DOCUMENT REVISION

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Summary Statement:

With respect to an abnormal arcing fault and arc flash there are risk control methods that proactively reduce incident energy. Technical feasibility and costs need to be considered.

Arc Flash Incident Energy Reduction

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Over the last 17 years that I have focussed my career on electrical safety, industry in Canada has become aware of and has been incented to hire electrical engineering consultants to complete arc flash hazard incident energy analysis studies for low and high voltage electrical equipment. I have identified and written many articles on the need for a defined scope of work and technical specification to be used and have provided a FREE very detailed and comprehensive document that can be adopted and used by industry. Within this scope of work it defines a target incident energy level of 75.0 cal/cm^2 to be considered and would require that the P.Eng. Electrical Engineer provides proposals to achieve this outcome with incident energy reduction methods where the initial calculations result in an incident energy level higher than this value. This is Part 2 of a two part article.

CSA Z462, Clause 4.1.5 Electrical safety policy advises that eliminating exposure to electric shock and arc flash is required by policy and that if an electrically safe work condition cannot be achieved appropriate risk control methods shall be implemented. CSA Z462, Clause 4.1.7.8 Risk assessment procedure identifies six hierarchy of risk control methods the employer can implement and in the order indicated.

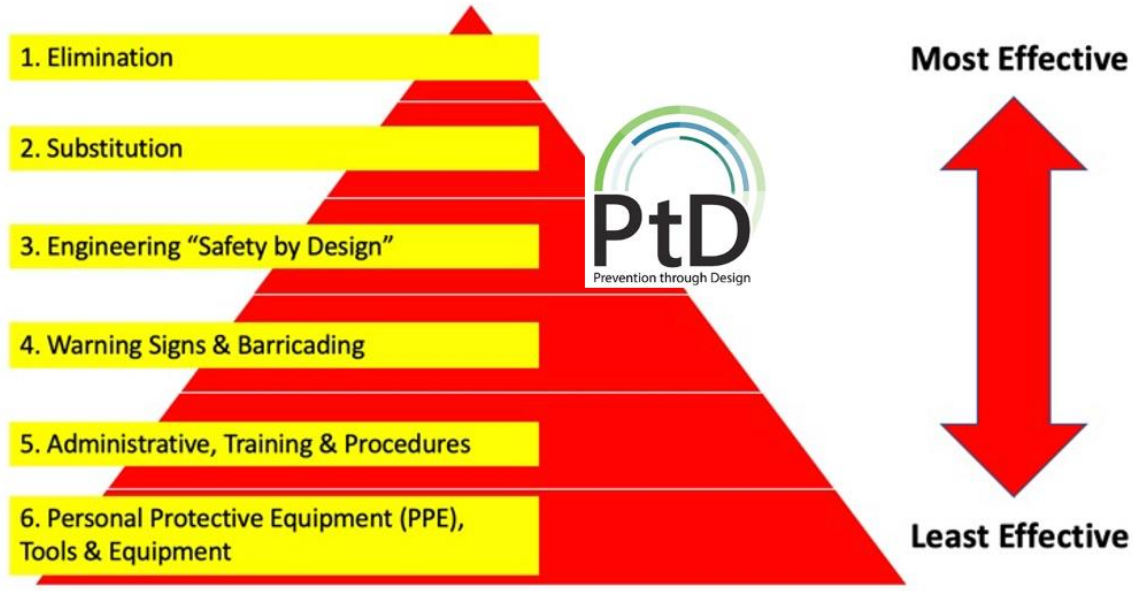

Figure 1 – Hierarchy of Risk Control Methods

As illustrated substitution and "engineering safety by design," "Prevention by Design (PtD)" are a higher priority than arc flash and electric shock personal protective equipment, tools and equipment. There are multiple options for reducing incident energy that can be considered. A reasonable and practical approach, technical feasibility and costs need to be considered. There needs to be a balance between potential options for incident energy reduction and arc flash PPE. Some electric shock PPE can actually increase the arc flash related working distance and reduce incident energy by 50% or more for under $100.

The following are a generic list of options for reducing incident energy (review Method 1 to 4 in Part 1 of this article).

Method 5 High Voltage Power Circuit Relay Maintenance Mode Switch

In this case new high voltage switchgear with power circuit breakers would be ordered with a ON/OFF switch wired into a programmable relay's auxiliary input. Existing electrical equipment can be retrofitted. When the switch is turned on the relay's settings are changed from Group A to Group B, where Group B would be set so there is no intentional delay. This results in significant incident energy reduction if an abnormal arcing fault would occur on the load side of the power circuit breaker. Incident energy is reduced on the switchgear bus for the main breaker and sub-fed electrical equipment for the feeder circuit breakers.

Bus Name	Protective Device Name	Maintenance Mode	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time/Tol (sec.)	Equip Type	Electrode Config	Box Width (in)	Box Height (in)	Box Depth (in)	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm2)
MB-8100	FPR-TX1 (Phase)	OFF	0.48	49.32	35.21	44.50	31.77	0.2000	0.0833	MCC	VCBB	12	14	10	25	9' 0"	18"	31.1
	FPR-TX1 (Phase Maint.)	ON	0.48	49.32	35.21	44.50	31.77	0.0167	0.0833	MCC	VCBB	12	14	10	25	5' 3"	18"	11.4

Method 6 Low Voltage Power Circuit Breaker Maintenance Mode Switch

In this case new low voltage switchgear with power circuit breakers would be ordered with a ON/OFF switch wired into a programmable relay's auxiliary input. Existing electrical equipment can be retrofitted. When the switch is turned on the relays settings are changed from Group A to Group B, where Group B would be set so there is no intentional delay. This results in significant incident energy reduction if an abnormal arcing fault would occur on the load side of the power circuit breaker. Incident energy is reduced on the switchgear bus for the main breaker and sub-fed electrical equipment for the feeder circuit breakers.

Bus Name	Protective Device Name	Maintenance Mode	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time/Tol (sec.)	Equip Type	Electrode Config	Box Width (in)	Box Height (in)	Box Depth (in)	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm2)
MCC-8100	MB-8100. (Phase)	OFF	0.48	49.21	35.17	44.39	31.72	0.1400	0.0000	MCC	VCBB	12	14	10	25	6' 3"	18"	15.7
	MB-8100. (Maint)	ON	0.48	49.21	35.17	44.39	31.72	0.0600	0.0000	MCC	VCBB	12	14	10	25	3' 11"	18"	6.9

Method 7 High Voltage Switchgear Arc Flash Relay

In this case a custom stand-alone "arc flash relay" or a multi-function relay has an arc flash relay option added is installed with a loop sensor or point sensors inside high voltage (or low voltage) electrical equipment. The relay is also equipment with current measurement as a secondary check when the abnormal arcing fault occurs. The arc is detected at the speed of light in milliseconds and in turn will open a circuit faster than just a traditional overcurrent element. The table below illustrates the potential incident energy reduction.

Bus Name	Protective Device Name	Arc Flash Detection	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time/Tol (sec.)	Equip Type	Electrode Config	Box Width (in)	Box Height (in)	Box Depth (in)	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm2)
52-0.	511A-P_Normal (Phase)	OFF	15.00	15.64	14.74	15.39	14.50	0.4815	0.0833	SWG	VCBB	30	45	30	152	14' 8"	3' 0"	17.1
	511A-P_Normal (AFD)	ON	15.00	15.64	14.74	15.39	14.50	0.0010	0.0833	SWG	VCBB	30	45	30	152	4' 9"	3' 0"	2.6

Method 8 IEEE 1584 Box/Electrode Configuration Misapplication

The IEEE 1584-2018 Edition included new box/electrode configuration, Vertical Conductor Box Barrier (VCBB) and Horizontal Conductor Box (HCB). If HCB is incorrectly selected against an defined electrical equipment asset it will yield a 200% increase in incident energy. Employers need to ensure that if an electrical engineering consultant's report illustrates the use of HCB that they can justify it with respect to the electrical equipment they applied HCB to.

Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time/Tol (sec.)	Equip Type	Electrode Config	Box Width (in)	Box Height (in)	Box Depth (in)	Gap (mm)	Arc Flash Boundary	Working Distance	Incident Energy (cal/cm2)
MB-8100	FPR-TX1 (Phase)	0.48	49.32	31.13	44.50	28.09	0.2000	0.0833	MCC	VCB	12	14	10	25	9' 0"	18"	21.2
	FPR-TX1 (Phase)	0.48	49.32	35.21	44.50	31.77	0.2000	0.0833	MCC	VCBB	12	14	10	25	9' 0"	18"	31.1
	FPR-TX1 (Phase)	0.48	49.32	30.90	44.50	27.88	0.2000	0.0833	MCC	HCB	12	14	10	25	8' 8"	18"	42.4

The Benefit of Incident Energy Reduction

The incident energy reduction techniques highlighted in this article (e.g., Part 1 and Part 2) do not eliminate the potential severity of injury or damage to health for a Qualified Person from been exposed to an abnormal arcing fault. The primary benefit would be to reduce the arc-rating of arc flash PPE required from an arc-rated Level 2 arc flash suit to an arc-rated Level 1 everyday task wear arc flash PPE as illustrated below.

Arc-Rating Level #	Arc Flash PPE Minimum Requirements
Level 1 **8.0-12.0 cal/cm²** **ATPV or E_{BT}** 	**Body:** Everyday/task wear long sleeved shirt/pant or coverall (with storage bag). 100% natural fibre clothing to be worn underneath. **Emergency Rescue:** "Escape Strap" vest available for use. **Head & Face:** CSA approved eyewear, clear lens. Arc-rated balaclava and arc-rated face shield (with storage bag) with true colour grey lens, CSA approved Class E hard hat and LED lamp. **Hearing:** CSA approved minimum ear canal insert ear plugs. **Hands:** Appropriate Class # of rubber insulating gloves with protectors (with storage bag sized to the Class #). **Footwear:** CSA approved Ohm rated leather/rubber footwear. Note: Rubber insulating gloves with protectors provide arc flash protection for the hands. Where there is no electric shock hazard exposure heavy duty leather work gloves or specifically tested arc-rated gloves provide arc flash protection for the hands.
Level 2 **Minimum 75, 100 or 140 cal/cm²** **ATPV** 	**Body:** Arc flash suit: bib overalls, and jacket with "Escape Strap." 100% natural fibre clothing to be worn underneath. Manufacturer's storage bag. **Emergency Rescue:** "Escape strap" can be used. **Head & Face:** CSA approved eyewear, clear lens. Arc flash suit hood with true colour grey lens, CSA approved Class E hard hat, arc flash suit hood ventilation system and LED lamp. **Hearing:** CSA approved minimum ear canal insert ear plugs. **Hands:** Appropriate Class # of rubber insulating gloves with protectors (with storage bag sized to Class #). **Footwear:** CSA approved Ohm rated leather/rubber footwear. Note: Rubber insulating gloves with protectors provide arc flash protection for the hands. Where there is no electric shock hazard exposure heavy duty leather work gloves or specifically tested arc-rated gloves provide arc flash protection for the hands. Arc flash suits are available with an ATPV of up to 140.0 cal/cm² and can be procured for use.

I will continue my efforts to communicate information in Electrical Safety Measures and share the

knowledge and experience I have in an effort to “Get it Right!!” My electrical safety journey and mission will continue!! Knowledge is power (when applied and applied correctly)! TAKE CONTROL of ARC FLASH (with a compliant Electrical Safety Program)!!!!!

If you are interested in discussing the information presented in this article or would like a specific topic presented do not hesitate to contact me at terry.becker@twbesc.ca or 587-433-3777.

Terry Becker, P.Eng., CESCP, IEEE Senior Member is the first past Vice-Chair of the CSA Z462 Workplace electrical safety Standard Technical Committee and currently a Voting Member and Clause 4.1 and Annexes Working Group Leader. Terry is also a Voting Member on the CSA Z463 Maintenance of electrical systems Standard and a Voting Member of the IEEE 1584 Guide for Performing for Arc-Flash Hazard Calculations. Terry is also a voting member of the CAN/ULC S801 Workplace Electrical Safety Standard for Utility Generation, Transmission and Distribution. Terry has presented at over 95 Conferences and Workshops on electrical safety in Canada, the USA, Italy, India and Australia. Terry is a Professional Engineer in the Provinces of BC, AB, ON and PEI. Terry is an Electrical Safety Specialist, Management Consultant, and can be reached at 1-587-433-3777 or by email terry.becker@twbesc.ca.