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Updated - 2017 National Electrical Code® (NEC®) 240.87 Questions and Answers

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Q: What is NEC 240.87?

A: The NFPA (National Fire Protection Association®) 70® – National Electrical Code® (NEC®) – Section 240.87 was first introduced in the 2011 edition, titled "Noninstantaneous Trip". At the time, it required a means to reduce clearing time when a circuit breaker without an instantaneous trip device was used.

This section required the inclusion of zone-selective interlocking (ZSI), differential relaying, or an "energy-reducing maintenance switching with local status indicator" wherever a circuit breaker without an instantaneous trip was applied. Since a circuit breaker without an instantaneous trip can only operate in either the long-time or short-time regions (not instantaneous), these three methods could help reduce the tripping and clearing time. Because the incident energy from an arc-fault event is directly dependent on the clearing time of the upstream circuit breaker (the time it takes to clear the arcing fault), these methods could reduce the PPE level needed and increase worker safety.

The requirements of this section, however, were seldom applicable since most circuit breakers employ self-protective instantaneous trips that cannot be removed or overridden.

Q: What changed in the 2014 revision of the NEC?

A: The 2014 NEC changed the scope of 240.87 substantially. The title, itself, changed from "Noninstantaneous Trip" to "Arc Energy Reduction". The application of the section no longer depends on the presence of an instantaneous device, but is now completely based on the ampere rating of the circuit breaker frame. Any circuit breaker that can be set to 1200A or more (even a 1200A frame that has been adjusted by the trip unit to a rating lower than 1200A) must implement one of the four cited methods, or an approved equivalent means, to reduce clearing time. This applies to main, feeder and branch circuit breakers – every application. One of the following methods must be provided:

- 1) **ZSI** - This system can reduce intentional short-time and ground-fault delays to help reduce the clearing time. Remember that it should be specified and the applicable circuit breakers must be designated on the plans. The ZSI scheme must include, at a minimum, the 1200A (or larger) circuit breaker and the circuit breaker in the tier above it or all the circuit breakers in the tier below it.
- 2) **Differential relaying** - This is an outboard system (not in the circuit breaker) consisting of CT's and relays that can detect a possible arc fault and signal the proper circuit breakers to trip via a shunt trip connection. This is generally not a manufacturer-supplied offering and is usually designed by the engineer. Differential relaying is commonly used on medium voltage systems.

- 3) **Energy-reducing maintenance switching with local status indicator** - This is an integral feature of the circuit breaker that provides for the installation of a remote switch and an indicator light. When activated, the function should set the circuit breaker's trip unit to "no intentional delay" to reduce the clearing time. Upon leaving the hazardous area the workers turn the switch off, returning the settings to their previous values.
- 4) **Energy-reducing active arc flash mitigation system** - This is any one of several special systems that, by one or more detection means (CT's, optical sensors, etc.), automatically helps limit the energy released during an arc-fault event. This method includes "crowbar" type devices that actively introduce additional arcs or short circuits into the circuit to more quickly quench the arcing fault.
- 5) **An approved equivalent means** - Any alternative method that affords equivalent safety as the four methods listed above can be evaluated and approved by the Authority Having Jurisdiction (AHJ). This approval is usually obtained by prior discussion between the engineer or designer and the AHJ.

Q: What is changing in the 2017 NEC code cycle?

A: The 2017 NEC introduces the option for an instantaneous setting, optimized for arc flash mitigation, in 240.87. The options of Zone Selective Interlocking, differential relaying, energy-reducing maintenance switching, and an energy-reducing active arc flash mitigation system are still included. When an arc fault occurs, the fastest way for an upstream circuit breaker to clear the fault (and minimize the arc flash energy) is by operating in its instantaneous region. To do this, the instantaneous pickup setting of the device must be set below the value of the anticipated arc fault. Remember, the arc fault value is a fraction of the available fault current and is also dependent on voltage. The 2017 NEC allows this setting of the instantaneous trip to fulfill the requirements of 240.87. This can be done either by having an appropriate adjustable setting, or by having an instantaneous override set at or below the arc fault value (an instantaneous override is an integral instantaneous trip that is set at or above the highest adjustable instantaneous setting of the device).

The challenges of the new options are twofold. First, this setting must remain adjusted below the anticipated arc fault level at all times. In many cases, this is an acceptable application solution and will result in the best possible arc flash mitigation performance. In other cases, requirements for coordination (either typical or Selective Coordination, as required by the NEC) may require that the instantaneous setting be higher than the anticipated arc fault level.

Secondly, the value of the arcing current must be established. For simple systems, a single calculation – similar to the calculation of the available fault current – may be sufficient to find this value. The designing engineer may consult IEEE 1584™, 2002 - IEEE Guide for Performing Arc Flash Hazard Calculations, Section 9.14 - which includes simplified calculations for circuit breakers. IEEE 1584 is referenced in the informational notes of NEC-2017 section 240.87 as a method to determining arcing current. For more complex systems, a study – either by the Engineer or a power study firm – may be required to determine the anticipated arc fault level to properly set the adjustable instantaneous or verify the effectiveness of an instantaneous override. The accurate determination and documentation of the arc fault value is critical to insure the effective application of either of these two new options for 240.87 compliance.

Q: What does 240.87 actually require for conformance based on the 2017 NEC?

A: If Zone Selective Interlocking, differential relaying, energy-reducing maintenance switching, or an energy reducing active arc flash mitigation system is used, the use and documentation in the bill of material will conform with the Code requirement, and additional calculations are not needed. If one of the new options is used (based on the instantaneous setting), then additional calculations are required to document proper compliance.

Q: What compliant options are offered by Siemens today?

A: Siemens offers several options for compliance, but one needs to be aware of the specific version of the code being applied. When the 2014 cycle of the NEC is being applied, the following solutions are compliant:

ZSI: Siemens offers ZSI integration between the Siemens Sentron, VL and WL families of circuit breakers. Siemens Molded Case Circuit Breakers (MCCBs) and Power Circuit Breakers (PCBs) are compatible on a single network.

DAS: An option in the Siemens WL circuit breaker is the Dynamic Arc Sentry (DAS). This functionality is available in both UL489 and UL1066 breaker configurations. In conjunction with the ETU776 trip unit, the DAS allows use of a remote switch or proximity sensor to change the trip unit settings to a second parameter set optimized for safety during maintenance operations. With the associated status light, the Siemens DAS system for the WL circuit breaker fulfills the requirements of 240.87 as an "Energy-reducing maintenance switching with local status indicator". The ability of the WL ETU776 to interface with the Siemens Sm@rtGear™ switchgear adds even more flexibility and capability to initiate and monitor the DAS maintenance mode. Please reference the DAS Application Note (CBWP-DASWP-1016) for additional information.

Sm@rt DAS: Another option, applying to both Siemens VL and WL circuit breakers in Power Panels, Switchboards, and

Switchgear, is Sm@rt DAS. This integrated solution is only provided in the preconfigured Sm@rt DAS portfolio and uses a controller and up to 10 breakers over a communication network. Each breaker is controlled via the controller using a remote switch or proximity sensor as an input. The controller then changes the trip unit settings to a second parameter set, optimized for arc energy reduction, during maintenance operations. Additional controllers can be added for equipment with more than 10 breakers. The Sm@rt DAS solution is applied with the WL ETU776 trip units and the VL ETU586 trip units. The second set of parameters for the WL breakers is stored in the WL ETU. For the VL, the second set of parameters is stored in the controller. With the associated status light, the Siemens Sm@rt DAS system fulfills the requirements of 240.87 as an "Energy-reducing maintenance switching with local status indicator". The abilities of the WL ETU776 and VL ETU586 to interface with the Siemens Sm@rtGear™ switchgear adds even more flexibility and capability to initiate and monitor the DAS maintenance mode.

When the 2017 cycle of the code is adopted, all of the above solutions will still be compliant and, in addition, all Siemens circuit breakers, by themselves, become another option if set below the calculated arc fault value.

For a more comprehensive overview of Siemens solutions, please reference Siemens '2017 NEC 240.87 Arc Energy Reduction Product Solutions' brochure, document number PDBR-24087-0217.

Q: What about the Instantaneous Setting for 2014 Code compliance?

A: In the 2011 NEC, only applications where an instantaneous device was not present were required to provide additional means to reduce arc-fault energy. In 2014, the wording was changed such that a properly adjusted instantaneous device was not included in the list of approved energy-reducing measures. A properly adjusted instantaneous trip setting - meaning one that is set above the nuisance trip level but below the anticipated arc-fault level - is actually often a more effective means to reduce arc energy than the other four listed measures. Normally, the fastest possible clearing time of a circuit breaker occurs when it operates in its instantaneous region. Siemens circuit breakers have no intentional delay in the instantaneous trip settings. In molded case circuit breakers, this properly-set instantaneous operation will usually clear a fault somewhere between one third of a cycle and one cycle (approximately 6 to 17ms). In the 2017 NEC, a properly set instantaneous (or instantaneous override) has been added as an acceptable method to fulfill the requirements of 240.87. Here is a comparison of the relative performance of the other acceptable methods:

- **Zone Selective Interlocking** - Depending on the configuration, ZSI reduces the clearing time of a circuit breaker that is operating in its short-time or ground-fault region. In a device equipped with ZSI, a fault current higher than the instantaneous trip setting will cause the device to trip in the instantaneous region with no interaction from the ZSI. If the instantaneous trip is set correctly (as previously defined), the arc will be cleared in the minimum possible time yielding the minimum possible energy. If the instantaneous trip is set above the arc-fault level and an arc fault occurs, the ZSI will operate to insure that no intentional delay is introduced in the first ZSI equipped circuit breaker upstream of the fault. However, ZSI circuitry inherently takes time to operate. For purposes of illustration, consider the case of an arc fault whose magnitude is below the instantaneous trip setting but above the short-time pickup. In this example case, if no blocking signal is received from the downstream circuit breaker (meaning the fault has occurred between the two breakers), the previously set short-time delay (in this example, 300ms) will be reduced to the minimum ZSI operating time of 50ms plus the mechanical opening and clearing time of the circuit breaker. The operation of the ZSI has indeed reduced the arc energy by reducing the time to clear by 250ms (300ms preset – 50ms minimum), however a properly selected instantaneous trip level would even eliminate the 50ms minimum, resulting in faster clearing time under an arc-fault condition.
- **Differential Relaying** - This method requires the use of programmable relays to evaluate multiple currents to detect the presence of an arc fault and actuate the opening of the circuit breaker using a shunt trip. This method can reduce the clearing time of an arc-fault event, however there is an inherently longer current evaluation (large program in the relay as opposed to the program in a very fast solid state trip unit) and a longer actuation time of a shunt-trip coil versus the integrated mag-latch coil used by the trip unit. Depending on the circumstances, a properly set instantaneous device may clear an arc fault more quickly.
- **Energy-reducing Maintenance Switch** - This method is no faster than a true instantaneous trip. Additionally, in order for the maintenance switch to be effective, the maintenance mode instantaneous trip level must be less than the prospective arc-fault current. If the instantaneous level is properly set, having it in a maintenance mode that has a lower instantaneous pickup level makes no difference in the clearing time of the circuit breaker. A properly set instantaneous provides the same level of safety as an engaged maintenance switch and offers the added benefit of continuous protection.
- **Energy-reducing Active Arc Flash Mitigation System** - This category includes active systems such as "crowbar" devices. The clearing time will depend on the active device used, the initiating system (optical, differential relaying, etc.) and the application. In some cases this method may clear an arc fault more quickly than an instantaneous device in a circuit breaker, but this would depend on the circumstances.

The proper setting of an instantaneous device to reduce arc-fault energy and achieve selective coordination depends on the results of a full coordination and arc flash study that takes into account both the prospective arc-fault current and the inrush / transient load surge (nuisance tripping level). Keep in mind that in applications where the NEC requires Selective Coordination, it may not be possible to have both a proper setting for an instantaneous device and code-mandated Selective Coordination. This is because a common method to achieve Selective Coordination is to select devices such that the instantaneous settings are greater than the available fault current, which is - by definition - above the possible arc-fault current. In those instances, the other cited methods in 240.87 may be used to satisfy both sections of the code.

In summary, for projects that fall under NEC 2014, a properly set instantaneous device with no intentional delay is an effective method to reduce the clearing time and should be considered an equivalent (if not improved) means to the other methods cited in NEC 240.87.

Q: Are there special cases where equivalent protection by an instantaneous device may be possible without requiring a coordination study?

A: 2014 NEC 240.87 requirements apply to any applicable circuit breaker in any application. However, smaller multi-tenant residential installations where there is only a single, large, main circuit breaker (1200A or 1600A, for example) and multiple smaller meter mains sometimes present a unique condition. In these installations, the provision of low voltage power circuit breakers or ZSI for the main and tenant feeder circuit breakers may not be practical, or even sometimes possible. What other opportunities might exist? In some commercial systems, large in-rush requirements (high efficiency step-down transformers and large motors, for example) require tight coordination to make sure the instantaneous trip-levels of larger devices are set high enough to avoid nuisance tripping. The requirements of Selective Coordination can also cause the instantaneous pick-up settings to be at high levels. Smaller multi-tenant residential applications, on the other hand, do not have these sources of high in-rush currents and are generally not subject to Selective Coordination requirements imposed by the NEC.

In many typical multi-tenant applications, the in-rush requirements may be below the lowest instantaneous setting of a thermal-magnetic molded case circuit breaker. In fact, it is common to find the main devices in these types of applications with their original factory settings functioning normally after many years of service (for safety purposes, Siemens always ships circuit breakers at their minimum settings). In these cases - where the lowest instantaneous setting for the thermal-magnetic circuit breaker can be used and maintained - permanently keeping the circuit breaker at its lowest instantaneous setting could be thought of as having the same safety effect as having an energy-reducing maintenance switch on all the time. In both cases, the circuit breaker would act with no intentional delay and at the lowest available instantaneous setting. Based on the specific realities of this type of application, it would stand to reason that keeping an instantaneous at its lowest setting could be considered an approved equivalent means.

For this reason, it may be possible for the engineer or design-build designer to approach the AHJ, prior to the project bid, and discuss the possibility of meeting the requirement of an approved equivalent means with this method. The suitability of the settings and methods used and the application requirements are the responsibility of the engineer.

Additionally, if the project falls under the 2017 NEC, in many cases setting the instantaneous to a lower setting will satisfy the requirements of 240.87. Depending on the transformer size and impedance, there may be settings that will provide satisfactory coordination and still be set lower than the anticipated arc fault level.

Q: Are there other ways to address the changes in NEC 240.87?

A: Yes. One means is to avoid (when possible) 1200A or larger devices. Where two smaller devices can be used (for example, as two of the six disconnect devices allowed for a service entrance), the requirements of additional options would be minimized. Another means is to use fused switches, since fused devices are not covered under the 2011 or 2014 versions of NEC Article 240. Fused switches will, however, be subject to similar requirements under a new section, NEC 240.67, effective January 1, 2020. This provision is a new addition to the 2017 code cycle.