NEC 2017 : ARC ENERGY REDUCTION ARTICLE 240.87

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IEEE 1584 AFIE EQUATION

IEEE 1584 defines the incident energy *E* as

$$E = C_f E_n \left(\frac{t}{0.2} \right) \left(\frac{610^x}{D^x} \right)$$

C_f is a calculation factor defined based on the nominal voltage
E_n is the “normalized” incident energy
t is the arcing time in seconds
D is the “working distance” (mm)
and *x* is the distance exponent from IEEE 1584.

JUST KIDDING!

NEC 2014 - ARTICLE 240.87

240.87 Arc Energy Reduction. Where the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted is 1200 A or higher, 240.87(A) and (B) shall apply.

(A) Documentation. Documentation shall be available to those authorized to design, install, operate, or inspect the installation as to the location of the circuit breaker(s).

(B) Method to Reduce Clearing Time. One of the following or approved equivalent means shall be provided:

(1) Zone-selective interlocking

(2) Differential relaying

(3) Energy-reducing maintenance switching with local status indicator

(4) Energy-reducing active arc flash mitigation system

(5) An approved equivalent means

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(5) An instantaneous trip setting that is less than the available arcing current

(6) An instantaneous override that is less than the available arcing current

(7) An approved equivalent means

RELATIVE COST COMPARISON

(1) Zone-selective interlocking - $

(2) Differential relaying - $$$

(3) Energy-reducing maintenance switching with local status indicator - $

(4) Energy-reducing active arc flash mitigation system - $$$$$

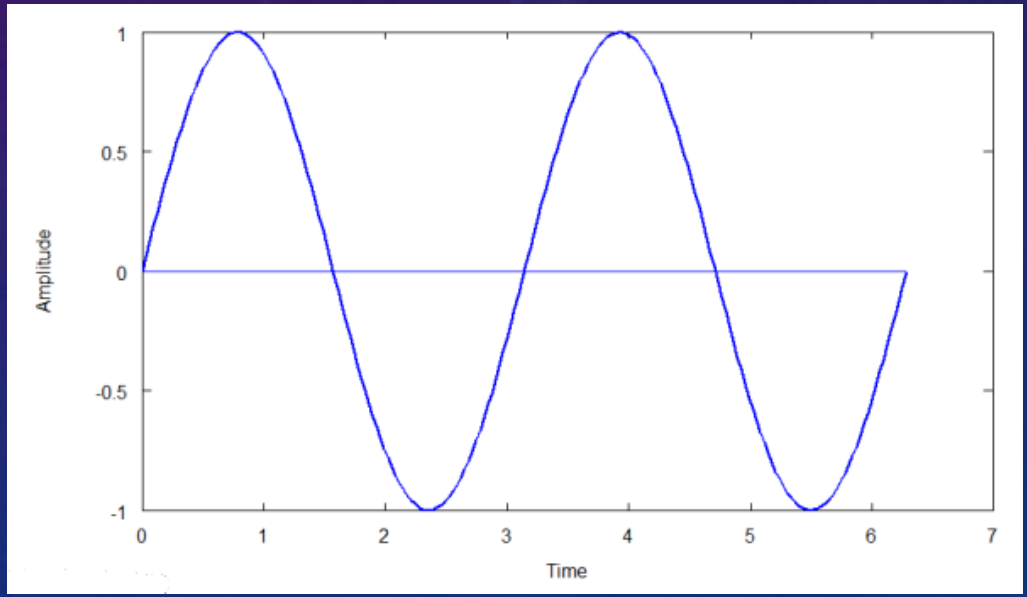
(5) An instantaneous trip setting that is less than the available arcing current -$0.00

(6) An instantaneous override that is less than the available arcing current -$0.00

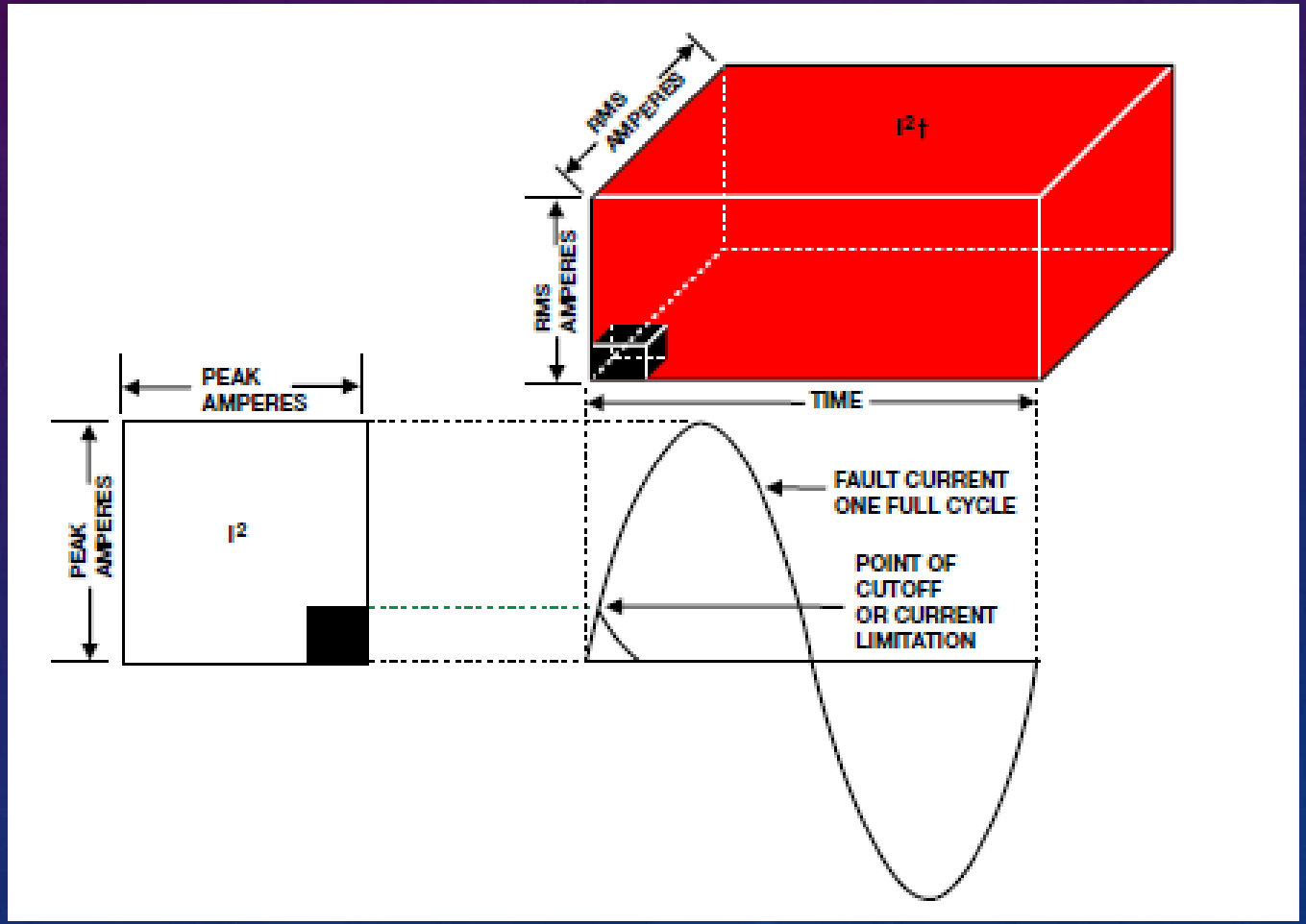
(7) An approved equivalent means – ???

“TIME” IS YOUR ENEMY

1. You cannot adjust the level of fault current. It is what it is!
2. Ohm’s Law: I = V/Z
3. But, you can affect the amount of time the fault current or arc energy flows.
4. This is related to how fast a circuit breaker takes to trip which reduces the arc energy.



LIMIT THE THERMAL & MECHANICAL ENERGY BY OPENING FASTER



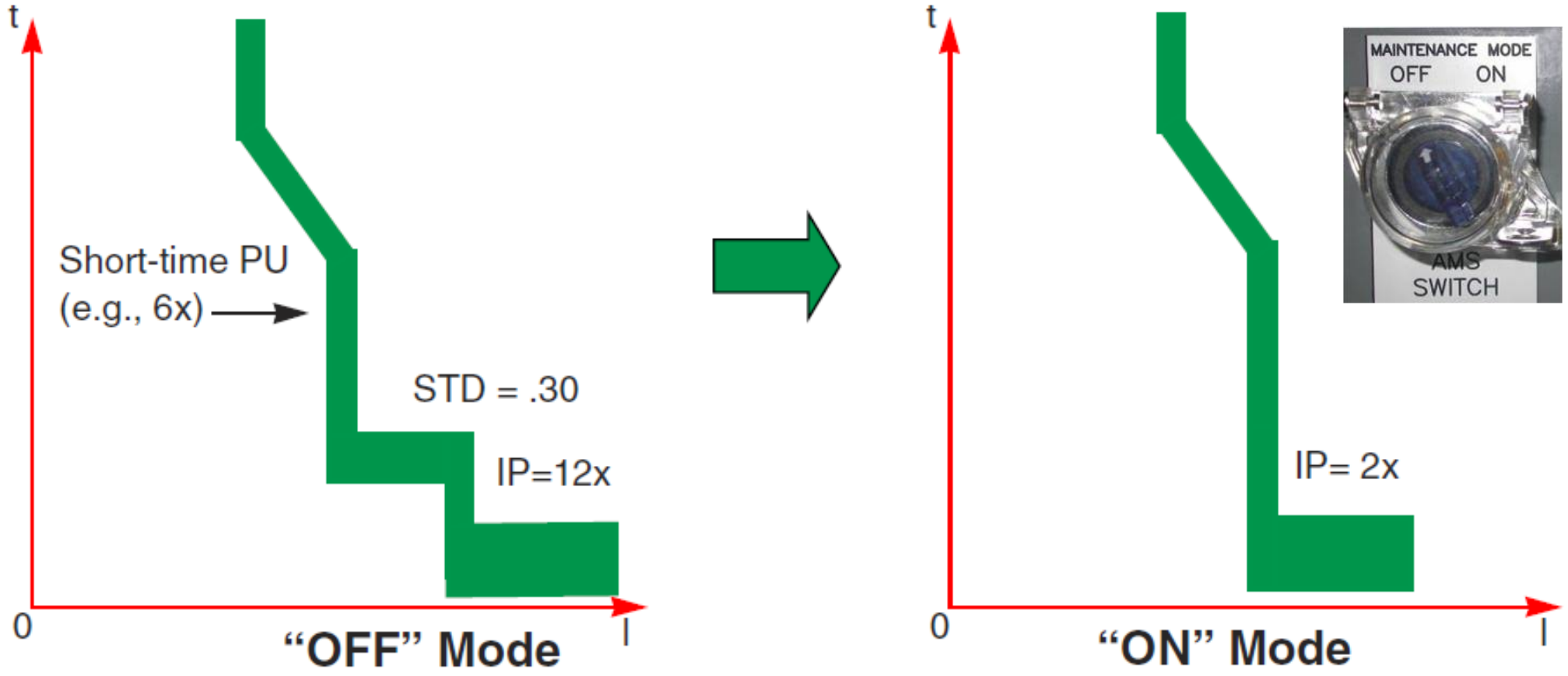
240.87 B (Method 3) – ERMS Switch

Energy-reducing maintenance switching with local status indicator

What does an ERMS switch do?

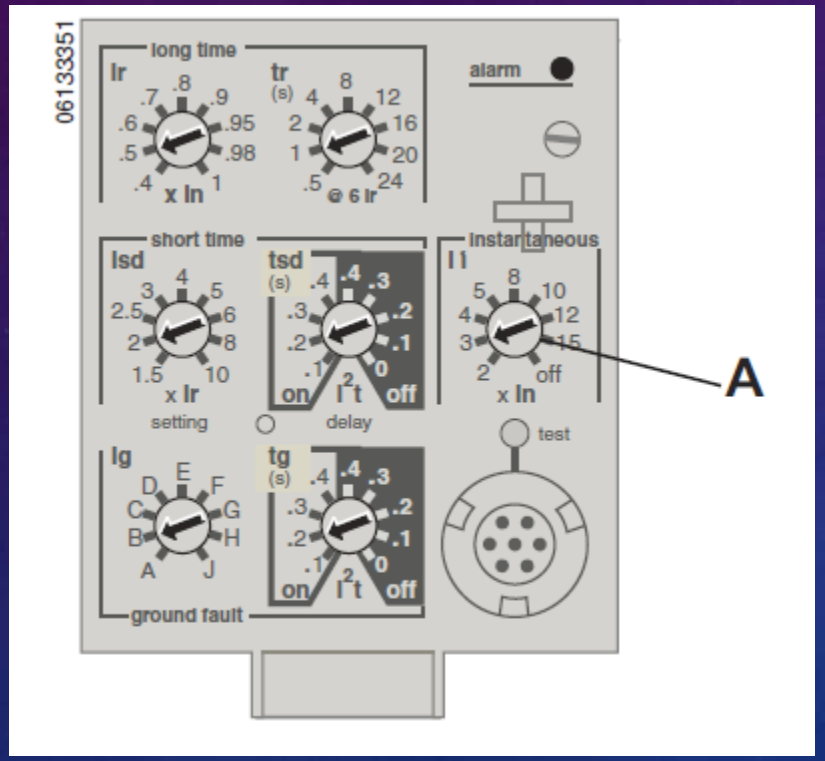
1. Turns short time delay to zero
2. Lowers the instantaneous trip setting of the breaker via a pushbutton.
3. It is NOT a magic device.
4. Approx. $1500 per breaker extra cost.

Figure 2: ERMS Switch “OFF” and “ON” Mode

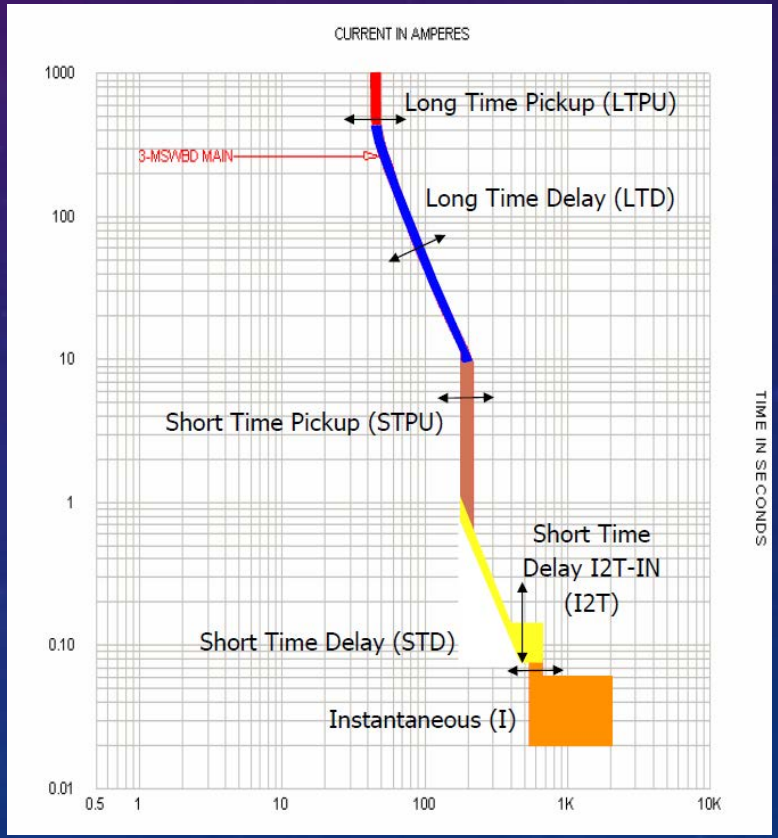


SOLID STATE OR MICROPROCESSOR TRIP UNITS

Trip Unit Adjustments



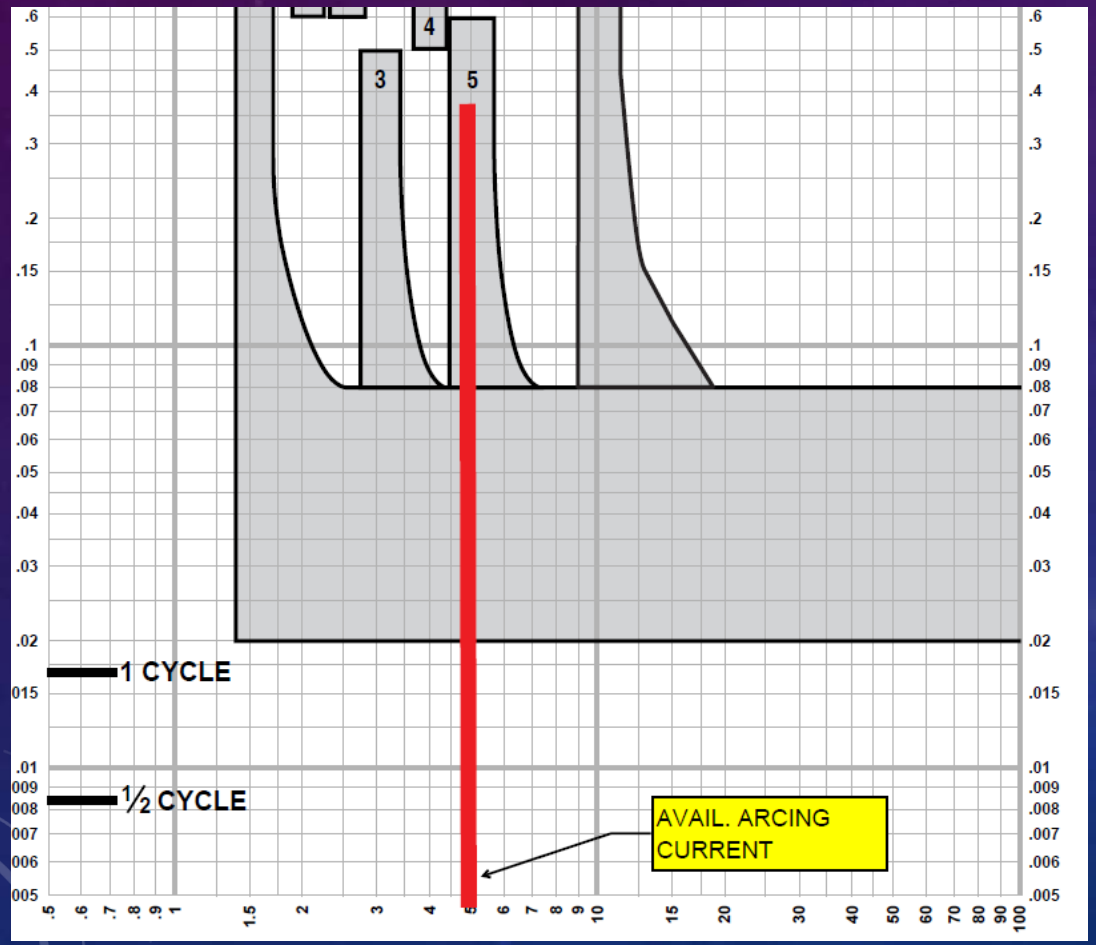
TCC Adjustability

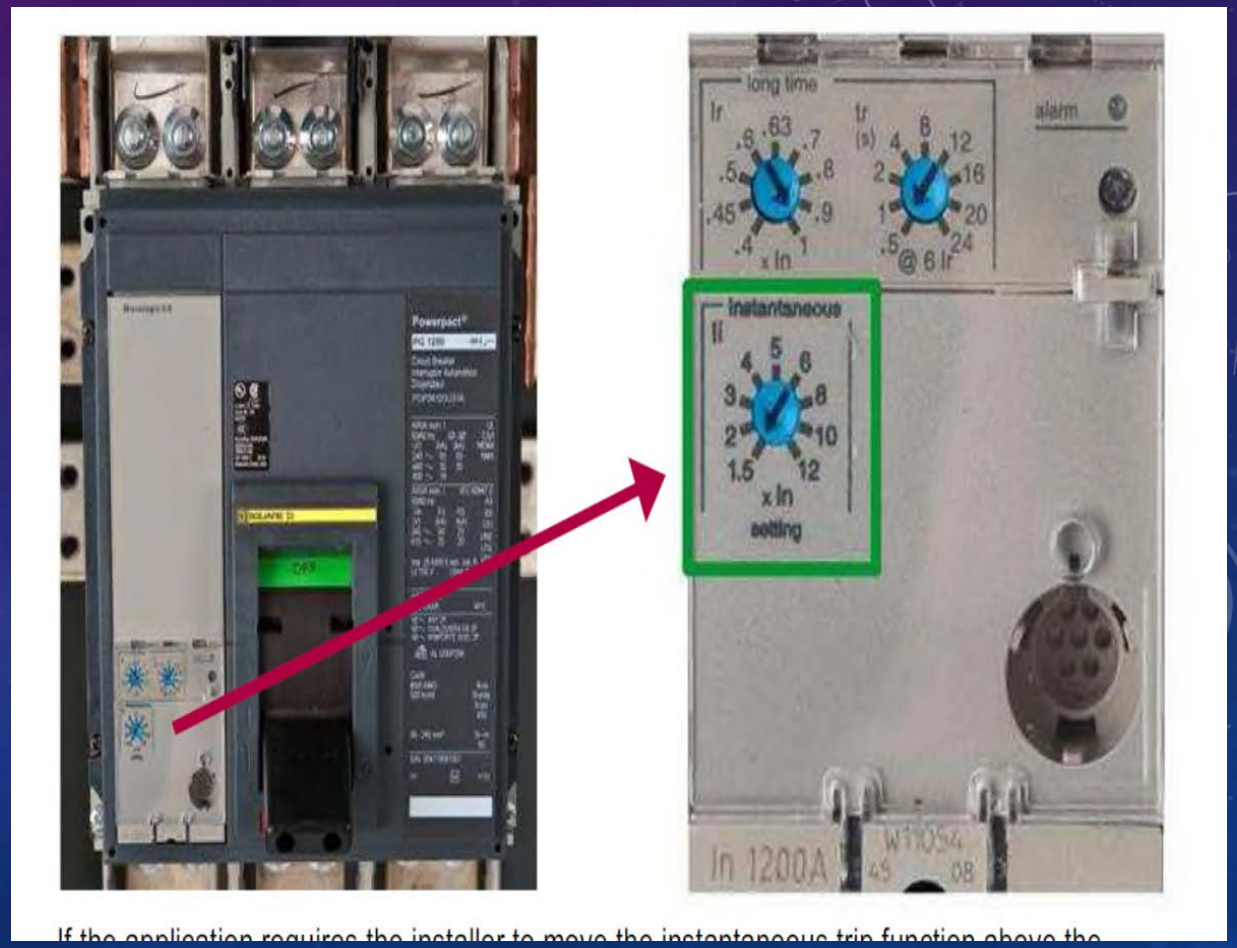


(4) -AN INSTANTANEOUS TRIP SETTING THAT IS LESS THAN THE AVAILABLE ARCING CURRENT

- How do I know what my available arcing current?
- Someone has to perform an Arc Flash study!
- AF studies aren’t free.
- You must have a study to know the available arcing current.
- Can the Inst. trip be set below the available arcing current?

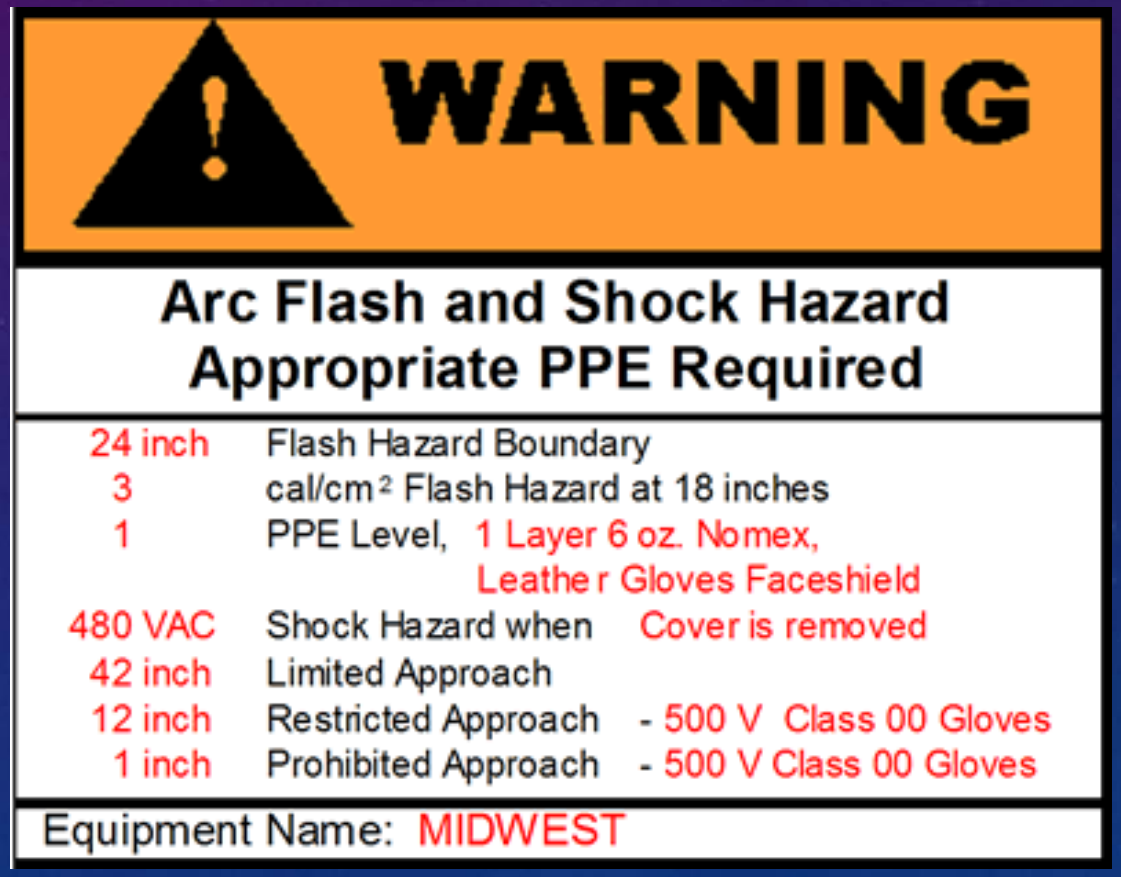
AVAILABLE ARCING CURRENT IS 5,000 AMPS





EXAMPLE: 1200A CIRCUIT BREAKER

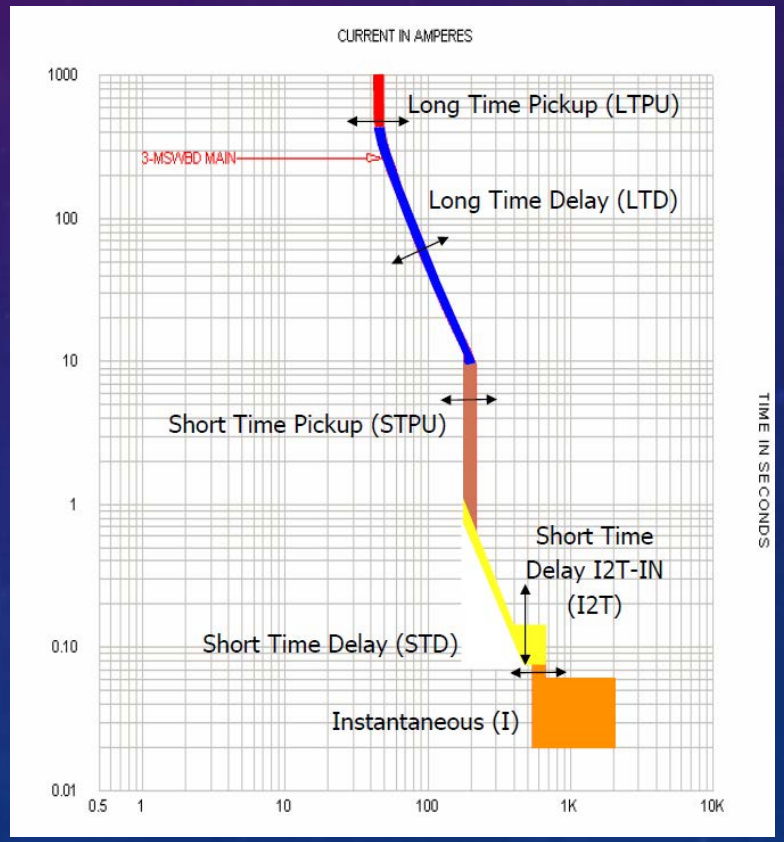
1. Instantaneous pick up at 10X = 10 x 1200A = 12,000A
2. Instantaneous pick up ay 2X = 2 x 1200A = 2,400A
3. Arc Incident Energy is proportional to current, time, & distance from the arc.
4. Arc Flash labels show cal per cm^2
5. Which setting on the breaker has a lower arc indent energy level?

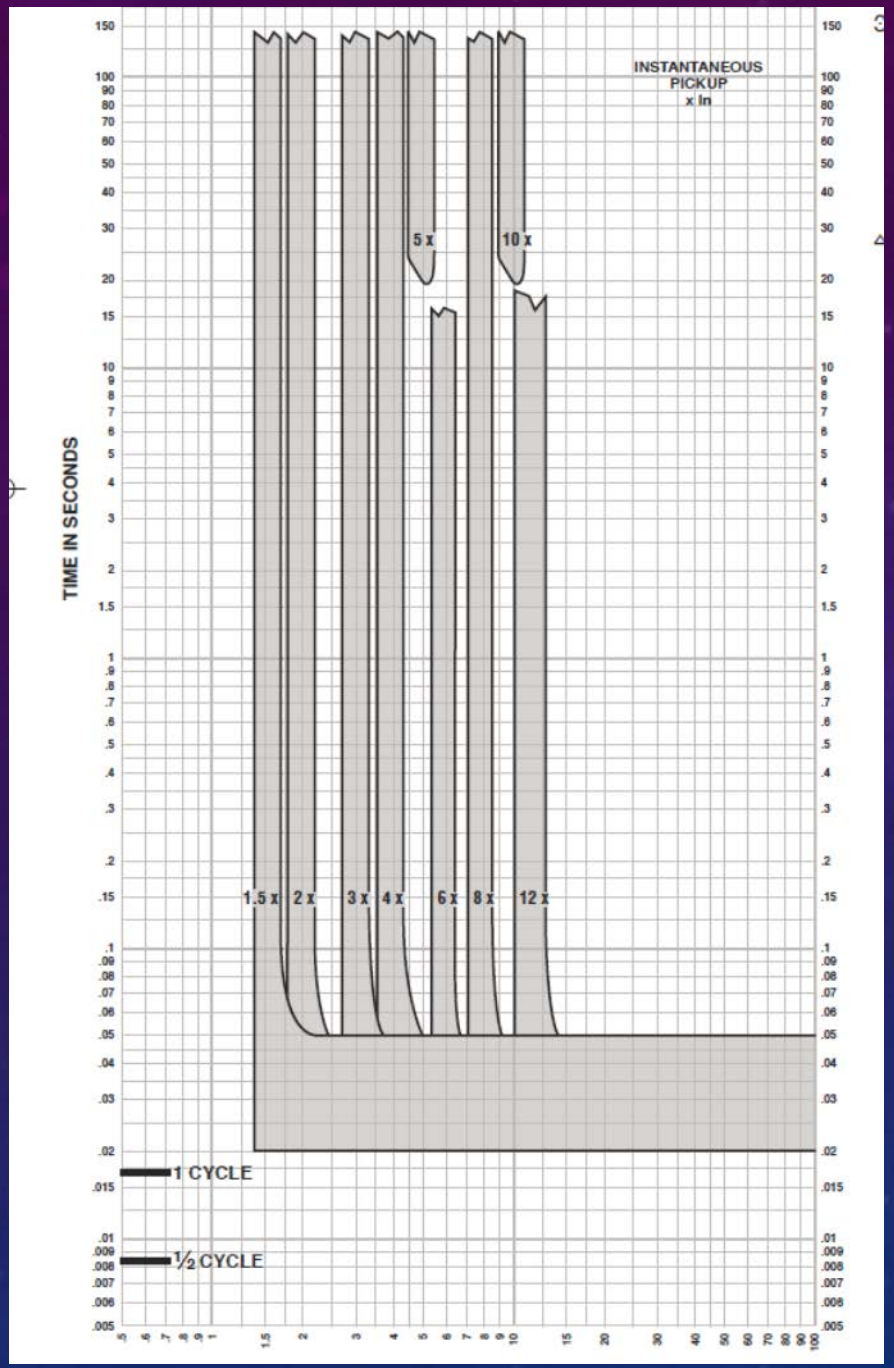


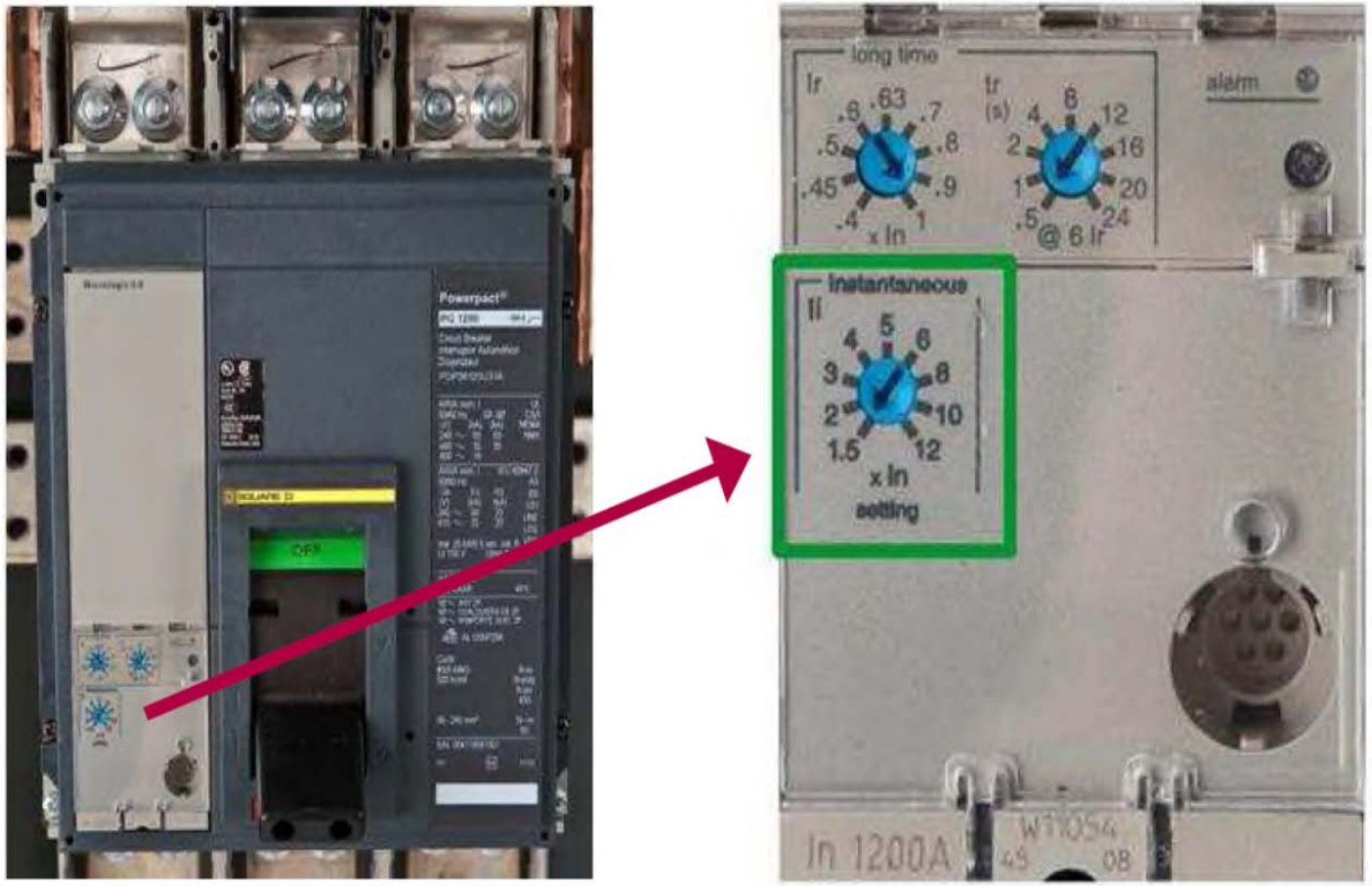
CIRCUIT BREAKER TIME CURRENT CURVE (TCC)

The Time Current Curve is our visual “predictor” of how fast the circuit breaker opens.

It’s a map of time vs. current







If the application requires the installer to move the instantaneous trip function above the

(6) AN INSTANTANEOUS OVERRIDE THAT IS LESS THAN THE AVAILABLE ARCING CURRENT

- What is an instantaneous override?
- You can’t see it.
- You can’t adjust it.
- It’s not printed on the breaker!

INSTANTANEOUS OVERRIDE

"Instantaneous override" are fixed, factory trip settings to protect the breaker during high short circuit conditions.

The I.O. setting is usually set higher than the standard instantaneous setting and will function without regard to any other settings.

It is designed to open the breaker in 25 msecs or less. (0.025 seconds)

WHERE CAN I FIND IT?

PowerPact™ M-, P- and R-Frame, and Compact™ NS630b–NS3200 Circuit Breakers
Section 13—Trip Curves

Table 103: Instantaneous Override Values Characteristic Trip Curve

UL/IEC Circuit Breaker	Instantaneous Override[1] (kA Peak)[2]	UL/IEC Circuit Breaker	Instantaneous Override[1] (kA Peak)[2]
RG 600	130 ± 10%	MG300	20 ± 15%
RG 800	130 ± 10%	MG350	20 ± 15%
RG 1000	130 ± 10%	MG400	20 ± 15%
RG 1200	130 ± 10%	MG450	20 ± 15%
RG 1600	130 ± 10%	MG500	20 ± 15%
RG 2000	130 ± 10%	MG600	20 ± 15%
RG 2500	130 ± 10%	MG700	20 ± 15%
RJ 600	90 ± 15%	MG800	20 ± 15%
RJ 800	90 ± 15%	MJ300	20 ± 15%
RJ 1000	90 ± 15%	MJ350	20 ± 15%
RJ 1200	90 ± 15%	MJ400	20 ± 15%
RJ 1600	90 ± 15%	MJ450	20 ± 15%
RJ 2000	90 ± 15%	MJ500	20 ± 15%
RJ 2500	90 ± 15%	MJ600	20 ± 15%
RK 600	130 ± 10%	MJ700	20 ± 15%
RK 800	130 ± 10%	MJ800	20 ± 15%
PG 1000	55 ± 10%	NS3200H	
PG 1200	55 ± 10%	NS630bN	
PJ 250	15 ± 10%	NS800N	
PJ 400	22 ± 10%	NS1000N	
PJ 600	22 ± 10%	NS1250N	
PJ 800	22 ± 10%	NS1600N	
PJ 1000	22 ± 10%	NS630bH	
PJ 1200	22 ± 10%	NS800H	
PK 250	55 ± 10%	NS1000H	
PK 400	55 ± 10%	NS1250H	
PK 600	55 ± 10%	NS1600H	
PK 800	55 ± 10%	NS630bL	
PK 1000	55 ± 10%	NS800L	
PK 1200	55 ± 10%	NS1000L	
PL 250	20 ± 10%	NS1250L	
PL 400	22 ± 10%	NS1600L	
PL 600	22 ± 10%		
PL 800	22 ± 10%		
PL 1000	22 ± 10%		
PL 1200	22 ± 10%		

1 Faults at or above instantaneous override value will be cleared at 25 msec or less.
2 Test X/R=4.9; divide by 2.1 for nominal RMS

WHAT DOES IT MEAN?

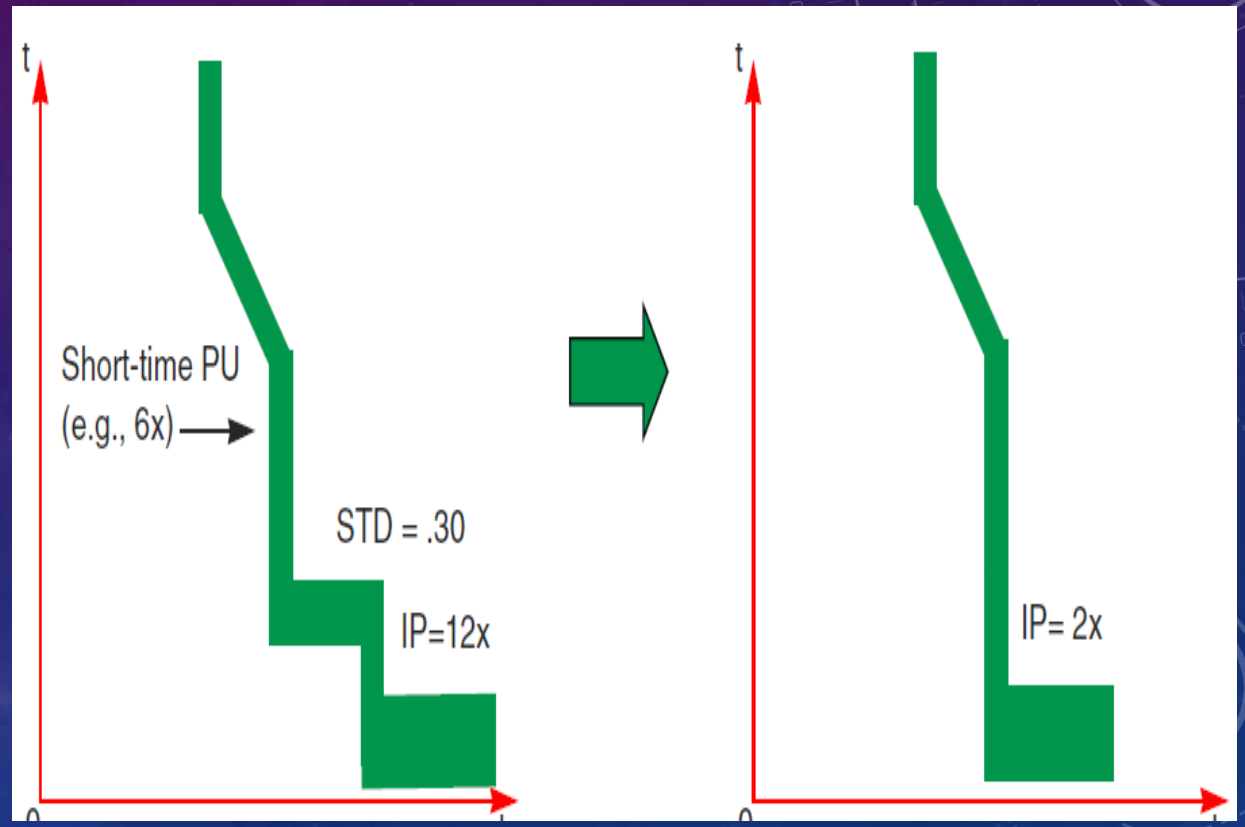
- A PG 1200A breaker has a short circuit interrupting rating of 65,000A RMS sym @ 240V.
- A PG 1200A breaker has an instantaneous override setting of 55,000A peak or 26,190A RMS +/- 10%
- At 26,000A or higher the breaker says, “I’m not waiting around, I’m outta here” and open in 25 msec.
- Therefore 26,000A RMS must be less than the available arcing current determined by the AF study in order to be an acceptable arc flash mitigation method per 240.87. (B) (6)

240.87 B (7) – ANY APPROVED MEANS

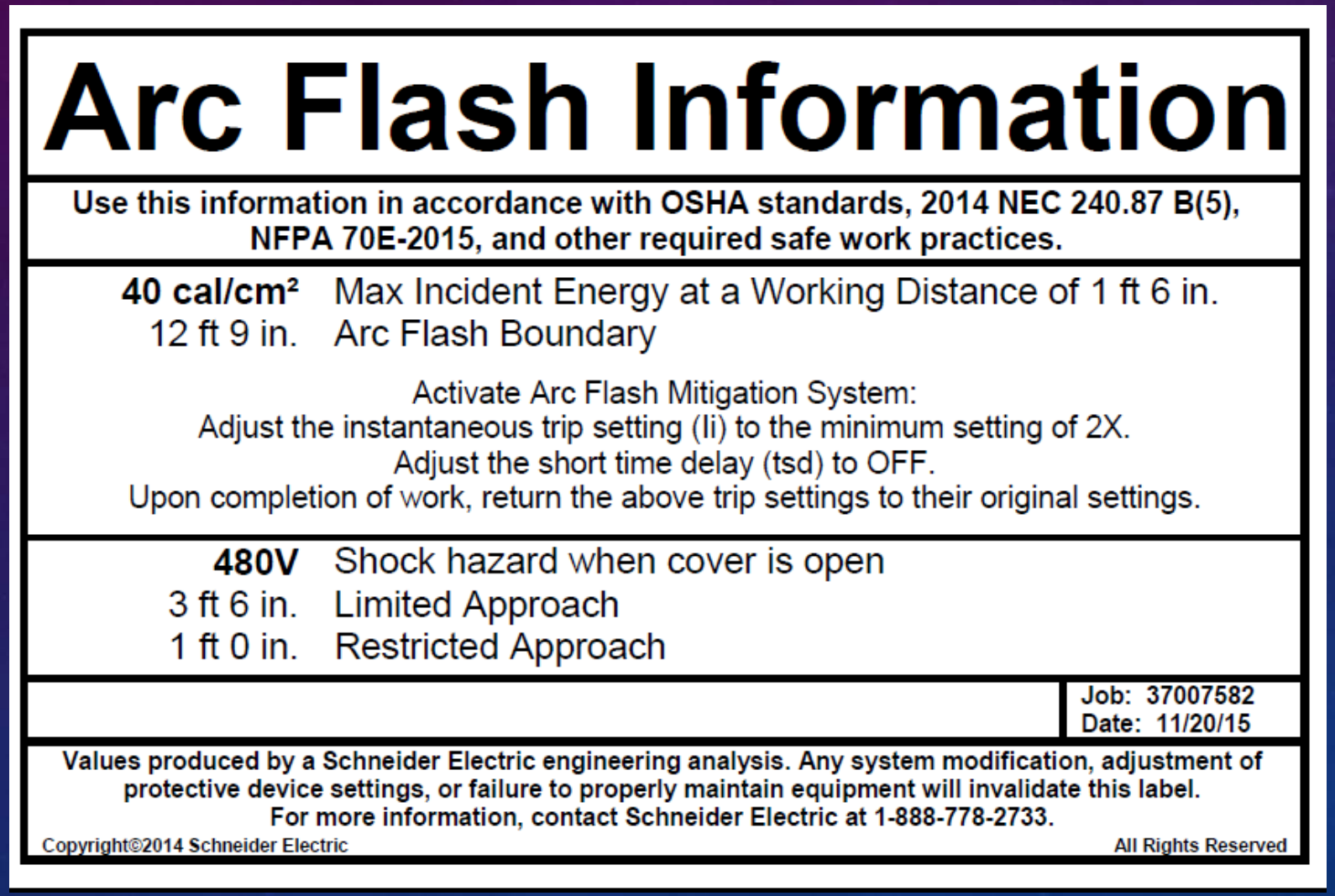
1. Keep in mind that the Code does not quantify how much energy must be reduced.
2. It just states “A Method to Reduce Clearing Time”
3. Dialing down the instantaneous trip meets the intent of the code.
4. The NEC panel intentionally left this as an approved means option.
5. It does the same thing as using method 5.

METHOD 7: SAME END RESULT AS METHOD 3

- Dialing down the Instantaneous trip setting is equivalent to activating the ERMS push button.
- Both methods reduce the arc energy by reducing the breaker's clearing time.
- Manually dialing down the trip allows a certain degree of control over the adjustment. The ERMS switch does not.
- It also doesn't cost any more money!
- Both methods require documentation per paragraph A.



ARC FLASH LABEL FOR METHOD #7



Arc Flash Information

Use this information in accordance with OSHA standards, 2014 NEC 240.87 B(5), NFPA 70E-2015, and other required safe work practices.

40 cal/cm² Max Incident Energy at a Working Distance of 1 ft 6 in.
12 ft 9 in. Arc Flash Boundary

Activate Arc Flash Mitigation System:
Adjust the instantaneous trip setting (Ii) to the minimum setting of 2X.
Adjust the short time delay (tsd) to OFF.
Upon completion of work, return the above trip settings to their original settings.

480V Shock hazard when cover is open
3 ft 6 in. Limited Approach
1 ft 0 in. Restricted Approach

Job: 37007582
Date: 11/20/15

Values produced by a Schneider Electric engineering analysis. Any system modification, adjustment of protective device settings, or failure to properly maintain equipment will invalidate this label.
For more information, contact Schneider Electric at 1-888-778-2733.

ARC RATING FOR PPE

1. NFPA 70E Section 130.3 Requires an Arc Flash study.
2. How do you know what your Arc Rating for PPE if you don't measure the arc flash incident energy levels?
3. Both methods require the operator to return the breaker setting to it's original level

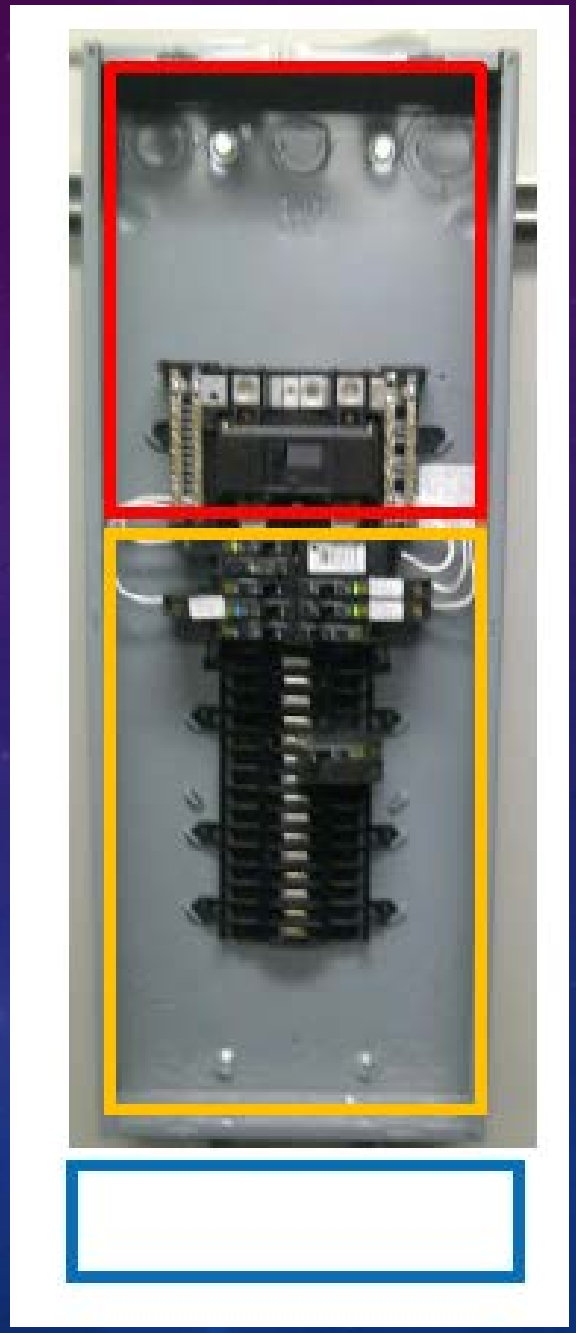
NFPA 70E Hazard/Risk Categories (HRC)		
HAZARD/RISK CATEGORY	CLOTHING DESCRIPTION	REQUIRED MINIMUM Arc Rating of PPE cal/cm²
1 HRC	*Arc-rated FR shirt and FR pants or FR coverall* (1 layer)	4
2 HRC	*Arc-rated FR shirt and FR pants or FR coverall* (1 or 2 layers)	8
3 HRC	*Arc-rated FR shirt and FR pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum* (2 or 3 layers)	25
4 HRC	*Arc-rated FR shirt and FR pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum* (3 or more layers)	40

ALL 3 METHODS REQUIRE QUALIFIED PERSONNEL TO OPERATE

Method # 3

Method # 5 and #7

- Will the means really reduce the hazard?
  - Equipment must be labeled for the arc flash hazard that exists in Zone 1
  - Any arc energy reduction means only reduces the hazard in Zone 3, unless equipment is compartmentalized.
  - Remember, I said the ERMS switch wasn't magic!



Zone 1 – Line side of main device

Zone 2 – Load side of main device

Zone 3 – Downstream equipment

RELATIVE COST COMPARISON

(1) Zone-selective interlocking - $

(2) Differential relaying - $$$

(3) Energy-reducing maintenance switching with local status indicator - $

(4) Energy-reducing active arc flash mitigation system - $$$$$

(5) An instantaneous trip setting that is less than the available arcing current -$0.00

(6) An instantaneous override that is less than the available arcing current -$0.00

(7) An approved equivalent means – $0.00

NEC 240.87 - SUMMARY

1. NEC 240.87 lists (7) methods to mitigate arc flash energy.
2. Reducing the opening time of the breaker reduces the arc flash energy
3. The ERMS switch with local status indicator is most common method used to reduce clearing time.
4. Dialing down the instantaneous trip setting of a molded case breaker also reduces the clearing time.
5. Don’t always default to “where’s the ERMS switch?” It’s NOT a magic switch!
6. No extra cost when using the dial down method.