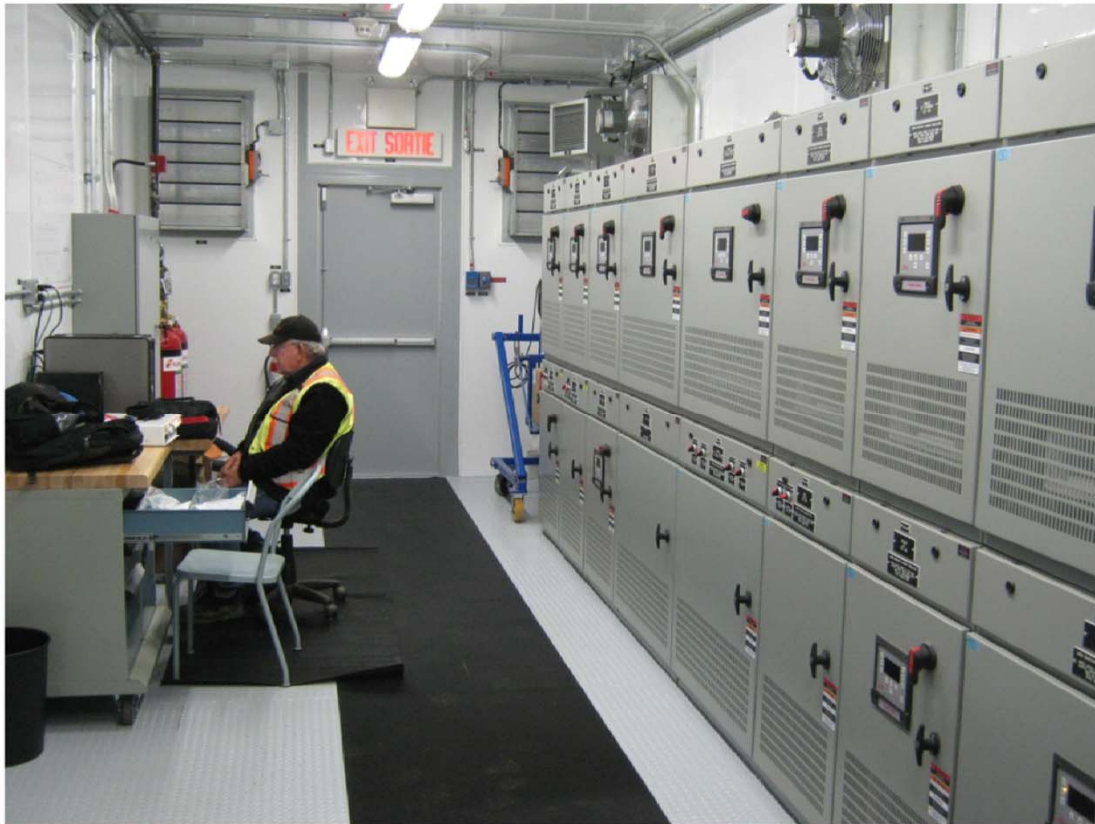


ARC FLASH HAZARD ANALYSIS and MITIGATION in Airfield Electrical Vaults



2011-IESALC
Wilmington, NC

**IES ALC
Conference**



**Wilmington, NC
October 17 2011**

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Mgr. Power Products**

**Liberty Airport
Systems**

1. The Basics of Arc Flash Hazard
2. Arc Flash Hazard Case Examples
 - Ottawa International Airport
 - Campbell River Airport
3. Protection Philosophies
 - Equipment Protection
 - Personnel Protection



Making the Airfield Safer

Recent industry regulations have mandated that airports *quantify* the dangers of Arc Flash Hazards in LV and MV equipment.

NFPA 70E – *Standard for Electrical Safety in the Workplace*, defines requirements for:

- Shock and Arc Flash Boundaries
- Personal Protective Equipment (PPE)

This presentation describes two Arc Flash Hazard Analyses and the remedies taken to reduce the arc flash hazard level and protect electrical personnel.



‘Eighty (80) % of electrical injuries are burns resulting from an arc-flash ignition of flammable clothing.’

It All Starts With An Electrical Arc

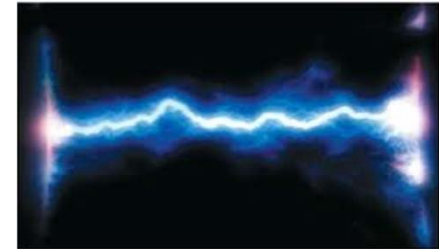
The Arc Fault Current is usually much *less* than the bolted fault current and *below* the rating of circuit breakers.

- Unless the over current protective devices are selected to handle the arc fault condition, they **will not trip** and the full force of an arc flash will occur.

The transition from arc fault to arc flash takes a finite time, increasing in intensity as the pressure wave develops.

- Energy from an arcing fault is directly proportional to the arc clearing time, thus **reducing the arcing time** is critical.

The challenge is to *sense* the arc fault current and shut off the voltage *before* it develops into a serious arc flash condition.



Arc Flash is an electrical explosion that results from a **low impedance connection** to ground or another voltage phase in an electrical system.

- An electric arc will oscillate and escalate if not constrained
- The arc fault is sustained by the establishment of a highly-conductive metal plasma
- The plasma will conduct as much energy as available and is limited only by the impedance of the arc
- Arc temperature can reach 35,000°

This massive energy discharge can vaporize copper and cause an explosive 40,000:1 volumetric increase, the *Arc Blast*.

- An arc current propels itself *away* from the power source
- Fatal burns can occur at distances over 10 ft.



Two major factors can influence the possibility of an arc flash.

1. Human error

2. Equipment failure

The majority of arc flash incidents are caused by *human error*.

- Dropped tools
- Accidental contact with live parts
- Loose tools left in equipment by previous workers

Equipment problems may include:

- Removing Draw-out Switchgear CCRS under power
- Damage to insulation which exposes live parts
- Corrosion or build-up of residue
- Improper installation
- Current overload
- Voltage transients

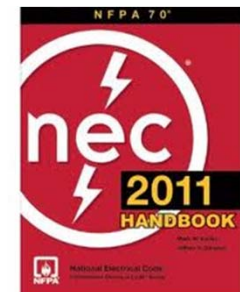


NFPA 70E (2012) - *Standard for Electrical Safety in the Workplace*

contains requirements for warning labels; provides guidance on implementing appropriate work practices that are required to safeguard workers from injury while working on or near exposed electrical conductors or circuit parts that could become energized.



NFPA 70 (NEC) - The NEC refers to arc flash in Section 110.16, which reads, "Flash Protection. Switchboards, panel boards, industrial control panels ... which 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 NEC labeling requirements apply to any electrical equipment installed or modified after 2002.

OSHA 1910.132(d)

Where work will be performed within the flash protection boundary, the flash hazard analysis shall determine, and the employer shall document, the incident energy exposure to the worker (in cal/cm²)

**OSHA 1910.269(I)(6)**

Flame resistant (FR) clothing and PPE shall be used by the employee based upon the incident energy exposure associated with the specific task.

Canadian Standards Association CSA Z462

- Z462 Arc Flash standard is Canada's equivalent to NFPA 70E
- Released in 2008

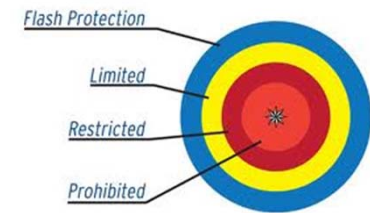
**Institute of Electronics & Electrical Engineers IEEE 1584– 2002**

- Guide to Performing Arc-Flash Hazard Calculations.



NFPA 70E Article 130.3 – Arc Flash Analysis

Where work will be performed within the flash protection boundary, the flash hazard analysis shall determine the Flash Protection Boundary



NFPA 70E Article 130.3(b) – PPE

Flame-resistant clothing and PPE shall be used by the Employee based upon the *Incident Energy Exposure* associated with the specific task.

Note:

Table 130.2(c) – Approach Boundaries for Voltage Levels

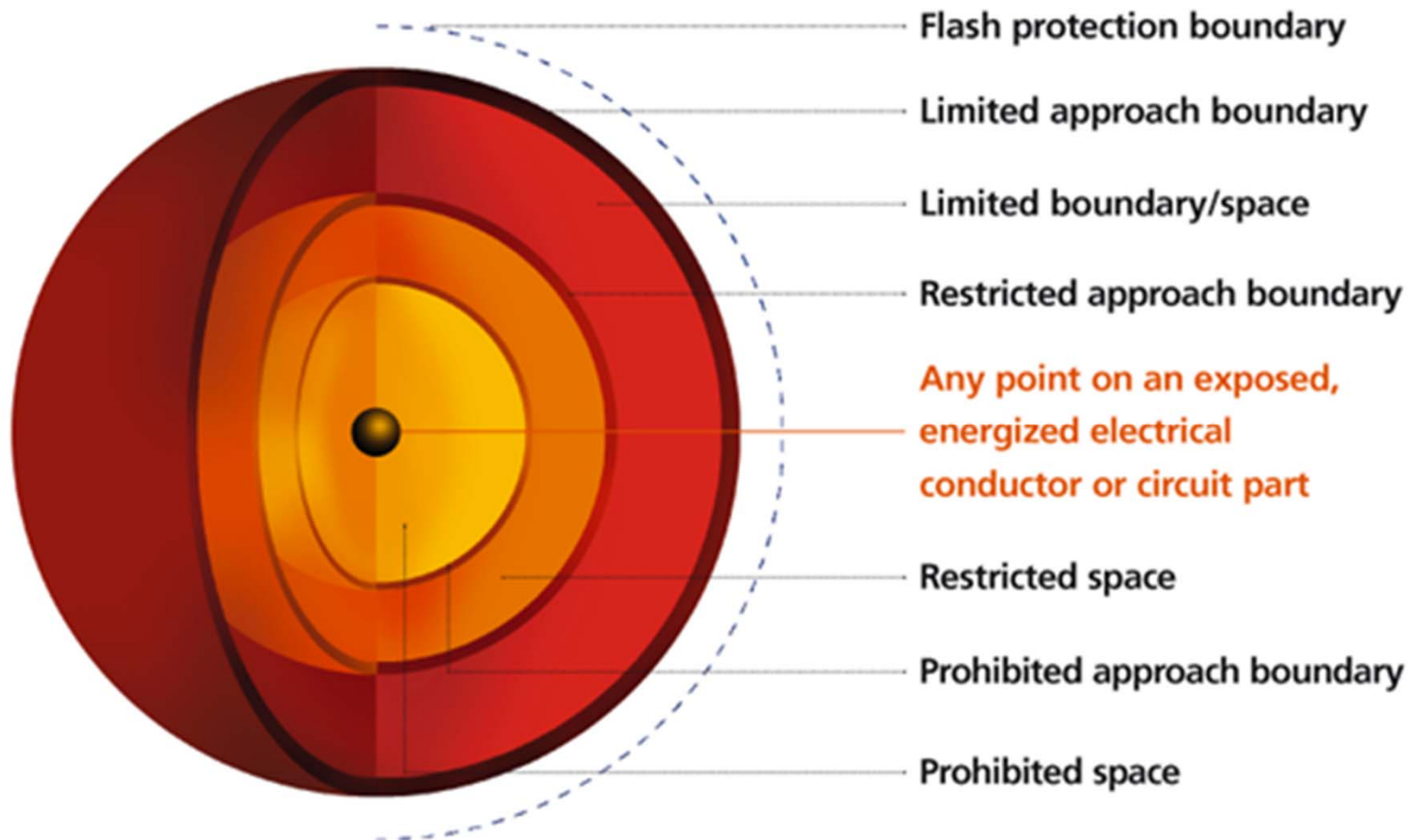
Table 130.7(c)(9)(a) – Hazard/Risk Category Classifications

Table 130.7.(c)(10) – Protective Clothing and PPE



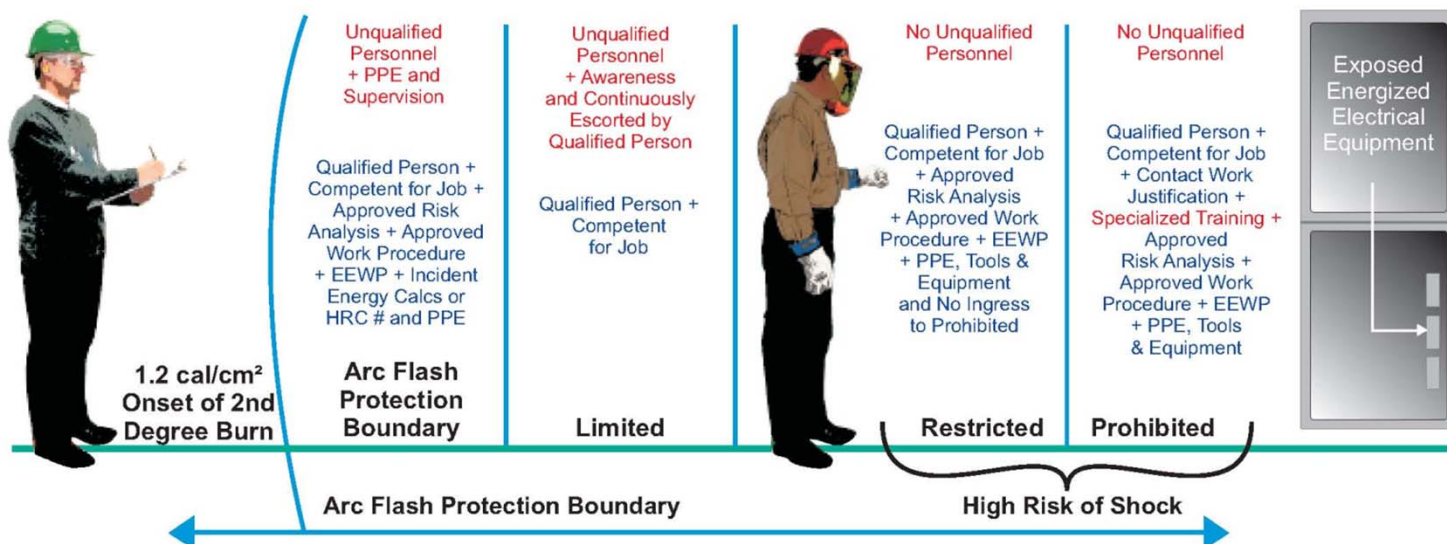
SHOCK APPROACH & FLASH PROTECTION BOUNDARIES

Limits of Approach: NFPA 70E, Annex C, Fig. C.1.2.4



NFPA 70E APPROACH BOUNDARIES

Boundaries for Arc Flash Protection and Shock - Approach Limits



Example of
Detailed Arc Flash and Shock Warning Label

Note:
Arc Flash + Shock PPE
for 600 V Energized
Work Task as example



! WARNING

**Arc Flash and Shock Hazard
Appropriate PPE Required**

ARC FLASH PROTECTION		SHOCK PROTECTION	
Working Distance:	18 inches	Shock Hazard when cover is removed	600 VAC
Incident Energy:	6.0 cal/cm ²	Limited Approach	42 inch
Arc Flash Protection Boundary	48 inch	Restricted Approach	12 inch
		Prohibited Approach	1 inch
		Glove Class:	0

Refer to CSA Z462 and company's Electrical Safety Program for PPE requirements.

Equipment Name: MCC#3
Arc Flash Analysis By: XYZ Consulting

Nov. 19, 2009 Std: IEEE 1584
File: "ABC PLANT REV X. xyz"

CSA Z462 Table 1 / NFPA 70E Table 130.2 (C)
Approach Boundaries to Energized Electrical
Conductors or Circuit Parts for Shock Protection

	Limited	Restricted	Prohibited
480V	3 ft. 6 in. 1.07 m	1 ft. 0 in. 305 mm	0 ft. 1 in. 25 mm
600V	3 ft. 6 in. 1.07 m	1 ft. 0 in. 305 mm	0 ft. 1 in. 25 mm
4160V	5 ft. 0 in. 1.52 m	2 ft. 2 in. 660 mm	0 ft. 7 in. 187 mm
13800V	5 ft. 0 in. 1.52 m	2 ft. 2 in. 660 mm	0 ft. 7 in. 187 mm

NFPA 70E calls for Arc Flash Warning Label

- CSA requires Arc Flash and Shock Hazard warnings


WARNING

Arc Flash Hazard
Appropriate PPE Required

Equipment Type	600V Switchgear
Grounding	Grounded
Work Distance	23 inches (600 mm)
Available 3-Ph Bolted Current	45 kA
Flash Protection Boundary	200 inches
Incident Energy at 23 inches	28.95 cal/cm ²
PPE Level	4

Label created and printed from www.arcadvisor.com

NFPA 70E


WARNING

Arc Flash and Shock Hazard
Appropriate PPE Required

ARC FLASH PROTECTION	SHOCK PROTECTION
Working distance: 46 cm (18 in)	Shock hazard when cover is removed: 600 VAC
Incident energy: 0.8 cal/cm ²	Limited approach: 107 cm (42 in)
Arc flash prot. boundary: 26 cm (10 in)	Restricted approach: 50 cm (12 in)
Hazard/Risk Category: #0	Prohibited approach: 2.54 cm (1 in)
Refer to CSA Z462 for requirements	Glove Class: 0

Equipment Name: TRANSFER SWITCH
 A.F. Analysis by: Liberty Airport Systems

May 27, 2009 Std. IEEE 1584
 File: "ARC FLASH - MAY 2009.dwg"

CSA Z462

**Airfield Electrical Vault
Protection Co-ordination Study
&
Arc Flash Hazard Analysis Study**



Ottawa International Airport



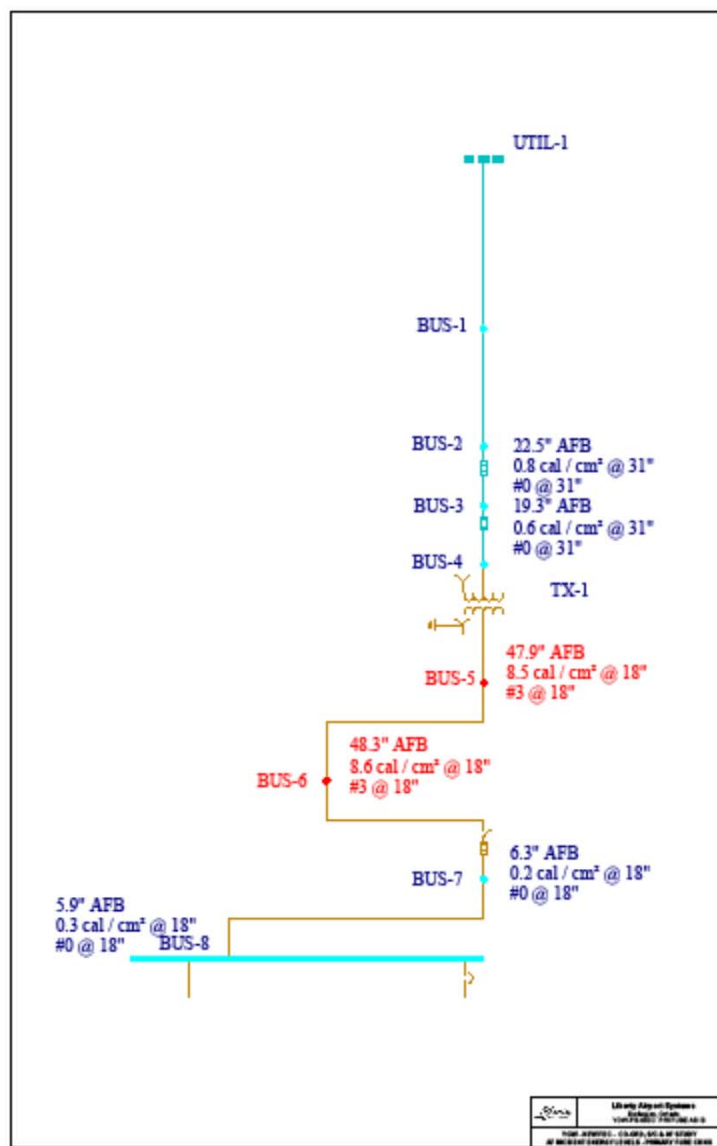
Ottawa IA – Utility feed to new electrical vault

- 500 kVA Pad-mount Transformer 27.6 kV – 600V
Y – Y Connection
4% Impedance (Z)
- Fault Level 124 MVA @ 27.6kV
13,129A @ 600V @ Transformer secondary
- Bay-O-Net Fuse, 15A Dual Sensing – “As is”
Arc Flash Level ‘3’ outside Vault – “As is”

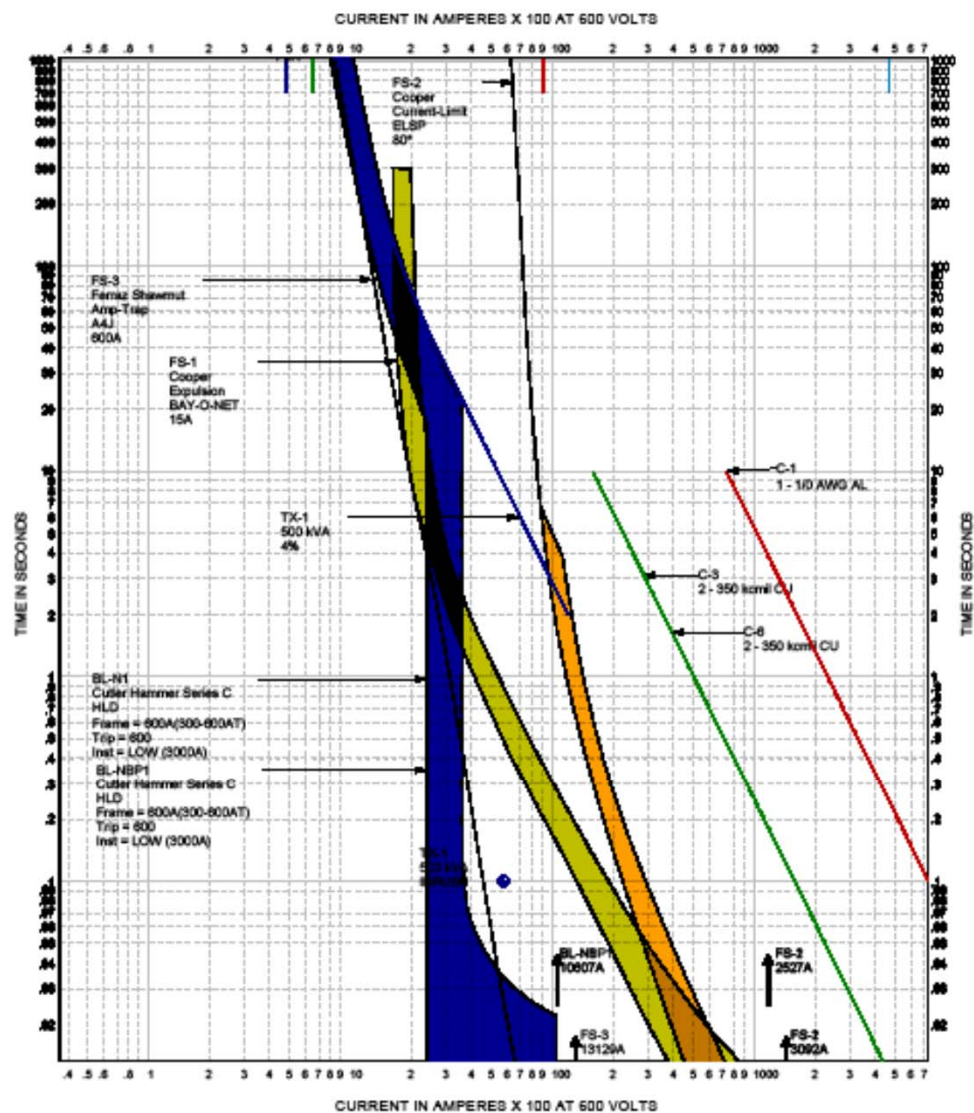
Remediation

- Bay-O-Net Fuse, 12A Dual Element – “Alternate”
- Current-limiting Back-up Fuse (ELSP) within Transformer tank
Arc Flash Level ‘1’ outside Vault – “Alternate”
- 600V feed to FEC – 600A fast acting Class J fuse (A4J)
- Arc Flash Level ‘0’ within Vault

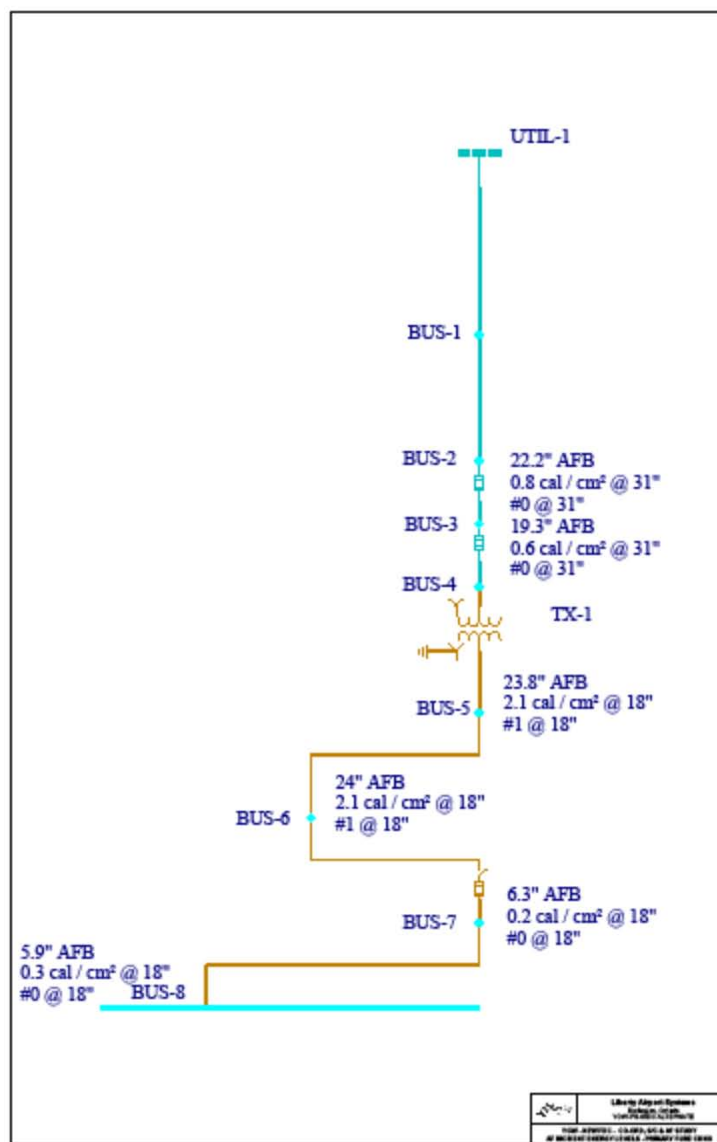
OTTAWA IA – SINGLE LINE (BEFORE)



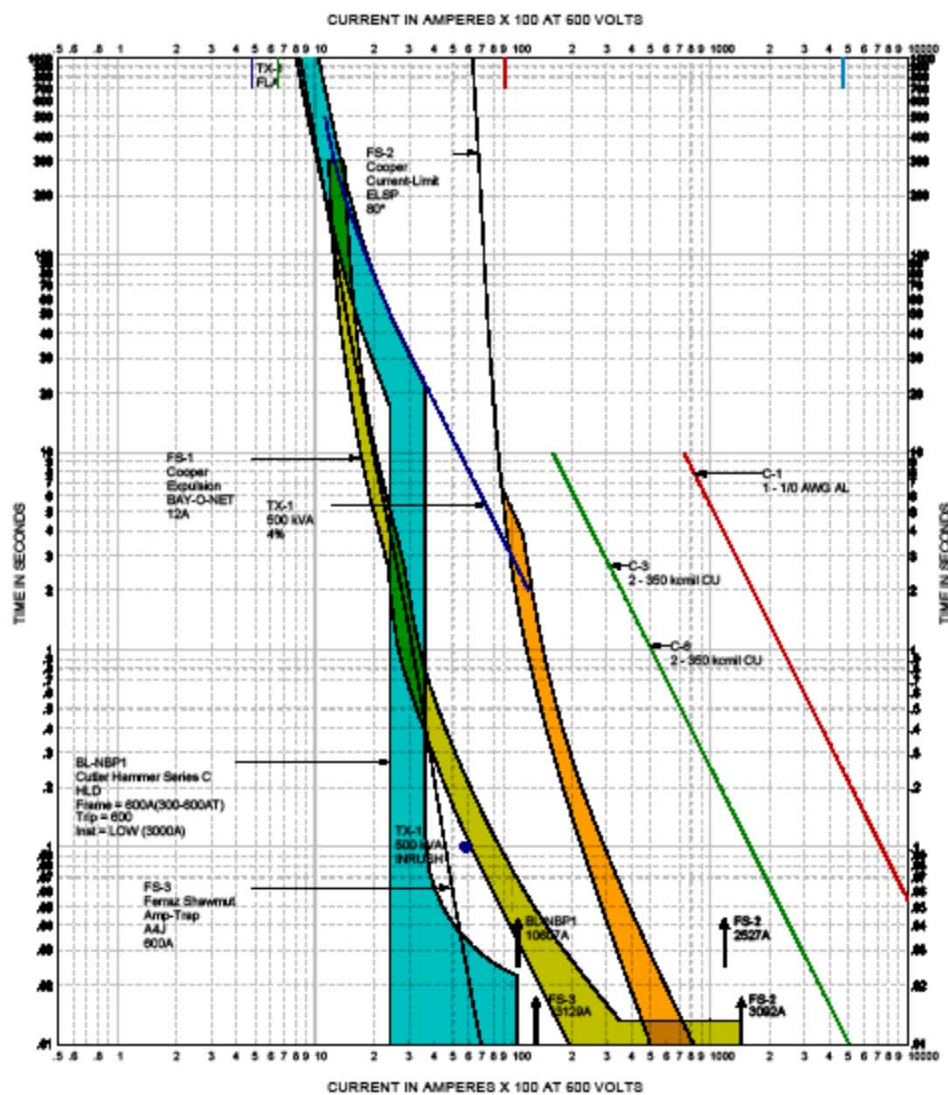
OTTAWA IA – FAULT CURRENTS (BEFORE)



OTTAWA 1A – SINGLE LINE (AFTER)



OTTAWA IA – FAULT CURRENTS (AFTER)



Protection Coordination Study and Arc Flash Hazard Analysis Study



Campbell River Airport





Campbell River Airport

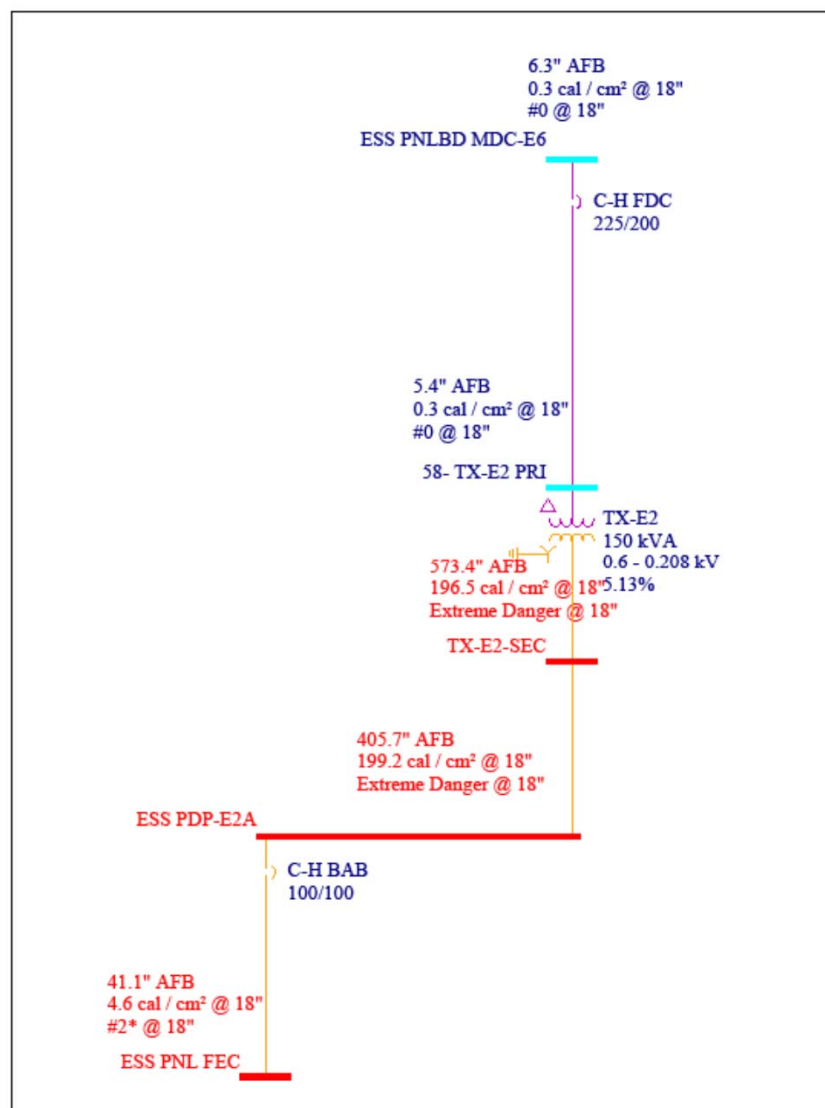
- 208V Distribution Panel fed by dry-type Transformer
 - 150 kVA, 600 – 208V
- Distribution Panel Arc Flash Level – **Extreme Danger**
 - Without a secondary breaker, the Arc Flash Boundary 573.4" = **48'**

Remediation

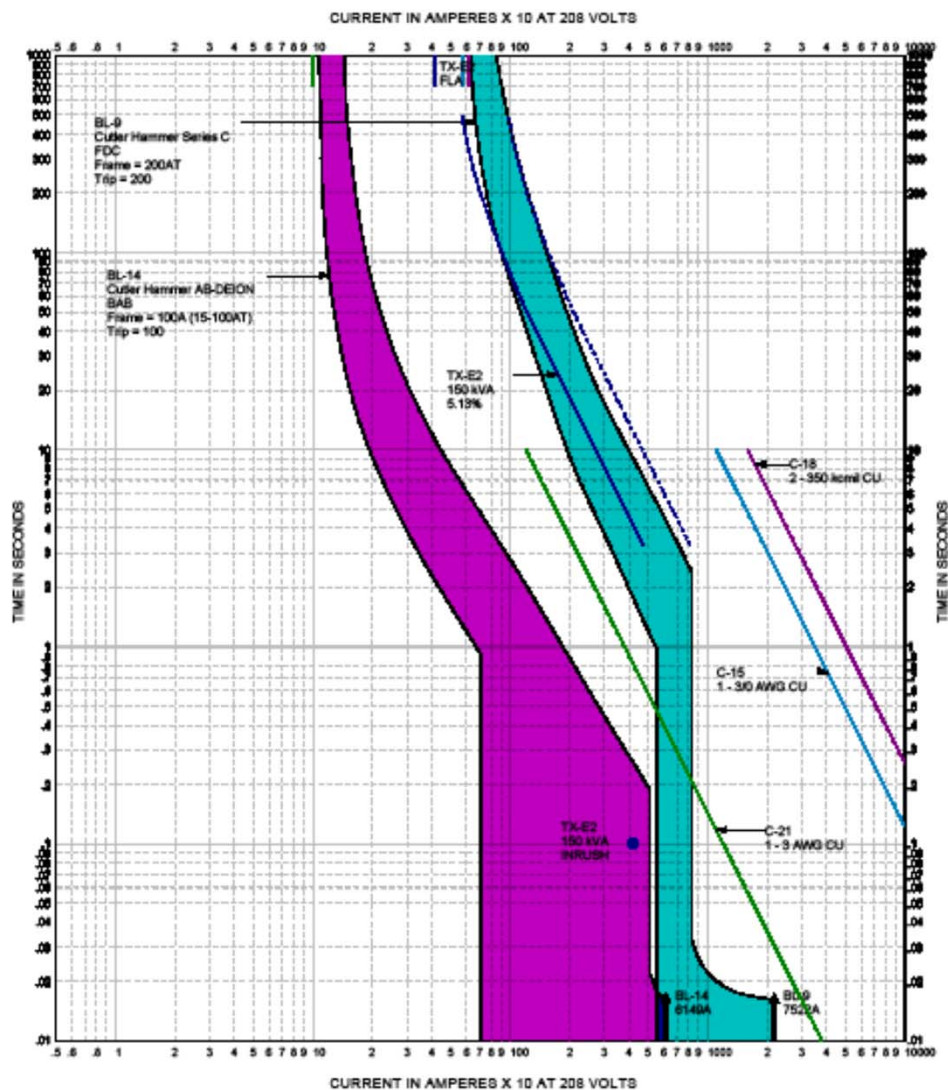
- Distribution panel with the addition of secondary breaker, with solid state trip unit.
 - Arc Flash Level reduced to Level '1'
 - Arc Flash Boundary reduced to 15.3" at the Distribution Panel

Note: Extreme danger still exists at the Transformer secondary to the line side of the main breaker, but the panel board is much safer for airport personnel.

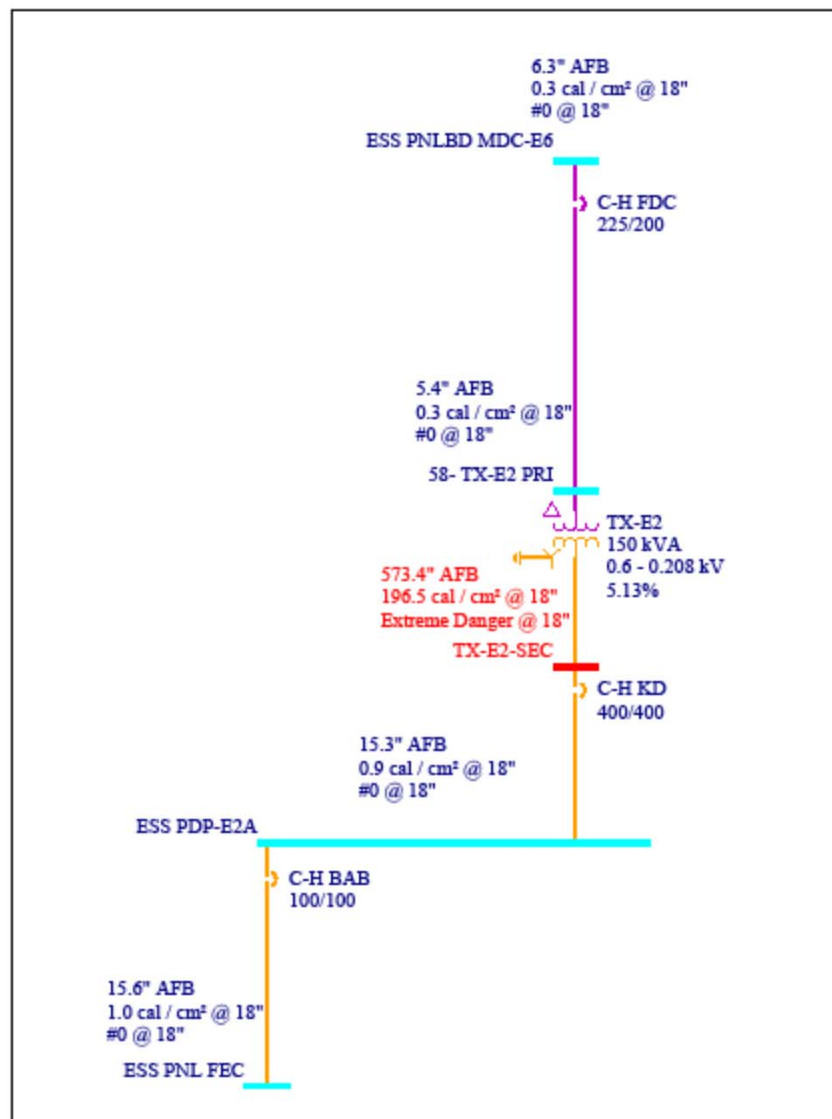
CAMPBELL RIVER — SINGLE LINE (BEFORE)



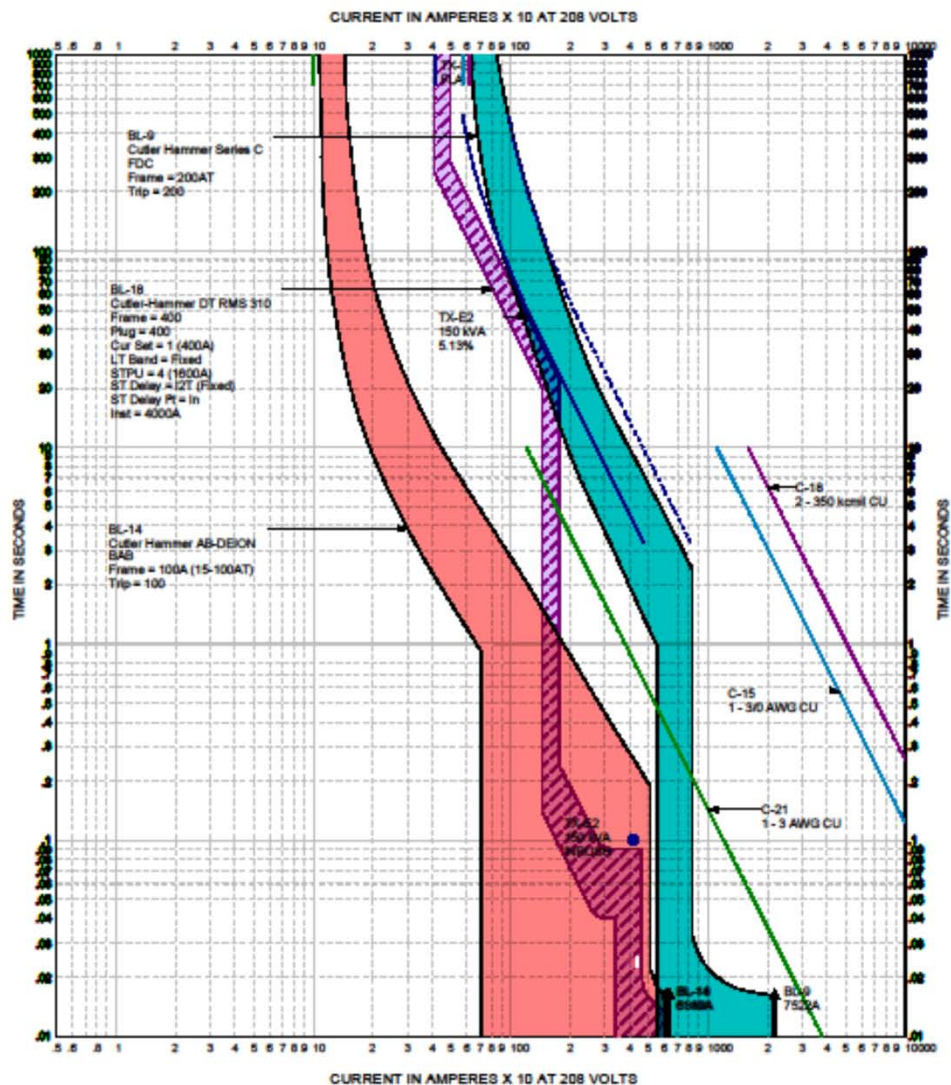
CAMPBELL RIVER – FAULT CURRENTS (BEFORE)



CAMPBELL RIVER — SINGLE LINE (AFTER)



CAMPBELL RIVER – FAULT CURRENTS (AFTER)



Arc Flash Analysis

An Arc Flash Hazard Analysis provides the information to identify and minimize the hazard risk to airport personnel.

Typical remediation includes:

1. Specifying current limiting fuses on low voltage switchgear breakers
2. Specifying fast acting fuses in lieu of time-delay fuses
3. Addition of main breakers with selective tripping elements
 - Use solid state vs. traditional magnetic breakers
4. Reduce Time Current Curve protection settings of upstream protection devices

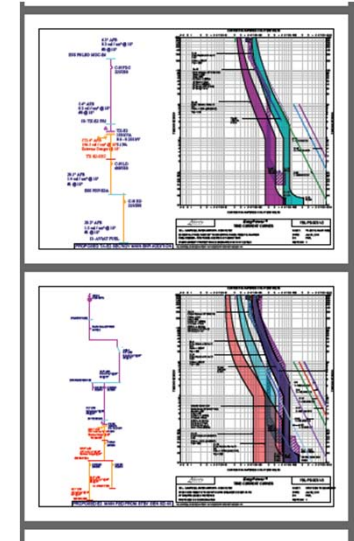


Liberty Airport Systems provided a detailed study of the electrical distribution system for airfield vaults, including:

- Short Circuit Study
- Device Evaluation
- Protection Coordination
- Arc Flash Hazard Analysis
- Labeling per results of Arc Flash Analysis

However, this is just a small part of a more comprehensive Safety Program.

- It is up to the Airport to develop the procedures to implement into a complete site safety program. Arc Flash Studies are but a portion of a complete Safety Plan.



Liberty endeavors to increase the awareness of hazards present within electrical distribution system of the airfield electrical center.

- Awareness improves future designs and installation safety

We desire that everyone goes home at the end of their shift – Healthy and Safe.

