WHEN YOU DO NOT HAVE AN ARC FLASH STUDY

How to Estimate Arc Flash Incident Energy

When you do not have an up-to-date AF study

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Arc Flash Incident Energy

1. Too much PPE **<u>→ Undesirable</u>**, Not enough PPE **<u>→ Unacceptable</u>**
2. Electrical systems studies are not about what will happen, they are about what could happen
3. Risk control is about preventing dangerous events that could happen,

   and
4. Keeping consequences of dangerous events acceptable,

   i. e.
5. Reducing risk to an acceptable level, see bullet #1

Arc Flash Incident Energy

If you overestimate… you may wear too much PPE… **undesirable**
If you underestimate… Well… **unacceptable**

What is an arc flash number for?

- An input to a risk assessment

How is an arc flash study done?

- An exact calculation based on estimated, guessed, assumed and unknown variables

What if you do not have a current (IEEE 1584-2018) arc flash study?

- Energy boundary method to adapt 2002 study, in IEEE papers by M. Valdes & L. Floyd
- NFPA 70E table 130.7 (C) (15)
  - **Really, is this the best we can do?**
- CSA Z462 a different and better table
  - **A move in a more realistic and better direction!**
- Other methods, with a little prework…
  - **What do you know? What can your reasonably find out? How to be conservative.**

An explosion, chaotic and hard to predict

Need to understand how big it “can” be, impossible to know exactly what it will be!

Why try to find out what arc flash energy might be

It's all about controlling risk

Proper task planning requires identifying, analyzing and controlling risk for the worker

Risk Assessment: Part of risk management involving:

1) Identifying sources of risk
2) Analyzing risk sources to estimate risk level
3) Evaluating risk → determine if risk treatment/ control is required

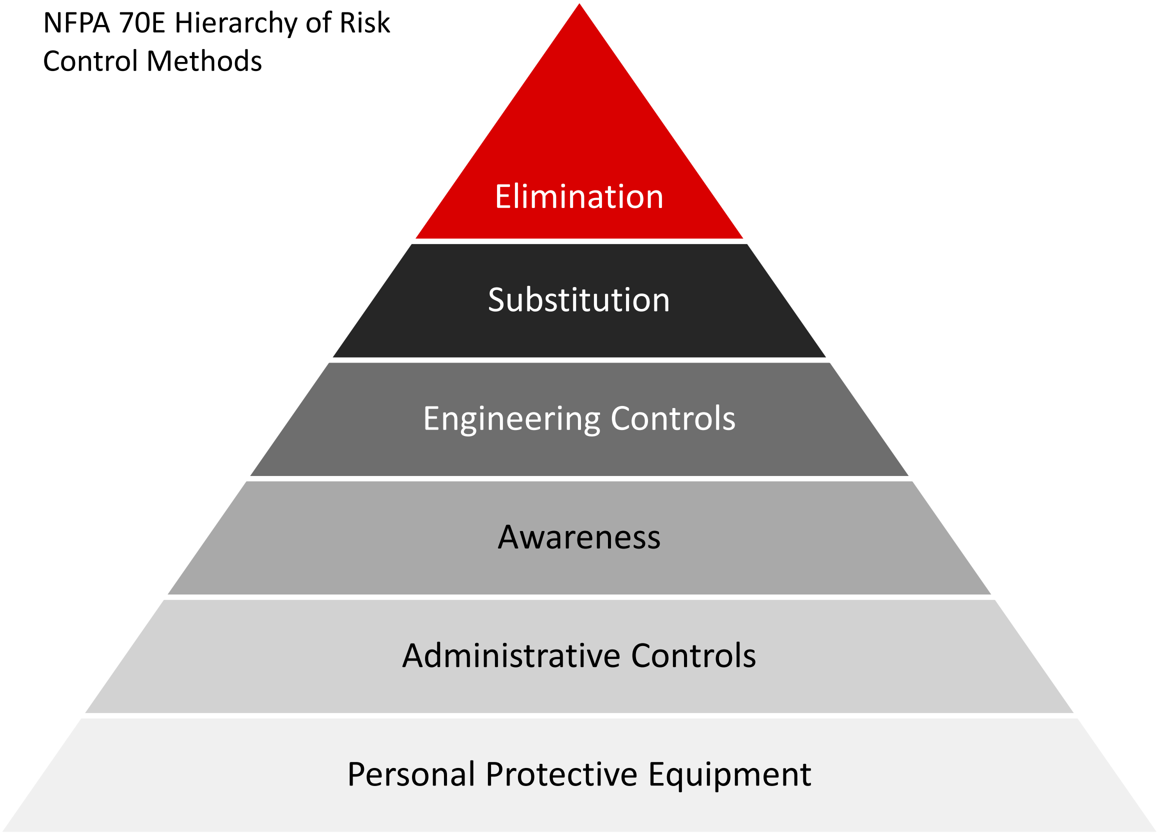
To that end it must be evaluated if an electrical explosion could happen and if it happens how impactful it may be…

– An AF number is about the "possible" impact (severity of the potential injury). **It is not about the probability of the event.**

A risk assessment may consider probability of an event, but an arc flash study does not, it only addresses severity.

The risk controls implemented may range from deciding not to accomplish the task as originally envisioned or to simply wear PPE, and/or to implement other controls…

NFPA 70E Hierarchy of Risk Control Methods

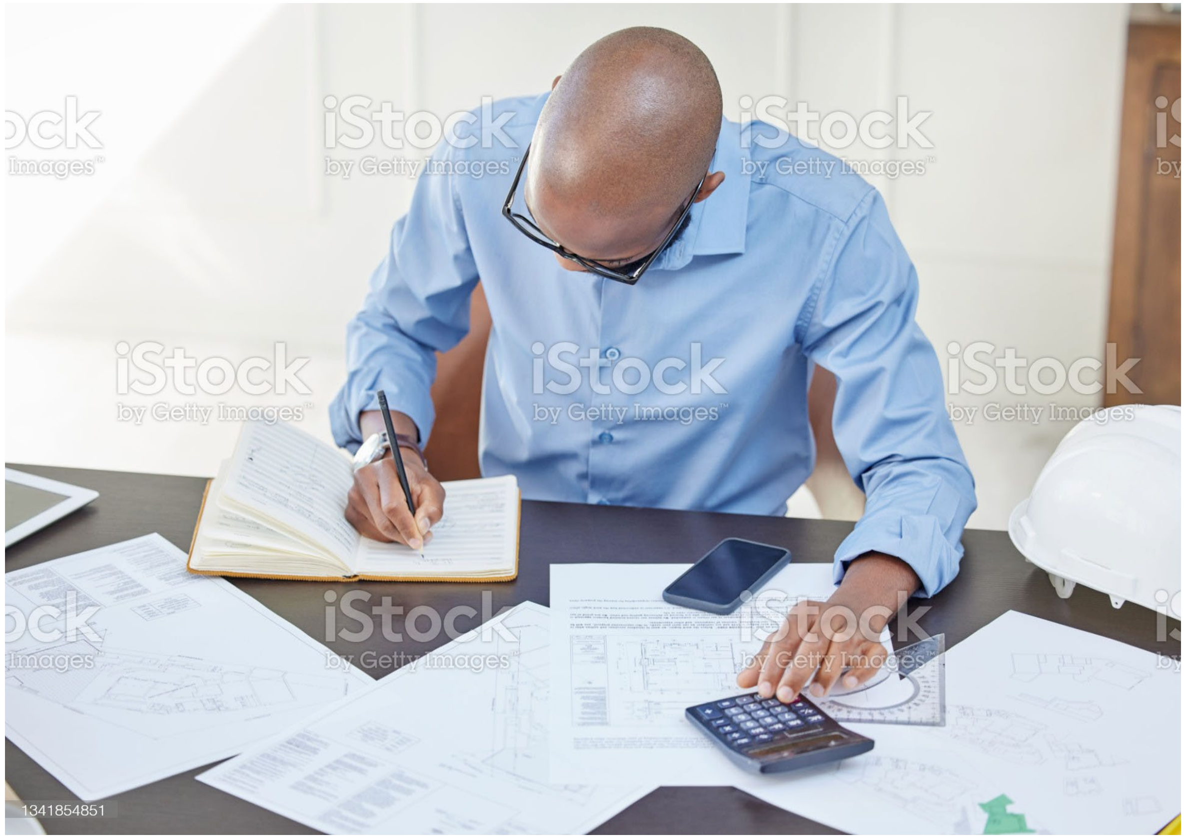


Why try to find out what arc flash energy might be

Not so much about what "will" happen, but more about what "could" happen…

Electrical system studies are not an exact science

- Short circuit studies are always wrong, in an acceptable way.
  - High short circuit current (I_{bf}) estimates ensure equipment is adequately rated because rating too high may be undesirable but rating too low is unacceptable.
  - For most electrical system studies, a bias towards conservatively wrong results is built into the method or how data is acquired.
- Arc Flash studies use multiple variables that are estimated and can impact arcing current (I_a) towards too high or too low.
- I_a drives protection time… high I_a creates more arc flash energy "per" unit time, but low I_a can create more time… which results in the most AF energy?… depends
- For arc flash its more conservative to consider a range for possible inputs rather than 1 value which may be too high or too low



ABB

Arc flash calculations

2 step process

First, arcing current (I_a)

- Voltage V: Usually well known within a narrow range
- Bolted fault current (I_{bf}): Estimated high, particularly in LV & may vary significantly, typically downward, due to expected or known & unexpected or unknown topology changes
- Arcing Gap (G): Can be measured, but usually is not, often guessed at. Guessing large is more conservative, drives lower I_a & higher E_i
- Electrode orientation (V or H): Seems obvious if you see the conductors, but it's the direction power comes from that is important & one needs to see it relative to the task to be sure.
- Box or no box (CB or OA): Box size does not impact I_a, but impacts E_i per the model… but very large boxes may be like OA if the arc is unconstrained which leads to potentially lower than expected I_a
- Defines "average" I_a & "minimum" I_a. Minimum I_a doesn't consider minimum I_{bf}, maximum gap or voltage regulation… **minimum may not be minimum**

Second, Incident Energy (E_i)

- I_a from step 1: 2 values, an average & a minimum
- Protection time (t): Derived from the expected response of the protection to the I_a that flows through it, or from the response of the protection mechanism used to mitigate the AF event. High I_a may cause the protection to be a lot faster, & low I_a the opposite
- Working distance (D): How far the worker's chest is from conductor terminals. Usually comes form values in IEEE 1584 guide but may vary for multiple reasons.
- Size of the box (correction factor): Small & deep is more conservative but has relatively low effect.
- V & G are also used

Many of these values or inputs are not ever exactly known… OK if error is conservative or within margin that other factors account for, purposely or not. Ex: it is often stated that PPE is conservatively rated. Anecdotal evidence seems to support that… but how much is not quantified. The IEEE model itself is probably conservative with respect to E_i… in my opinion it may not be conservative with respect to low I_a, i. e. does it truly account for how low I_a can be because it ignores factors not in the original test data.

And some variance can have significant impact on E_i

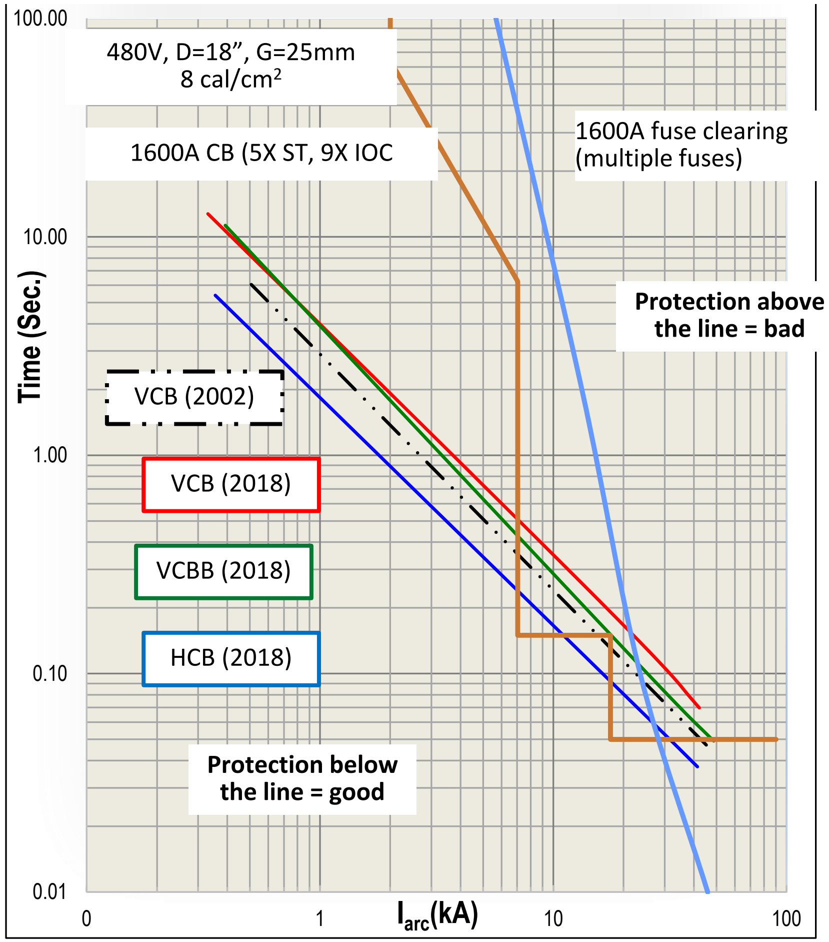
Constant Energy Boundary (CEB)

A way to graphically see how a protection system may perform against a specific PPE performance target vs a range of arcing current …

Shown: 480V, 18” D, 25mm G, in a box for <=100kA I_{bf}

- If I_{bf} is not a well-known variable, I_a is even less so…
- Both the CB & fuse are “steeper” than the CEBs
- Hence low I_a can result in higher energy than high I_a… **counterintuitive**
- **Though at “high” I_a both may be good enough**
  - **Fuse size matters whether its current limiting or not**
  - **CB size, type and settings matter**

8 cal/cm² Constant Energy Boundary, 480V, D=18”, G=25mm



If you have an IEEE 1584-2002 based study

Method fully described described in 2 IEEE papers by M. Valdes & L. Floyd.

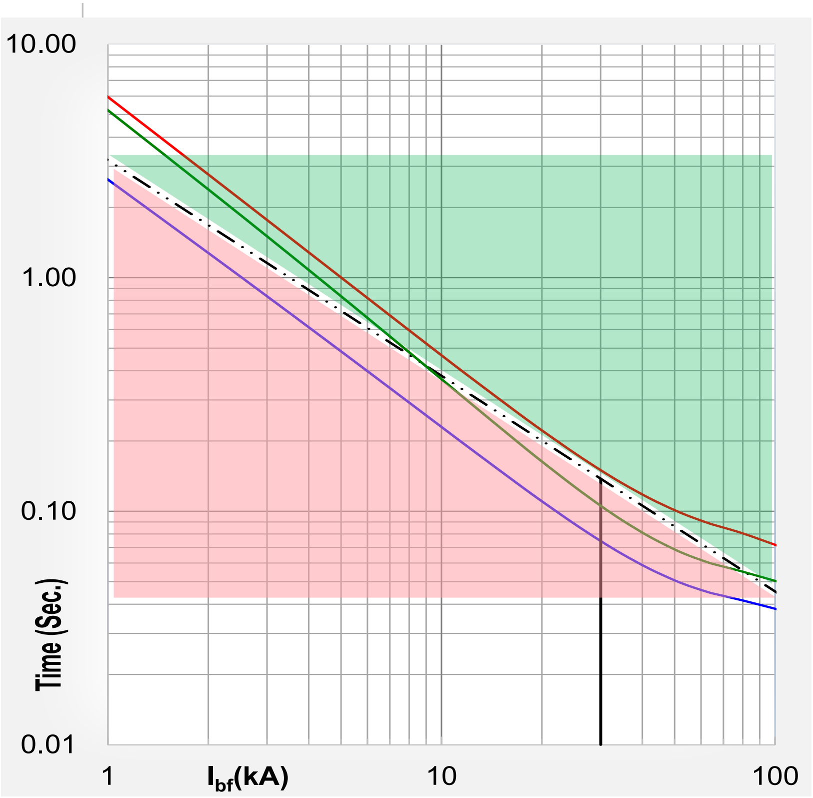
- CONSIDERATIONS FOR ADAPTING IEEE 1584-2002 ARC FLASH STUDY RESULTS TO A POST IEEE 1584-2018 RISK ASSESSMENT (Valdes & Floyd, IEEE ESW 2020), and IEEE IAS Transactions 2021.
- PART II OF: CONSIDERATIONS FOR ADAPTING IEEE 1584-2002 ARC FLASH STUDY RESULTS TO A POST IEEE 1584-2018 RISK ASSESSMENT; APPLYING THE METHOD (Valdes, IEEE PPIC 2021)

If you have a 2002 study but not a 2018 study

If you have an IEEE 1584-2002 study but not a 2018 study….

- 2002 study → 8 cal/cm^2 PPE & per this chart 2018 study with same inputs "may" be good enough for VCB or VCBB, but not HCB…But "may be" is not good enough…
- IEEE 1584-2018 I_{arc} often higher than IEEE 1584-2002 I_{arc}, → the protection will be = speed, or faster, not slower…
- For Ibf where the new I_{arc} is higher, if the protection was good enough for 8 cal/cm^2 before, its good enough for 8 cal/cm^2 now… this chart shows that
- Margin between 2002 values & PPE selected, even better
- If the 2002 line is plotted at the highest E_i level calculated in the 2002 study and the 2018 lines are plotted at the available PPE level the margin between can be leveraged

8 cal/cm^2 Constant Energy Boundary, 480V, D=18", G=25mm



Graph vs. I_{bf} not drawn by normal system analysis software

NFPA 70E

- TABLE 130.7(C)(15)(a) **Arc-Flash PPE Categories for Alternating Current (ac) Systems**
- **The** official estimating method
- But is it the **best?**

NFPA 70E

The official 2nd method

Task based hazard risk analysis

1) Does the task require PPE? Fundamental risk assessment question
   - TABLE 130 (5) **Estimate of the Likelihood of Occurrence of an Arc Flash Incident for ac and dc Systems**
   - Method is not complex, based on what you are doing, what you are doing it to and how good a condition what you are doing it to seems to be is the likelihood neglible or not… it's a "0" or a "1"… there is no 0.5!!!
   - If not neglible then go to the next step

2) If so what level of PPE? 2nd question, 2nd table
   - TABLE 130.7(C)(15)(a) **Arc-Flash PPE Categories for Alternating Current (ac) Systems**
   - Selection depends on: Voltage, short circuit current (I_{bf}) maximum, OCPD performance at ??? current & type of equipment

NFPA 70E

No mention of

- bus bar/electrode orientation or IEEE 1584-2018 differences
- I_{arc}
- minimum I_{bf}
- working distance or task
- OCPD size, fuses & CB =?

Switchgear with Power CB or fused switches? No such thing as switchgear with fused switches!

The most important thing about E_i mitigation is what the OCPD does @ I_a

Nothing in this table helps understand I_a.

Equipment	*Arc-Flash PPE Category*	*Arc-Flash Boundary*
Panelboards or other equipment rated 240 volts and below Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	1	485 mm (19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	900 mm (3 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
600-volt class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	4.3 m (14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	4	6 m (20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Metal-clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Arc-resistant switchgear 1 kV through 15 kV [for clearing times of less than 0.5 sec (30 cycles) with an available fault current not to exceed the arc-resistant rating of the equipment], and metal-enclosed interrupter switchgear, fused or unfused of arc-resistant-type construction, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	N/A (doors closed) 4 (doors open)	N/A (doors closed) 12 m (40 ft)
Other equipment 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)

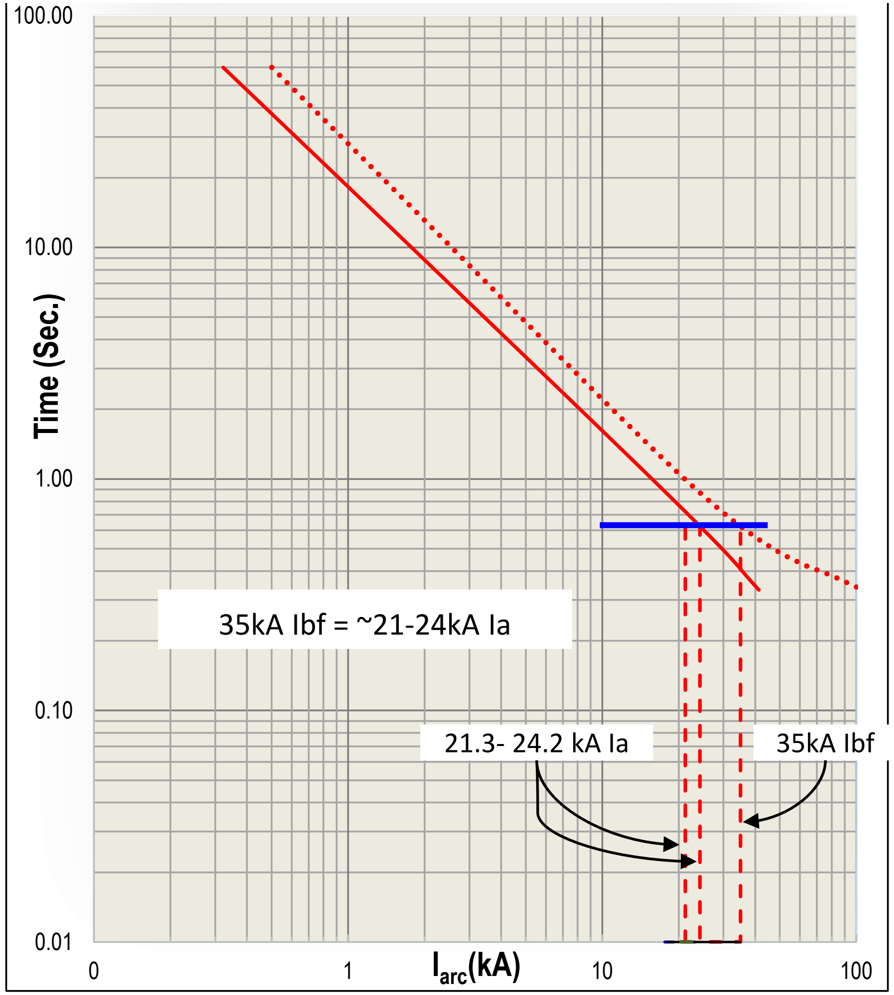
Note: For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.

NFPA 70E, table 130.7(C)(15)(a)

Focuses on a "maximum" I_{bf} and what the OCPD does at fault current.

- A user would need to know available fault current
- To determine what the OCPD does at the fault current you need the OCPD curve or a coordination study
- From the above you can determine clearing time at fault current **which has nothing to do with arc flash** but does tell you what PPE to wear based on this table?

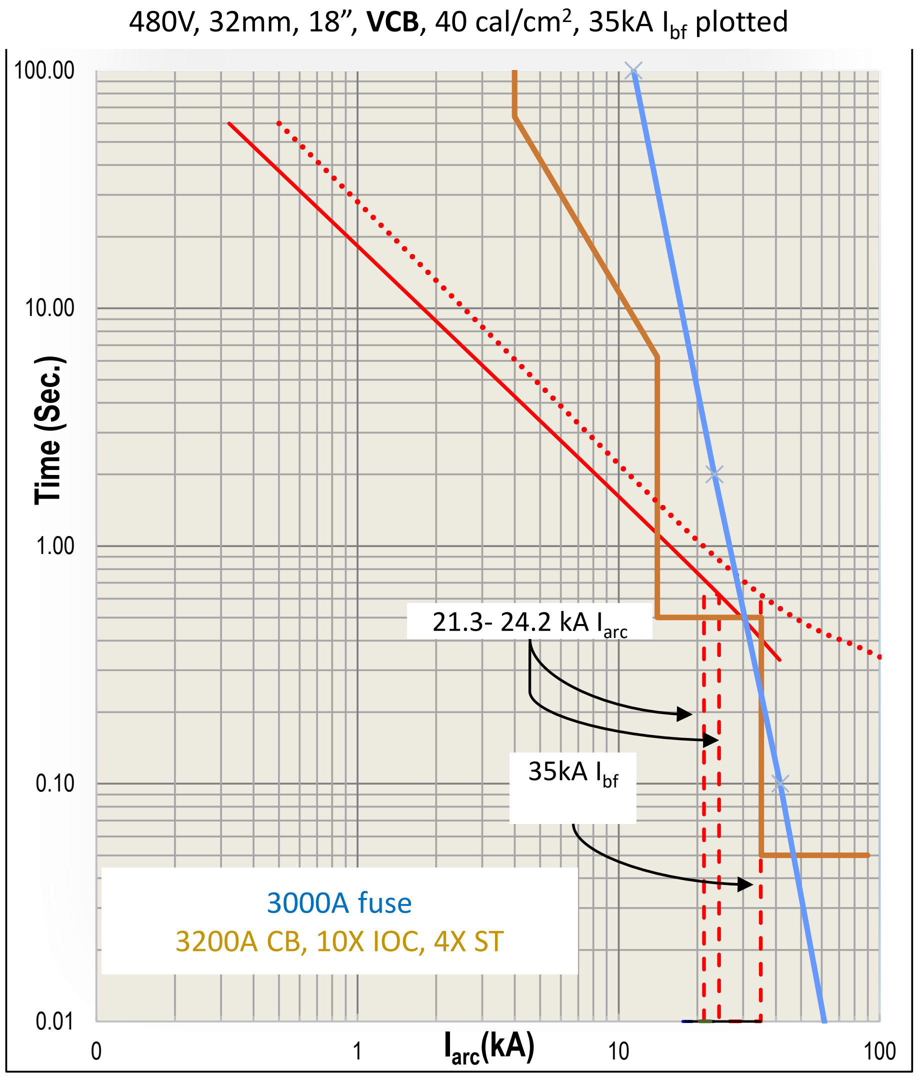
480V, 32mm, **VCB**, 18", 40 cal/cm², 35kA Ibf plotted



NFPA 70E, table 130.7(C)(15)(a)

At 35kA I_{bf} fuse meets table criteria, CB does not. At I_{arc} CB meets criteria, fuse does not… by a >2x… if VCB

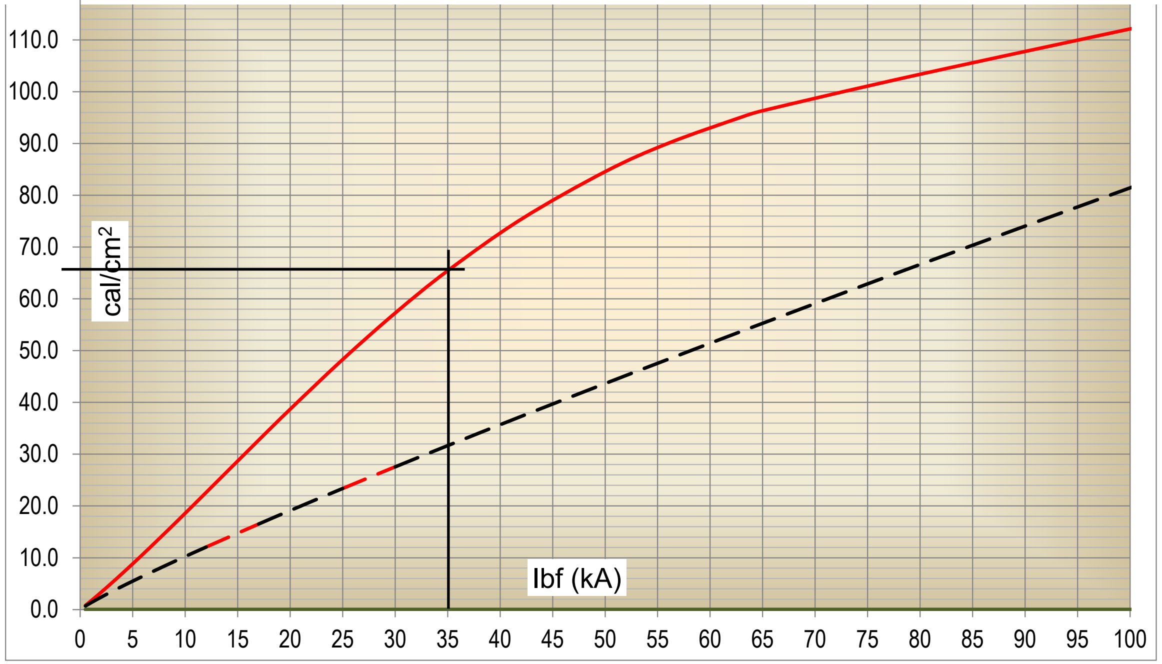
But switchgear can pose an HCB threat, especially at the rear where the cable are.



NFPA 70E, table 130.7(C)(15)(a)

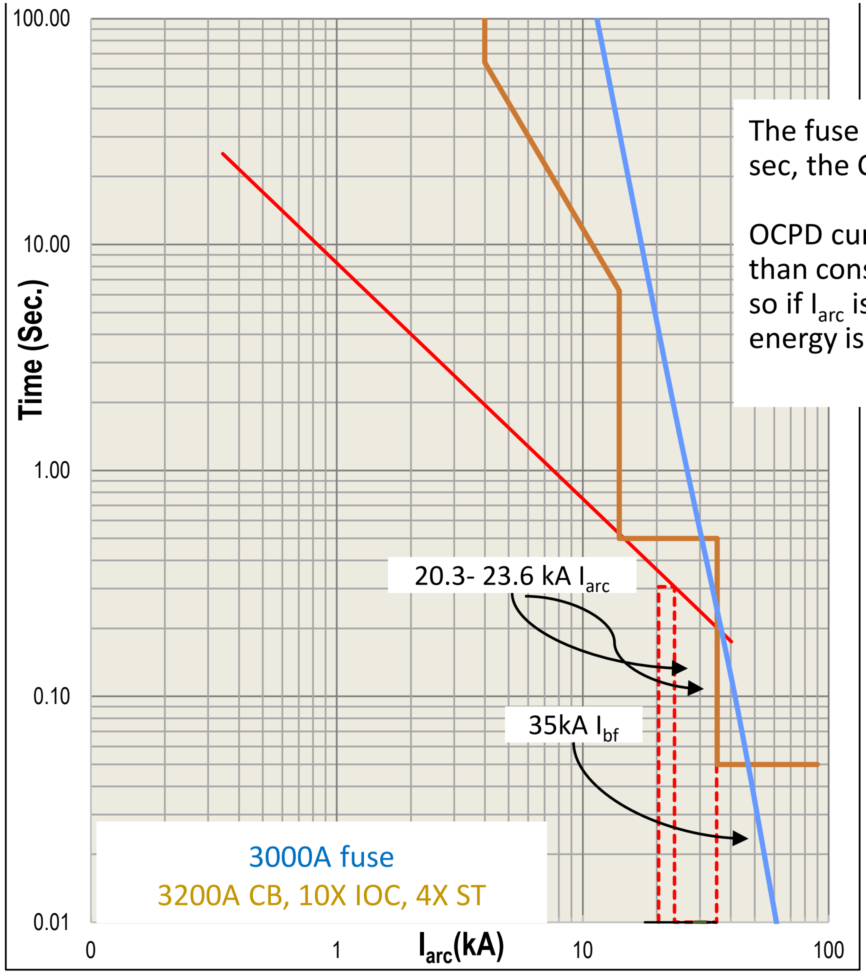
Switchgear or Switchboards…

At 35kA I_{bf} if the CB or fuse clears at 0.5 seconds, as required in the table… at I_{arc} E_i **is significantly above 40 calories/cm²**



At I_{arc} proportional to 35kA I_{bf} if the CB or fuse is at 0.5 seconds the energy would be >65 cal/cm²

480V, 32mm, 18", **HCB**, 40 cal/cm², 35kA I_{bf} plotted



The fuse could be at 4 sec, the CB at ?...

OCPD curves are steeper than constant E_i curves so if I_{arc} is lower the energy is higher ! …

NFPA 70E, table 130.7(C)(15)(a)

- As of today, no changes to account for the different I_{arc} & E_i in the new IEEE guide even though incident energy can be over twice as high.
- Table requires users to know I_{bf} & OCPD performance at I_{bf}… Both hard to know without a coordination study and, also, irrelevant information, maybe even dangerous information.
  - Even with a coordination study, does the user understand impact of motor contribution or different power sources? May contribute to I_{bf} & E_i, but not to the I_{arc} the OCPD reacts to.
- Equipment descriptions do include OCPD type or size & have wrong equipment description that do not follow applicable standards. Switchgear does not have fused switches.
- No consideration of task or bus bar direction, both, easily verifiable in field.
- Most entries can result in higher energy if arcing current is low, or worse if low through the OCPD but not low at the arcing point.

Suggest the NFPA 70E table, though an official method, should be a method of last resort… Better → check with somebody that understands arc flash calculations

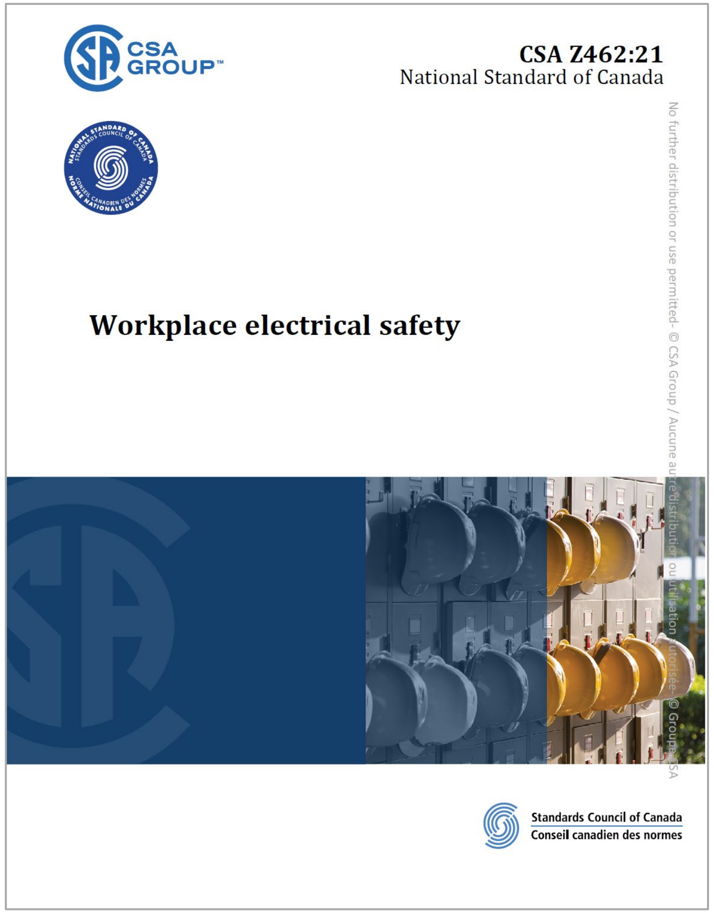
Thorough IEEE 1584-2018 based analysis to be presented at IEEE ESW 2022.

A better table

- CSA Z462 (Canadian, **Workplace electrical safety**)
- Arc-flash PPE categories for alternating current (ac) systems. Pg. 210… **new in 2021.**
- **An alternative to the original table**

A better table….

CSA Z462 (Canadian, **Workplace electrical safety**) Arc-flash PPE categories for alternating current (ac) systems. Pg. 210…**new in 2021**



Introduced in the 2021 version of the CSA electrical safety standard.

An alternate table in the appendix. Based on IEEE 1584-2018 analysis.

- ✓ Includes circuit size & OCPD size considerations
- ✓ Includes considerations for I_{bf} & I_{arc} variation
- ✓ Includes considerations for possible error, i. e. human factors
- ✓ Based on factors verifiable in the field without engineering studies

A better table… it may seem very conservative at times because it needs to be when one is facing unknowns and serious negative consequences, even if they are low probability

Remember: If you overestimate… you may wear too much PPE… **undesirable**

If you underestimate… Well… **unacceptable**

CSA Z462:21, table V.1 Arc-flash PPE categories for alternating current (ac) systems

(1) Equipment	(2) Nominal voltage	(3) Upstream device at same voltage in separate compartment *	(4) Arc flash PPE category
Panelboard, Motor control centre (MCC), Disconnect switch, or Other equipment (rated ≤ 800 A) Minimum working distance: 46 cm	240 V (1ϕ)	Transformer:	
		≤ 15 kVA	N/A
		≤ 50 kVA (Z ≥ 1.8%), or ≤ 75 kVA (Z ≥ 3%)	2
		≤ 250 kVA	4
		Fuses:	
		≤ 150 A	N/A
		≤ 600 A	2
		≤ 800 A	4
		Circuit breaker with fixed or adjustable T/M or M trip unit:	
		≤ 80 A	N/A
		≤ 300 A	2
		≤ 800 A	4

Identifies equipment, type & size & important task factor

Identifies V! Important for I_{arc} estimate

Identifies OCPD type & size to establish a response range to I_{arc}

Identifies source size, to establish an I_{bf} range

Possible settings identified that may be observed on site

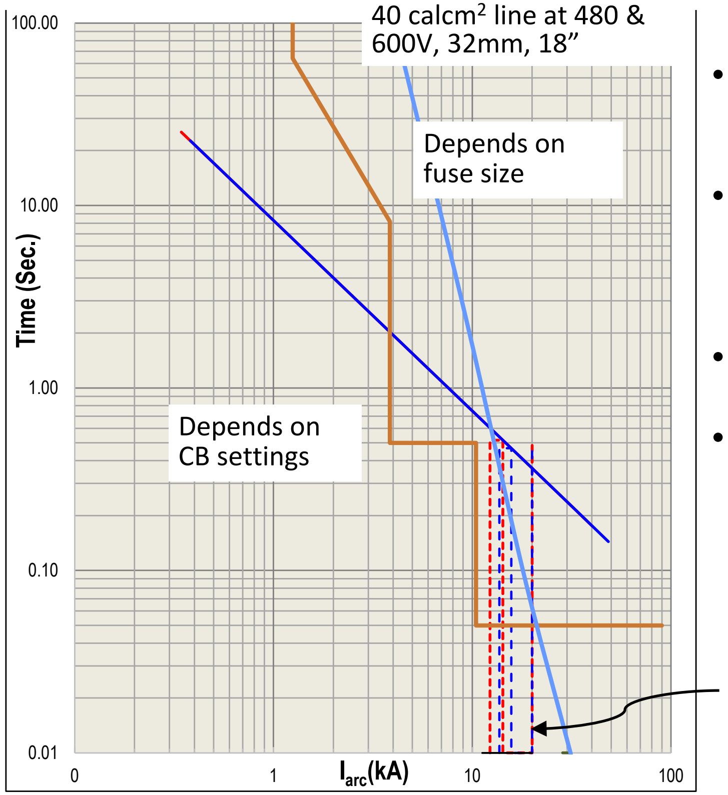
Panelboard, Motor control centre (MCC), Disconnect switch, or Other equipment (rated ≤ 800 A) Minimum working distance: 46 cm	208 V (3ϕ)	Transformer:		
		≤ 10 kVA	N/A	< 0.46 m
		≤ 45 kVA (3ϕ), or 3 x 10 kVA (1ϕ)	2	2.0 m
		≤ 150 kVA (3ϕ), or 3 x 25 kVA (1ϕ)	4	4.5 m
		Fuses:		
		≤ 60 A	N/A	< 0.46 m
		≤ 200 A	2	2.0 m
		≤ 800 A	4	4.5 m
		Circuit breaker with T/M or M trip unit:		
		Fixed or adjustable magnetic not set at lowest setting:		
		≤ 30 A	N/A	< 0.46 m
		≤ 90 A	2	2.0 m
		≤ 400 A	4	4.5 m
		Adjustable magnetic set at lowest setting:		
		≤ 225 A	2	2.0 m
		≤ 600 A	4	4.5 m

- **All information the worker may find at job site!**
- **This should reduce error opportunities.**
- **Also uses relevant information!**

CSA Z462:21, table V.1 Arc-flash PPE categories for alternating current (ac) systems…

Larger equipment, up to category 5, 65 cal/cm²

If fuses > 800A not even 65 cal/cm² is enough.
At 480 or 600V… seems exaggerated.



- Ignores motor contribution or multiple sources
- Conservative, yes, but for a reason. If in doubt one must be conservative.
- Too much PPE is undesirable.
- Realizing too late it was not enough is unacceptable.

Switchgear, Switchboard, or Other equipment (rated > 800 A) Minimum working distance: 46 cm	480 to 600 V (3ϕ)	Fuses: ≤ 400 A ≤ 800 A	 4 5	 4.5 m 6.5 m
		Circuit breaker with fixed or adjustable T/M or M: Fixed or adjustable magnetic not set at lowest setting: ≤ 175 A ≤ 350 A Adjustable set at lowest setting: ≤ 400 A ≤ 600 A	 4 5 4 5	 4.5 m 6.5 m 4.5 m 6.5 m
		Circuit breaker with adjustable LSIG trip unit: ST Pickup: ≤ 3500 A ST Delay: ≤ 0.5 s INST Pickup: ≤ 9500 A	4	4.5 m
		ST Pickup: ≤ 3500 A ST Delay: ≤ 0.3 s INST Pickup: ≤ 16 000 A	4	4.5 m
		ST Pickup: ≤ 3500 A ST Delay: ≤ 0.1 s INST Pickup: ≤ 30 000 A	4	4.5 m
		ST Pickup: ≤ 6000 A ST Delay: ≤ 0.5 s INST Pickup: ≤ 18 000 A	5	6.5 m
		ST Pickup: ≤ 6000 A ST Delay: ≤ 0.3 s INST Pickup: ≤ 29 000 A	5	6.5 m
		ST Pickup: ≤ 6000 A ST Delay: ≤ 0.1 s	5	6.5 m

A tool

It's hard to know, up to a point

PPE is usually selected in 8, 12, 25, 40 or maybe 65 cal/cm^2

Only need to know if below a level or in between levels. Exact cal/cm^2 value not important if it will not drive different behavior or a different risk control.

Different equipment is usually modeled in specific manners, Ex:

- Group mounted switchboards & distribution panels, **front**: 18", 25mm, VCB probable, std box or larger, shallow for lighting panels
- Group mounted switchboards **rear**: 18", 25mm, HCB may be possible, std box or larger
- Low Voltage Power Switchgear, **front**: 24", 32mm, HCB, std box
- Low Voltage Power Switchgear, **rear**: 18", 32mm, HCB, std box or larger
- MCC, starter sections: 18", HCB or VCBB, 25mm, std box or smaller, maybe shallow
- MCC mains: 18", HCB, 25mm, VCB or VCBB, std box, maybe shallow

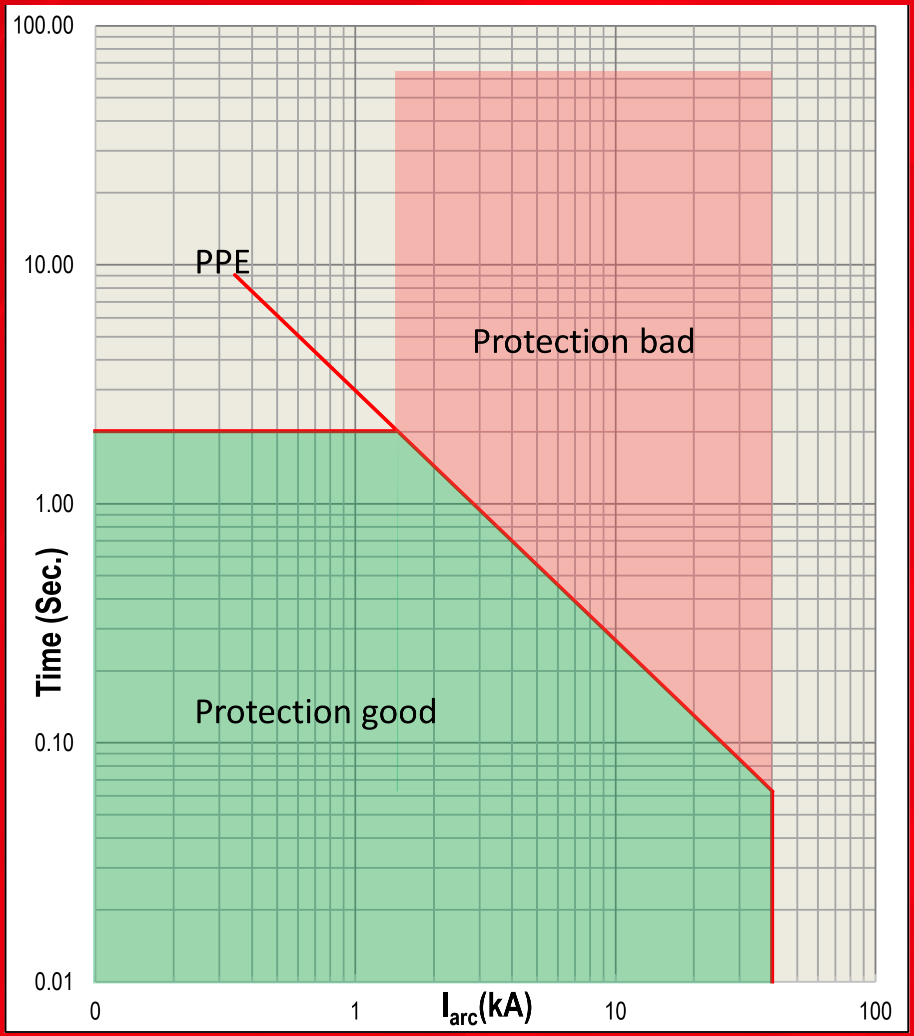
Note gaps can be larger which drives more energy and lower I_{arc}

Other considerations:

- Multiple sources of power or motor contribution
- Gaps can be larger than typical values in IEEE 1584
- Its not what you are working on, it is what you are exposed to!
- HCB → perpendicular to worker, where power comes from!
- VERY large boxes may mean lower arcing current & hence slower protection

A graphical method

- Determine what you need to know to select PPE
- Consider variance in fault current
- Use variables you may have access to



Different situations may be similar from AF study perspective

Equipment	Gap	WD	VCB	HCB	VCBB
Panels/swbd front	25mm	18”	X		X
Swbd rear	25mm	18”	X	X	
Swgr front	32mm	24”		X	
Swgr rear	32mm	18”		X	
MCC dist	25mm	18”	X	x	X
MCC mains	25mm	18”	X	X	X

- Large switchboards, especially individually mounted, may not be built that differently from switchgear… 32mm, or more, may be more correct than 25mm.
- VCBB tends to show up in smaller or equipment where the arc is constrained… Produces more I_{arc}
- HCB - the bus bar or cable pointing at the worker?
- May require some assessment by the worker or qualified staff, but it is verifiable in the field
- If not sure, estimate gap high/large

Constant Energy boundaries very useful

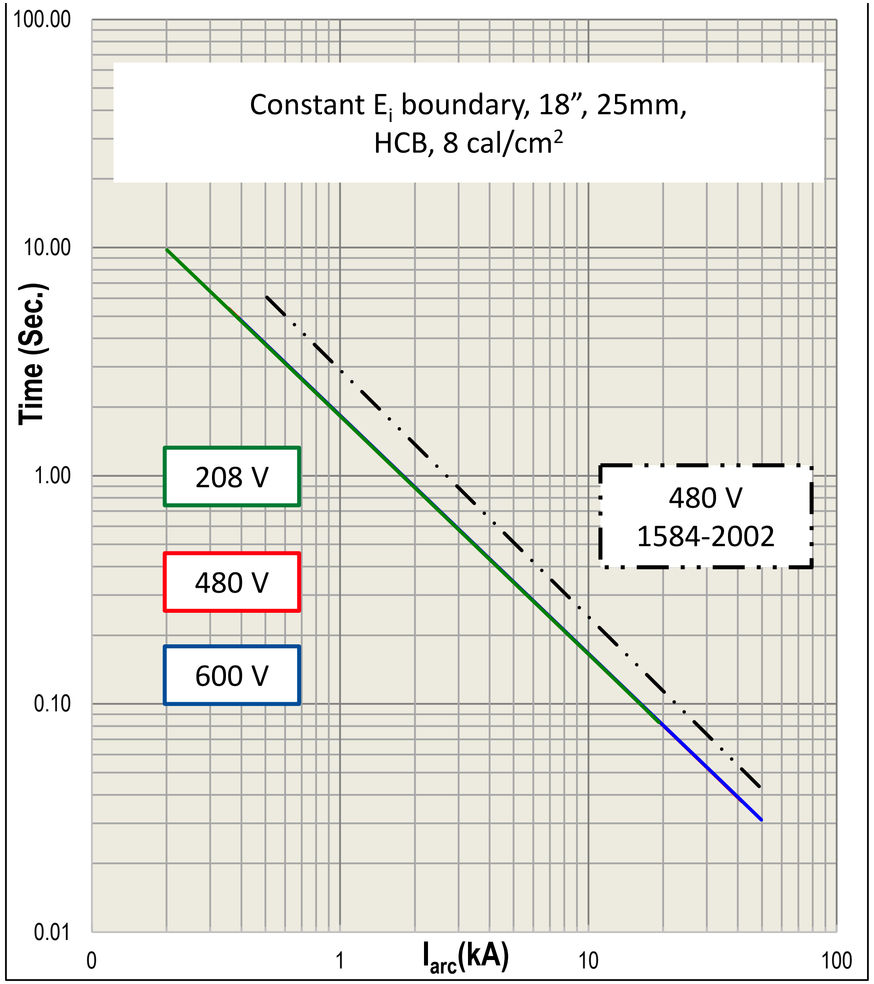
The only thing that matters is if the protection curve is under the line at arcing current, if under, then 8 cal/cm^2 PPE is good enough.

How low arcing current is does depend on voltage.

Energy depends on, working distance, arcing current & time, that is why these lines are on top of each other.

Need to know I_{arc} to identify time which depends on

- I_{bf} (axis of graph)
- Voltage (208, 480, or 600 V)
- Gap (25 or 32mm)
- Electrode orientation (HCB ~ VCB), VCBB higher



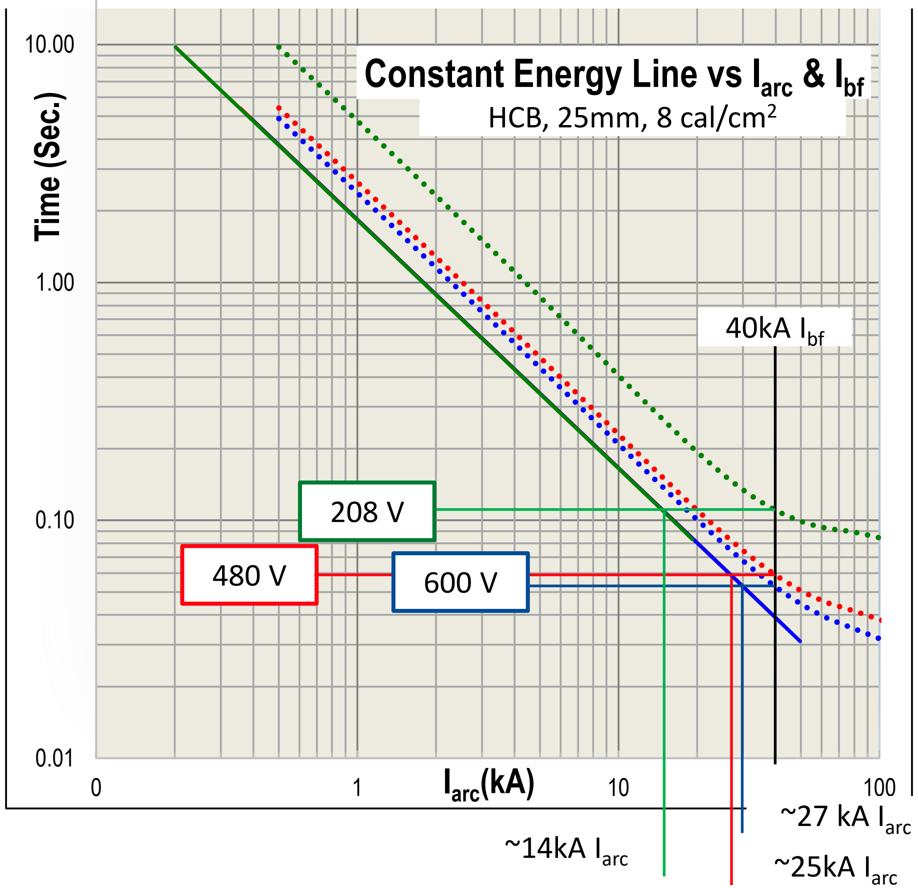
Estimating I_{arc}, HCB

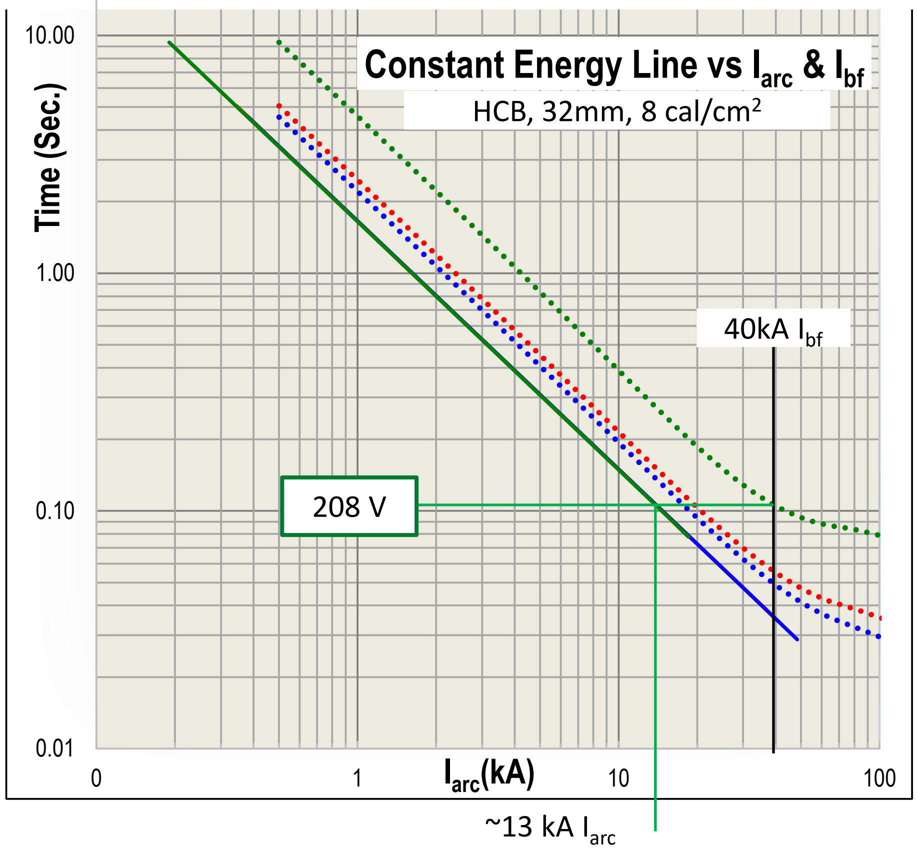
For this purpose, the 8 calories not important

Read graph high. Subtract 25% for range, avg to min I_{arc}.

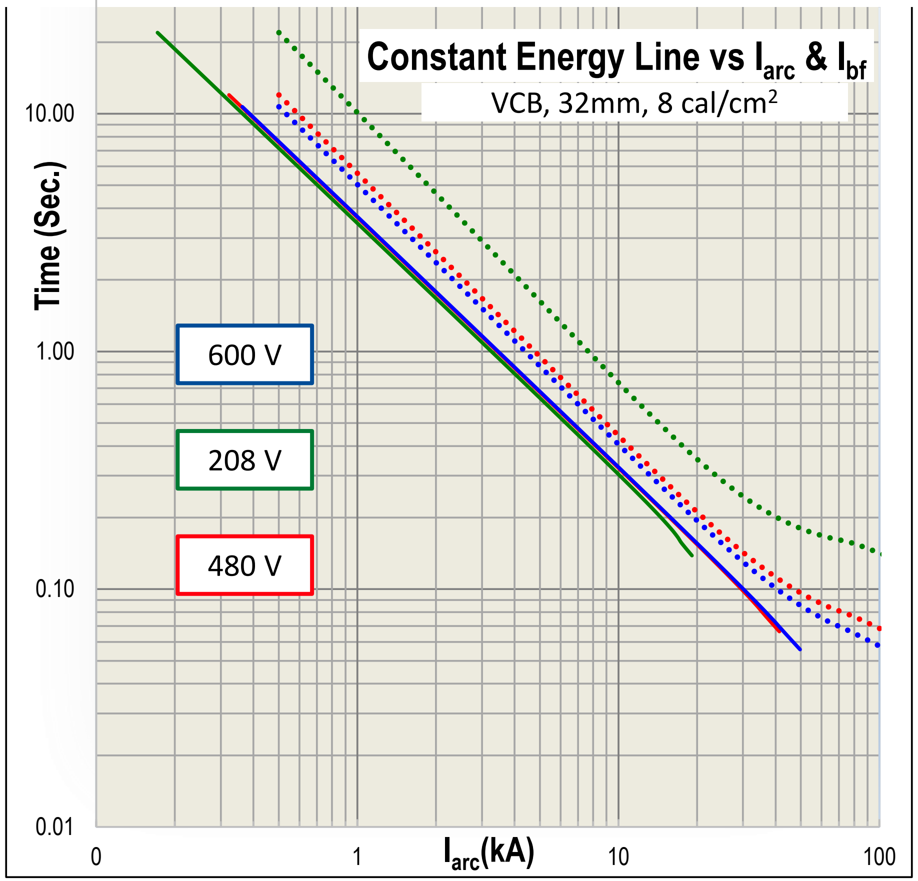
Need 6 graphs HCB, VCB & VCBB at 25 and 32 mm

It is an ESTIMATE

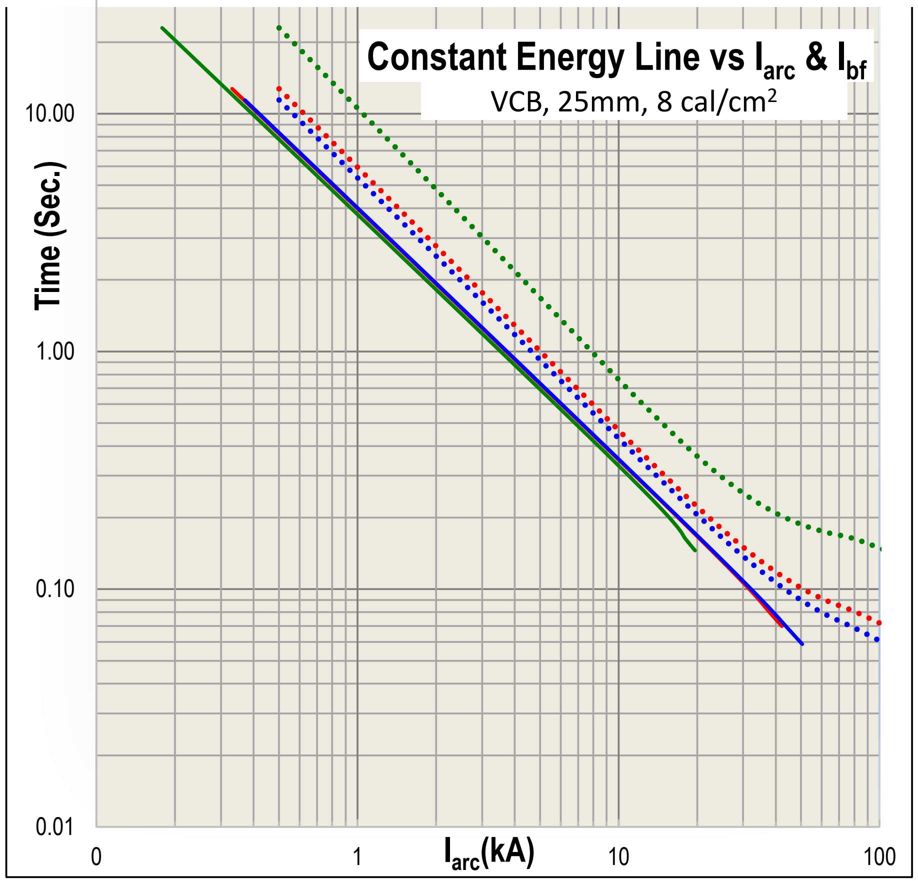




VCB

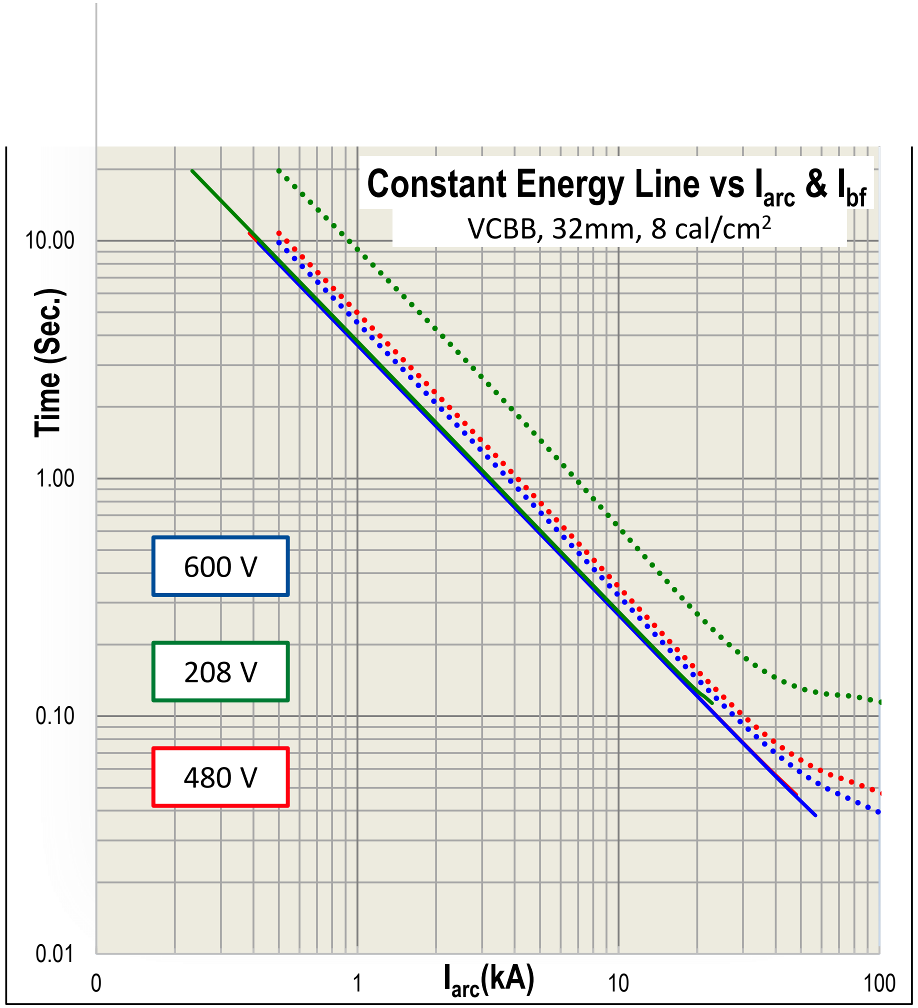


Constant Energy Line vs I_{arc} & I_{bf}
VCB, 32mm, 8 cal/cm^2
Time (Sec.)
10.00
1.00
0.10
0.01
0
1
10
100
I_{arc}(kA)
600 V
208 V
480 V

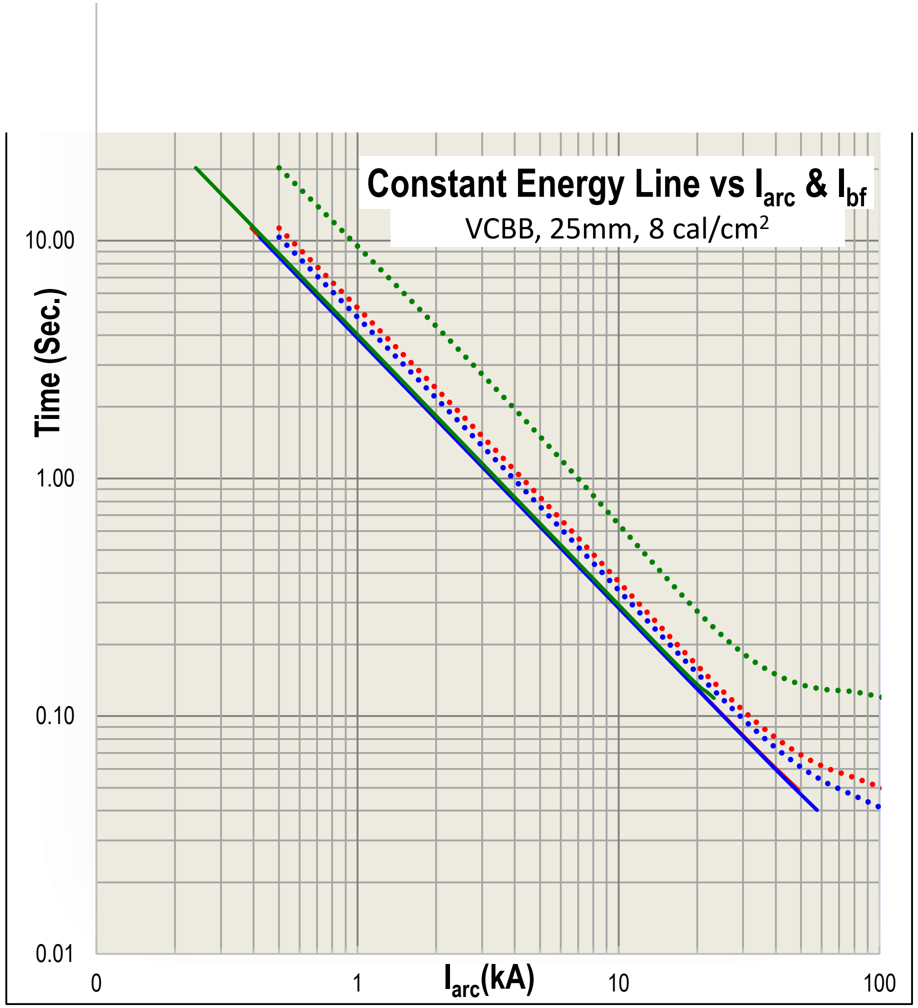


Constant Energy Line vs I_{arc} & I_{bf}
VCB, 25mm, 8 cal/cm^2
Time (Sec.)
10.00
1.00
0.10
0.01
0
1
10
100
I_{arc}(kA)

VCBB

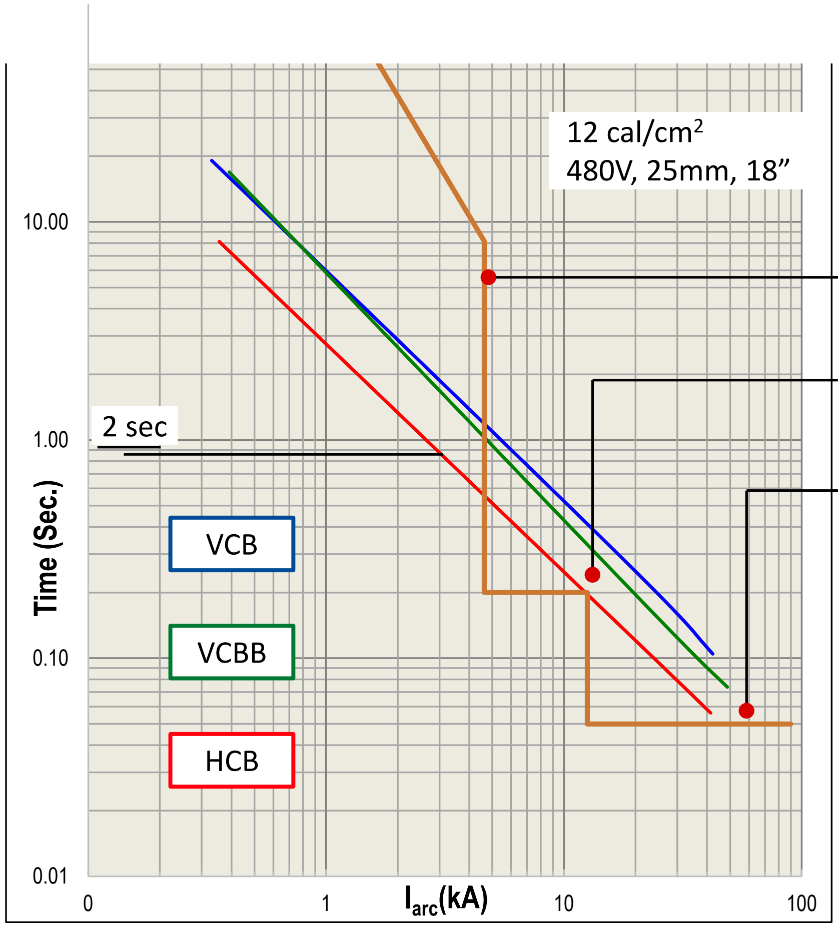


Constant Energy Line vs I_{arc} & I_{bf}
VCBB, 32mm, 8 cal/cm²
Time (Sec.)
10.00
1.00
0.10
0.01
0
1
10
100
I_{arc}(kA)
600 V
208 V
480 V



Constant Energy Line vs I_{arc} & I_{bf}
VCBB, 25mm, 8 cal/cm²
Time (Sec.)
10.00
1.00
0.10
0.01
0
1
10
100
I_{arc}(kA)

CB curves



If CB has a ST pickup it tends to drive where good protection starts.

This corner tends to drive performance for 12 cal/cm^2 and above. IOC pickup threshold

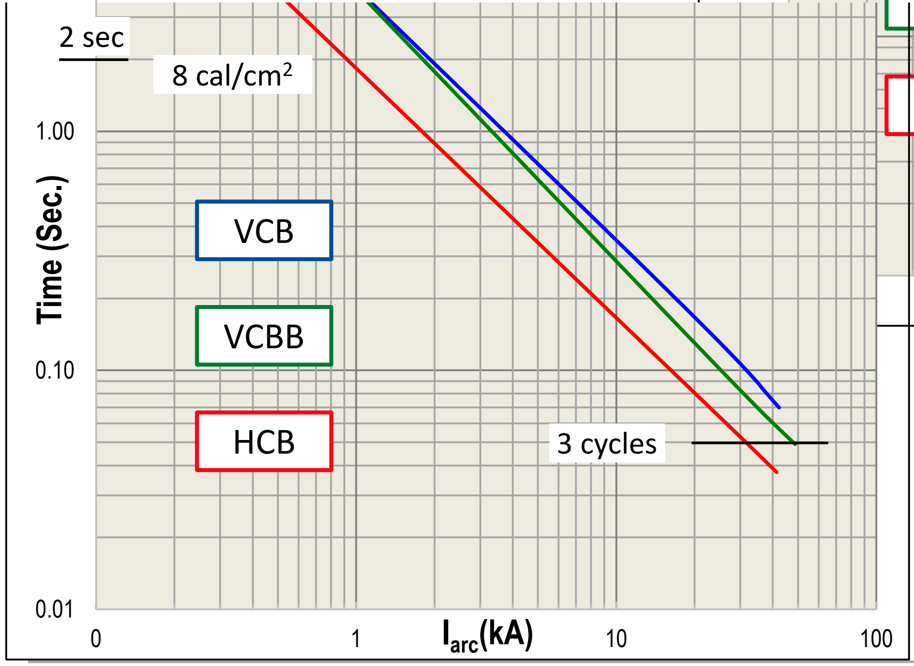
For 8 cal/cm2 instantaneous clearing time is important, most CBs 3 cycles or less, a few large ones may be a cycle slower

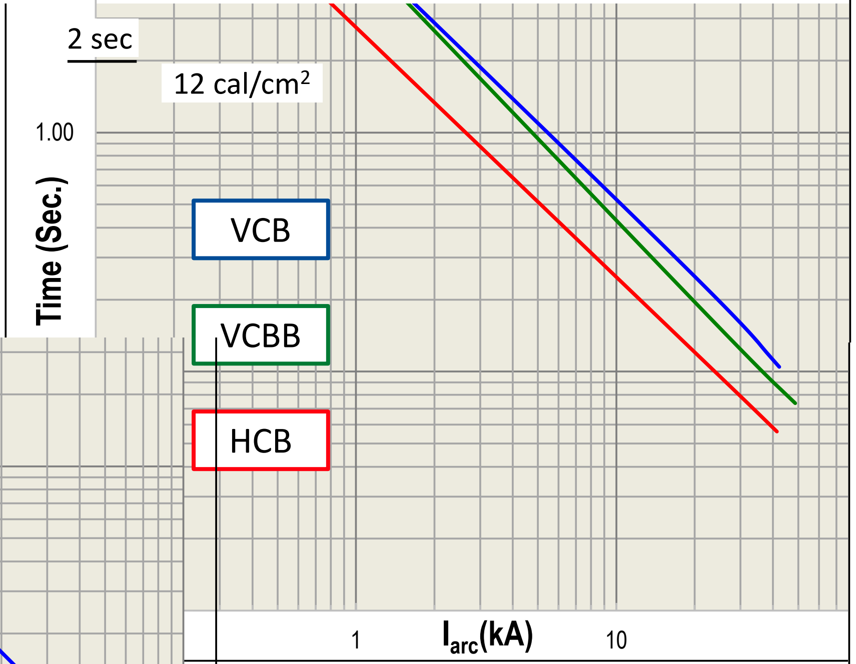
For fuses, there is a single point you need to worry about… where the line crosses the boundary. To the right good, to the left, not so good!

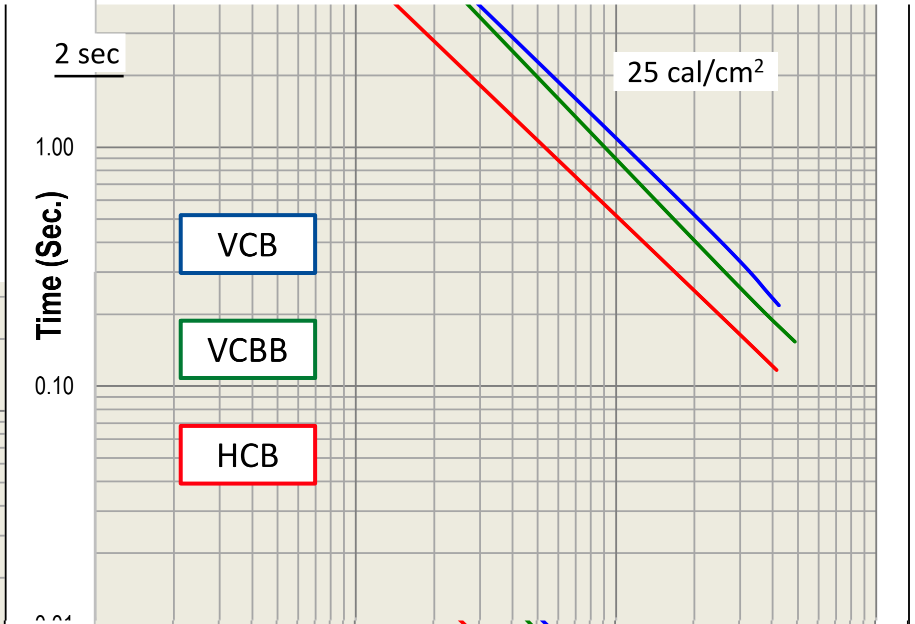
480V, 18”, 25mm

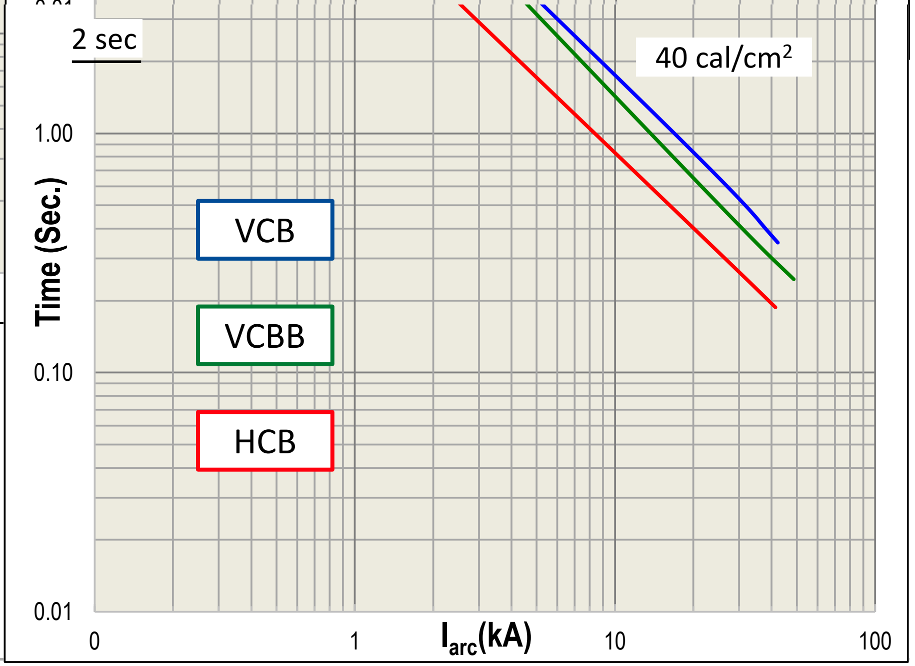
Panelboards, switchboards, MCC

- If OCPD curve is under applicable line from the lowest possible I_{arc} then the PPE is enough





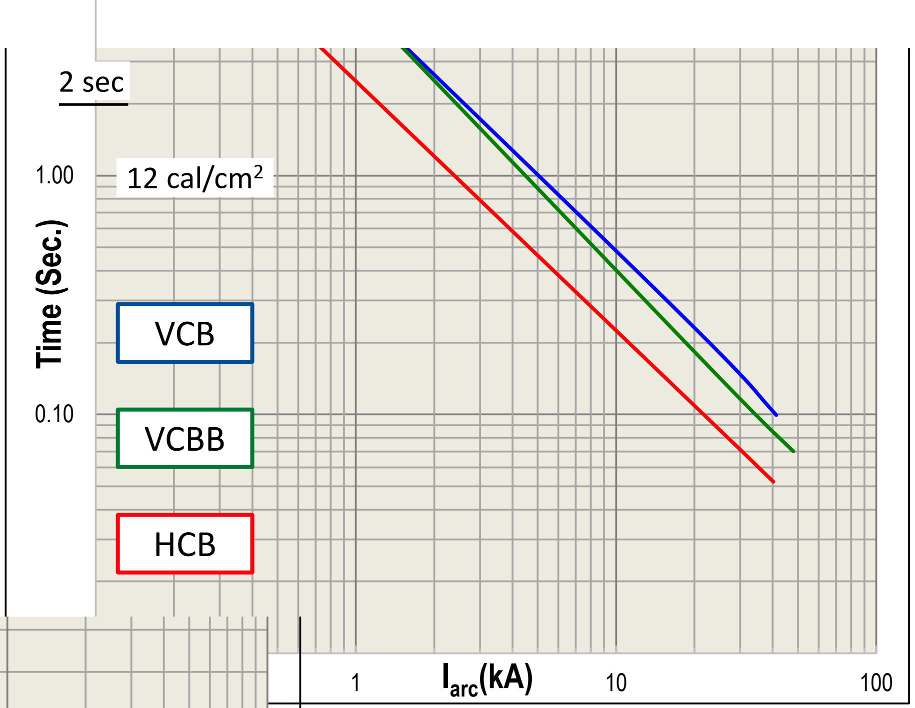


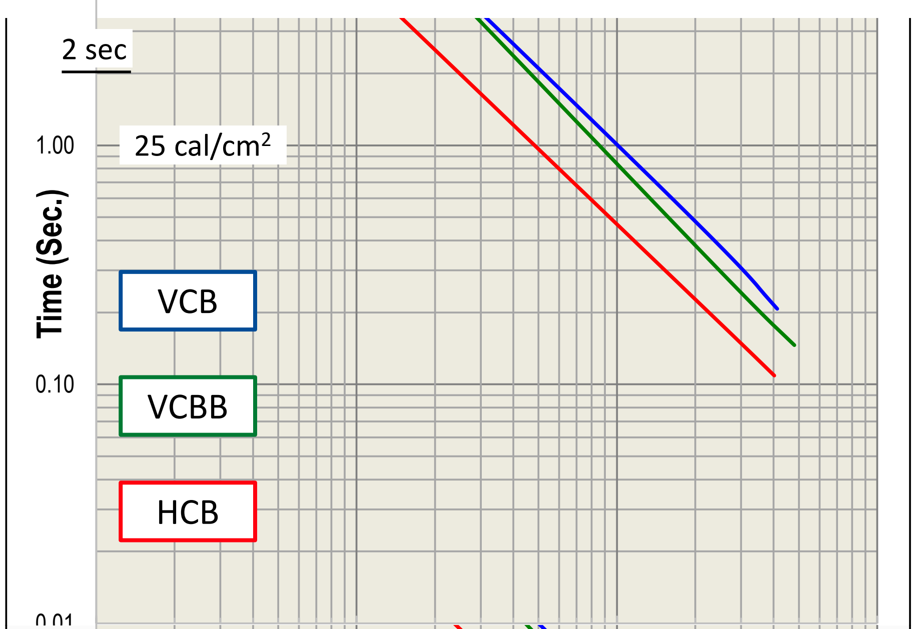


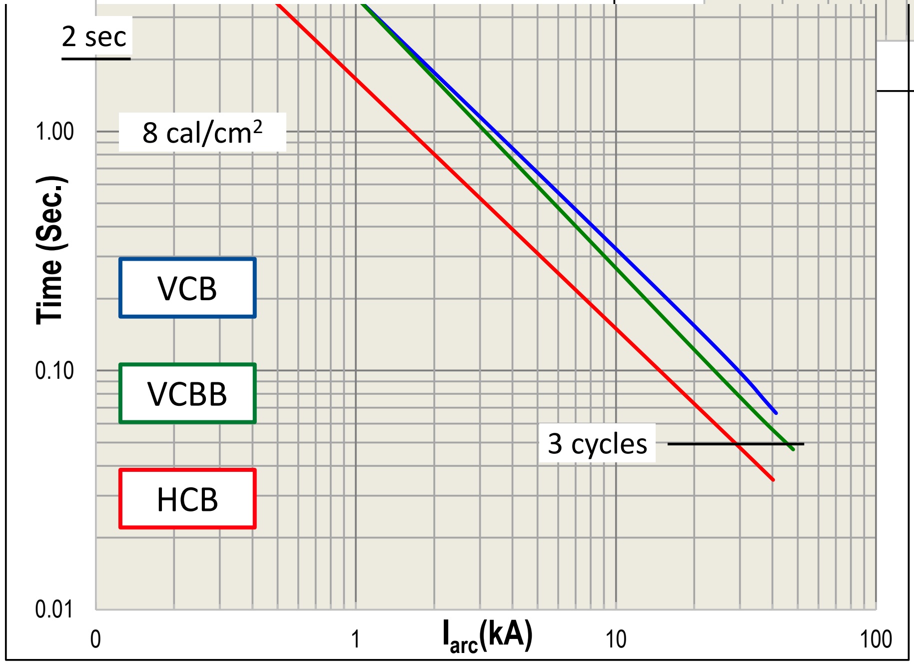
If OCPD curve crosses the constant energy line, then a better estimate of I_{arc} is needed

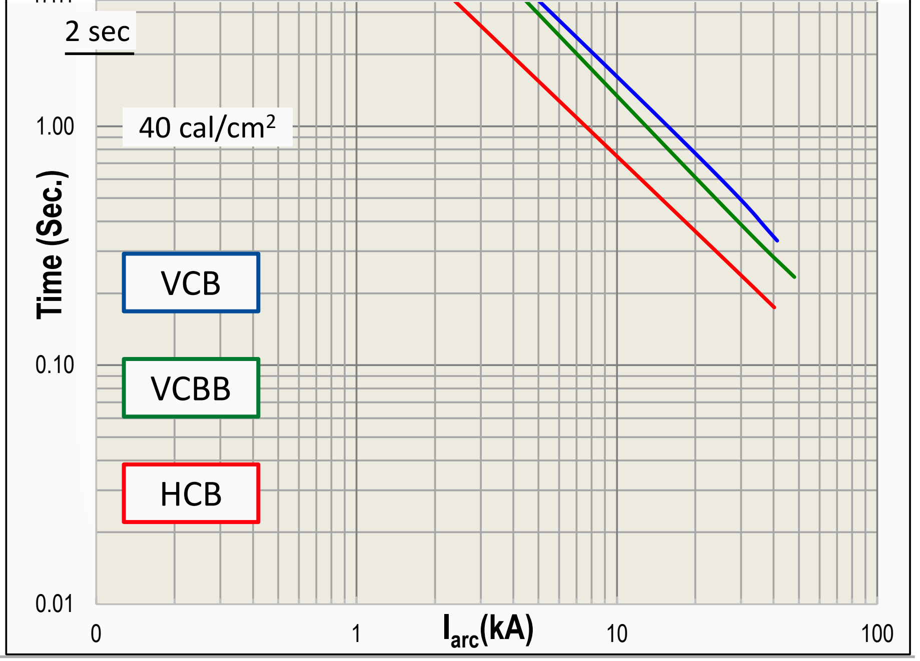
480V, 18”, 32mm

LV Switchgear rear



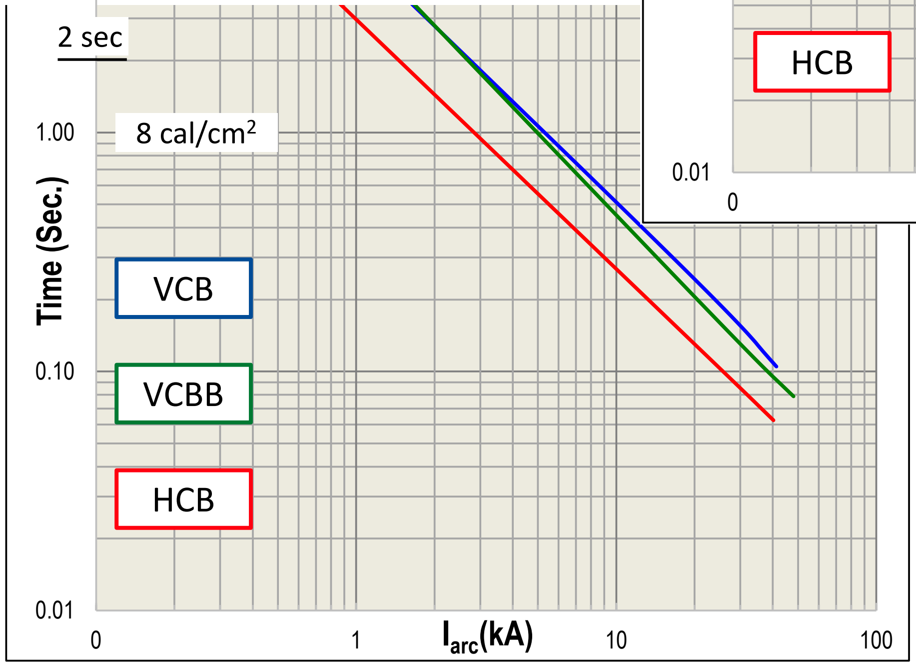


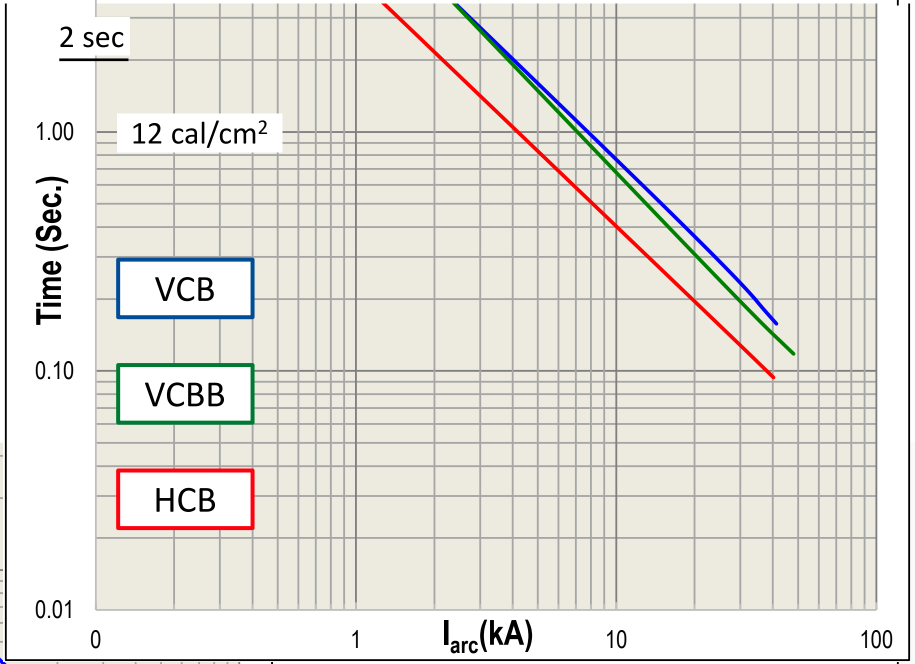


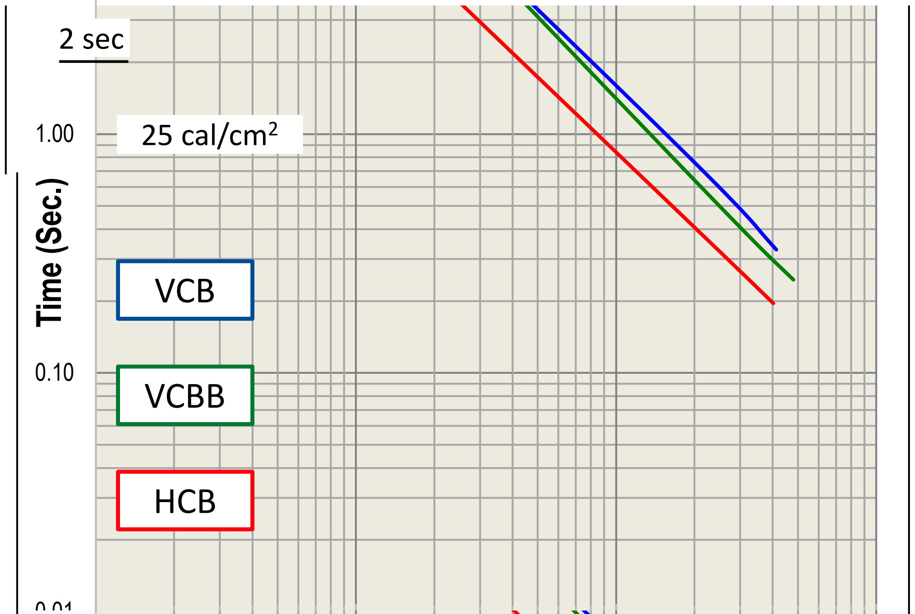


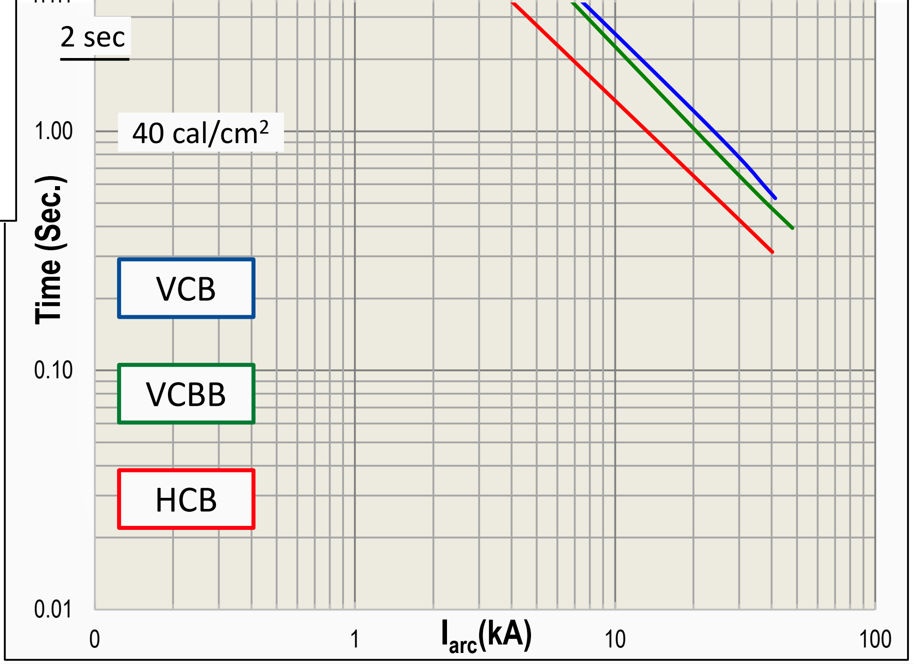
480V, 24”, 32mm

LV Switchgear front



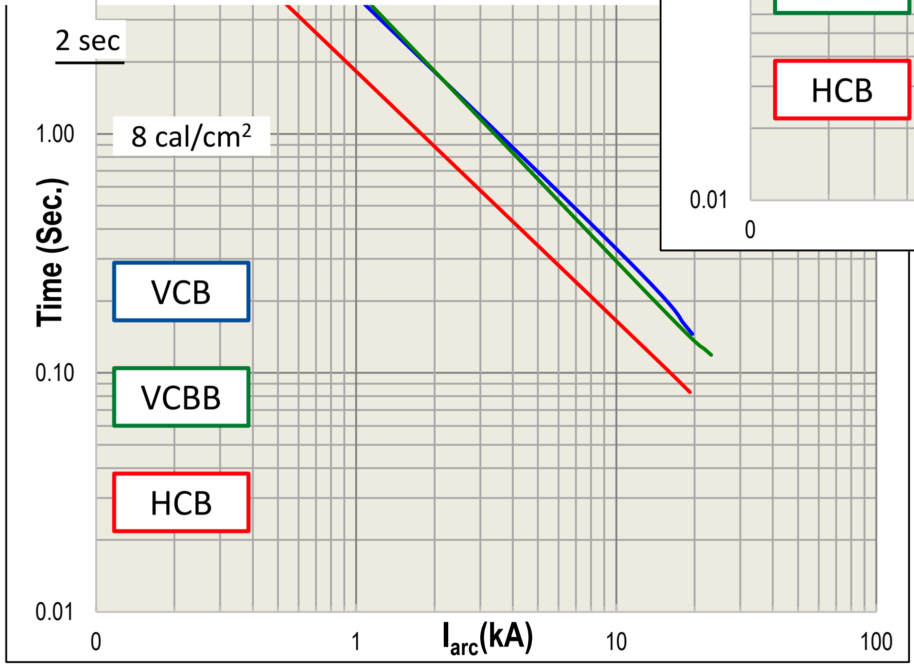


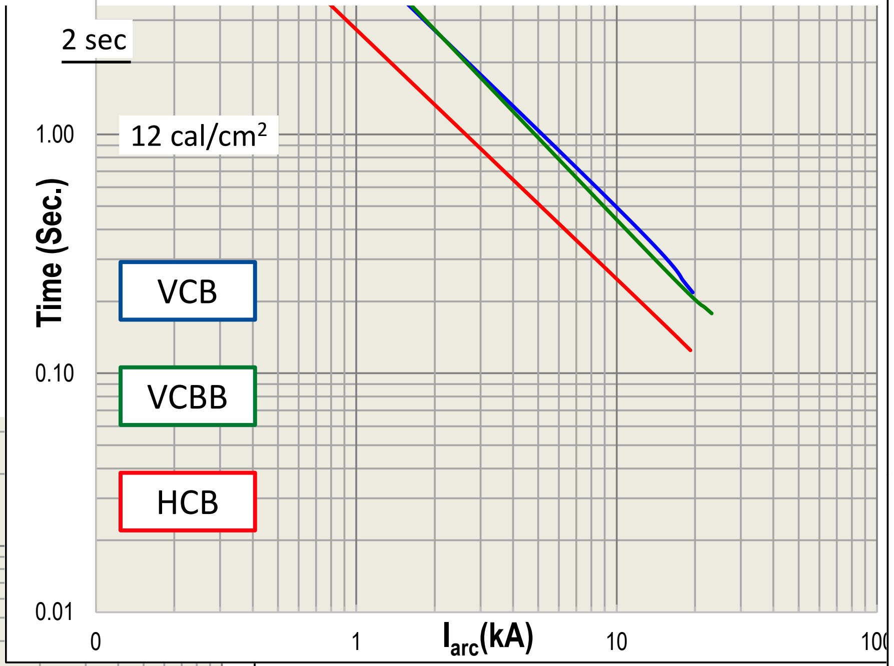


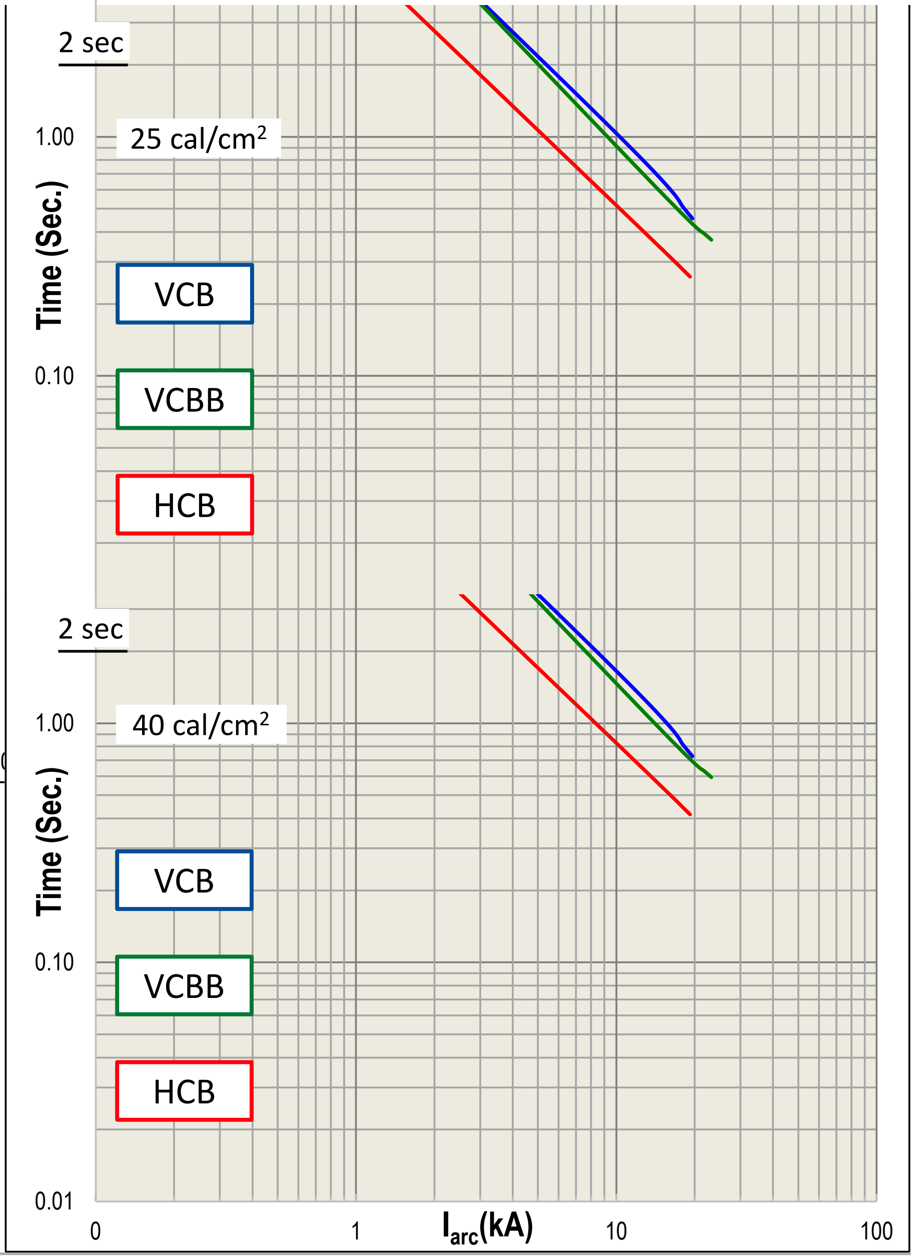


208V, 18”, 25mm

Panelboards, switchboards, MCC

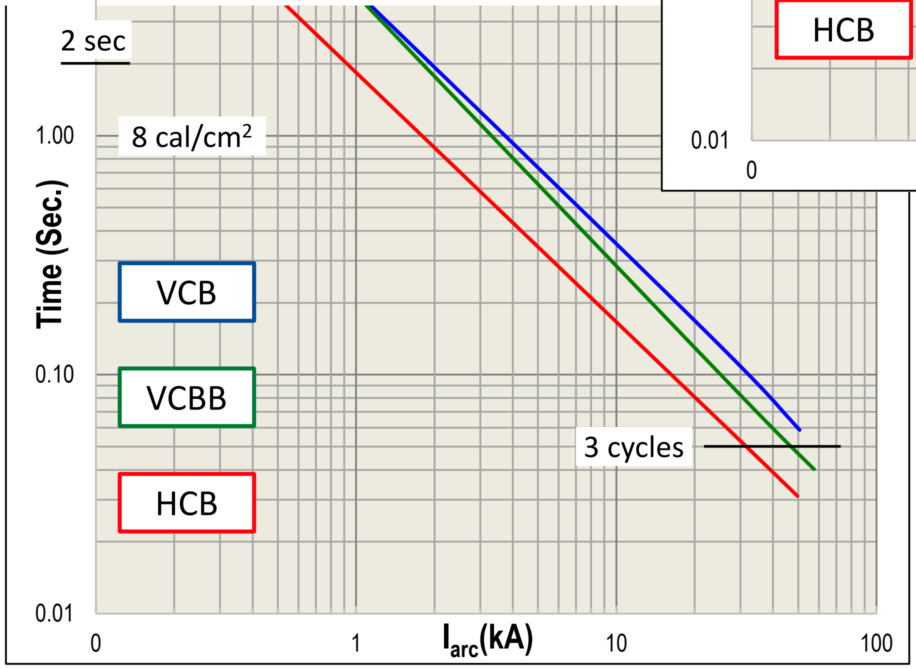


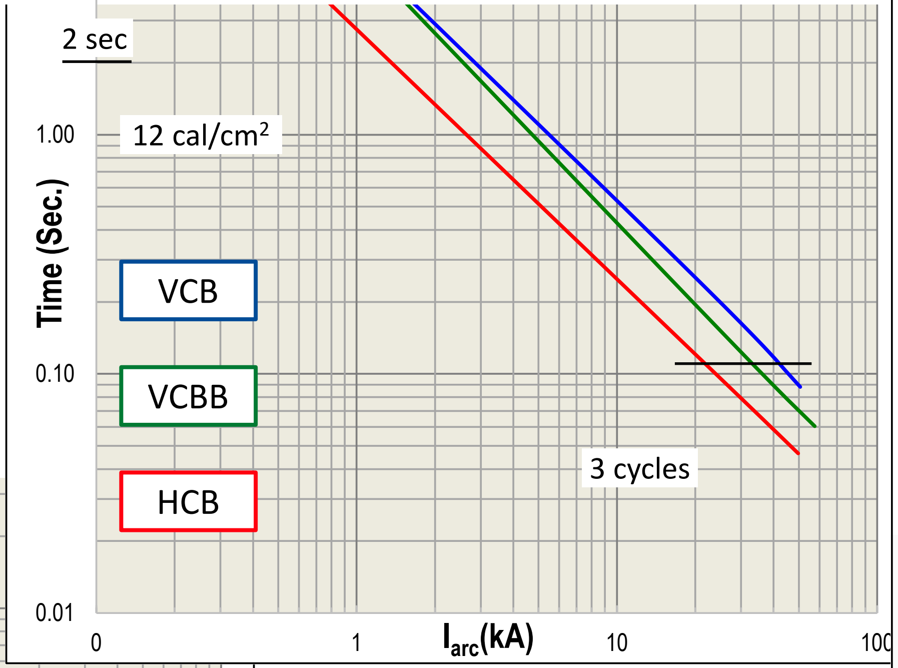


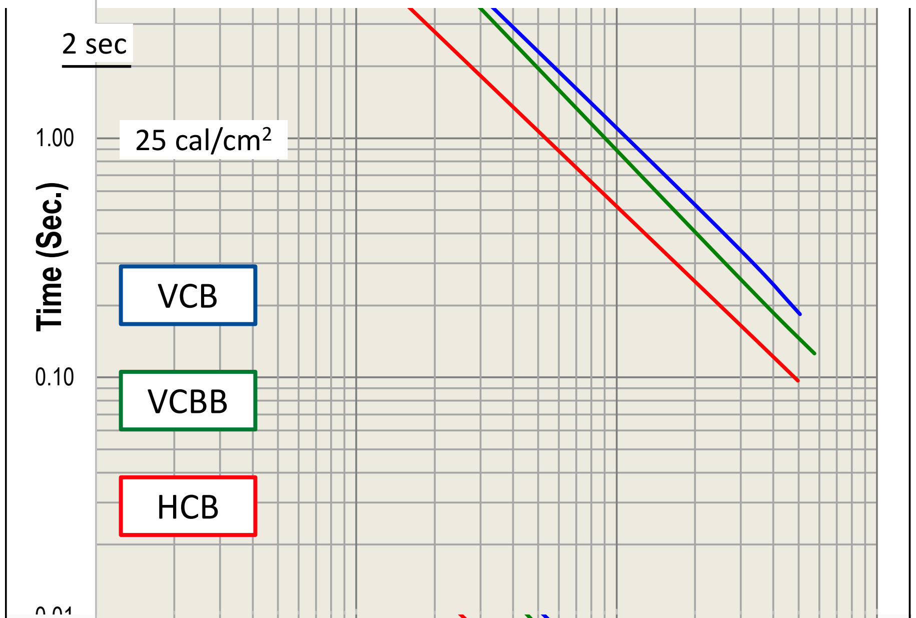


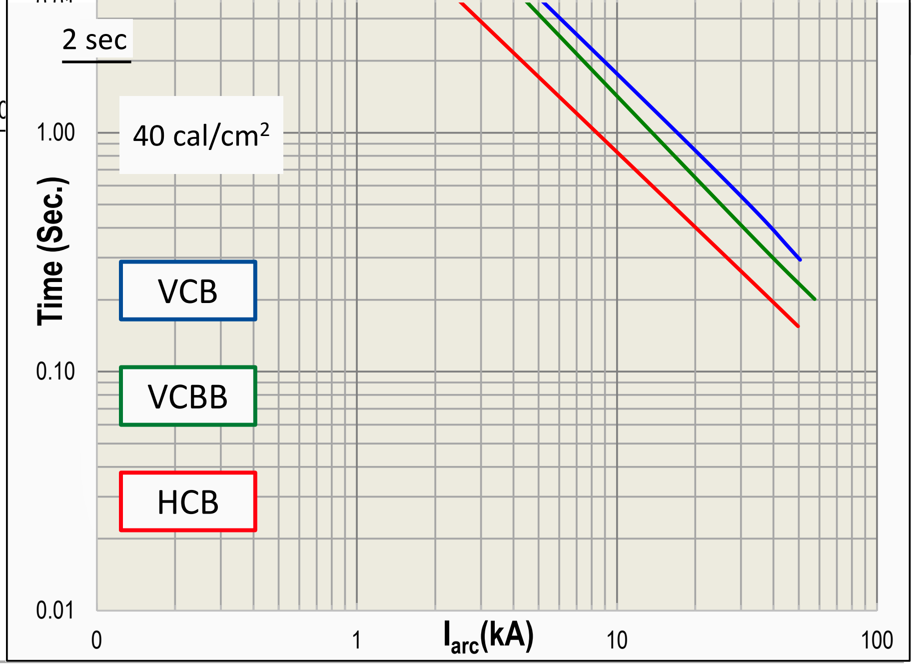
600 V, 18”, 25mm

Panelboards, switchboards,
MCC



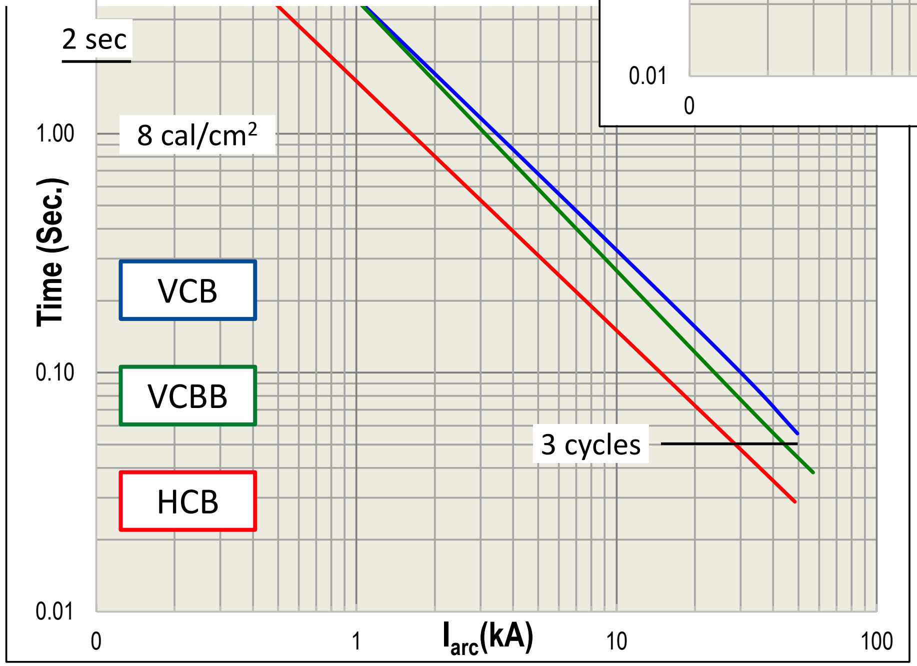


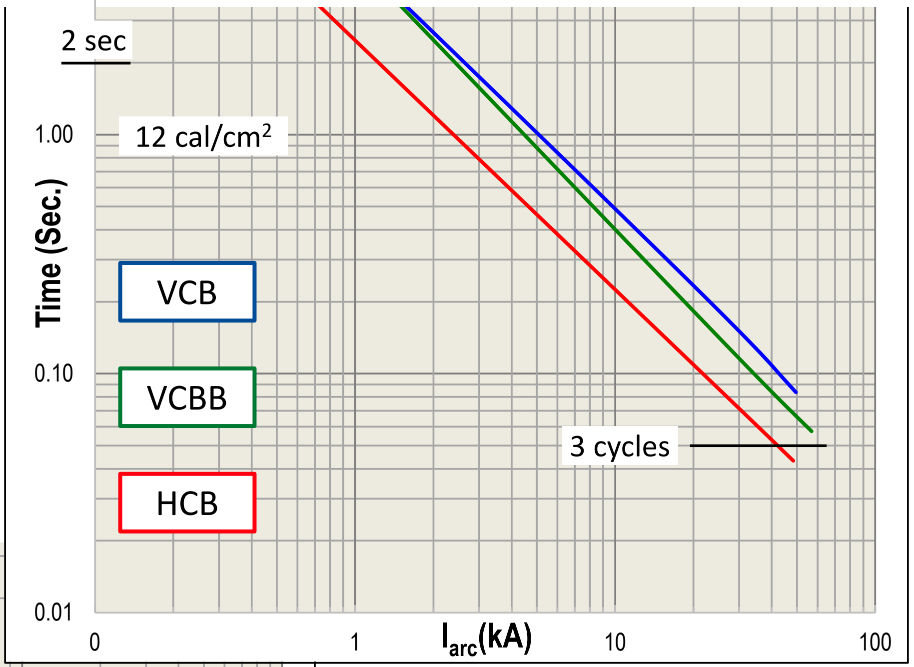


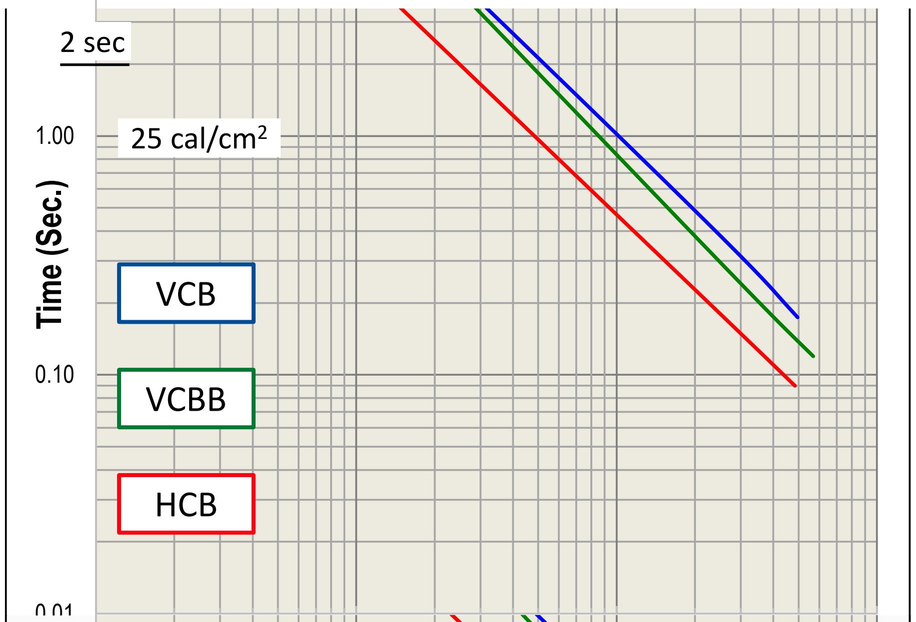


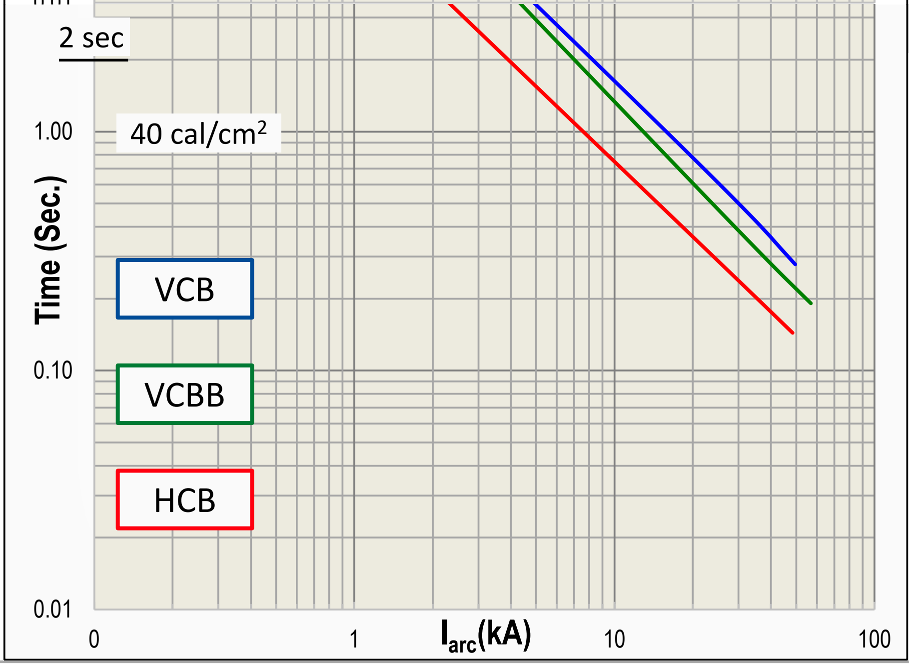
600 V, 18”, 32mm

LV Switchgear rear



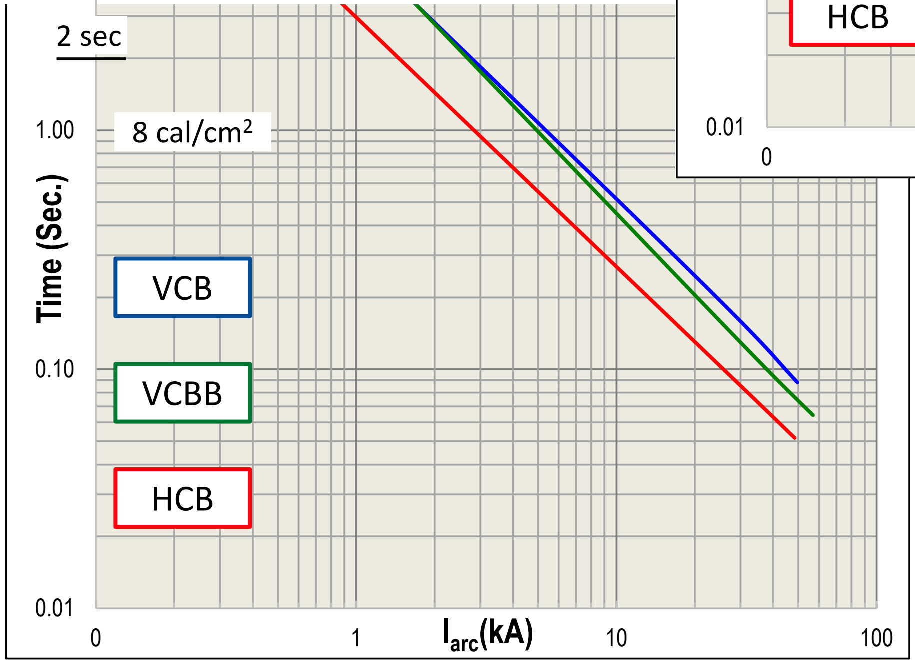


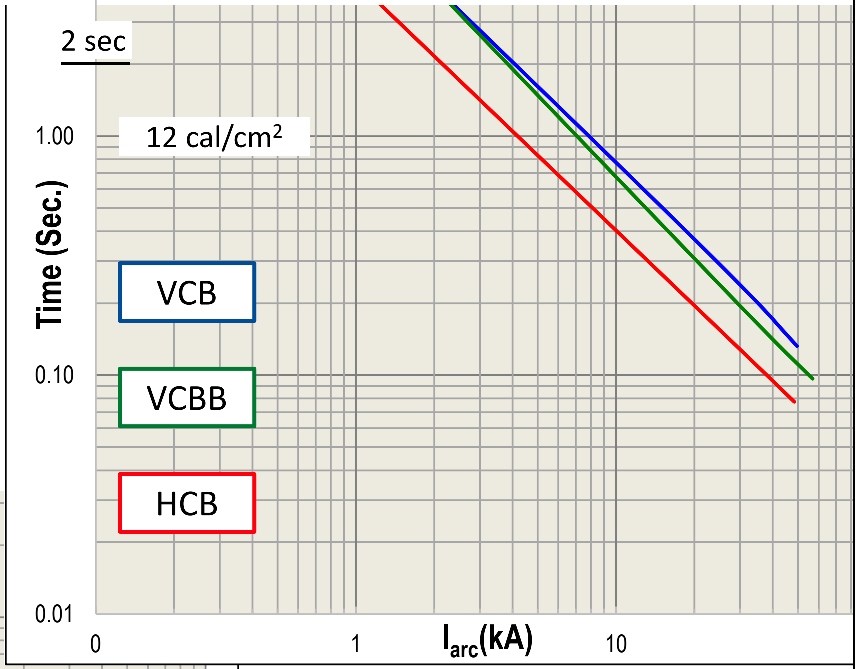


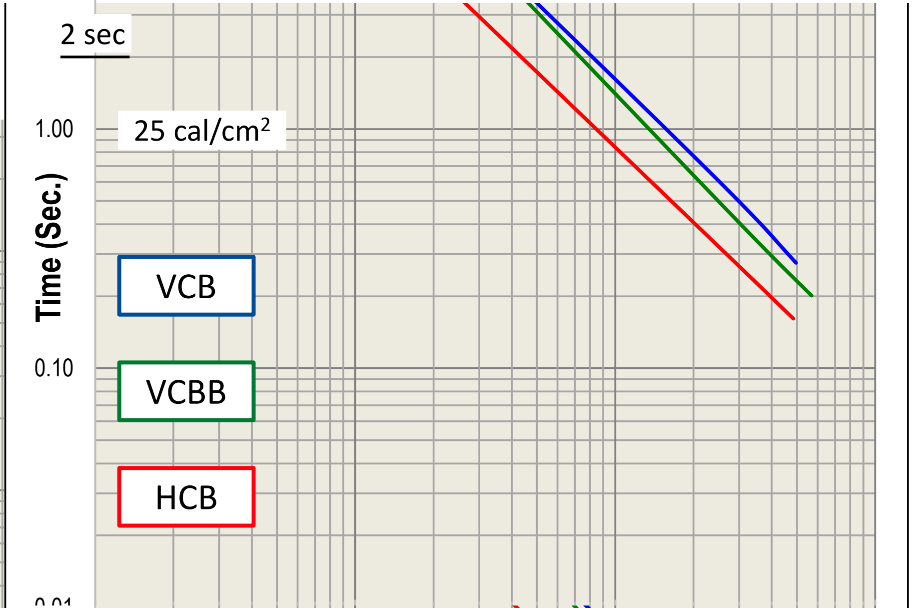


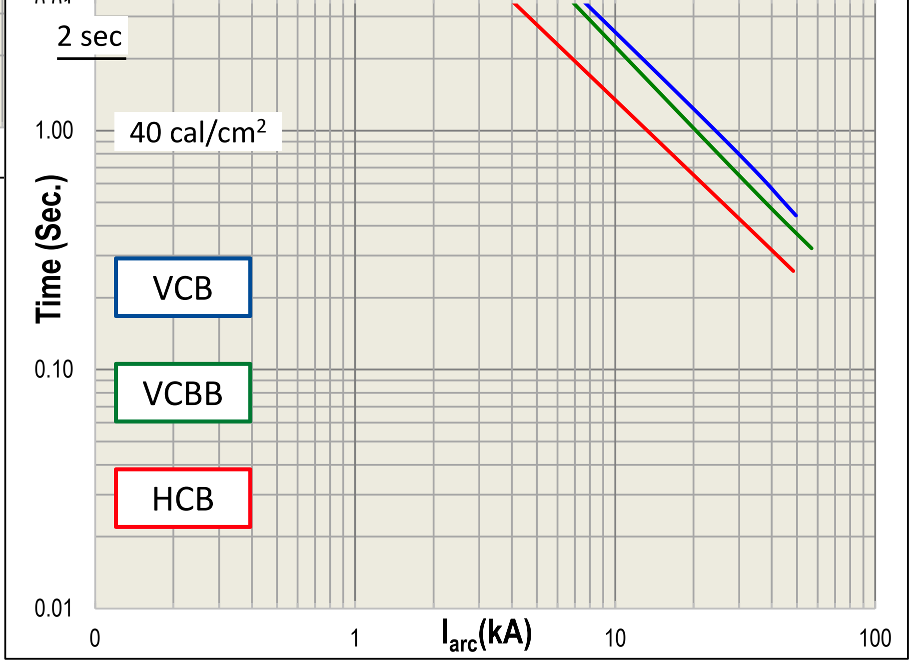
600 V, 24”, 32mm

LV Switchgear front









Summary

- Arc Flash calculations are to get a data point needed for risk analysis and management
- Electrical system information is estimated, probably wrong to some degree, bias the error so it is acceptable. Too much PPE is undesirable, finding out it was not enough is unacceptable.
- Need to understand what protection will do. For that you need to know arcing current, minimum and maximum.
- You only need to know what will drive behavior, more detail may be unnecessary
- Tables are static and may or may not apply– need to make sure the conditions in the table apply to the situation, and they may be very conservative
- Graphical methods allow to more easily consider fault current variance– low fault current can be more dangerous than high fault current
- Only use tools you understand. The real world is often different than underlying assumptions in the method. Need to know how to adapt the method.

Questions ?

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DEC 2021

Extinguish or Reduce Arc Flash Energy

World’s fastest equipment: UFES, IS-Limiter, and FCP

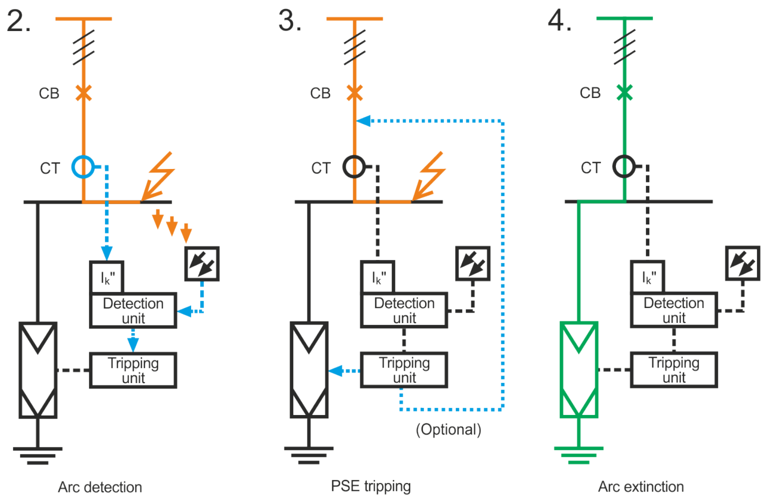
ABB

UFES (Ultra Fast Earthing Switch)

Active arc elimination in less than 4ms

Application of an Ultra-Fast Earthing Switch

- Operation independently of protective relay(s)
- **Fast detection** of an internal arc fault typically by means of:
  - Light sensing
  - Instantaneous current sensing
- **Arc elimination** by means of ultra-fast short-circuit earthing with specific primary switching elements
- Max. time for arc elimination: ~ 4ms after detection!
- Ratings:
  - Medium Voltage: 17.5kV – 40.5kV, 50kA and 63kA
  - Low Voltage: 1.4kV, 63kA and 100kA
- Maximum arc protection for personnel and equipment



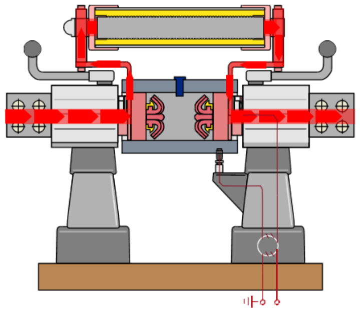
Current Limiting Equipment

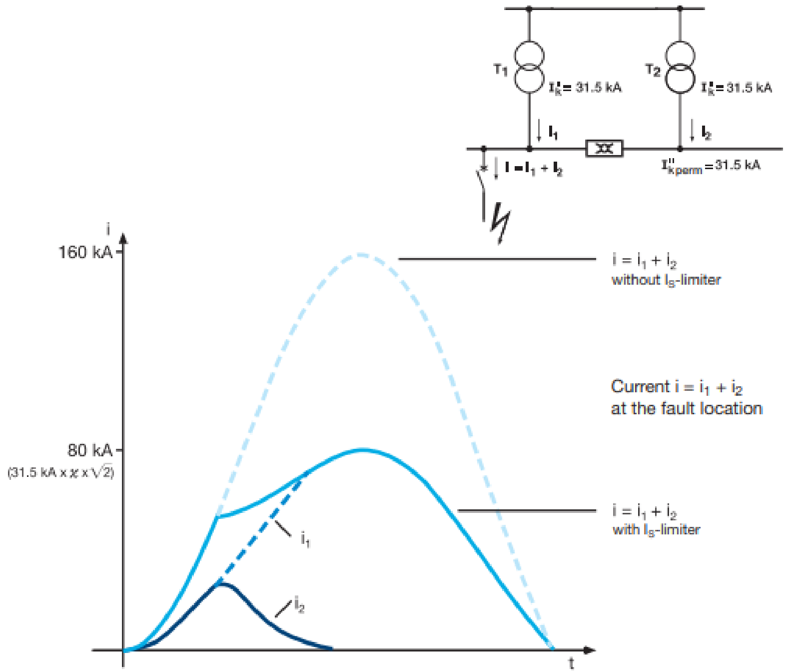
IS-Limiter and Fault Current Protector

Current Limiting Device options

- Ideal equipment to solve short-circuit problems stemming from substation extensions or grid interconnections
- Short-circuit current is limited during very first current rise
- Capable of di/dt and selective/directional tripping, eliminating nuisance tripping
- Refurbishment of inserts

- **IS-Limiter:**
  - Low Voltage: 750V, up to 5000A, up to 140kA
  - Medium Voltage: 12kV – 40.5kV, up to 4000A, up to 210kA
- **Fault Current Protector:**
  - Medium Voltage: 7.2kV – 17.5kV, up to 2500A, up to 63kA
  - Outdoor rated





ABB