NEC 2017: Arc Energy Reduction

Article 240.87

Ken Box, P.E.
Square D by Schneider Electric
Consulting Engineer Specialist
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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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: $I = \frac{V}{Z}$
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

Short-time PU (e.g., 6x) → STD = .30 → IP = 12x → "OFF" Mode

IP = 2x → "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 is?
- 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 at 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 cm²**

5. Which setting on the breaker has a lower arc incident 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
(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" 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?

Table 103: Instantaneous Override Values Characteristic Trip Curve

<table>
<thead>
<tr>
<th>UL/IEC Circuit Breaker</th>
<th>Instantaneous Override (^1) ((\text{kA Peak})^2)</th>
<th>UL/IEC Circuit Breaker</th>
<th>Instantaneous Override (^1) ((\text{kA Peak})^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RG 600</td>
<td>150 ± 10%</td>
<td>MS600</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RG 800</td>
<td>150 ± 10%</td>
<td>MS805</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RG 1000</td>
<td>150 ± 10%</td>
<td>MG400</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RG 1200</td>
<td>150 ± 10%</td>
<td>MS450</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RG 1600</td>
<td>150 ± 10%</td>
<td>MG600</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RG 2000</td>
<td>150 ± 10%</td>
<td>MS600</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RG 2500</td>
<td>150 ± 10%</td>
<td>MS700</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RJ 900</td>
<td>90 ± 15%</td>
<td>MS900</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RJ 900</td>
<td>90 ± 15%</td>
<td>MJ300</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RJ 1200</td>
<td>90 ± 15%</td>
<td>MJ400</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RJ 1600</td>
<td>90 ± 15%</td>
<td>MJ600</td>
<td>20 ± 15%</td>
</tr>
<tr>
<td>RJ 2000</td>
<td>90 ± 15%</td>
<td>MJ800</td>
<td>20 ± 15%</td>
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</table>

1. Faults at or above instantaneous override value will be cleared at 25 msec or less.
2. Test X/RI=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.
<table>
<thead>
<tr>
<th>Energy Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 cal/cm²</td>
<td>Max Incident Energy at a Working Distance of 1 ft 6 in. 12 ft 9 in. Arc Flash Boundary</td>
</tr>
</tbody>
</table>

Activate Arc Flash Mitigation System:
- Adjust the instantaneous trip setting (li) 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.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>480V</td>
<td>Shock hazard when cover is open</td>
</tr>
<tr>
<td>3 ft 6 in.</td>
<td>Limited Approach</td>
</tr>
<tr>
<td>1 ft 0 in.</td>
<td>Restricted Approach</td>
</tr>
</tbody>
</table>

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
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

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(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.