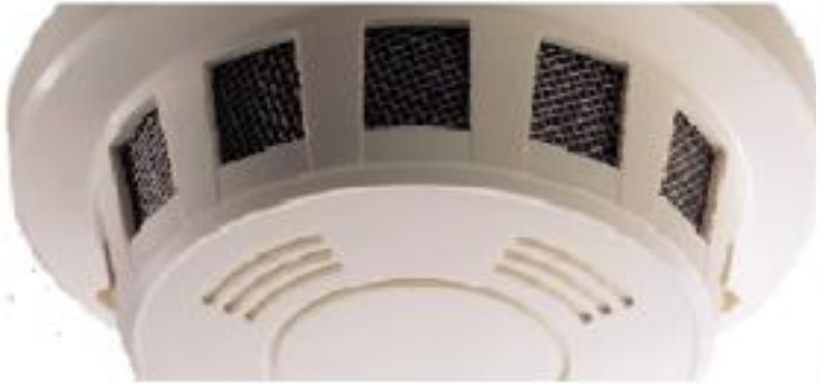


Operator training, contingency plan, safety device

Contingency Plan – What to ask yourself.

- Is a needed spare on hand and ready to install
  - Critical equipment
  - Long lead time
  - Obsolete
- Is re-configuring the electrical system possible
- Is redundant equipment installed
  - double-ended substation
- Has an alternative supply been identified
  - Rental diesel engine-driven generator units

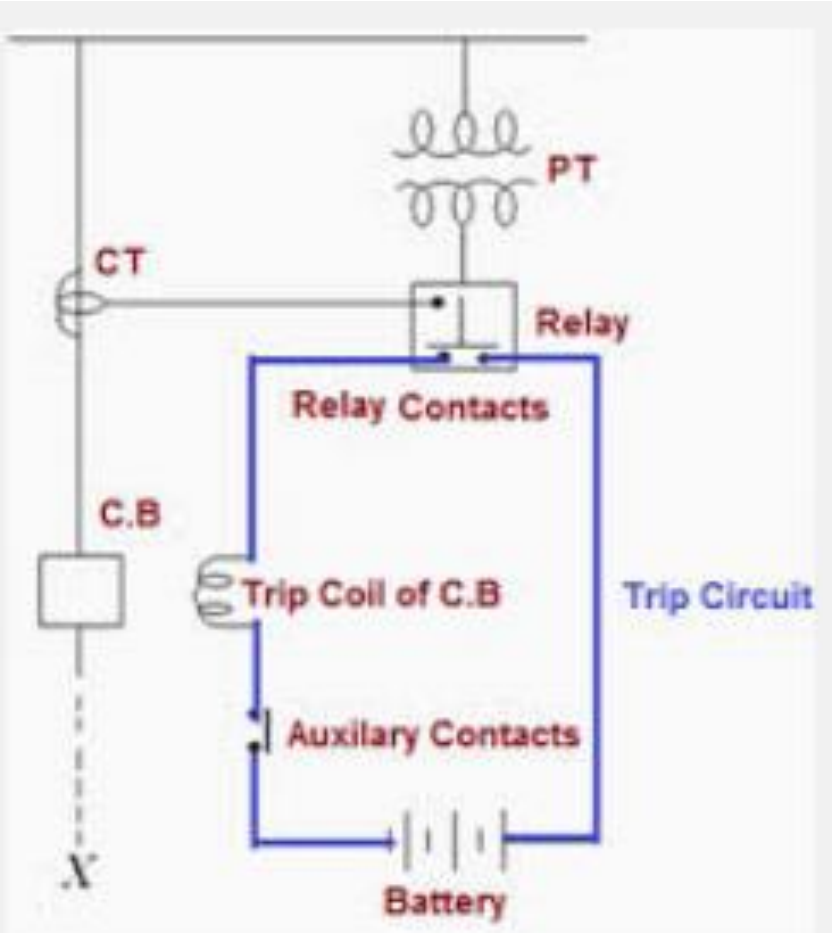
Safety Device



Preventive Maintenance Program

Electrical protection - a system of many components

- Instrument
- Relay
- Control wire
- Trip coil
- Battery
- Etc.



Preventive Maintenance Program Examples

Frequency	Flooded Lead Acid	Flooded Ni-Cd	Sealed Lead Acid (VRLA)
Monthly	Check and record charger voltage and current, electrolyte levels and for evidence of corrosion and leaks,…	Check and record charger voltage and current, electrolyte levels,…	Check and record charger voltage and current, ambient temperature, and for evidence of corrosion, leaks, overheating …
Quarterly	Check the specific gravity for lead-antimony batteries*, and the temperature of 10% of the cells…	Check the pilot cell electrolyte temperature	Check the internal ohmic values and negative terminal temperature of 10% of the cells…
Annually	Check the specific gravity of all the cells for lead-antinomy batteries as well as all inter-cell resistances …	check all inter-cell resistances …	Check the inter-cell resistance and the amount of AC ripple in the charger waveform, charger alarm accuracy…

Preventive Maintenance Program Examples

2.1.3.4.2 Perform a capacity test (also called performance test or discharge test) every 5 years for flooded lead acid and flooded Ni-Cd batteries, and every 2 years for sealed lead acid (VRLA) batteries.

Sources:

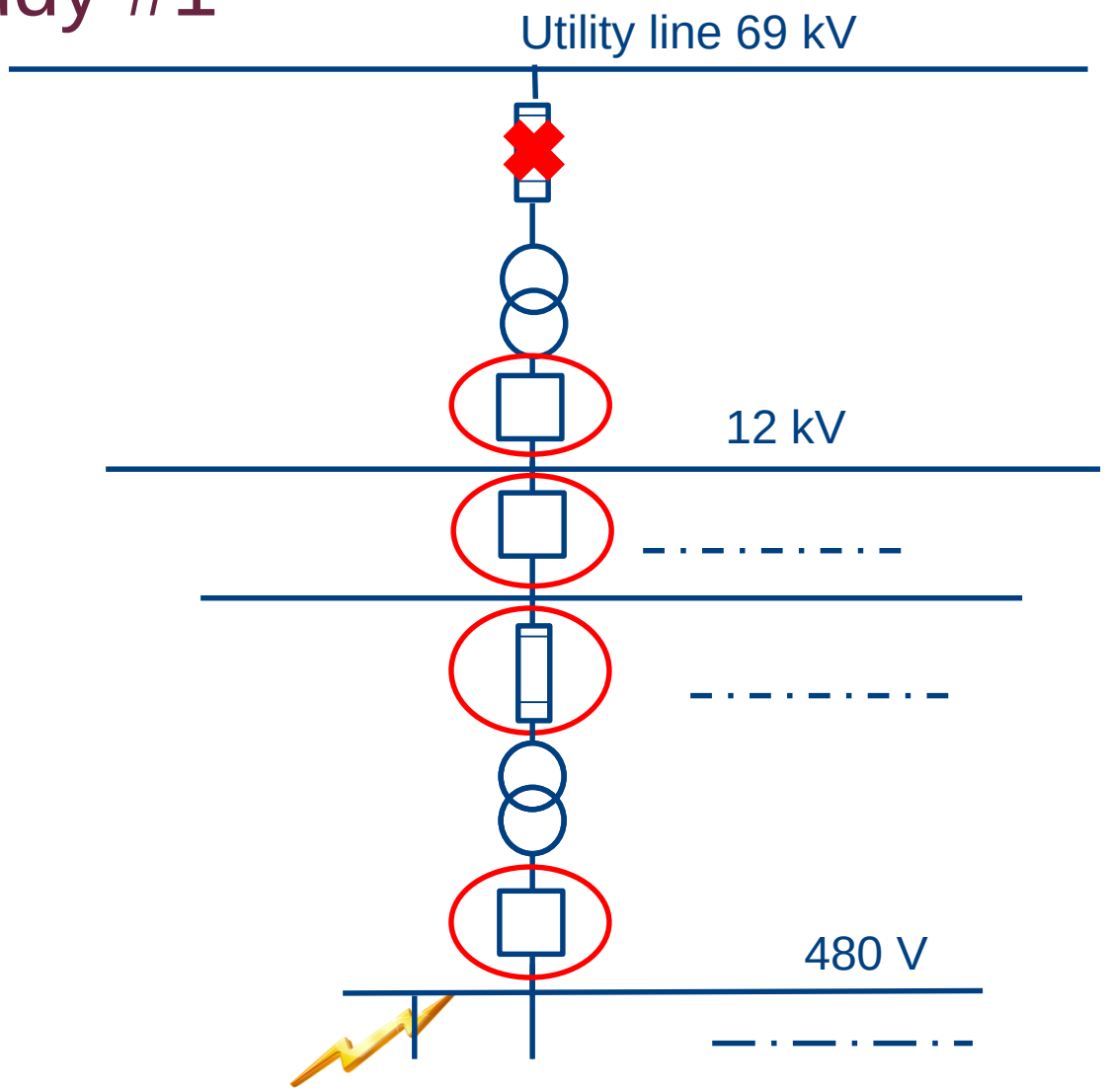
DS 5-19: Switchgear and Circuit Breakers

DS 5-20: Electrical Testing

Case Study #1

- Site Information
  - A simple manufacturing facility
  - 24/7 operation
  - Utility power is the single electric powere source

Case Study #1



Case Study #1

- Damage Investigation
  - Explosion & fire involving 480V cabinets
  - Tank rupture of the mineral oil-filled 12 kV/480V transformer
  - Minimum business interruption: contingency plan in place

Case Study #1

- Damage investigation
  - Key contributing factor: Lack of adequate maintenance
    - 12 kV switchgear's battery - discharged
    - 480 V circuit breaker: seized
    - 12 kV fuse for transformer had a known problem

Case Study #1

- Conclusion
  - Overall maintenance program needs improvement
  - Contingency plan minimized the BI
  - No fire following: no combustible load in the electrical room

Case Study #2

- Site Information
  - A simple manufacturing facility
  - 24/7 operation
  - Utility power is the single electric power source

Case Study #2

- Site Electrical system:
  - Utility power: 69 kV
  - 480V feeder
    - Solid grounded system
    - Fused switch with ground fault protection
    - >100 ft. bus bar above the production area
    - 40 years old

Case Study #2

- Electrical PM
  - Annual IR scan
  - Annual transformer oil sample – screen & DGA
  - 3 year switchgear PM

Case Study #2

- The incident
  - Bus bar failed (close to the plug-in)
  - Auminum bus & enclosure steel frame vaporized
  - Suspended ceiling above blew off
  - Hot particles from the bus duct explosion ignited the combustible material above the ceiling and a fire followed

Case Study #2

- Damage investigation
  - Ground fault protection did not operate
  - Fuses of two phases melted
  - Entire bus damaged
  - Significant smoke/water damage to food product
  - 100% production shutdown

Case Study #2

- Damage investigation
  - GFP
    - Unknown setting of GFP
    - No electrical study to identify setting
    - No recorded testing/maintenance
  - The 480 V bus bar
    - No documented maintenance activities

Case Study #2

- Conclusion
  - Coordination study needed for GFP
  - Test GFP during 3 year PM
  - Improve bus PM
  - Fire related issues
    - Automatic sprinkler installation
    - FD pre incident planning

Questions