SKM Power*Tools for Windows

Electrical Power Systems Design and Analysis Software


"I introduced into my ears two metal rods with rounded ends and joined them to the terminals of the apparatus"
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“At the moment the circuit was completed, I received a shock in the head – and began to hear a noise –

a crackling and boiling”

“This disagreeable sensation, which I feared might be dangerous, has deterred me so that I have not repeated the experiment”

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Alessandro Volta

1745 - 1827

Arc Flash

What is the purpose of an arc flash study?

- To determine the protective clothing requirements for persons working on live equipment
- Living with what one has and minimize the risks
- Designing electrical safety into the power distribution design

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Why Integrated Software

For Arc Flash Evaluation?

Why Integrated Software?

- We all love Microsoft (we own stock)?
- I can't find that NFPA book to do it by hand ?
- I lost my calculator?
- The boss wanted the PPEs yesterday?

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Why Integrated Software?

In Real Estate, it's location

In Arc Flash, it is

Accuracy

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Standards Related to Safety

NEC 110.16

NFPA 70E

IEEE Std. 1584

Also we have OSHA &

The Occupational Health and Safety Act and its regulations

Electrical Hazards

•NEC® 2002 Article 110.16

110.16 Flash Protection. Switchboards, panelboards, industrial control panels, and motor control centers in other than dwelling occupancies, that are likely to require examination, adjustment, servicing, or maintenance while energized, shall be field marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

Reprinted from NEC® 2002


WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required

•NEC® 2005 Article 110.16

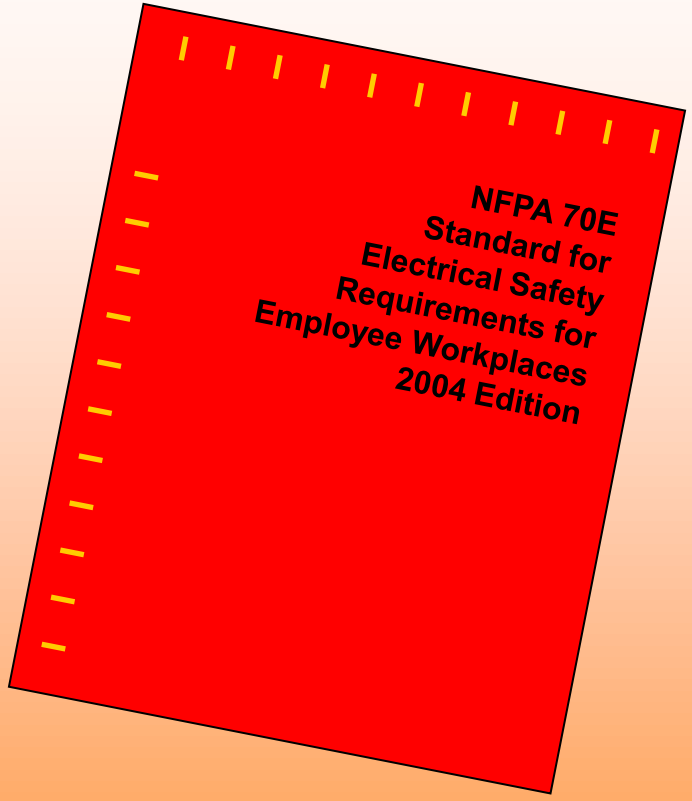
FPN No. 1: NFPA 70E-2004, Standard for Electrical Safety in the Workplace, provides assistance in determining severity of potential exposure, planning safe work practices, and selecting personal protective equipment.

FPN No. 2: ANSI Z535.4 – 1998, Product Safety Signs and Labels for application to products.

Reprinted from NEC® 2005

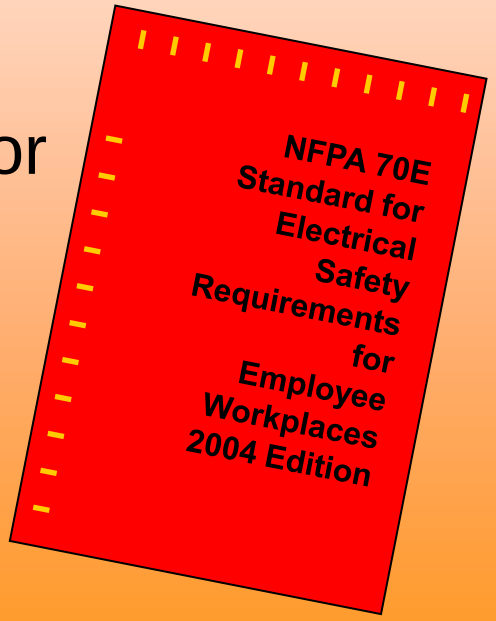
NFPA 70E

- Requirements for safe work practices
- Addresses hazards:
  - Shock
  - Arc Flash
- Requirements for shock and arc flash boundaries
- Requirements for personal protective equipment
- Incident Energy and flash boundary calculations (<1000V, 5kA-106kA)



NFPA 70E

130.3 Flash Hazard Analysis. A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use. Requirements for safe work practices



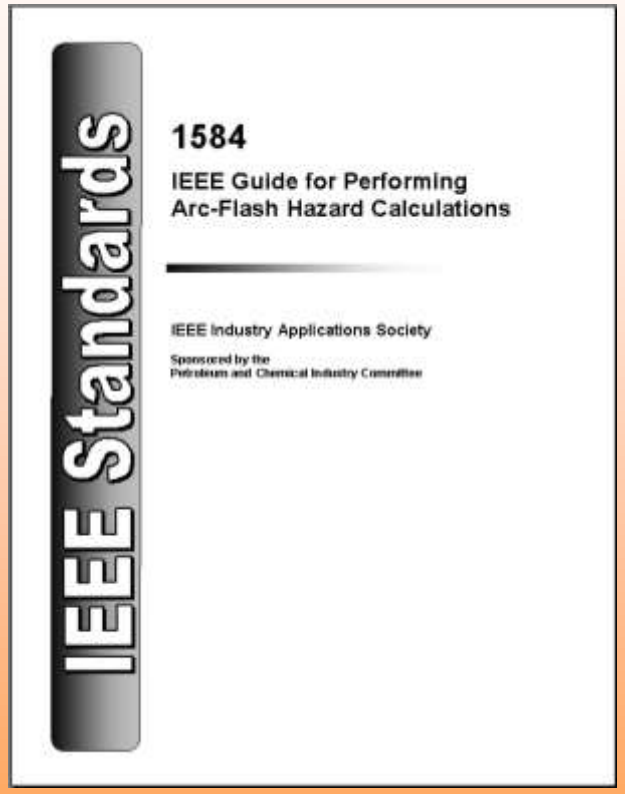
NFPA 70E

(B) Protective Clothing and Personal Protective Equipment for Application with a Flash Hazard Analysis. Where it has been determined that work will be performed within the Flash Protection Boundary by 130.3(A), the flash hazard analysis shall determine, and the employer shall document, the incident energy exposure of the worker (in calories per square centimeter). The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Flame-resistant (FR) clothing and personal protective equipment (PPE) shall be used by the employee based on the incident energy exposure associated with the specific task. Recognizing that incident energy increases as the distance from the arc flash decreases, additional PPE shall be used for any parts of the body that are closer than the distance at which the incident energy was determined As an alternative, the PPE requirements of 130.7(C)(9) shall be permitted to be used in lieu of the detailed flash hazard analysis approach described in 130.3(A).

FPN: For information on estimating the incident energy, see Annex D.

IEEE Std 1584 - 2002

- Addresses Arc Flash Calculations:
  - Arcing Fault
  - Incident energy
  - Flash boundary
- Valid Ranges
  - 208 V to 15 kV
  - 700A to 106kA
  - Gap 13mm to 153mm
- Out of Range
  - Use Lee Equation



WARNING

Arc Flash and Shock Hazard
Appropriate PPE Required

24 inch	Flash Hazard Boundary
3	cal/cm² Flash Hazard at 18 inches
1DF	PPE Level, 1 Layer 6 oz Nomex ®, Leather Gloves Faceshield
480 VAC	Shock Hazard when Cover is removed
36 inch	Limited Approach
12 inch	Restricted Approach - 500 V Class 00 Gloves
1 inch	Prohibited Approach - 500 V Class 00 Gloves

Equipment Name: Slurry Pump Starter

Courtesy E.I. du Pont de Nemours & Co.

To do Arc Flash Evaluations

- Start with an accurate one line
- Have accurate one line component definitions
- Have accurate Short Circuit potentials
- Have knowledge of the protective devices' opening times
- An accurate description of the operation
- **And it is all kept up to date**

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Role of Integrated Software

- Provide a one-line and system model of the power system
- Run studies for sizing and analysis (studies are required for worker safety, protection of equipment, and reliable operation)

Studies (Examples)

- *Load Analysis* is used to verify that equipment is sized properly for continuous loads.
- *Short Circuit Analysis* is used to verify that equipment is sized properly to withstand and interrupt short circuits.
- *Protective Device Coordination* sets protective devices to allow normal system operation while protecting equipment from damage and workers from injury.
- *Harmonic Analysis* is used to minimize harmonic distortion and verify the equipment is sized properly to withstand harmonic current and voltage.
- *Arc Flash Hazard Analysis* is used to calculate the incident energy released when an arcing fault occurs.

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In reality

- These studies are not always performed
  (When changes are made or about to made)
- Plant operating conditions vary
- Assumptions (issues) have to be made
- But with Arc Flash today, studies need to be up to date

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Preparing to Work Safely
What do we need to know or do?

- Documented Procedures
- Know Fault Current Calculations
- Know Safe Approach Distance
- Know Arcing Fault Clearing Time
- Know the Incident Energy Exposure Calculations
- Know Hazard Risk Category

Preparing to Work Safely
What do we need to know or do?

- Documented Procedures
  - Job briefing (written work processes & procedures)
  - Energized work permit

- Know Fault Current Calculations
- Know Safe Approach Distance
- Know Arcing Fault Clearing Time
- Know the Incident Energy Exposure Calculations
- Know Hazard Risk Category

Safe Work Practices

OSHA 1910.333 (a) (1) & NFPA 70E 130.1

not to work “hot” or “live” except when Employer can demonstrate:

1. De-energizing introduces additional or increased hazards
2. Infeasible due to equipment design or operational limitations

NFPA 70E - 2004

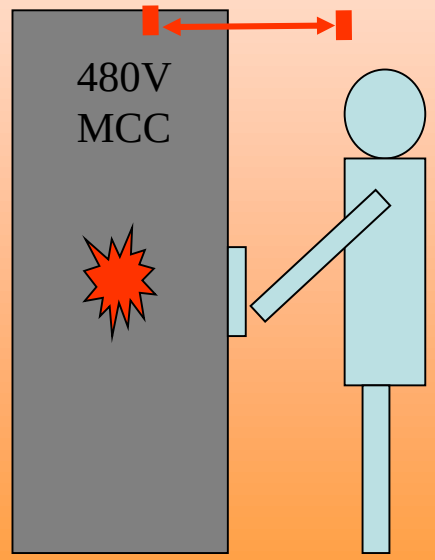
Appropriate safety-related work practices shall be determined before any person approaches exposed live parts within the Limited Approach Boundary by using both shock hazard analysis and flash hazard analysis.

NFPA 70E - 2004

A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.

NFPA 70E

The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed.



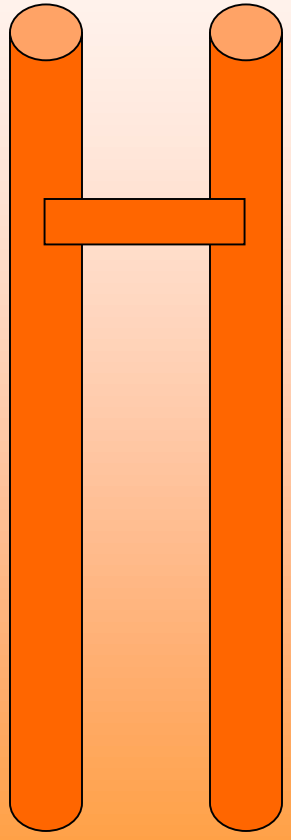
NFPA 70E - 2004

If live parts are not placed in an electrically safe work conditions (i.e., for the reasons of increased or additional hazards or infeasibility per 130.1) work to be performed shall be considered energized electrical work and shall be performed by written permit only.

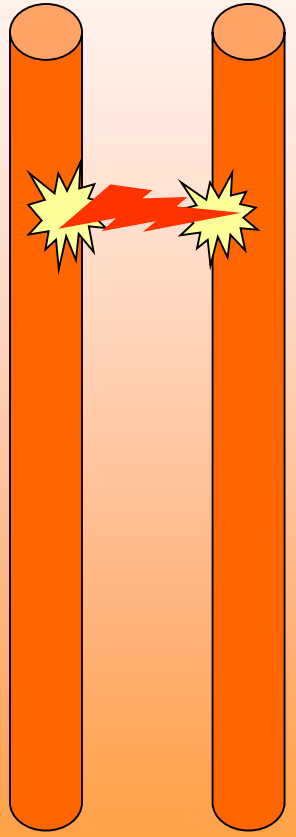
Preparing to Work Safely
What do we need to know or do?

- Documented Procedures
- Know Fault Current Calculations
  - Bolted Fault
  - Arcing Fault
- Know Safe Approach Distance
- Know Arcing Fault Clearing Time
- Know the Incident Energy Exposure Calculations
- Know Hazard Risk Category

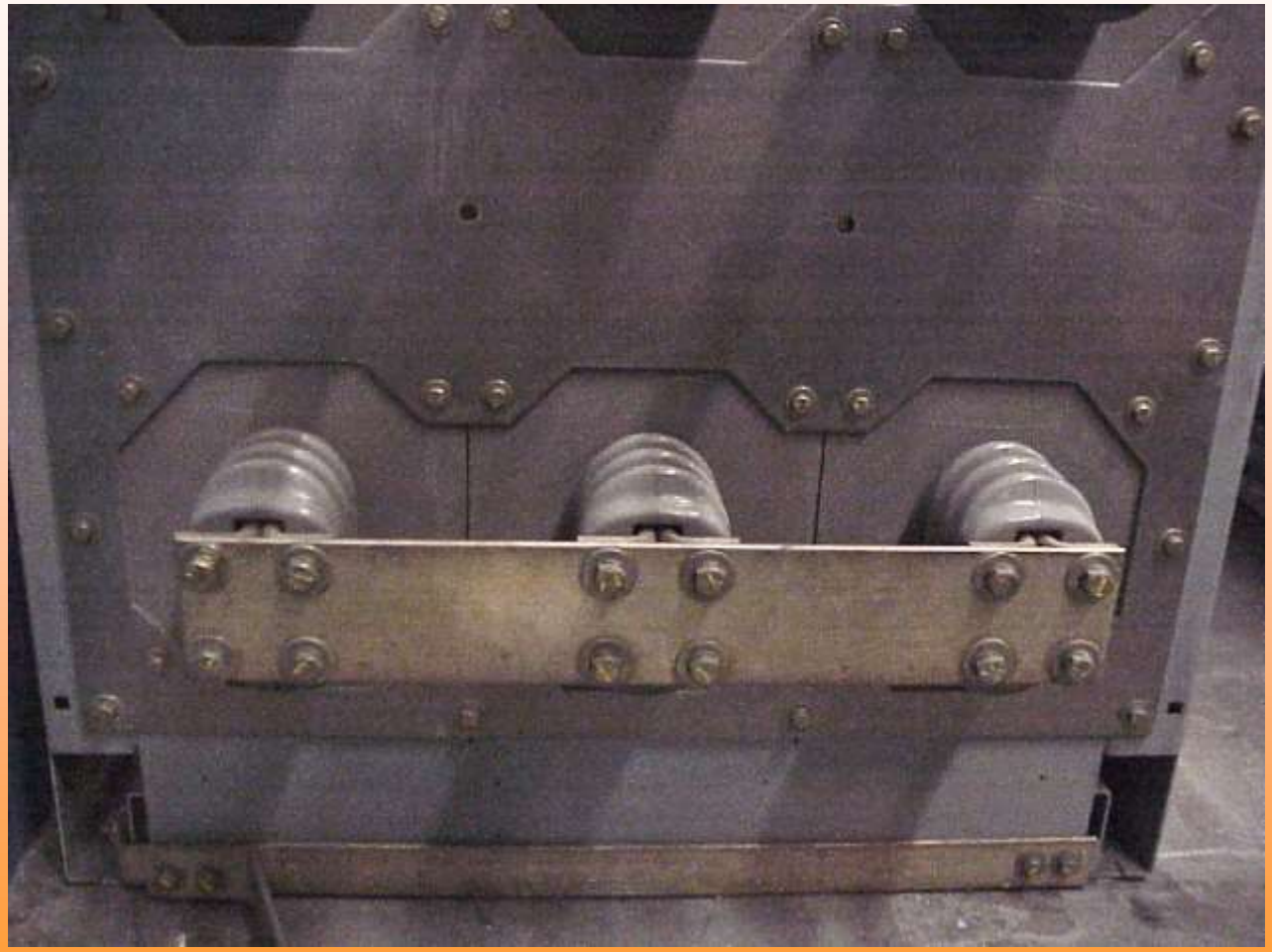
Bolted Short Circuit



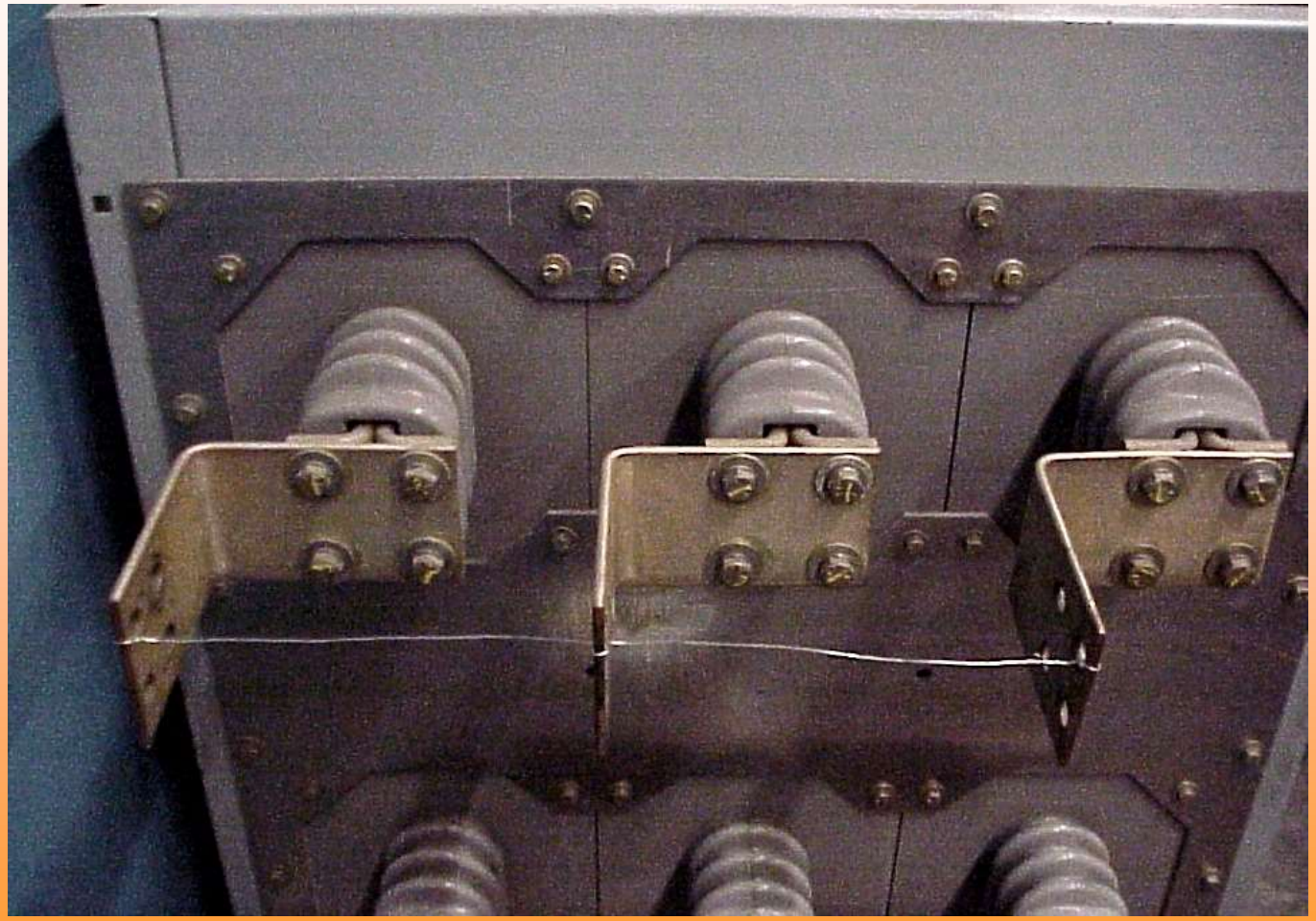
Arcing Short Circuit



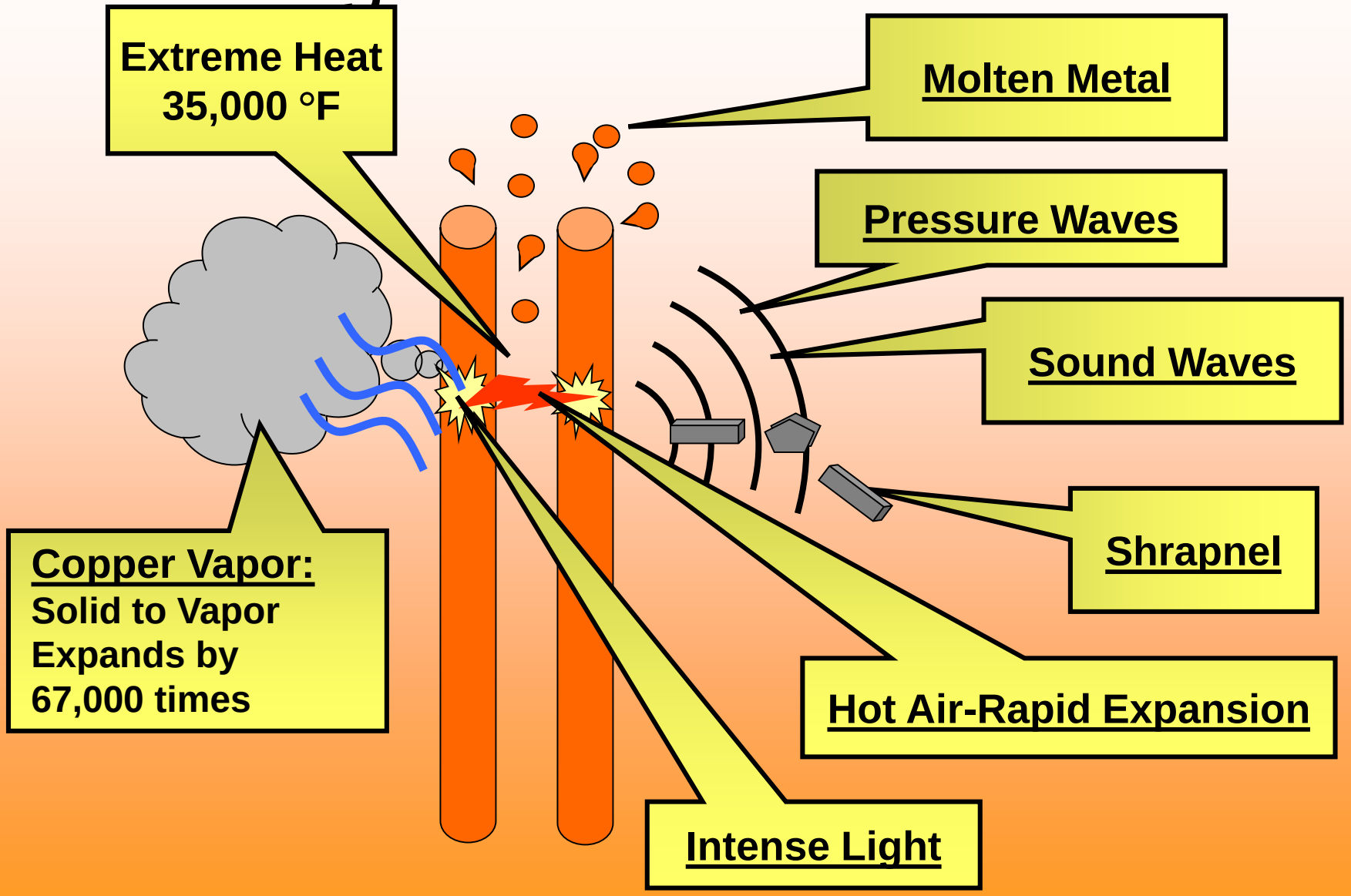
Test Rig for Bolted SC



Test Rig for Arching SC

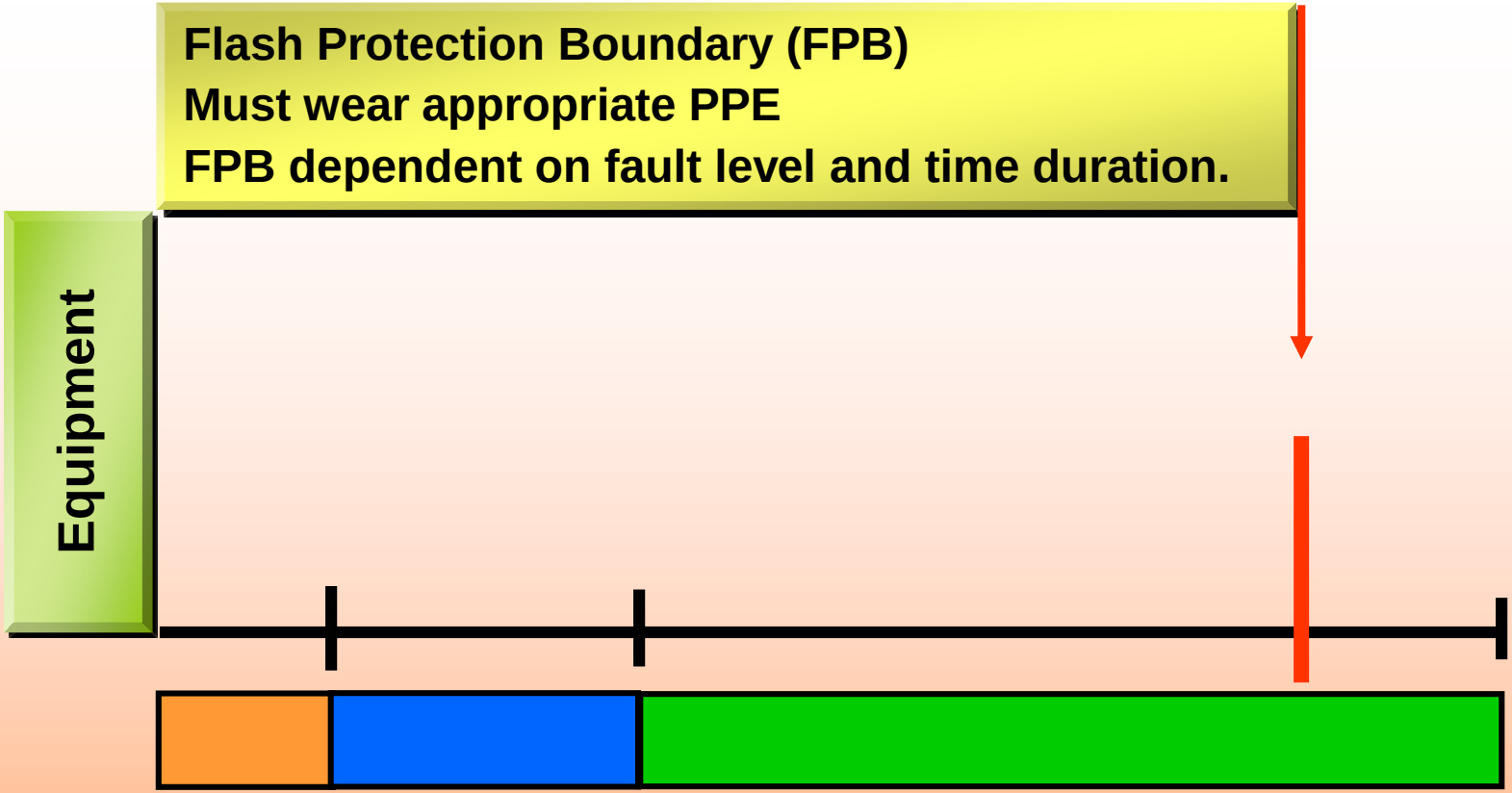


Arcing Short Circuit



Preparing to Work Safely
What do we need to know or do?

- Documented Procedures
- Know Fault Current Calculations
- Know Safe Approach Distance
  - Limits of approach
  - Flash boundary
- Know Hazard Risk Category
- Know Arcing Fault Clearing Time
- Know the Incident Energy Exposure Calculations



Prohibited Shock Boundary: Qualified Persons Only. PPE as if direct contact with live part

Restricted Shock Boundary: Qualified Persons Only

Limited Shock Boundary: Qualified or Unqualified Persons*
* Only if accompanied by Qualified Person

Note: shock boundaries dependent on system voltage level

Flash Boundary

D_B *arc flash boundary (mm) at incident energy of 5.0 (J/cm^2)*

$$D_B = [\ 4.184\ C_f\ En\ (t/0.2)\ (610^X / E_B)\ ]^{1/X}$$

where

E_B	*incident energy set 5.0 (J/cm^2)*
C_f	*1.0 for voltage above 1 kV and*
	1.5 for voltage at or below 1 kV
t	*arcing duration in seconds*
x	*distance exponent*

x	*Equipment Type*	*kV*
1.473	*Switchgear*	*<= 1*
1.641	*Panel*	*<= 1*
0.973	*Switchgear*	*> 1*
2	*all others*	

Preparing to Work Safely
What do we need to know or do?

- Documented Procedures
- Know Fault Current Calculations
- Know Safe Approach Distance
- Know Arcing Fault Clearing Time
  - Time current curves
  - Coordination studies
- Know the Incident Energy Exposure Calculations
- Know Hazard Risk Category

Preparing to Work Safely
What do we need to know or do?

- Documented Procedures
- Know Fault Current Calculations
- Know Safe Approach Distance
- Know Arcing Fault Clearing Time

- Know the Incident Energy Exposure Calculations
  - NFPA 70E Method
  - IEEE 1584 Method

Know Hazard Risk Category

NFPA 70E

Annex D: Sample Calculation of Incident Energy and Flash Protection Boundary

1) NFPA 70 Method with 100% and 38% of Bolted Fault

2) IEEE 1584 Empirical method

Use IEEE 1584 Calculations

Preliminary IEEE 1584 work used in NFPA 70E

NFPA 70E equations limited to < 1000V

IEEE 1584 equations expanded to 15,000V

NFPA 70E 38% Arcing Fault Current is overly conservative and doesn’t guarantee worst case incident energy.

Incident Energy

Energy Per Unit of Area Received On A Surface Located A Specific Distance Away From The Electric Arc, Both Radiant And Convective, in Units of cal/cm^2.

Incident Energy

$$\log(En) = K1 + K2 + 1.081 \log(Ia) + 0.0011\,G$$

En	*Incident energy (J/cm^2) normalized for 0.2s arcing duration and 610mm working distance*
K1	*–0.792 for open configuration* *–0.555 for box configuration (switchgear, panel)*
K2	*0 for ungrounded and high resistance grounded systems* *-0.113 for grounded systems*
Ia	*Arcing fault current*
G	*gap between bus bar conductors in mm*

solve $En = 10^{\log En}$

Incident Energy

Incident Energy convert from normalized:

$$E = 4.184\ C_f\ En\ (t/0.2)\ (610^X / D^X)$$

E	*incident energy (J/cm^2)*
C_f	*1.0 for voltage above 1 kV and 1.5 for voltage at or below 1 kV*
t	*arcing duration in seconds*
D	*working distance*
x	*distance exponent*

x	*Equipment Type*	*kV*
1.473	*Switchgear*	*<= 1*
1.641	*Panel*	*<= 1*
0.973	*Switchgear*	*> 1*
2	*Cable, Open Air*	

Preparing to Work Safely
What do we need to know or do?

- Documented Procedures
- Know Fault Current Calculations
- Know Safe Approach Distance
- Know Arcing Fault Clearing Time
- Know the Incident Energy Exposure Calculations
- Know Hazard Risk Category
  - NFPA 70E

Appropriate PPE

Incident Energy From (cal/cm2)	Incident Energy To (cal/cm2)	Hazard Risk Category	Clothing Description	Clothing Layers	Required Minimum Arc Rating of PPE (cal/cm2)	Notes
0.0	1.2	0	Untreated Cotton	1	N/A	
1.2	4.0	1	FR Shirt & Pants	1	4	
4.0	8.0	2	Cotton Underwear + FR Shirt & Pants	1 or 2	8	
8.0	25.0	3	Cotton Underwear + FR Shirt & Pant + FR Coverall	2 or 3	25	
25.0	40.0	4	Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit	3 or more	40	

Preparing to Work Safely

We need to know or do:

- Prepare to work safely
- Know Fault Current Calculations
- Know Safe Approach Distance
- Know Arcing Fault Clearing Time
- Know the Incident Energy Exposure Calculations
- Know Hazard Risk Category

But Why?

NFPA 70E - 2004

A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.

Ok, it’s required

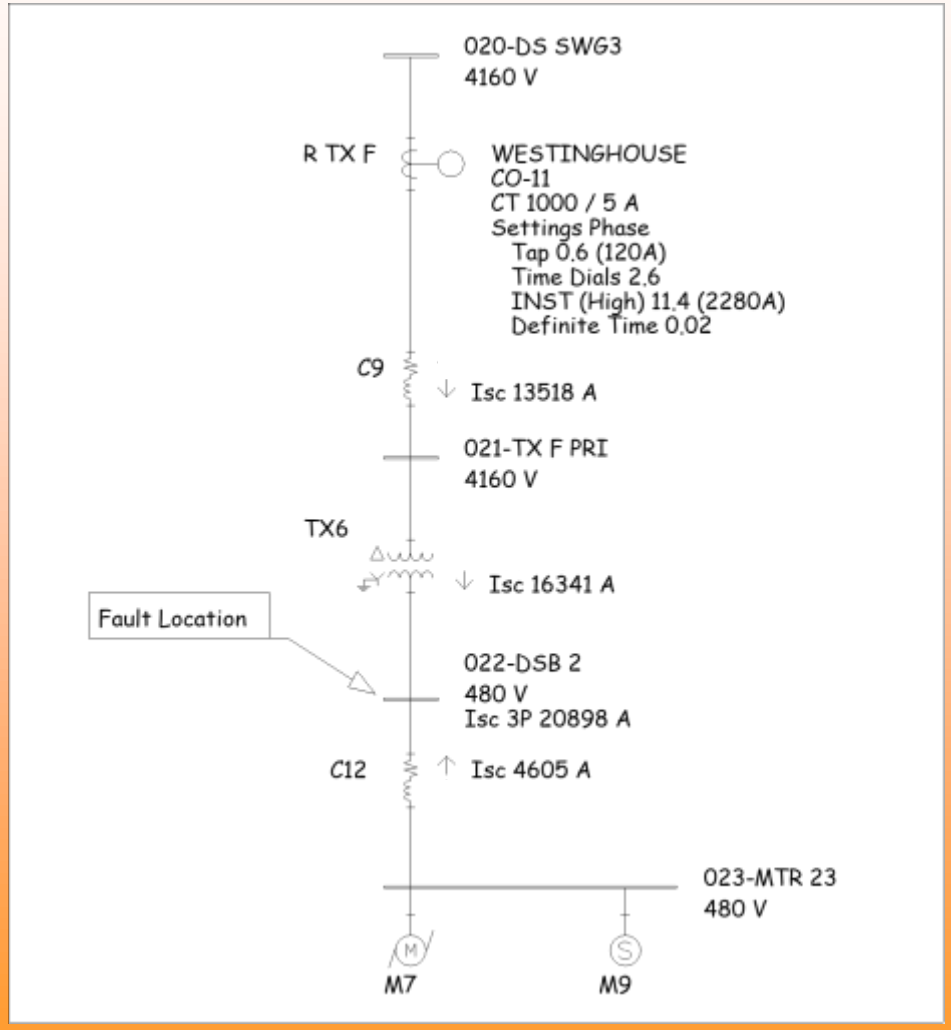
But How?

Break

Perform an Arc Flash Study Analysis

- Arc Flash Calculation Step Review
  - Determine System Modes of Operation
  - Calculate Bolted Fault Current at each Bus
  - Calculate Arcing Fault Current at each Bus
  - Calculate Arcing Fault Current seen by each Protective Device
  - Determine Trip Time for Each Protective Device based on Arcing Fault Current
  - Calculate Incident Energy at Working Distance
  - Calculate Arc Flash Boundary
  - Determine Required PPE

Bolted Fault Current



Arcing Fault Current

For bus voltage < 1 kV and 700A $\leq I_B \leq$ 106kA

$$\log (I_A) = K + 0.662 \log (I_B) + 0.0966\ V + 0.000526\ G + 0.5588\ V \log (I_B) - 0.00304\ G \log (I_B)$$

where

log	*log10*
I_A	*arcing fault current*
K	*–0.153 for open configuration and*
	–0.097 for box configuration
I_B	*bolted fault current – 3phase sym rms kA at the bus*
V	*bus voltage in kV*
G	*bus bar gap between conductors in mm*

For bus voltage >= 1 kV and 700A $\leq I_B \leq$ 106kA

$$\log (I_A) = 0.00402 + 0.983 \log (I_B)$$

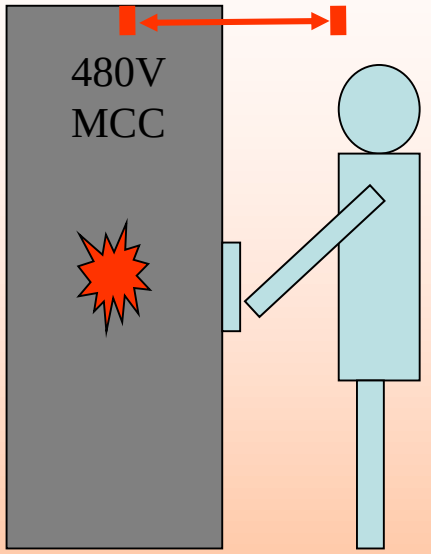
Identify Environment

- *Working Distance*
- *Grounded / Ungrounded*
- *Equipment Type*

  Open Air
  Switchgear
  Panel / MCC
  Cable

- *Bus Bar Gap*

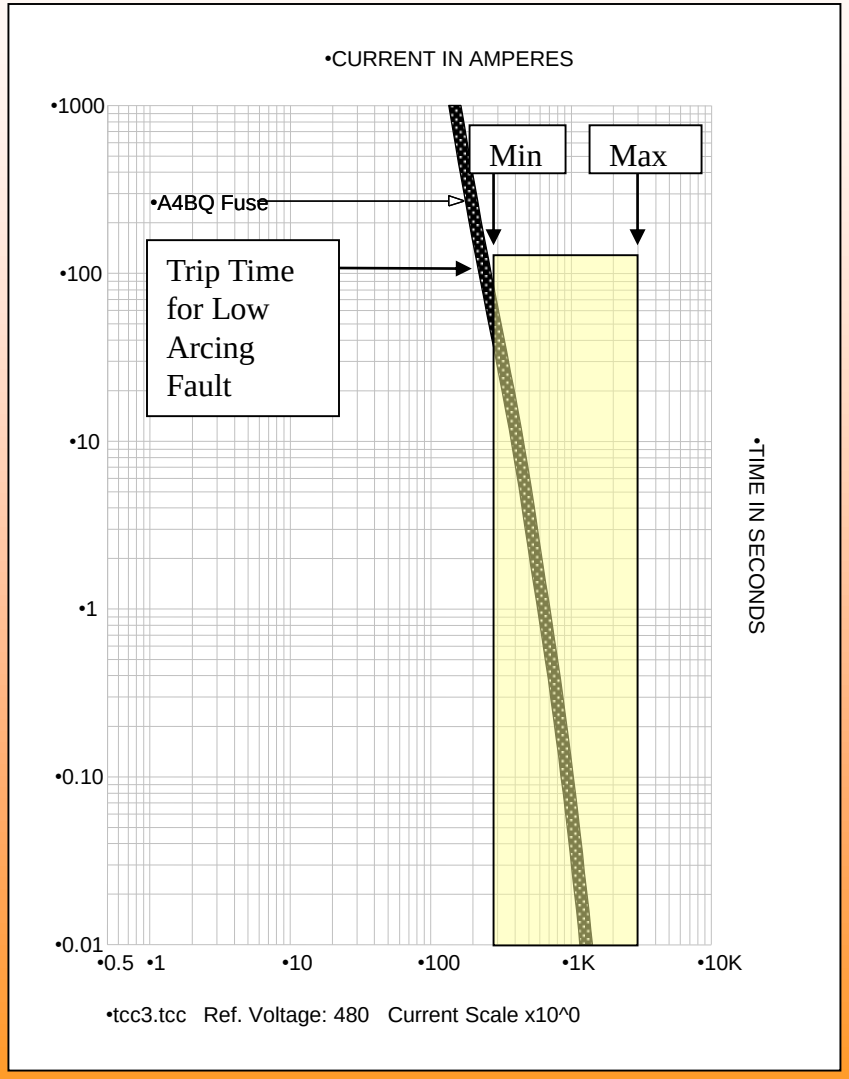
15kV Swgr	*152mm*
5kV Swgr	*104mm*
LV Swgr	*32mm*
Panel / MCC	*25mm*
Cable	*13mm*



There are Issues!

Arc Flash

Arcing Fault Clear Time



Arc Flash Incident

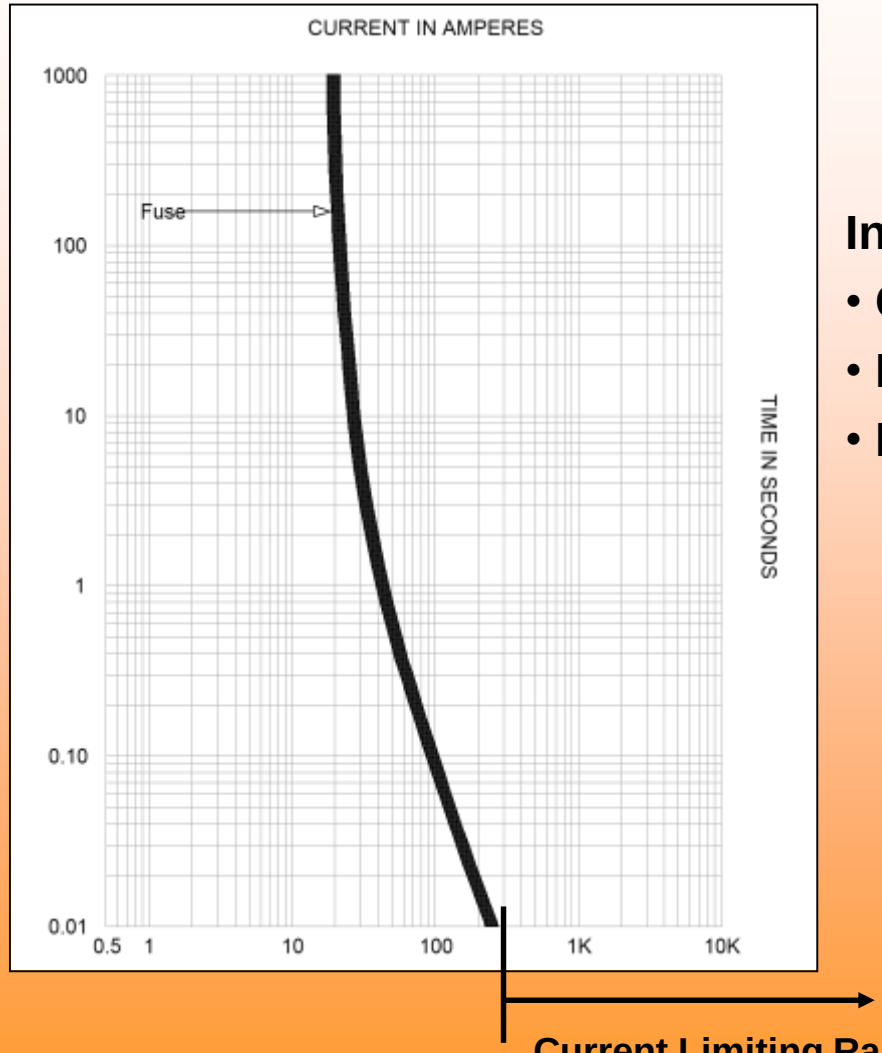
480 Volt System

22,600 Amp Symmetrical Fault

Motor Controller Enclosure

6-Cycle Arcing Fault (0.1 sec)

Issues – Current Limiting



In Current Limiting Range

- **Operates in < ½ Cycle**
- **Limits Current from 0 to >90%**
- **Limits More at Higher Currents**

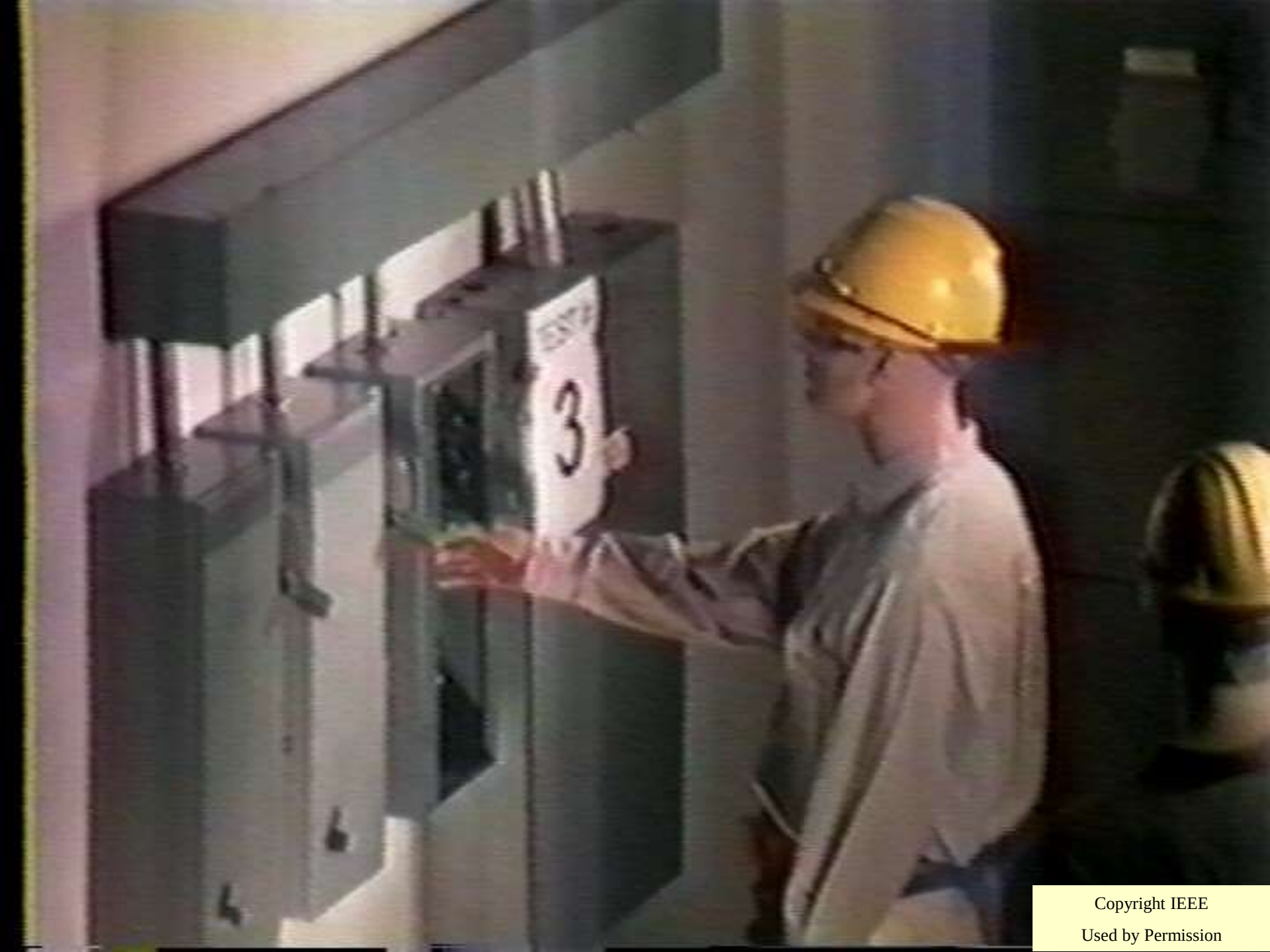
Arc Flash Incident

480 Volt System

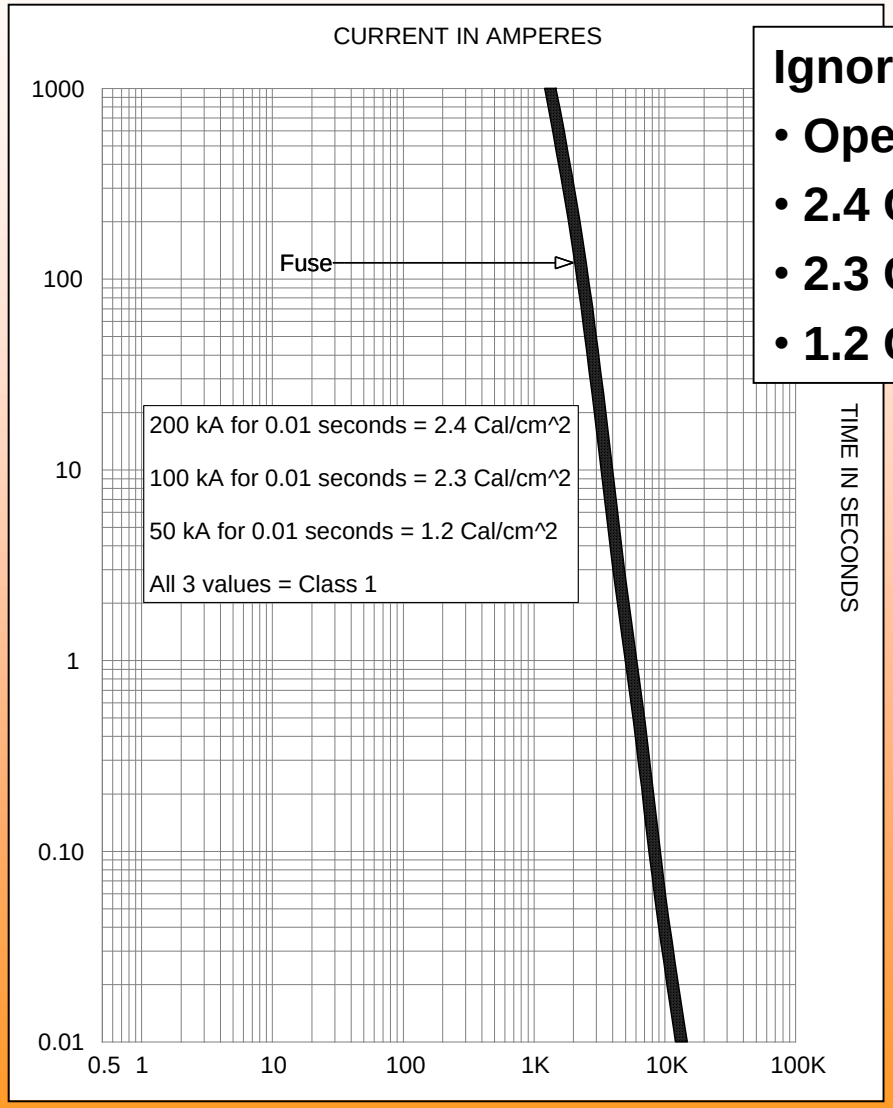
22,600 Amp Symmetrical Fault

Motor Controller Enclosure

Current Limiting Device with < ½ Cycle operation (.0083 sec). Note that Arcing Fault must be in current limiting range.



Issues – Current Limiting



Ignoring Current-Limiting Effects

- **Operates in 0.01s**
- **2.4 Cal/cm2 at 200 kA**
- **2.3 Cal/cm2 at 100 kA**
- **1.2 Cal/cm2 at 50 kA**

Issues – Fault Values

- *Maximum Faults used for Equipment Selection*
- *Minimum Faults Often Worst Case for Arc Flash*
  - *Requires accurate utility fault contribution (not infinite source)*
  - *Consider lowest pre-fault voltage*
  - *Consider operating conditions with minimum motors*
  - *Consider operating conditions with/without generators*
  - *Consider stand-by operating modes*

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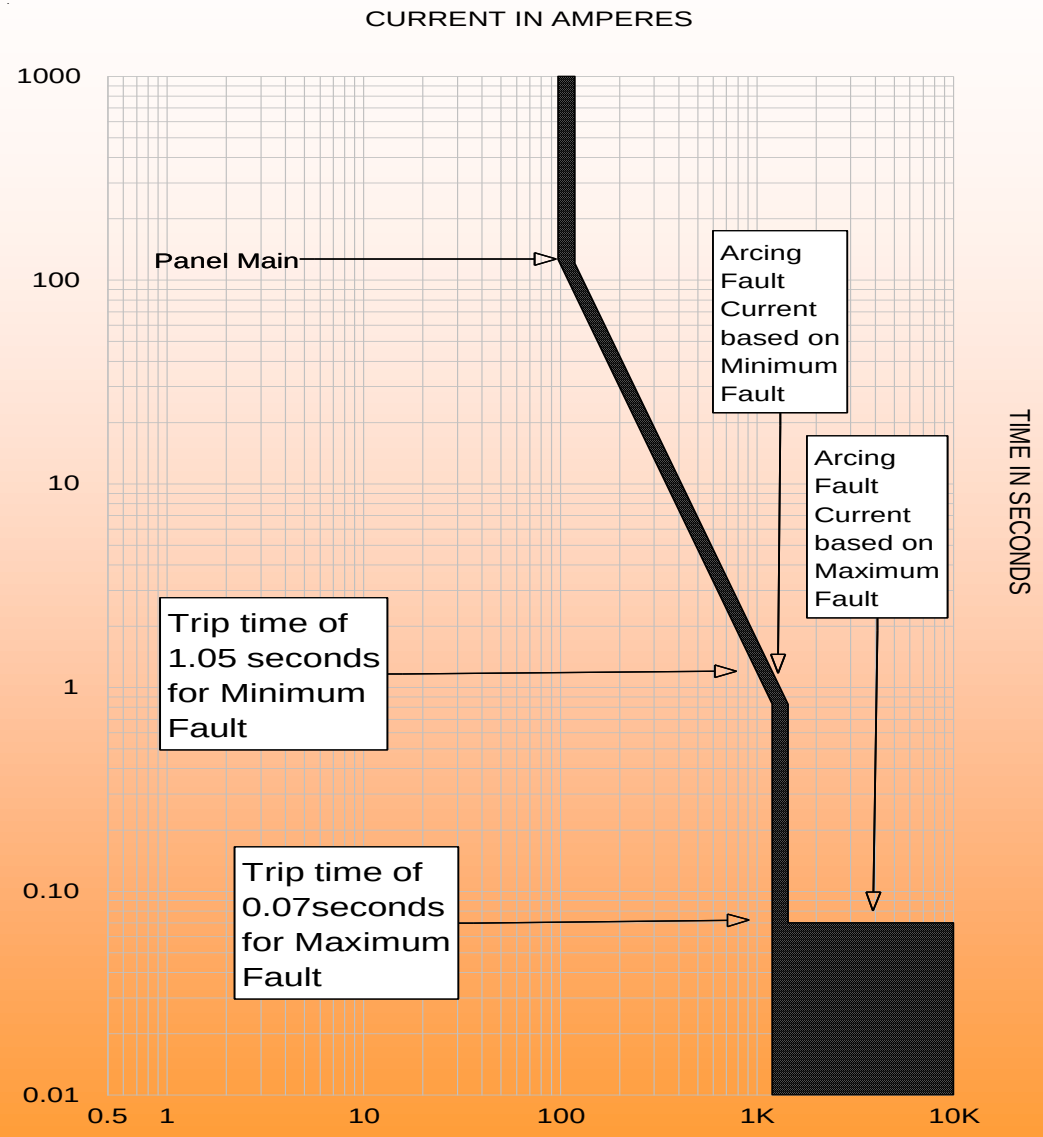
Minimum and Maximum Faults of Devices



tcc5.tcc Ref. Voltage: 480 Current Scale x10^0 1Line001.drw

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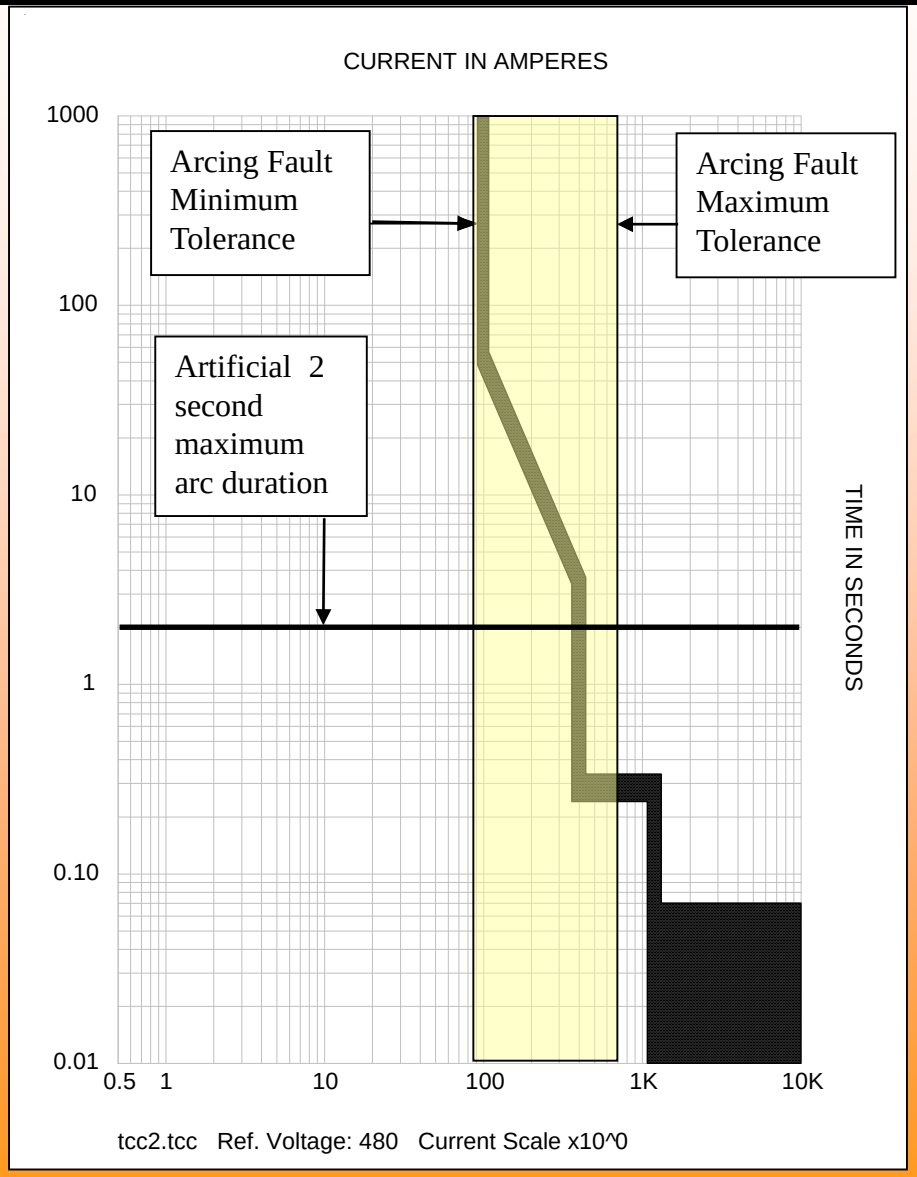
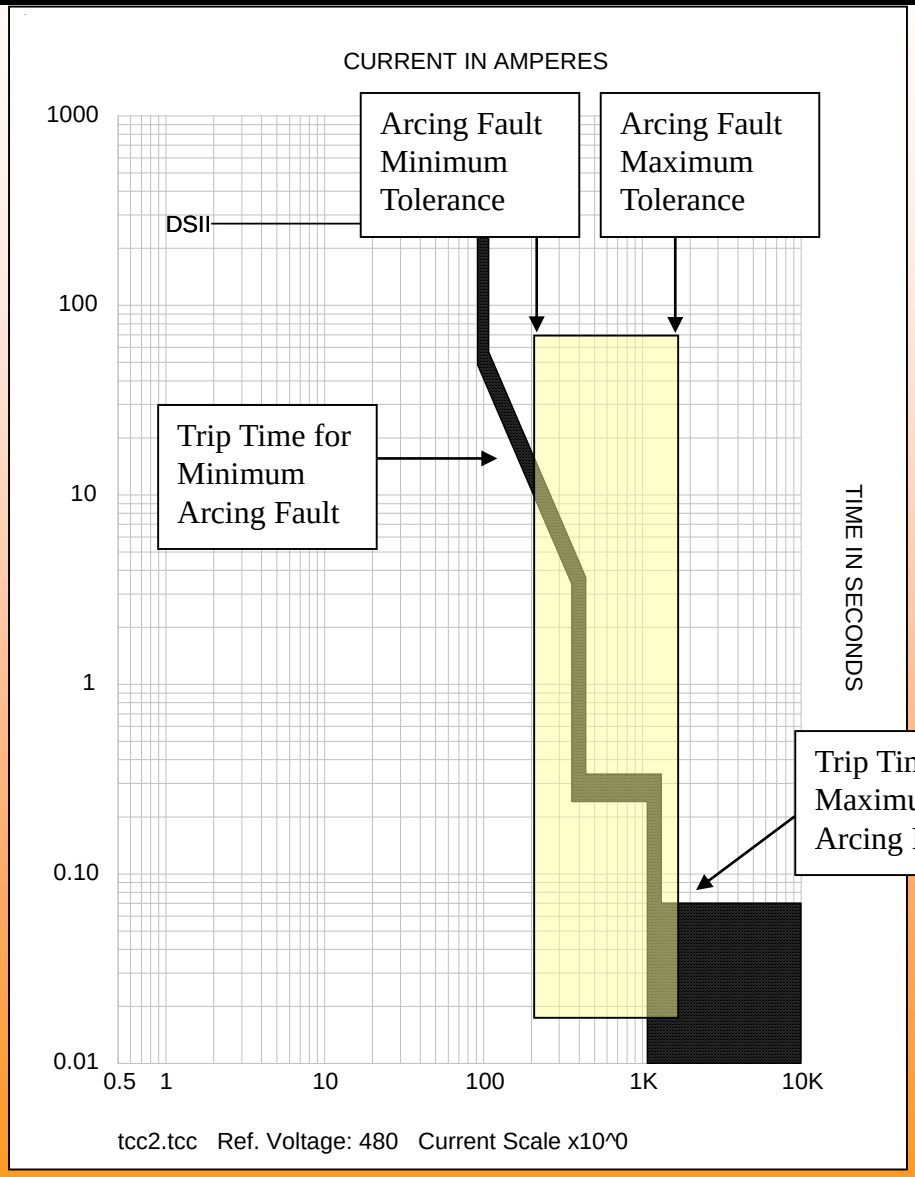
Issues – Long Trip Times



Issues - Faster Trip Times



Issues - Coordination

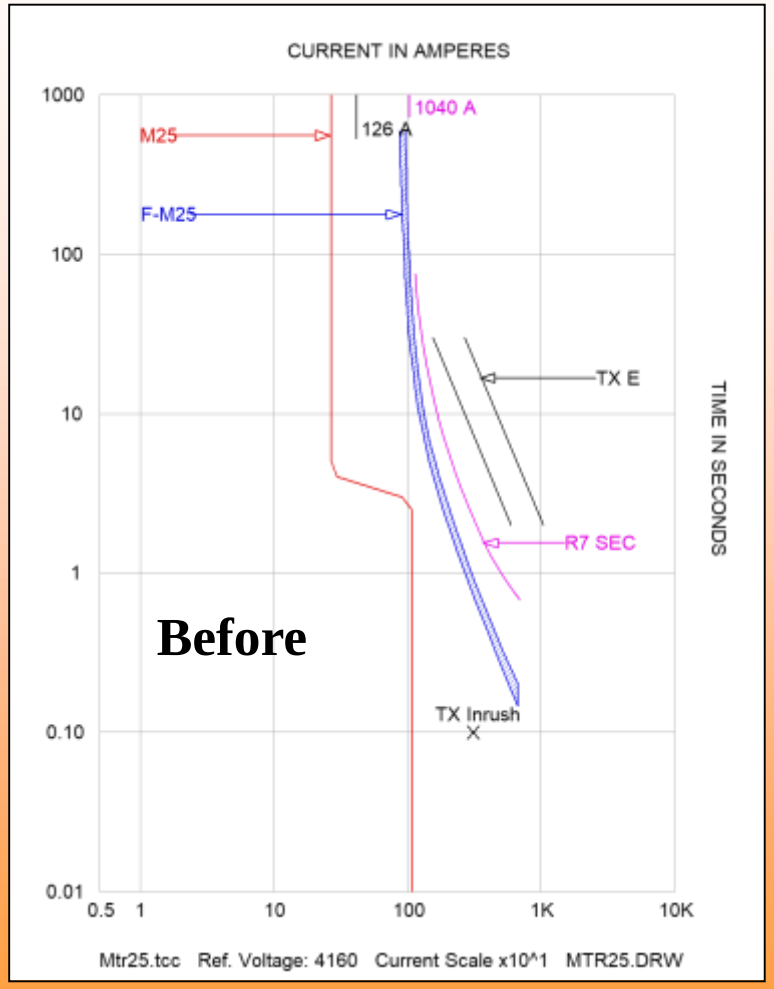
- *Coordination Traditionally used for Equipment Protection and System Reliability*

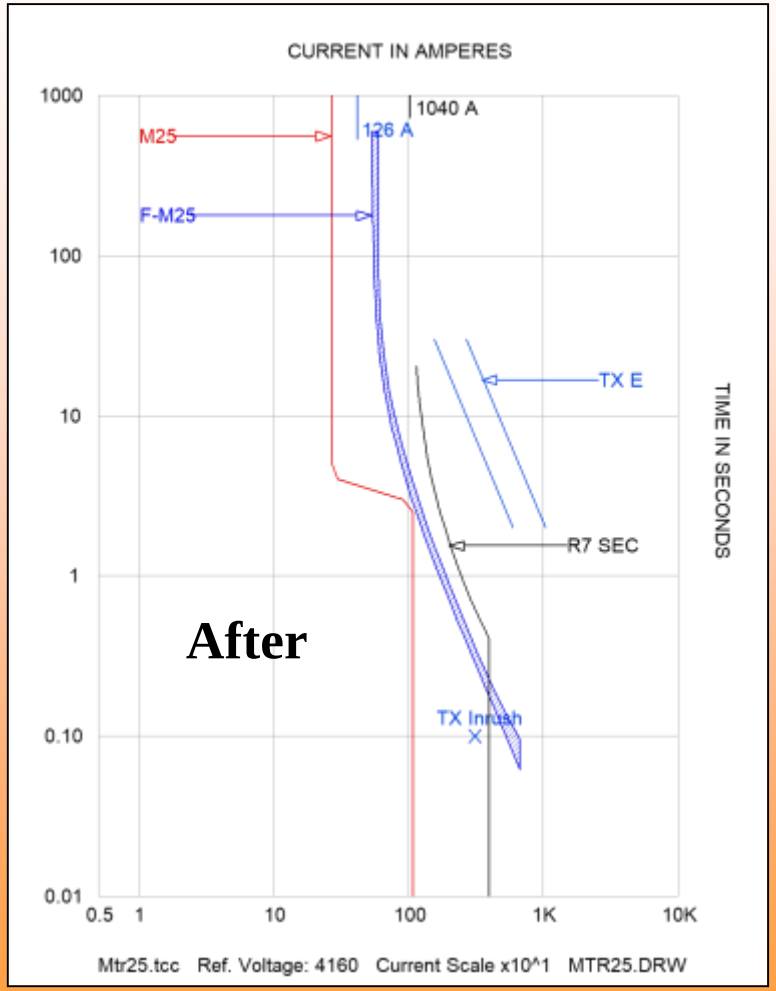
Arc flash requirements brings new safety focus to coordination studies looking at minimum faults and setting faster trip times.

Faster trip times may cause more nuisance trips.

Alternative protection schemes may gain popularity (differential protection, zone interlocking, light sensors, etc.)

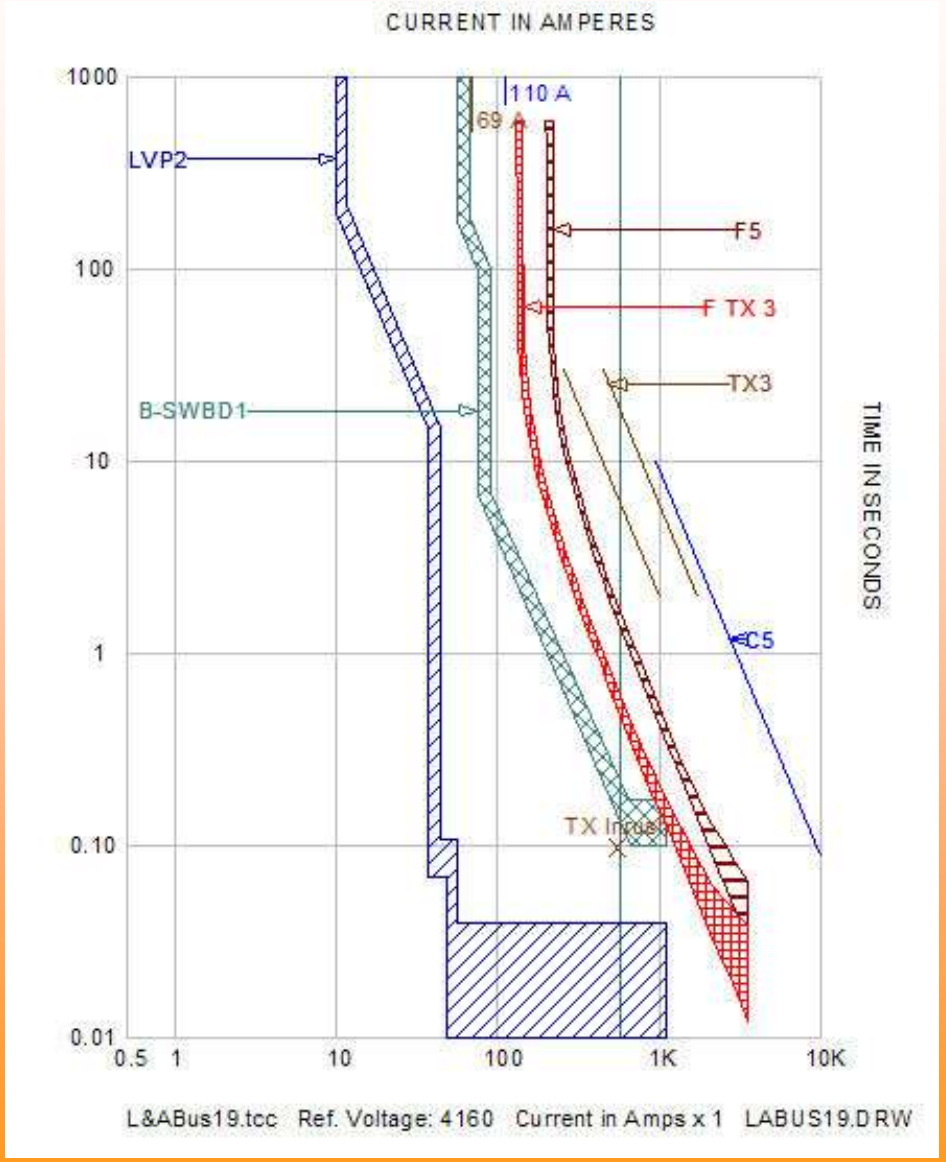
Issues - Faster Trip Times





Issues - Coordination

- *Coordinated*



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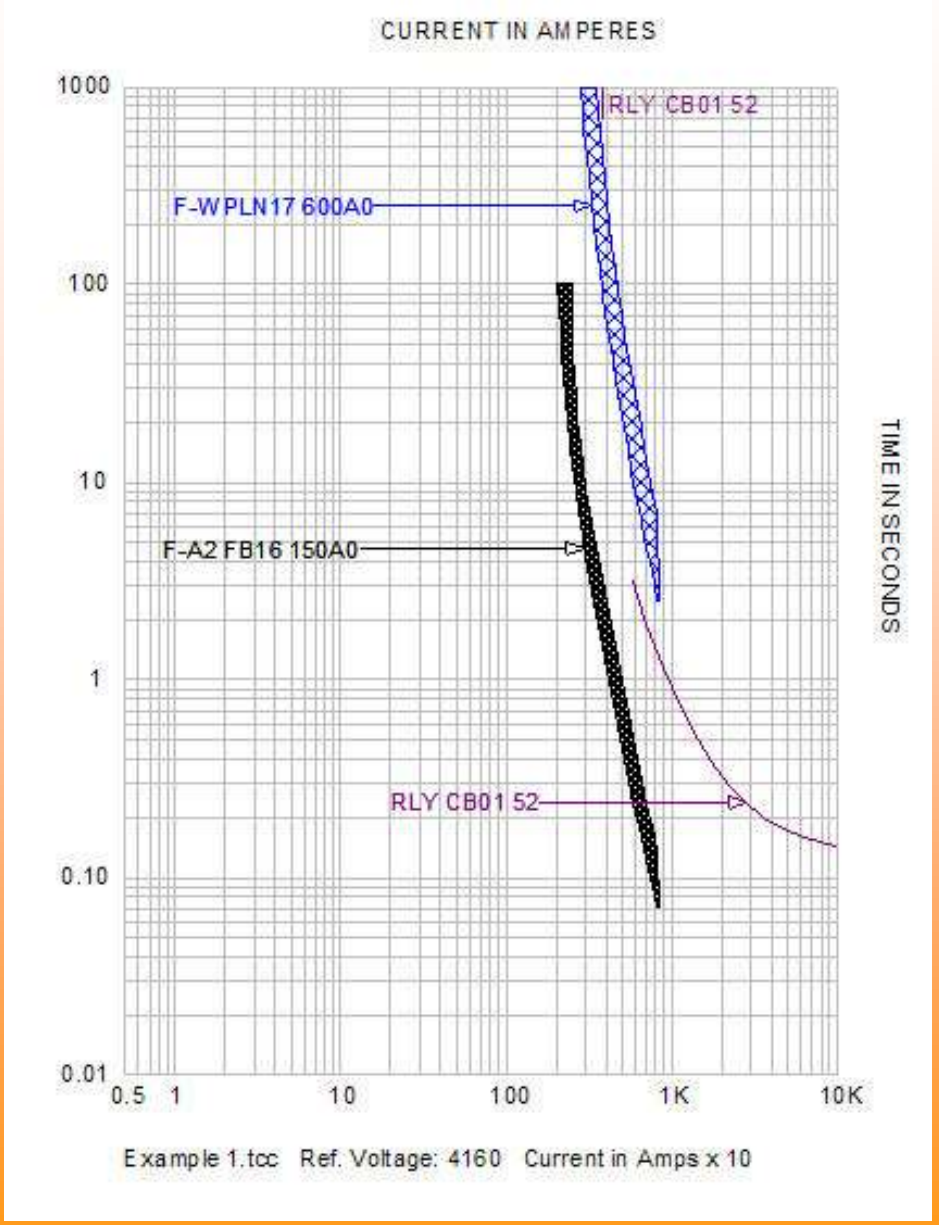
Issues - Coordination

- *Miscoordination*



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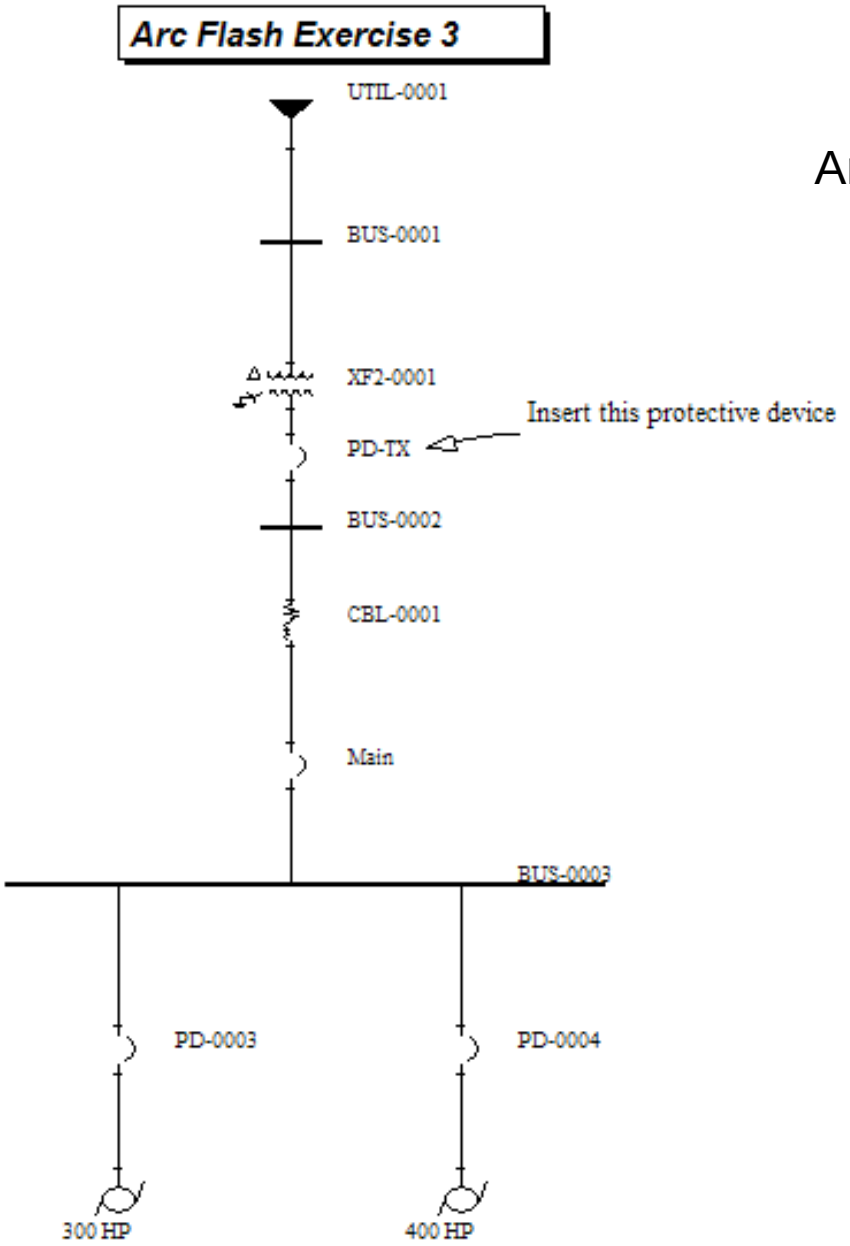

An exercise to show mis-coordination

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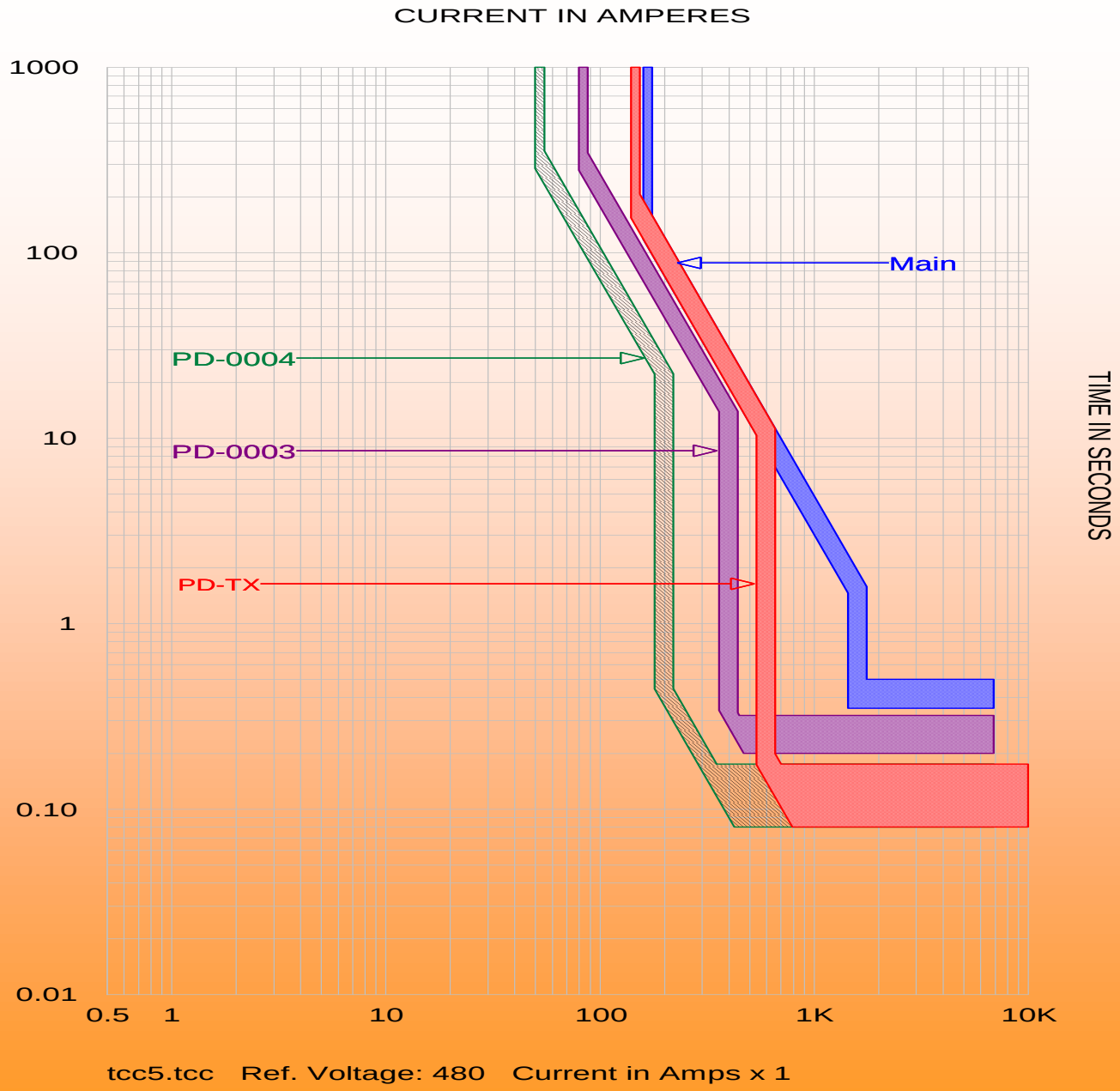
Mis-coordination



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☑ Check Upstream devices for mis-coordination

In Options Screen

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (mm)	Working Distance (mm)	Incident Energy (J/cm2)	Required Protective FR Clothing Category
BUS-0001	PD-TX	0.48	6.00	4.80	3.39	0.175	0.000	No	PNL	25	798	457	12.5	Category 1 (*N2)
BUS-0001	MaxTripTime @1000.0s	0.48	6.00	1.20	1.07	1000	0.000	No	PNL	25	62911	457	16160	Dangerous! (*N2) (*N9)
BUS-0002	PD-TX	0.48	6.82	1.16	0.80	0.175	0.000	Yes	PNL	25	732	457	10.8	Category 1
BUS-0002	Main	0.48	6.82	5.66	3.93	0.5	0.000	Yes	PNL	25	1299	457	27.7	Category 2
BUS-0003	PD-0004	0.48	6.90	3.28	2.27	0.175	0.000	Yes	SWG	25	752	457	10.4	Category 1
BUS-0003	PD-TX (Main)	0.48	6.90	1.16	0.80	0.175	0.000	Yes	SWG	25	752	457	10.4	Category 1 (*N5)
BUS-0003	PD-0003	0.48	6.90	2.46	1.70	0.32	0.000	Yes	SWG	25	908	457	13.7	Category 1
Category 0: Untreated Cotton														(*N2) < 80% Cleared Fault Threshold
Category 1: FR Shirt & Pants														(*N5) - Miscoordinated, Upstream Device Tripped
Category 2: Cotton Underwear + FR Shirt & Pants														(*N9) - Max Arcing Duration Reached

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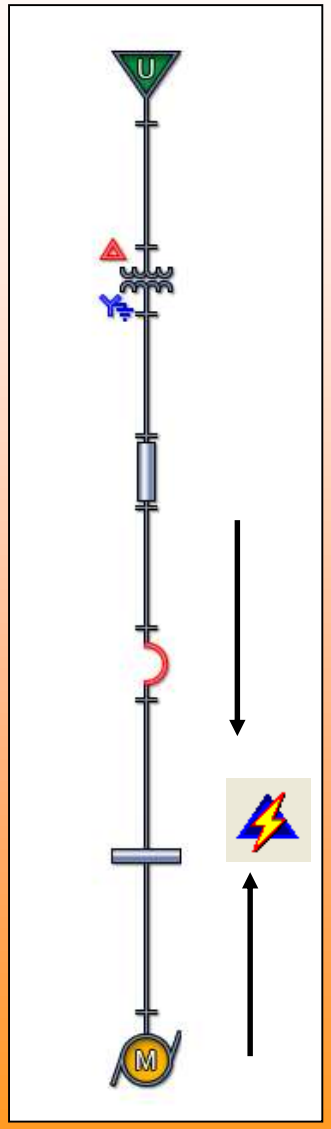
Issues – Parallel Contributions



30 kA Short Circuit Current from Utility clears in 0.5 sec.

Fault Location

5 kA Short Circuit Current from Motor decays in 5 cycles (0.08 sec).

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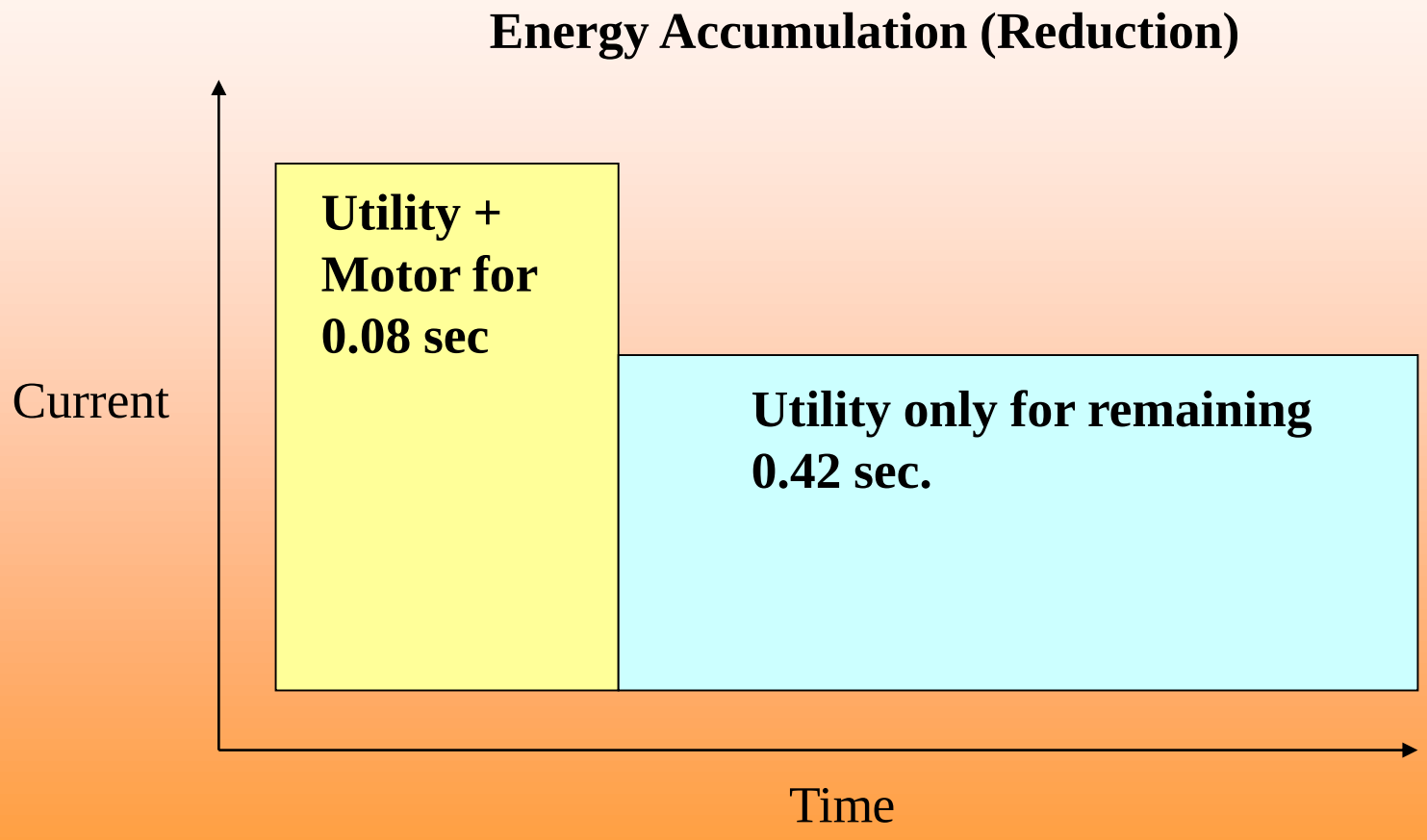
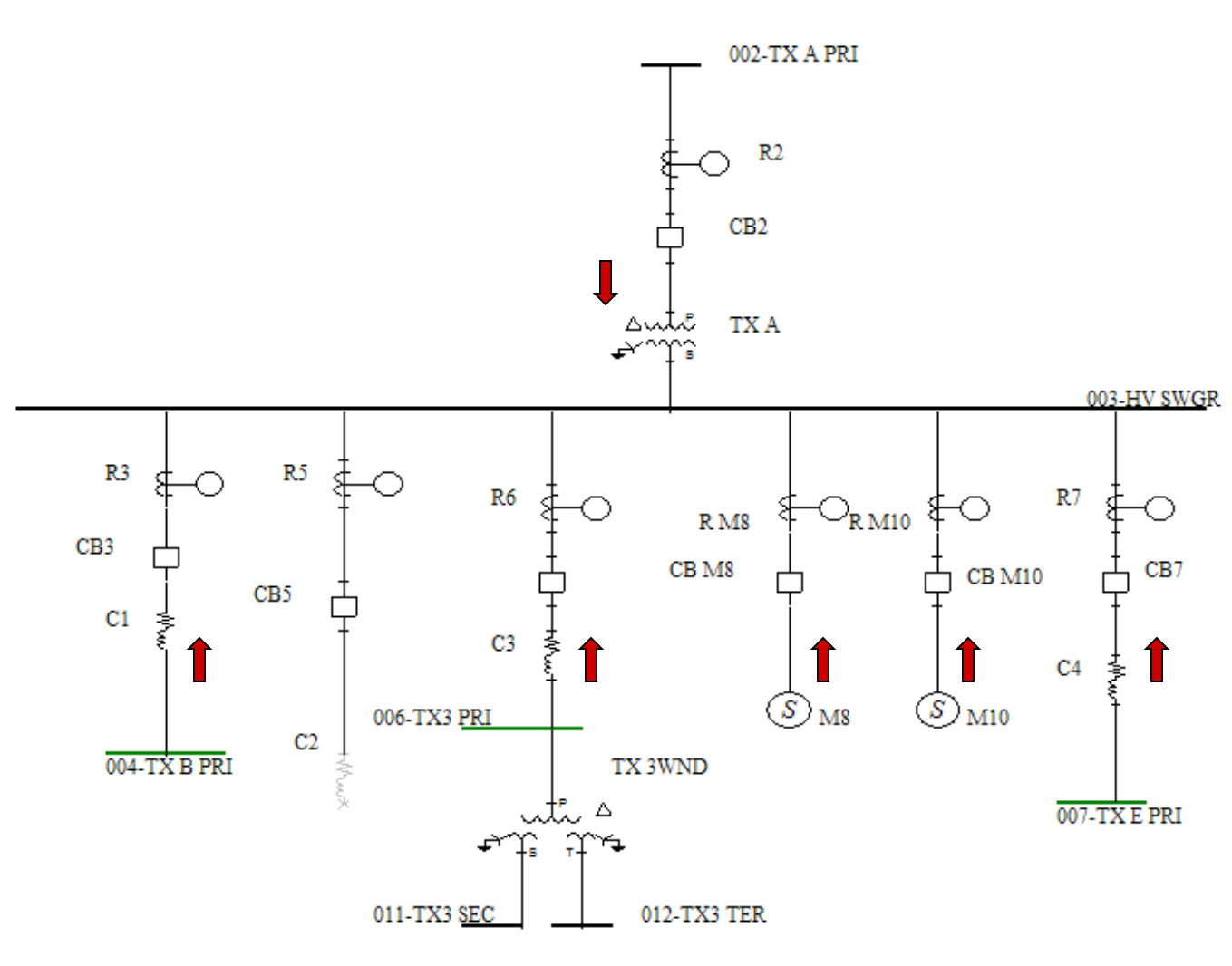
Issues – Parallel Contributions

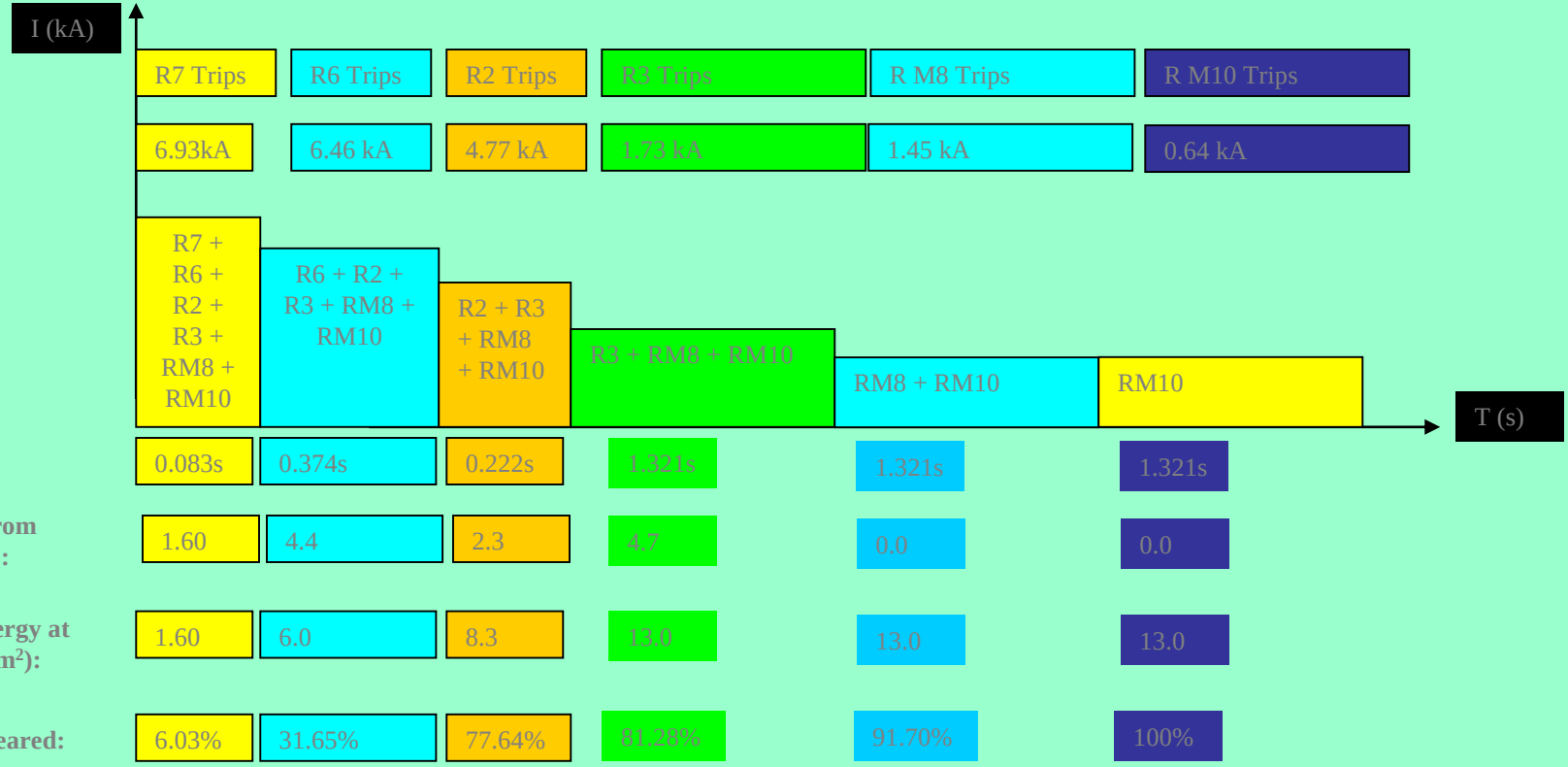


Fault on 003-HV SWGR



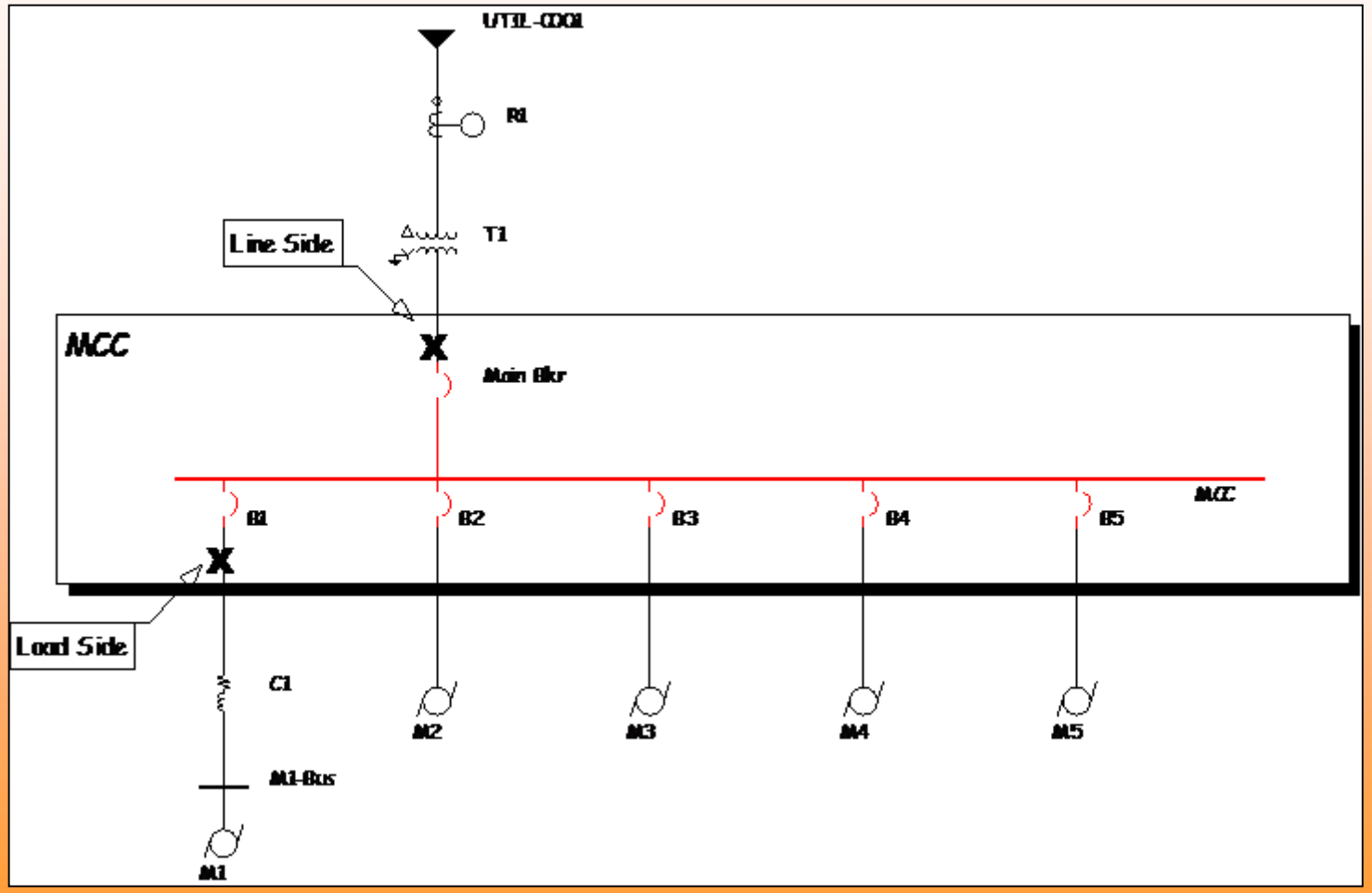
Arc Flash Calculation on 003-HV SWGR

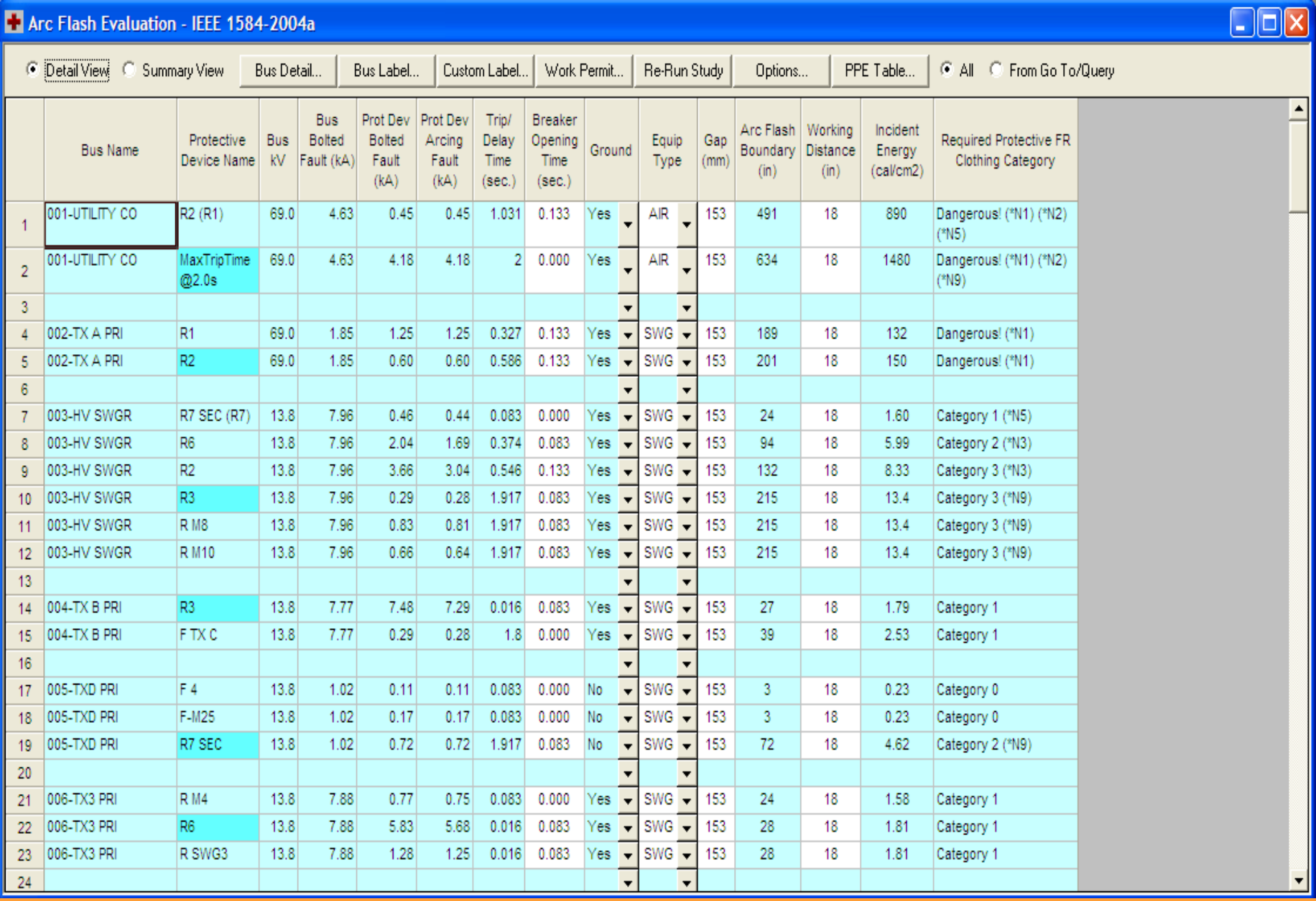
	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
6	003-HV SWGR	R7	13.8	7.96	0.48	0.47	0.083	0.000	Yes	SWG	153	24	18	1.6	Category 1
7	003-HV SWGR	R6	13.8	7.96	2.04	1.69	0.374	0.083	Yes	SWG	153	94	18	6.0	Category 2 (*N3)
8	003-HV SWGR	R2	13.8	7.96	3.66	3.04	0.546	0.133	Yes	SWG	153	132	18	8.3	Category 3 (*N3)
9	003-HV SWGR	R3	13.8	7.96	0.29	0.28	1.917	0.083	Yes	SWG	153	215	18	13	Category 3 (*N9)
10	003-HV SWGR	R M8	13.8	7.96	0.83	0.81	1.917	0.083	Yes	SWG	153	215	18	13	Category 3 (*N9)
11	003-HV SWGR	R M10	13.8	7.96	0.66	0.64	1.917	0.083	Yes	SWG	153	215	18	13	Category 3 (*N9)



Break

Issues – Line Side Activities





	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
1	001-UTILITY CO	R2 (R1)	69.0	4.63	0.45	0.45	1.031	0.133	Yes	AIR	153	491	18	890	Dangerous! (*N1) (*N2) (*N5)
2	001-UTILITY CO	MaxTripTime @2.0s	69.0	4.63	4.18	4.18	2	0.000	Yes	AIR	153	634	18	1480	Dangerous! (*N1) (*N2) (*N9)
3															
4	002-TX A PRI	R1	69.0	1.85	1.25	1.25	0.327	0.133	Yes	SWG	153	189	18	132	Dangerous! (*N1)
5	002-TX A PRI	R2	69.0	1.85	0.60	0.60	0.586	0.133	Yes	SWG	153	201	18	150	Dangerous! (*N1)
6															
7	003-HV SWGR	R7 SEC (R7)	13.8	7.96	0.46	0.44	0.083	0.000	Yes	SWG	153	24	18	1.60	Category 1 (*N5)
8	003-HV SWGR	R6	13.8	7.96	2.04	1.69	0.374	0.083	Yes	SWG	153	94	18	5.99	Category 2 (*N3)
9	003-HV SWGR	R2	13.8	7.96	3.66	3.04	0.546	0.133	Yes	SWG	153	132	18	8.33	Category 3 (*N3)
10	003-HV SWGR	R3	13.8	7.96	0.29	0.28	1.917	0.083	Yes	SWG	153	215	18	13.4	Category 3 (*N9)
11	003-HV SWGR	R M8	13.8	7.96	0.83	0.81	1.917	0.083	Yes	SWG	153	215	18	13.4	Category 3 (*N9)
12	003-HV SWGR	R M10	13.8	7.96	0.66	0.64	1.917	0.083	Yes	SWG	153	215	18	13.4	Category 3 (*N9)
13															
14	004-TX B PRI	R3	13.8	7.77	7.48	7.29	0.016	0.083	Yes	SWG	153	27	18	1.79	Category 1
15	004-TX B PRI	F TX C	13.8	7.77	0.29	0.28	1.8	0.000	Yes	SWG	153	39	18	2.53	Category 1
16															
17	005-TXD PRI	F 4	13.8	1.02	0.11	0.11	0.083	0.000	No	SWG	153	3	18	0.23	Category 0
18	005-TXD PRI	F-M25	13.8	1.02	0.17	0.17	0.083	0.000	No	SWG	153	3	18	0.23	Category 0
19	005-TXD PRI	R7 SEC	13.8	1.02	0.72	0.72	1.917	0.083	No	SWG	153	72	18	4.62	Category 2 (*N9)
20															
21	006-TX3 PRI	R M4	13.8	7.88	0.77	0.75	0.083	0.000	Yes	SWG	153	24	18	1.58	Category 1
22	006-TX3 PRI	R6	13.8	7.88	5.83	5.68	0.016	0.083	Yes	SWG	153	28	18	1.81	Category 1
23	006-TX3 PRI	R SWG3	13.8	7.88	1.28	1.25	0.016	0.083	Yes	SWG	153	28	18	1.81	Category 1
24															

Run Arc Flash Calculations

Detail View or Summary View

Detail View:

Detail View lists all protective devices at branches that contribute current to the faulted bus. This will vary from the Summary View only for buses that have multiple contributions.

Summary View:

If the Report Option is set to “Report Last Trip Device”, the Summary View will list the last device to trip whereby the accumulated current tripped meets or exceeds the specified threshold percent (ie… when at least 80% of total fault current has cleared).

If the Report Option is set to “Report Main Device”, the Summary View will list the device that carries the largest percentage of the fault contribution to the bus.

Arc Flash Evaluation - IEEE 1584-2004a

Detail View | Summary View | Bus Detail... | Bus Label... | Custom Label... | Work Permit... | Re-Run Study | Options... | PPE Table... | All | From Go To/Query

	Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
1	BUS-0001	PD-0001	13.8	8.37	0.00	0.00	2	0.000	Yes	SWG	153	672	36	20.6	Category 3 (*N2) (*N9)
2	BUS-0002	PD-0001	4.16	2.22	2.22	2.21	0.141	0.000	Yes	SWG	104	9	36	0.31	Category 0
3	BUS-0003	PD-0003	0.48	7.40	7.40	4.31	0.158	0.000	Yes	PNL	25	25	18	2.11	Category 1 (*N3)

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Other Tabs

Bus Detail:
Bus Detail generates a detailed label

Standard or Custom Label:
Generates standard and custom arc flash warning labels

Work Permit**:**
Produces energized work permits based on the calculated incident energy

Re-run Study:
Allows one to re-run the study to display the most up to date results, if you have made changes in the table

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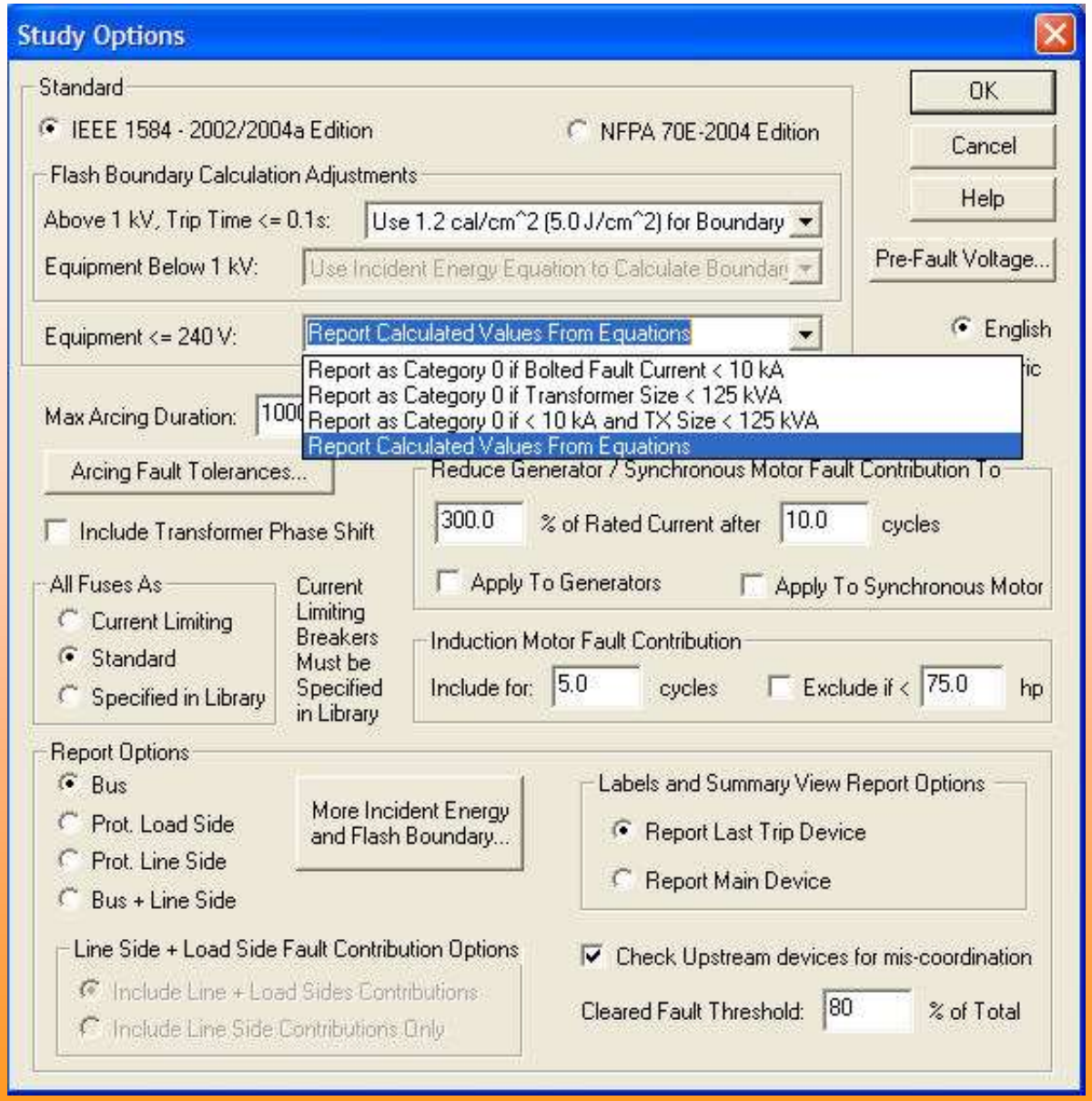
Options Tab


Study Options
Standard
IEEE 1584 - 2002/2004a Edition
NFPA 70E-2004 Edition
Flash Boundary Calculation Adjustments
Above 1 kV, Trip Time <= 0.1s:
Use 1.2 cal/cm^2 (5.0 J/cm^2) for Boundary
Equipment Below 1 kV:
Use Incident Energy Equation to Calculate Boundar
Equipment <= 240 V:
Report Calculated Values From Equations
Report as Category 0 if Bolted Fault Current < 10 kA
Report as Category 0 if Transformer Size < 125 kVA
Report as Category 0 if < 10 kA and TX Size < 125 kVA
Report Calculated Values From Equations
Max Arcing Duration:
Arcing Fault Tolerances...
Include Transformer Phase Shift
All Fuses As
Current Limiting
Standard
Specified in Library
Current Limiting Breakers Must be Specified in Library
Reduce Generator / Synchronous Motor Fault Contribution To
300.0
% of Rated Current after
10.0
cycles
Apply To Generators
Apply To Synchronous Motor
Induction Motor Fault Contribution
Include for:
5.0
cycles
Exclude if <
75.0
hp
Report Options
Bus
Prot. Load Side
Prot. Line Side
Bus + Line Side
More Incident Energy and Flash Boundary...
Labels and Summary View Report Options
Report Last Trip Device
Report Main Device
Line Side + Load Side Fault Contribution Options
Include Line + Load Sides Contributions
Include Line Side Contributions Only
Check Upstream devices for mis-coordination
Cleared Fault Threshold:
80
% of Total
OK
Cancel
Help
Pre-Fault Voltage...
English

For Equipment < or = to 240v ac

In NFPA 70E, Article 130, Table 130.7 (7)(9)(a) with Notes 1 and 3 (for <10kA short circuit current available, the hazard /risk category required may be reduced by one) Pages 70E-29 thru 31.

The Table shows hazard /risk categories of 0 and 1, but all would be 0 given note 3 conditions.

In IEEE 1584, dated 2002, on page 6, fourth paragraph, last sentence – “Equipment below 240 V need not be considered unless it involves at least one 125 kVA or larger low impedance transformer in its immediate power supply.”

Also on page 25, third paragraph, last sentence within the model and testing discussion – “The arc-flash hazard need only be considered for large 208 V systems: systems fed by transformers smaller than 125 kVA should not be a concern.”

Cleared Fault Threshold

Cleared Fault Threshold, determines the portion of the Total Arcing Fault current at the Bus that needs to be interrupted by protective devices to extinguish the arc. Therefore the remaining portion of Arcing Fault current, if any, can not sustain the arc and will not be considered in the accumulated incident energy. Enter a value in percent of the total bus fault current, the default value is 80%, which means that the final arc fault trip time is based on when 80% or more of the total fault current at the bus has been cleared. In the Summary View, the last device to trip that reaches the cleared fault threshold is the only protective device that will be listed under the bus, and the data from the device will be used in the Bus Detail report and Bus Label. The cleared fault threshold value is also used to determine which branches are searched for mis-coordination.

Report Options

Bus option – The bus report assumes that the fault occurs at the equipment bus. If the bus has multiple contributions, the devices that trip each branch contribution will be listed in the order they trip, and incident energy will be accumulated until a significant percentage of the fault current has tripped. The significant portion is defined by the “Cleared Fault Threshold” percentage you specify.

Report Options

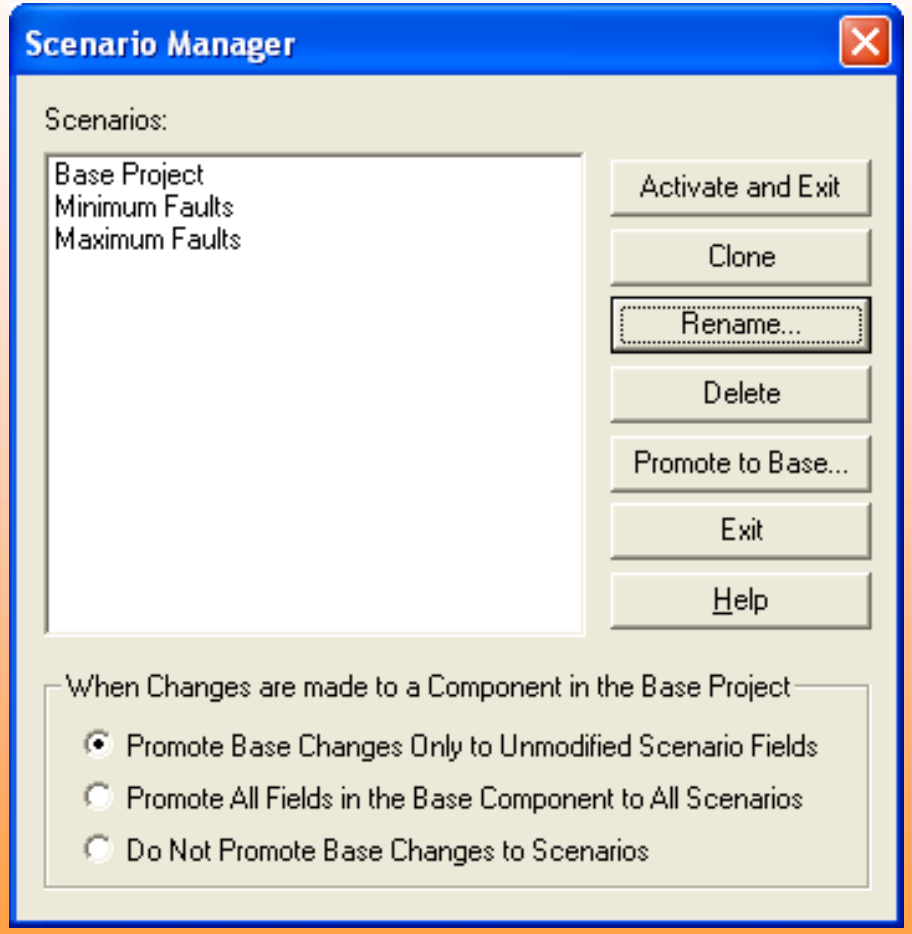
Protective Device Load Side option – The load side report applies a fault at the load side (To End) of each protective device whose line side (From End) is connected directly to a bus without having an impedance device between the bus and the protective device. The protective device being evaluated is the one that clears the fault. The fault current through the device will be used to calculate the arcing fault current and obtain the trip time from the TCC. You can then select to include Line + Load Sides Contributions (to represent both ends hot) in calculating the incident energy, or to include Line Side Contributions only in which case the load side contributions are not included (now working as if the load side is disconnected).

Protective Device Line Side option – The line side report applies a fault at the line side (From End) of each protective device whose load side (To End) is connected directly to a bus without having an impedance device between the bus and the protective device. You can then selected to include Line + Load Sides Contributions or to include Line Side Contributions only. The first case represent both ends hot, this occur if the main breaker failed to open, and the next upstream device is the one that must clear the fault. If there is more than one contribution when there is a fault at the line side, incident energy will be accumulated up to the fault contribution percentage specified. If Line Side Contributions Only is selected, the load side contributions are not included and it is now working as if the load side is disconnected.

Report Options

Bus + Line Side option – This option combines the bus report option and the line side report option into one report. Calculated result for the bus and line side will be listed next to each other for easier comparison of worse case scenario. A special custom label is supplied by PTW to put both bus and line side results in one single label.

Scenario Manager



Use Scenario Manager to evaluate alternative operating scenarios for the power system, including minimum and maximum fault conditions, and proposed design changes.

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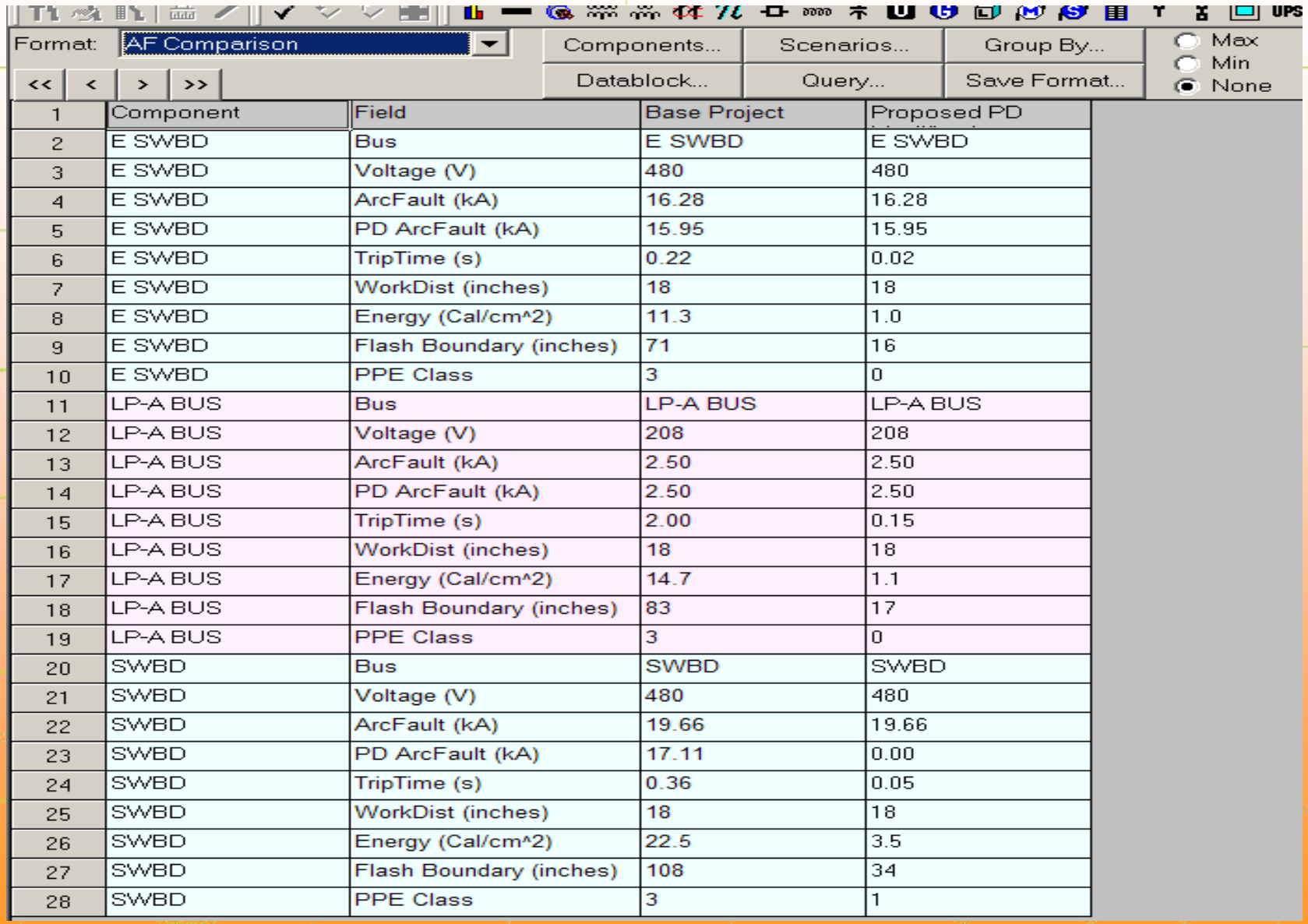
Data Visualizer Screen



1	Component	Field	Base Project	Proposed PD
2	E SWBD	Bus	E SWBD	E SWBD
3	E SWBD	Voltage (V)	480	480
4	E SWBD	ArcFault (kA)	16.28	16.28
5	E SWBD	PD ArcFault (kA)	15.95	15.95
6	E SWBD	TripTime (s)	0.22	0.02
7	E SWBD	WorkDist (inches)	18	18
8	E SWBD	Energy (Cal/cm^2)	11.3	1.0
9	E SWBD	Flash Boundary (inches)	71	16
10	E SWBD	PPE Class	3	0
11	LP-A BUS	Bus	LP-A BUS	LP-A BUS
12	LP-A BUS	Voltage (V)	208	208
13	LP-A BUS	ArcFault (kA)	2.50	2.50
14	LP-A BUS	PD ArcFault (kA)	2.50	2.50
15	LP-A BUS	TripTime (s)	2.00	0.15
16	LP-A BUS	WorkDist (inches)	18	18
17	LP-A BUS	Energy (Cal/cm^2)	14.7	1.1
18	LP-A BUS	Flash Boundary (inches)	83	17
19	LP-A BUS	PPE Class	3	0
20	SWBD	Bus	SWBD	SWBD
21	SWBD	Voltage (V)	480	480
22	SWBD	ArcFault (kA)	19.66	19.66
23	SWBD	PD ArcFault (kA)	17.11	0.00
24	SWBD	TripTime (s)	0.36	0.05
25	SWBD	WorkDist (inches)	18	18
26	SWBD	Energy (Cal/cm^2)	22.5	3.5
27	SWBD	Flash Boundary (inches)	108	34
28	SWBD	PPE Class	3	1

Issues

- Fault Values
- Parallel Contributions (number of motors or generators running and off)
- Line/Load Side Activities
- Coordination

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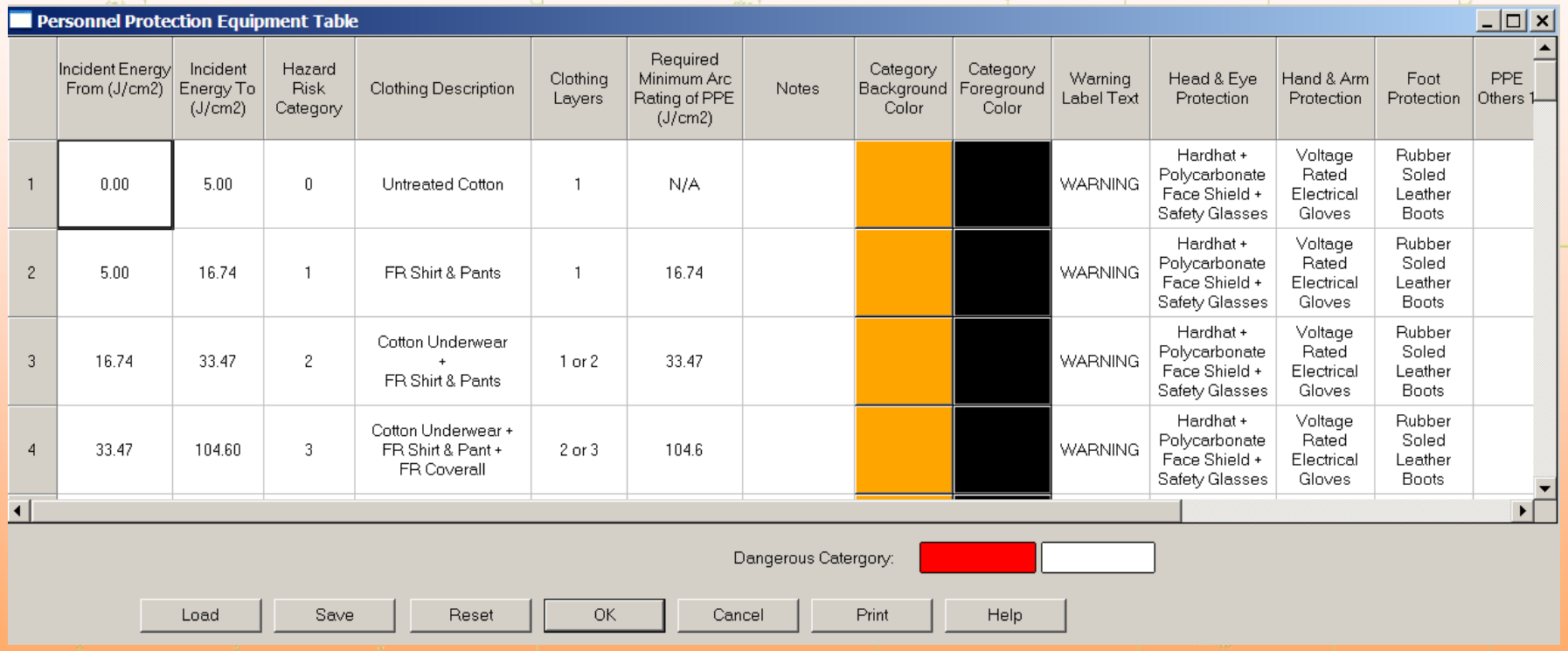
What is the purpose of an arc flash study?

- Living with what one has and minimize the risks
- Designing electrical safety into the power distribution design
- To determine the protective clothing requirements for persons working on live equipment

PPE Table

PPE Table...



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Labels using the Bus Detail button

⚠ WARNING - Arc Flash Hazard

Client	SKM Systems Analysis, Inc.				
Location	Main Plant				
Job #	SAMPLE	**Date**	08/05/02	**Engineer**	SKM

Bus	BUS-0001	**Category**	
Rated Volts	13800	**Rated Amps**	**Mf/Ty/Desc**
Main Device	PD-0001	**Device Settings**	
CUTLER-HAMMER, CX, 15.5kV		**Phase**	40.0 Amps
4C-40C			

Frame	**Sensor**	**Plug**
40	40	

Arc Flash Calculation Data Sheet - IEEE 1584-2004a

Bolted Short Circuit Fault	8.4 kA 3Phase		**Trip/Delay**	**Breaker Open**	**Arcing Duration**		
Arcing Fault in Protective Device			2.000 s	0.000 s	2.000 s		
Arc/Equipment Type	Switchgear	Gap: 153	Grounded				
Arc Flash Boundary	672 inches	**@ 1.2 cal/cm^2 - 2nd Degree Burn Boundary of Bare Skin**					
Working Distance	36 inches			21	24	30	48
Incident Energy	20.60 cal/cm^2			34.81	30.57	24.60	15.57
PPE Clothing Category	Category 3 - Cotton Underwear + FR Shirt & Pant + FR Coverall, less than 80% Contribution Accumulated						

Personnel Protection Equipment Table

Clothing Description	Hazard Risk Category	Clothing Layers	Arc Rating (cal/cm^2)	Notes
Untreated Cotton	0	1	N/A	
FR Shirt & Pants	1	1	4	
Cotton Underwear + FR Shirt & Pants	2	1 or 2	8	
Cotton Underwear + FR Shirt & Pant + FR Coverall	3	2 or 3	25	
Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit	4	3 or more	40	

Proper Protective Equipment Required

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Labels using the Standard Label button

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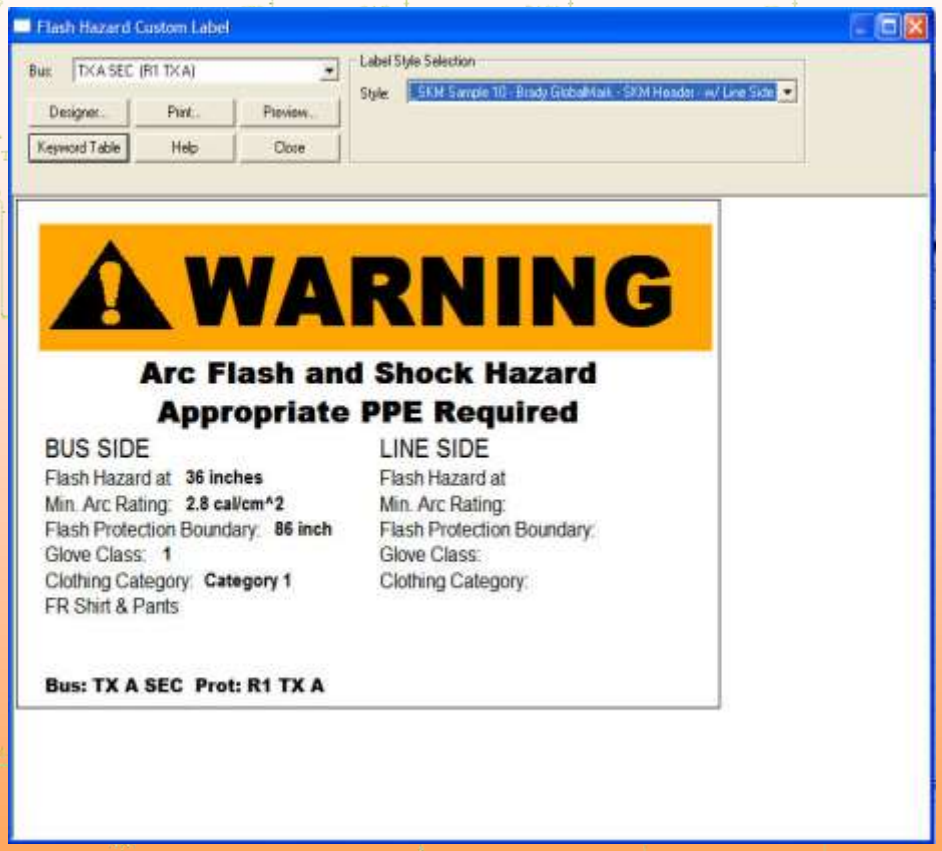
Labels using the Custom Label button



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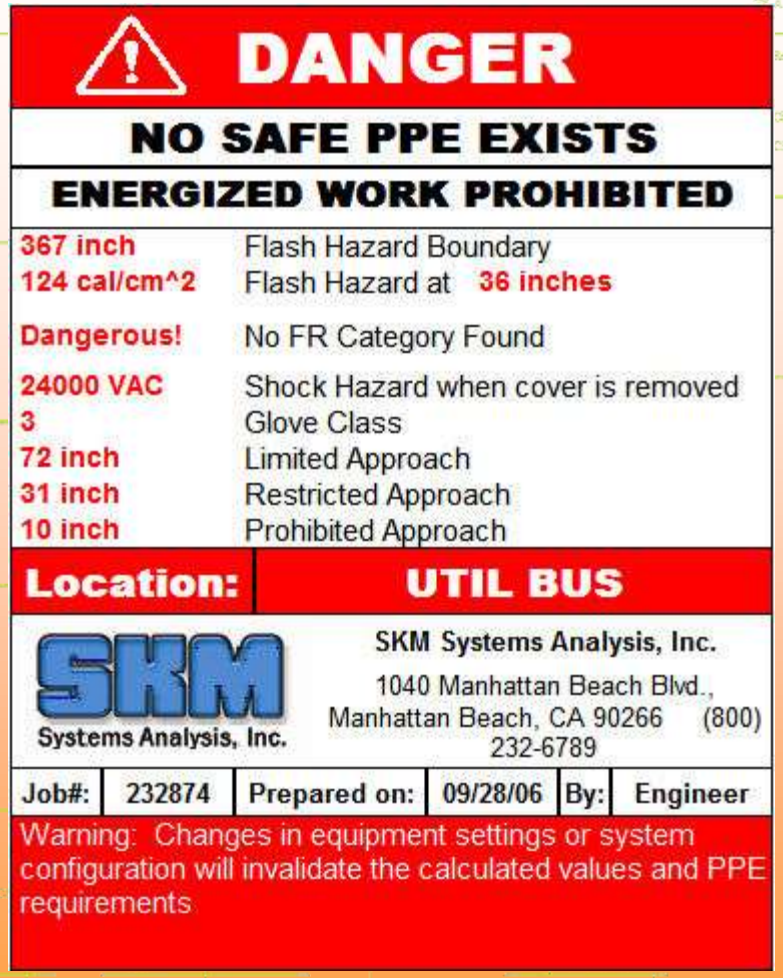
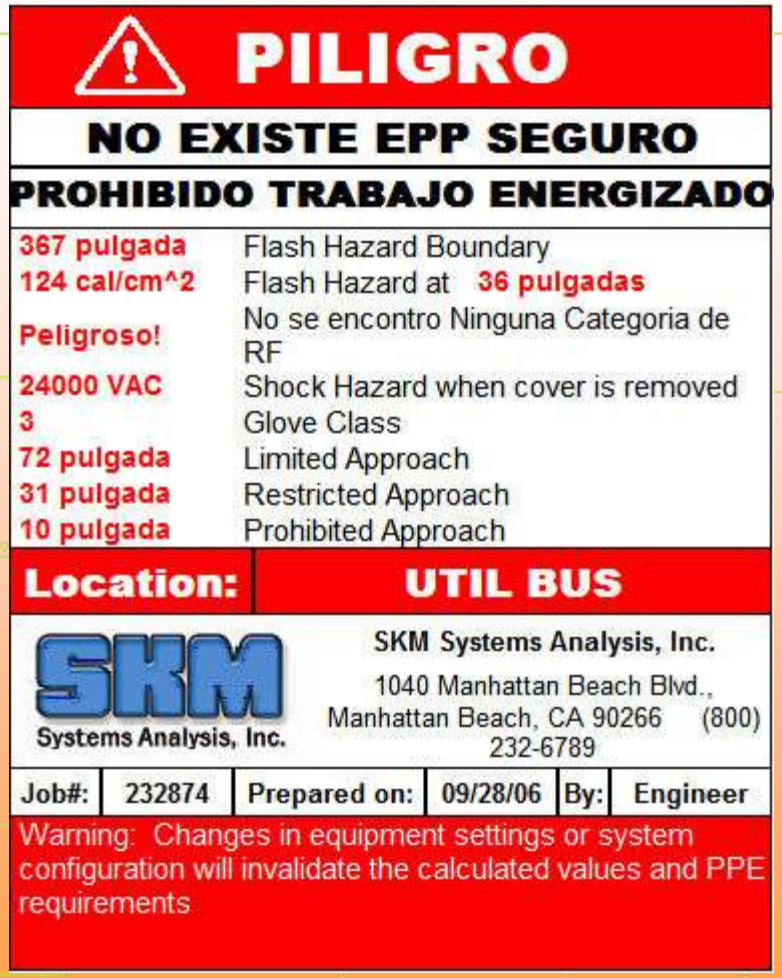
Labels using the Custom Label button





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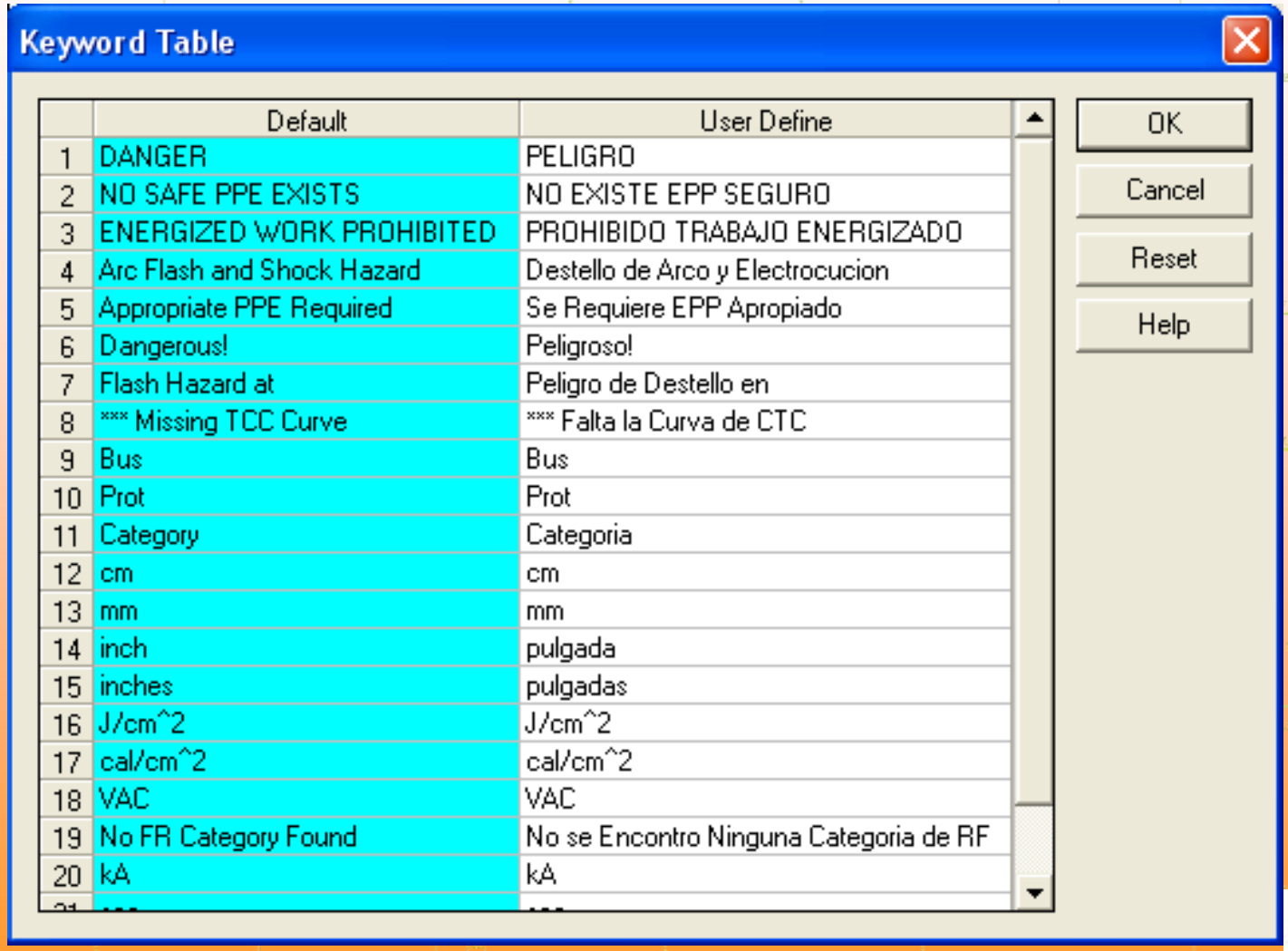
Labels using the Custom Label button



	Default	User Define
1	DANGER	PELIGRO
2	NO SAFE PPE EXISTS	NO EXISTE EPP SEGURO
3	ENERGIZED WORK PROHIBITED	PROHIBIDO TRABAJO ENERGIZADO
4	Arc Flash and Shock Hazard	Destello de Arco y Electrocucion
5	Appropriate PPE Required	Se Requiere EPP Apropiado
6	Dangerous!	Peligroso!
7	Flash Hazard at	Peligro de Destello en
8	*** Missing TCC Curve	*** Falta la Curva de CTC
9	Bus	Bus
10	Prot	Prot
11	Category	Categoria
12	cm	cm
13	mm	mm
14	inch	pulgada
15	inches	pulgadas
16	J/cm^2	J/cm^2
17	cal/cm^2	cal/cm^2
18	VAC	VAC
19	No FR Category Found	No se Encontro Ninguna Categoria de RF
20	kA	kA

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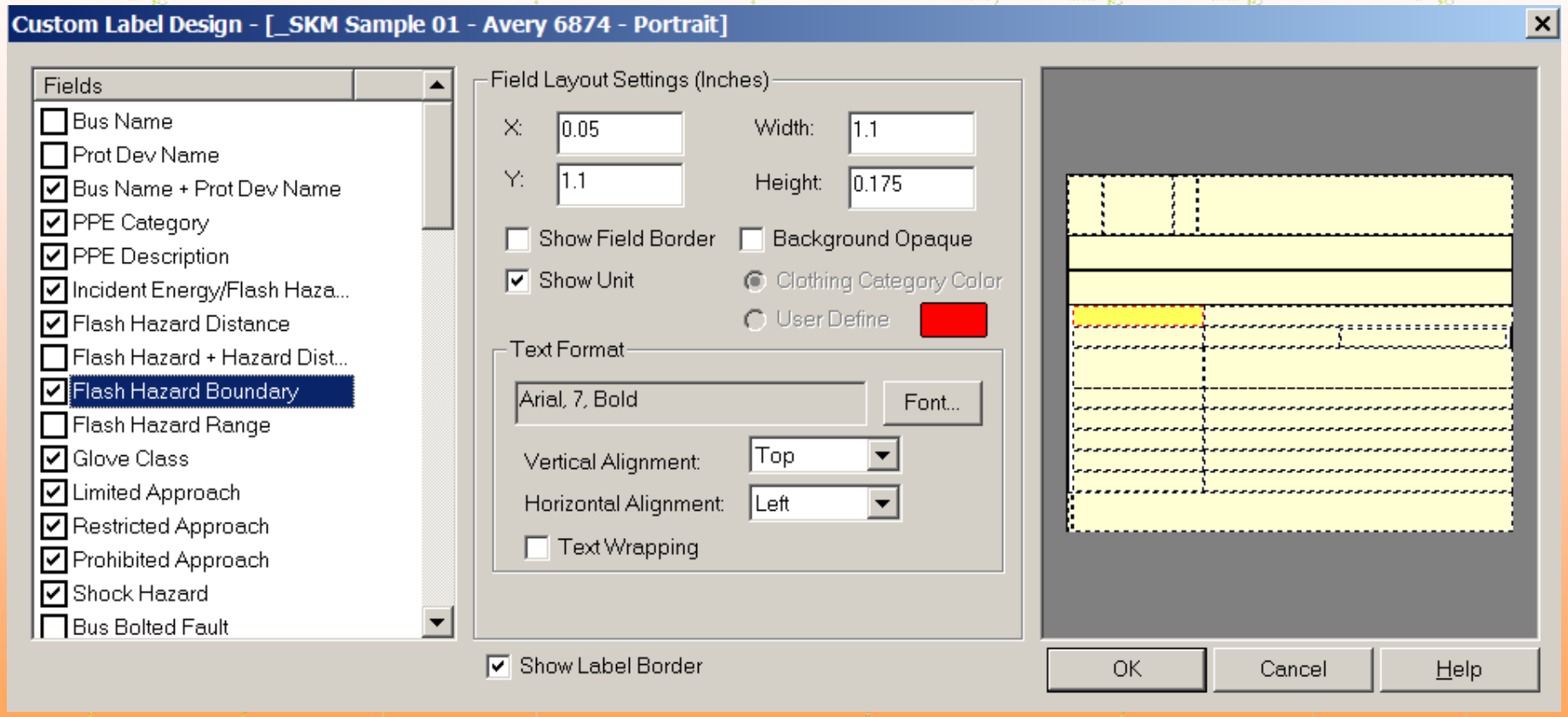
Labels using the Custom Label button



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Labels using the Custom Label button

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ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER: Job/Work Order Number: _____

(1) Description of circuit/equipment/job location:
001-UTILITY CO

(2) Description of work to be done:

(3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage:

Requester/Title Date

PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS DOING THE WORK:

Check When

(1) Detailed job description procedure to be used in performing the above detailed work: ☐

(2) Description of the Safe Work Practices to be employed: ☐

Flash Boundary	634 inch	Flash Hazard	1480 cal/cm^2	Working Distance	18 inches
Shock Hazard	69000 VAC	Limited Approach Restricted Approach Prohibited Approach	96 inch 38 inch 25 inch	Glove Class	DANGER
Requied PPE	Dangerous	No FR Category Found			

(3) Means employed to restrict the access of unqualified persons from the work area: ☐

(4) Evidence of completion of a Job Briefing including discussion of any job-related hazards: ☐

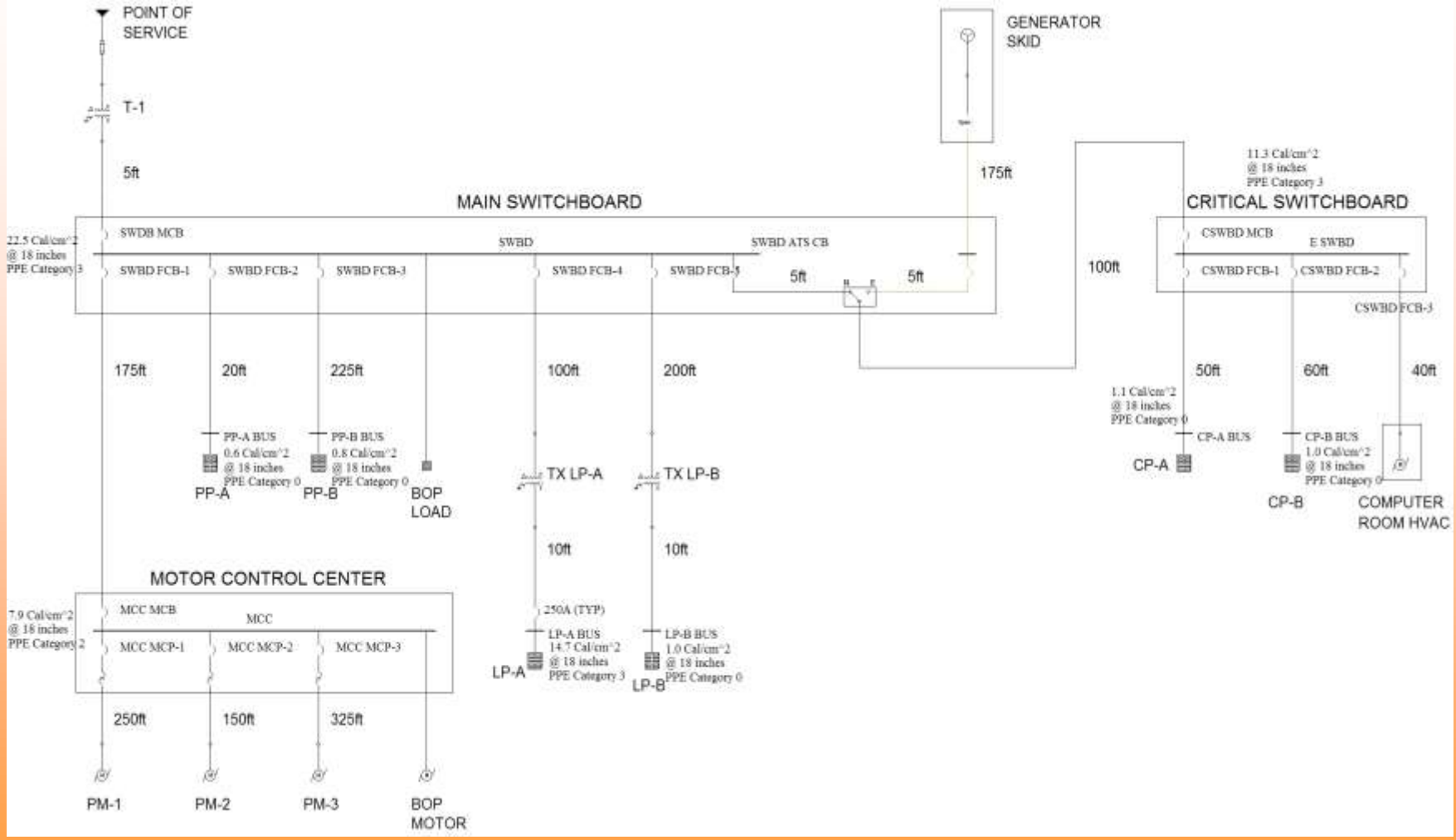
(5) Do you agree the above described work can be done safely? ☐ Yes ☐ No (If no, return to requester)

Electrically Qualified Person(s) Date

Electrically Qualified Person(s) Date

Produce Work Permits

One-line with Arc Flash Data



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Role of Integrated Software

- Integrated Software allows you to:
  - Use NFPA 70E methods in determining PPE
  - Or IEEE 1584
  - Run scenarios (of options, conditions, modes of operations) and visualize their results simultaneously so good engineering judgments can be made and documented
  - Print Reports, Permits, and Labels
  - It becomes part of the on-going safety program

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Costs of Not Performing Arc Flash Studies

- OSHA Fines
- Lost Productivity
- Medical Costs
- Legal Costs

So… why do I want to do studies by hand, with the calculator or tables?

Because

- I am from Texas
- And a full-fledged masochist

Have Great Evening!