Incorporating Arc-Flash Mitigation into the Design of New and Existing Facilities

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Introduction

- Has it really been 10 years?
- So much has changed
- So much remains the same

Short History of Arc-Flash Standard and Papers

- 1985 – Ralph Lee published the first paper *The Other Electrical Hazard, Electric Arc Blast Burns.*
- 1987 - Ralph Lee published the paper, *Pressures Developed from Arcs.*
- 1997 – Bingham, Doughty and Neal publish the paper *Testing Update on Protective Clothing and Equipment for Electric Arc Exposure.*
- 2000,- Doughty, Floyd, and Neal published *Predicting Incident Energy to Better Manage the Electric Arc Hazard on 600-V Power Distribution Systems*
- 2000 – NPFA-70E *Standard for Electrical Safety Requirements for Employee Workplaces* 2000 Edition.
- 2002 - IEEE Std. 1584-2002, *IEEE Guide for Performing Arc-Flash Hazard Calculations.*

Short History of Arc-Flash Standard and Papers

- 2004 – NFPA-70E *Standard for Electrical Safety in the Workplace* 2004 Edition.
- 2004 - IEEE Std. 1584a-2004, *IEEE Guide for Performing Arc-Flash Hazard Calculations – Amendment 1*.
- 2005 – NFPA 70 *National Electric Code* 2005 Edition.
- 2009 - NFPA-70E *Standard for Electrical Safety in the Workplace* 2009 Edition.
- 2011 - IEEE Std. 1584b-2011, *IEEE Guide for Performing Arc-Flash Hazard Calculations – Amendment 2.*
- 2012 - NFPA-70E *Standard for Electrical Safety in the Workplace* 2012 Edition.
- Future?

Where are we today?

- PPE Standards and options have evolved significantly over the last 10 years and will continue into the future.
- Mitigation options have expanded and will continue to evolve into the future.
- Facilities can be designed that will mitigate incident energies that will work regardless of changes in standards.

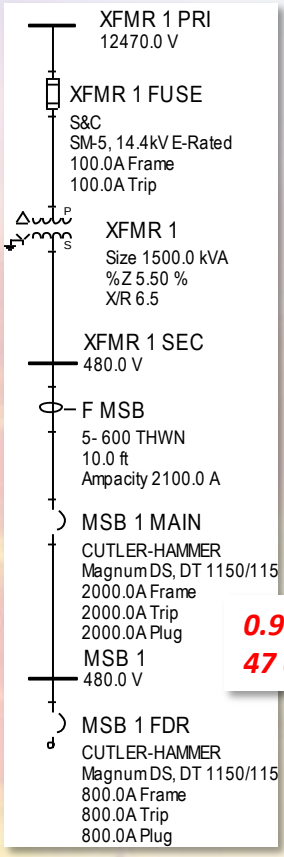
Reducing Incident Energy Through Design Practices

- Passive Mitigation
- Active Mitigation.
- Temporary Mitigation.

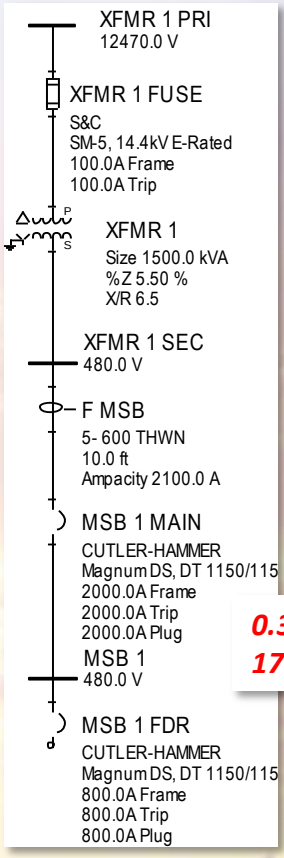
Passive Mitigation

- **Main Device Isolation**
  - Must be truly isolated, no common bus areas
  - Must Isolate ALL Sources
  - Very Important at Service Entrances and Utility Intertie points

Mains Isolation



0.9s Delay
47 cal/cm²



0.3s Delay
17 cal/cm²

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Southwest Energy Systems

A TYPICAL ARC FLASH EVENT

A TYPICAL ARC FLASH EVENT

A TYPICAL ARC FLASH EVENT

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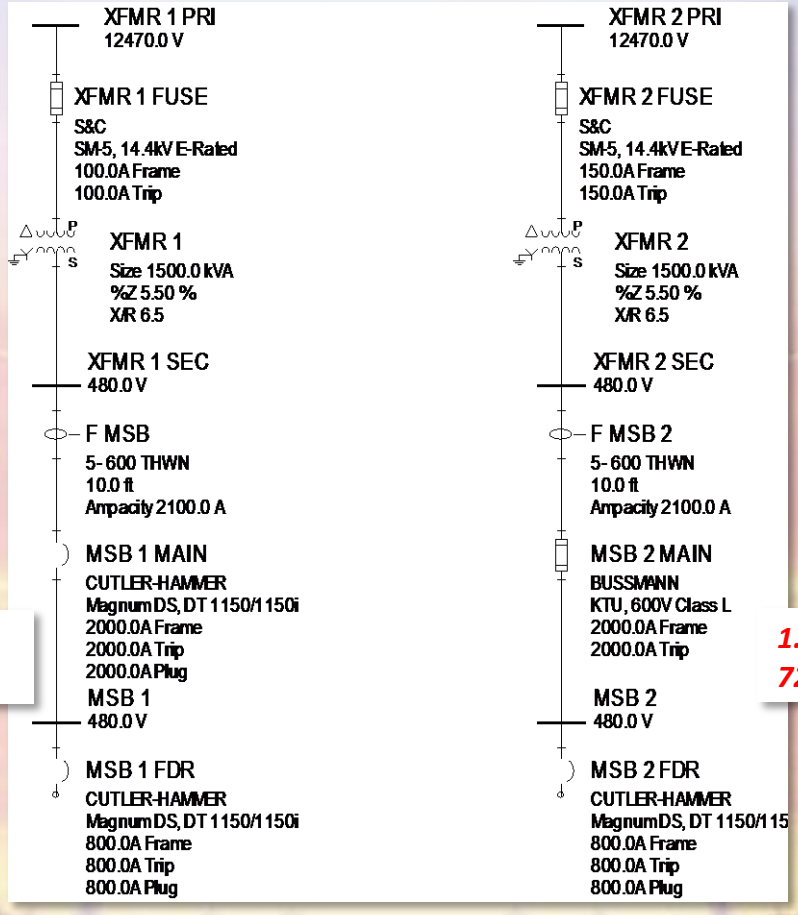
A TYPICAL ARC FLASH EVENT

Passive Mitigation

- **Main Device Selection**
  - Main Device type can affect incident energy
  - Main device settings can affect incident energy

Main Device Selection



0.3s Delay
17 cal/cm²

1.49s Delay
72 cal/cm²

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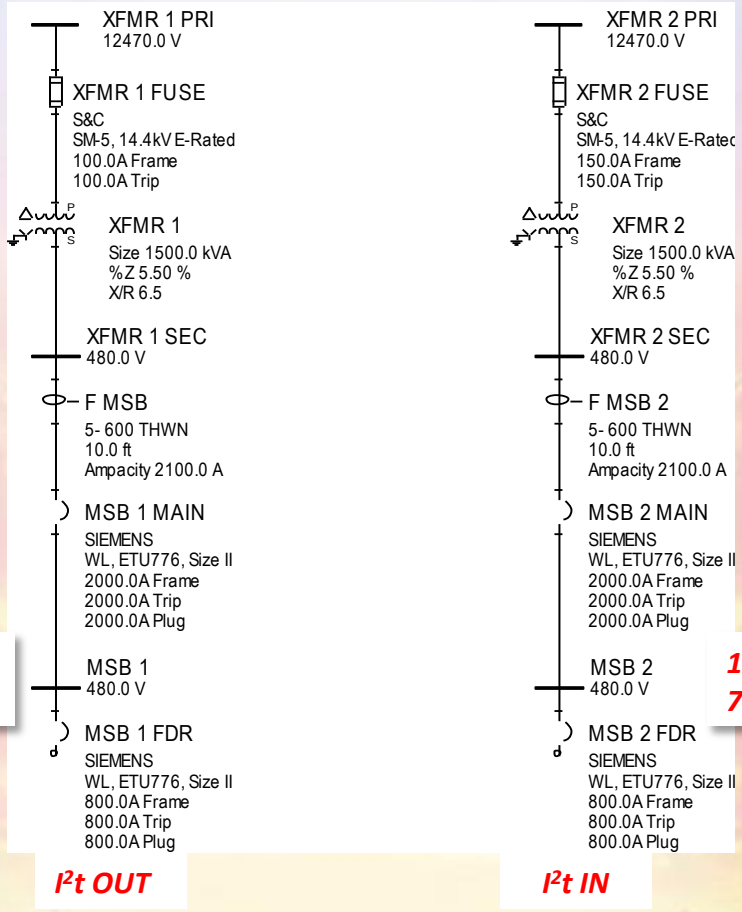
Main Device Settings



0.39s Delay
22 cal/cm²

1.45s Delay
70 cal/cm²

I²t OUT

I²t IN

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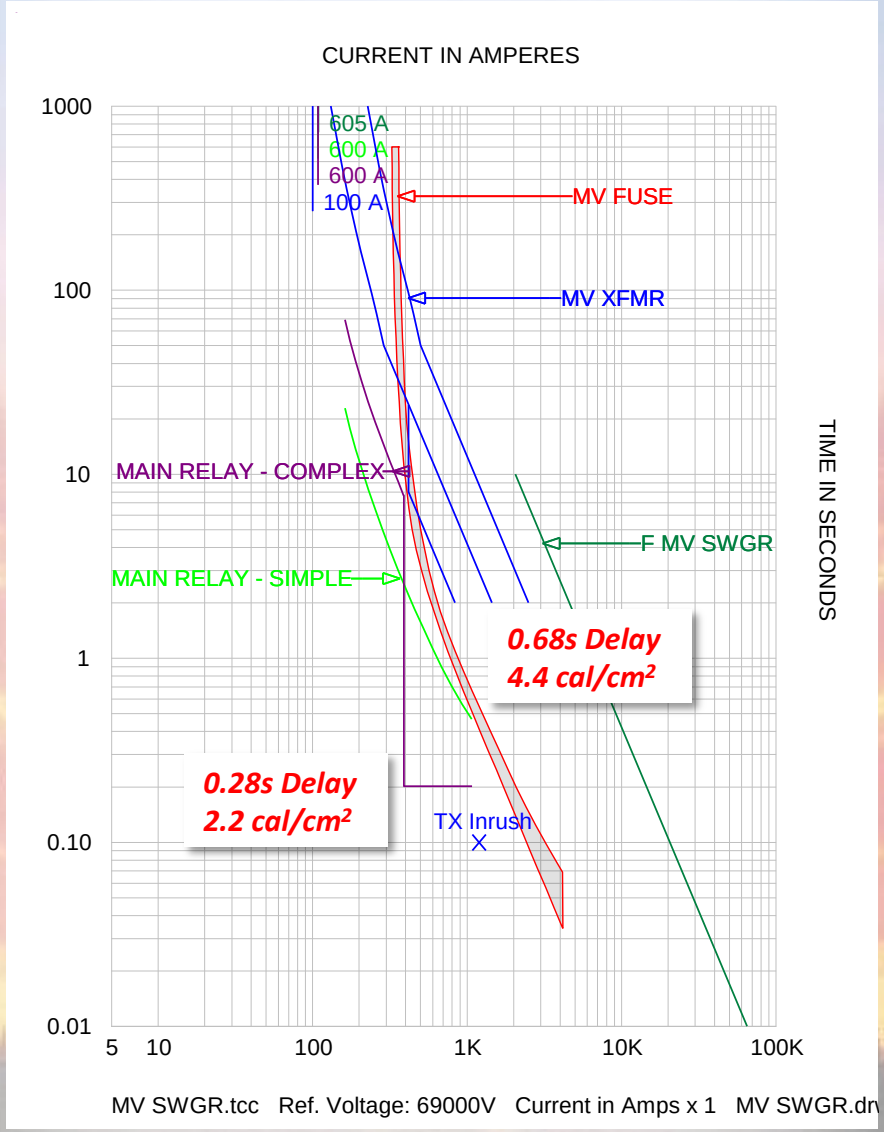
Main Device Settings



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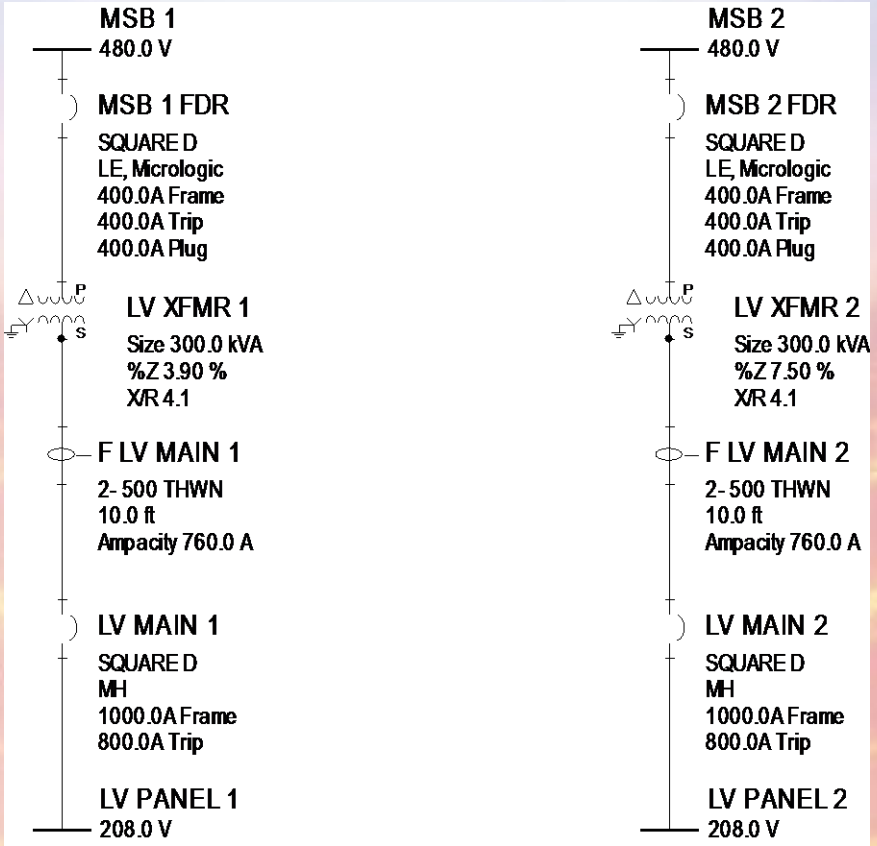
Passive Mitigation

- **Transformer Impedance Selection**
  - Higher impedance used to lower fault currents (lower fault ratings = lower cost equipment).
  - Higher impedance results in higher loses (heat)
  - Higher impedance result in longer arcing fault trip time (higher IE).

Transformer Impedance



0.06s Delay
0.9 cal/cm²

2s Delay
30 cal/cm²

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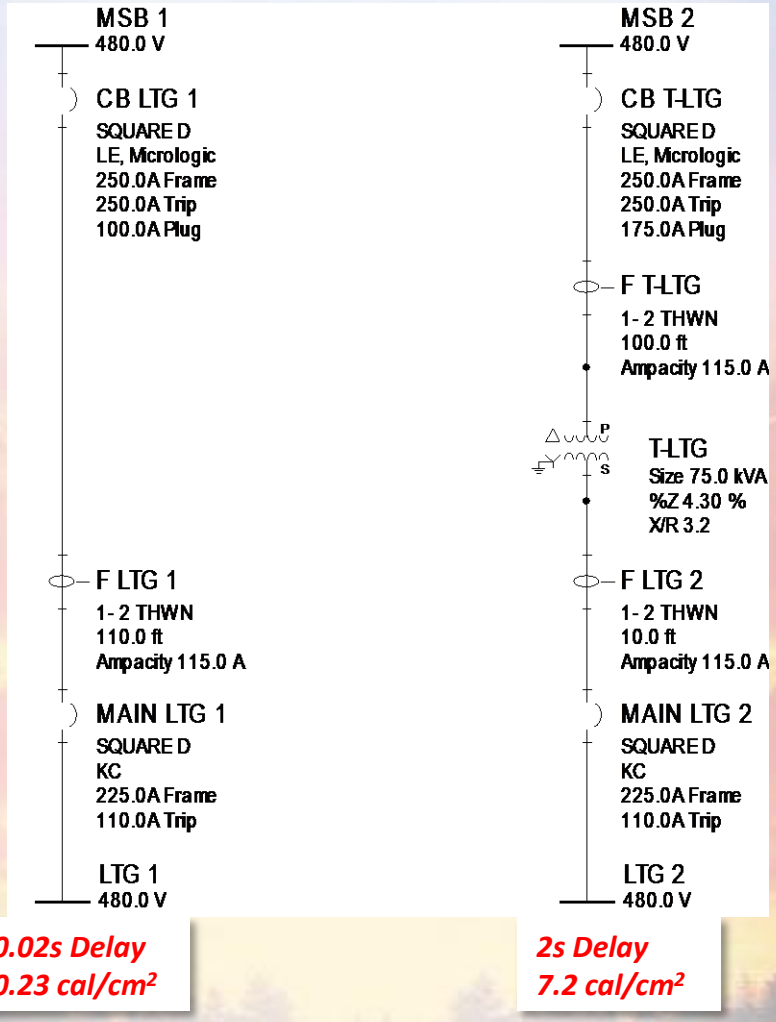
Passive Mitigation Failure

- **High Resistance Grounding (HRG)**
  - Reduces the Probability of an arc-flash. It does not reduce the magnitude (actually higher).
  - Requires Isolation transformers for loads that require solid grounding (ie: lighting), result in higher IE.

HRG Affect on Lighting Panels



0.02s Delay
0.23 cal/cm²

2s Delay
7.2 cal/cm²

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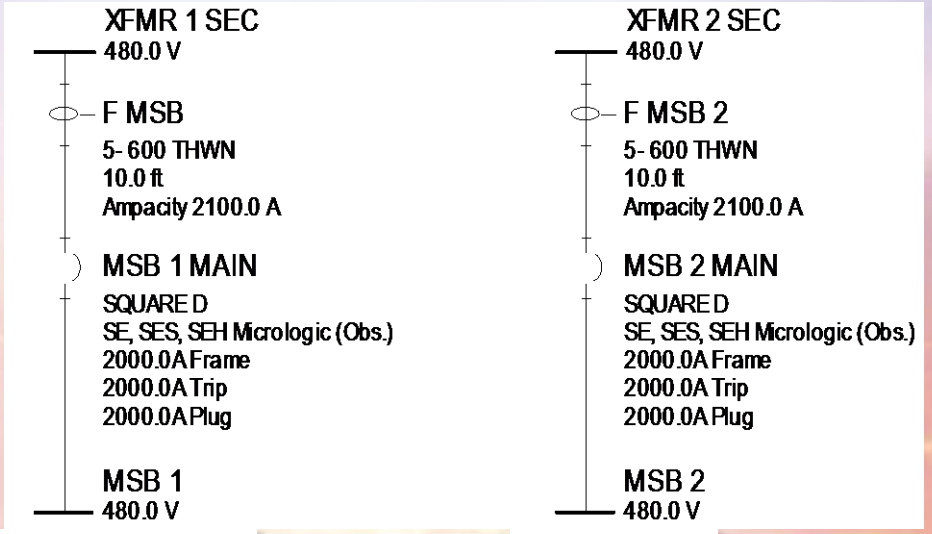
Active Mitigation

- Does not compromise selectivity
- Always active
- Fast clearing times
- Still requires main isolation
- Examples
  - Differential Protection
  - Communications Based protection(Zone Interlocking)
  - Arc Detection

Active Mitigation



No Mitigation
0.26s Delay
15 cal/cm²

AF Relay
0.08s Delay
4.6 cal/cm²

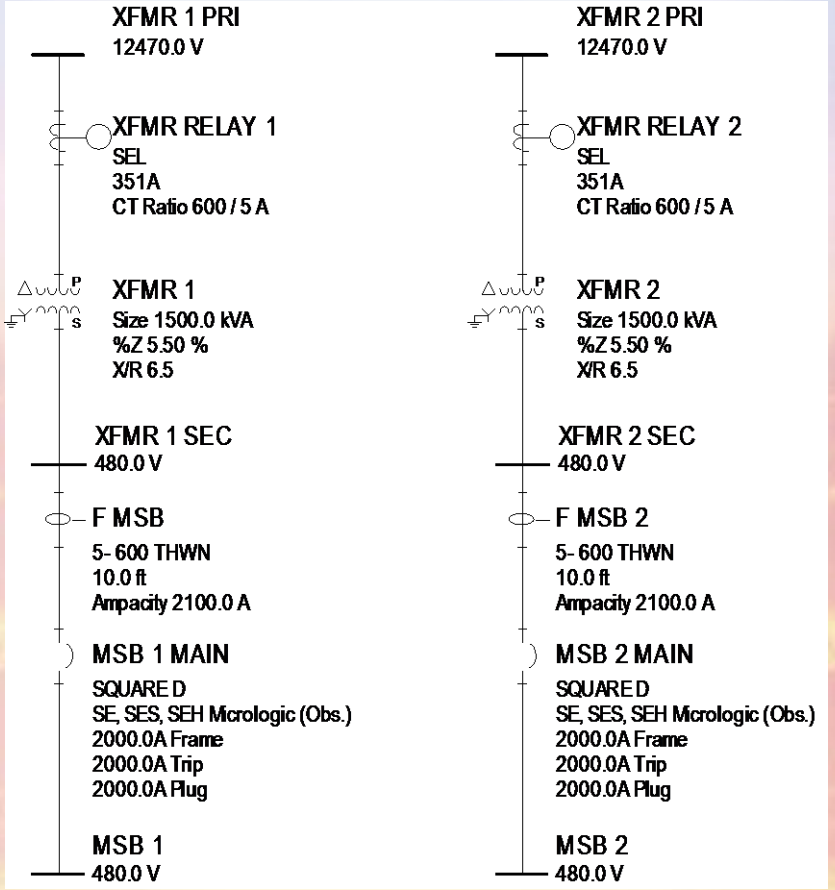
Temporary Mitigation

- Can significantly reduce incident energy
- Will compromise selectivity when active
  - Add visual or communications based notification so that it is not left active
  - Consider mechanical interlocks
- Depending on location may not require main isolation
- Effectiveness not guaranteed, it must be analyzed.
- Can be applied across transformers

Apply Maintenance Mode on the High Side of a Transformer

- Must be able to added either as discrete device or an additional function.
- The operating device must be able to safely interrupt the fault (not a load breaker device).
- Must be able to be set above load, but well below the expected arcing fault current.

Temporary Mitigation



No Mitigation
1.93s Delay
93 cal/cm²

Maint. Mode
0.1s Delay
5.7 cal/cm²

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Requiring Mitigation in Design and Construction

- It is easier and less expensive to incorporate mitigation into a design before it is built instead of trying of fix it once it is installed. This can be accomplished by requiring it both the design and construction specifications.
- The specification must require mitigation to a PPE level that meets the site-specific safety requirements.

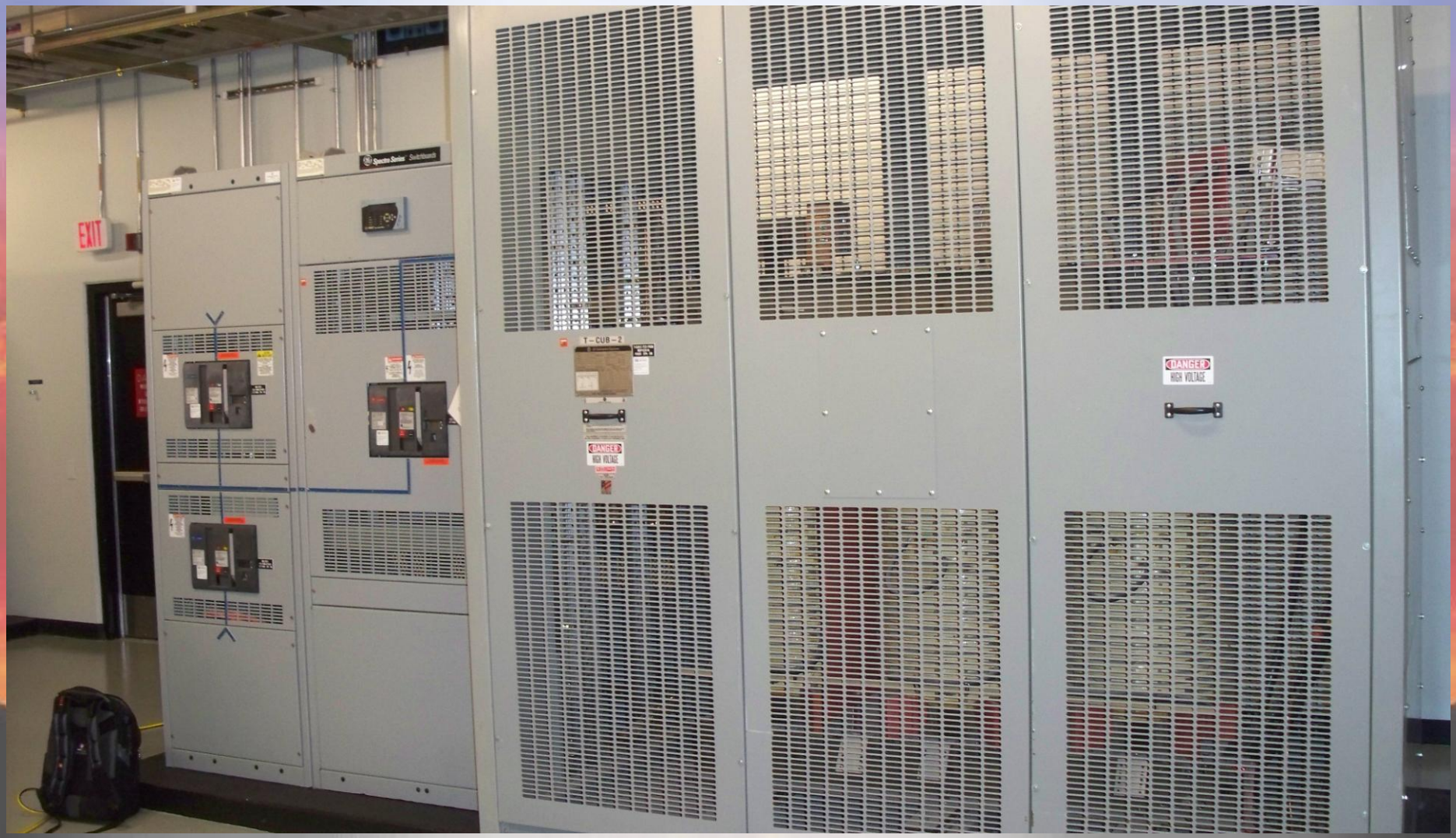
Requiring Mitigation in Design

- The specifications must require complete analysis of the mitigation in the design process, prior to equipment purchase, and the as-built configuration.
  - Existing Facilities require data collection by personnel familiar with the analysis and codes to identify condition or code based issues that might affect the design or analysis
  - Personnel collecting data must mark-up one-lines to reflect the as-found conditions

Equipment Specifications

- Require Isolated Main Devices.
- Require Isolation in Unit Transformers.
- Require designs that direct arc-energies away from personnel.
- Require sufficient number and locations for inspection windows to reduce the number of time covers have to be removed.
- Require devices with integral metering for all locations where load checks are required.

What We Want to Avoid



What We Want to Avoid

Conclusions

- There are ways to reduce incident energies in both new and existing facilities.
- The configurations and methods discussed here are SOME of the ways this can be accomplished.
- To make this happen it MUST be written in to all new specifications

Thank You

Questions?

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