

# Arc Flash Energy Reduction Techniques

## Energy-Reducing Maintenance Switching

Ideally, work on an electrical system can only be 100% safe if that system is totally de-energized while work is being performed. In many instances, such as in the “process” industries where facilities are required to operate continuously for “24/7”; a totally de-energized system may not always be possible for these situations. The electrical system may need to be energized to conduct maintenance or to perform trouble-shooting tasks. The steps involved in confirming that an electrical circuit is indeed de-energized, may also put the worker at risk.

Employees that work in the electrical inspection industry find that they may be exposed to shock and arc flash hazards while conducting the necessary inspections of electrical systems. To help address this, the 2011 Edition of the NEC [1] has a new set of solutions for addressing arc flash energy reduction in circuit breaker applications, as follows per Article 240.87:

*240.87 Non-instantaneous Trip. Where a circuit breaker is used without an instantaneous trip, documentation shall be available to those authorized to design, install, operate or inspect the installation as to the location of the circuit breaker(s).*

*Where a circuit breaker is utilized without an instantaneous trip, one of the following or approved equivalent means shall be provided:*

(1) Zone-selective interlocking

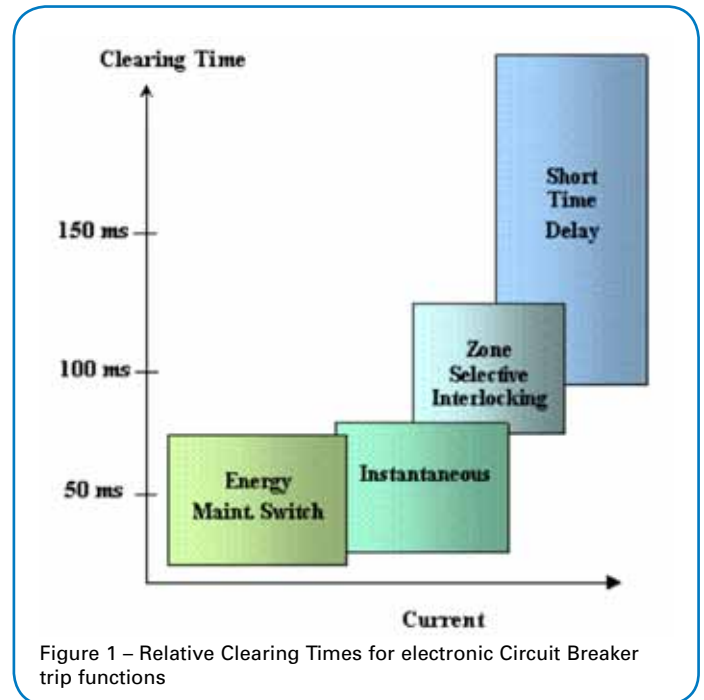
(2) Differential relaying

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

*Informational Note: An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to ‘no intentional delay’ to reduce the clearing time while the worker is working within an arc-flash boundary as defined in NFPA 70E, 2009, Standard for Electrical Safety in the Workplace, and then to set the trip unit back to a normal setting after the potentially hazardous work is complete.*

In order to maintain selective coordination in some applications, an upstream main circuit breaker may be chosen that does not have an instantaneous trip function. In these cases, if this main circuit breaker were to experience a short circuit condition, it would remain closed for its preset delay time. And the longer it takes to trip, the higher the arc flash risk.

Therefore, the idea behind the IBEW proposal and the subsequent new NEC requirement is that in cases where the circuit breaker is used without an instantaneous trip, an alternate means shall be provided to reduce the fault clearing time while a worker may be within an arc flash boundary of that circuit breaker. Many circuit breaker manufacturers have designs where the instantaneous function may be turned “OFF”. In cases where the instantaneous trip is turned “OFF”, the circuit breaker will not trip via its instantaneous function, and per the new NEC requirement, an alternate means for reducing the clearing time shall be provided.



The three devices and technologies listed in this new NEC requirement have been available in the electrical industry for several years now. While a Zone Selective Interlocking (ZSI) scheme will provide a faster trip time than the pre-set short delay (or ground-fault) trip time, its response is typically slower than both the “no intentional delay” of the Instantaneous trip times, and the trip times of Energy-Reducing Maintenance Switching devices. Depending on the circuit breaker manufacturer, ZSI trip times are in the range of 80-130ms, Instantaneous trip times are typically 20-80ms, and Energy-Reducing Maintenance Switching devices are as fast as less than 50ms.

Figure 1 shows a simple relative comparison of the tripping times for the various electronic circuit breaker trip functions – Short time delay, ZSI, Instantaneous, and Energy Maintenance Switching. The overlapping of the time bands indicate the typical variation to be expected between different types of circuit breaker designs (Molded Case versus Power circuit breakers), and between different circuit breaker manufacturers.

### What’s the purpose of Energy-Reducing Maintenance Switching

In situations where it may be impractical to de-energize the electrical equipment, in addition to employing all the other appropriate “traditional” solutions for arc flash reduction, it may be desirable to use an Energy-Reducing Maintenance Switch to further reduce the tripping time and subsequent arc flash hazard to personnel working on downstream energized equipment.

An “Energy Reducing Maintenance Switch” is a device that has been designed specifically to be used by personnel only while they are required to perform work on energized electrical equipment, as permitted by the NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces [2]. This device is not intended to be continuously active. The inclusion of this optional device as part of a system’s overall arc flash reduction strategy provides enhanced personnel protection. Once activated, the Energy-Reducing Maintenance Switch option provides a lockable switch feature that should be included in Lock Out/Tag Out (LOTO) safety procedures. Once the work has been completed, the Energy-Reducing Maintenance

Switch is de-activated and the system returned to its optimal protection state.

### How Energy-Reducing Maintenance Switching Works

The basic Energy-Reducing Maintenance Switching design is one that incorporates an additional electronic control circuit that may be separate from the normal instantaneous or short time protection circuits in the trip unit. The purpose of the separate control circuit is to allow the electrical worker, on demand, to 'switch-in' a system that will trip the over-current protective device in a time that will provide the minimum possible arcing time should an arc flash incident occur while energized work is

such design scheme provides flexibility in the selection of the pick-up level for tripping. The pick-up may simply be set one time only at the lowest, most sensitive level, or it may be set in relation to the calculated arcing fault current, the normal load current, and any possible transient currents from application specific transformer inrush or a motor starting [4]. An Energy-Reducing Maintenance Switching pick-up setting is then selected that is above the total load plus transient currents, but below the calculated minimum arcing current. This setting allows the device to trip at the expected arcing current, but avoids nuisance tripping from transient load currents.

Energy Reducing Maintenance Switch	Bolted Fault Current (kA)	Arcing Fault Current (kA)	Clearing Time (ms)	Incident Energy (cal/cm <sup>2</sup> )
Inactive	40	19.98	240	10.7
Active	40	19.98	50	2.23

Table 1 – Effect of an Energy-Reducing Maintenance Switching on Incident Arc Energy [4]

being performed on that device. The tripping times that can be achieved by the Energy-Reducing Maintenance Switching schemes may be faster or may be slower than the "Instantaneous" trip times of the trip unit, depending on the circuit breaker manufacturer.

Once the Energy-Reducing Maintenance Switching scheme is turned to an active state, 1) A local indicator is turned ON, 2) The local protection settings are overridden by the Energy-Reducing Maintenance Switching settings.

Manufacturers of Energy-Reducing Maintenance Switching schemes provide appropriate written instructions for the safe installation and testing of the schemes. Once qualified personnel completes the energized electrical work, the Energy-Reducing Maintenance Switching scheme is switched OFF and the system returned to its normal operating state.

### Energy-Reducing Maintenance Switching as an Arc Reduction Solution

There are currently a few different basic types of Energy-Reducing Maintenance Switching schemes available today.

The selection of the settings for the Energy-Reducing Maintenance Switching may be integral to the trip unit on the circuit breaker, or done by optional remote settings via a remote switch contact operation, and also via various communicating devices [3]. One

Table 1 shows the arc flash incident energy is reduced from 10.7 cal/ cm<sup>2</sup>, by approximately 80%, to 2.2 cal/ cm<sup>2</sup> by use of this Energy-Reducing Maintenance Switching scheme [4].

System data: 480V System voltage; Switchgear, 24" approach boundary, Solidly Grounded.

The total clearing time for this separate Energy-Reducing Maintenance Switching scheme may be faster than the Instantaneous trip time of the electronic trip unit, as shown in Figure 2. As a result of its very fast tripping time, this Energy-Reducing Maintenance Switching design will yield lower arc flash energy than even if the circuit breaker tripped via the normal "Instantaneous" trip response.

It's the benefit of this very fast tripping response that the 2011 NEC requires this type of technology to further enhance worker safety in hazardous arc flash circumstances.

An alternate Energy-Reducing Maintenance Switching design scheme is also available in a simpler configuration. With this circuit breaker manufacturer [5], the Energy-Reducing Maintenance

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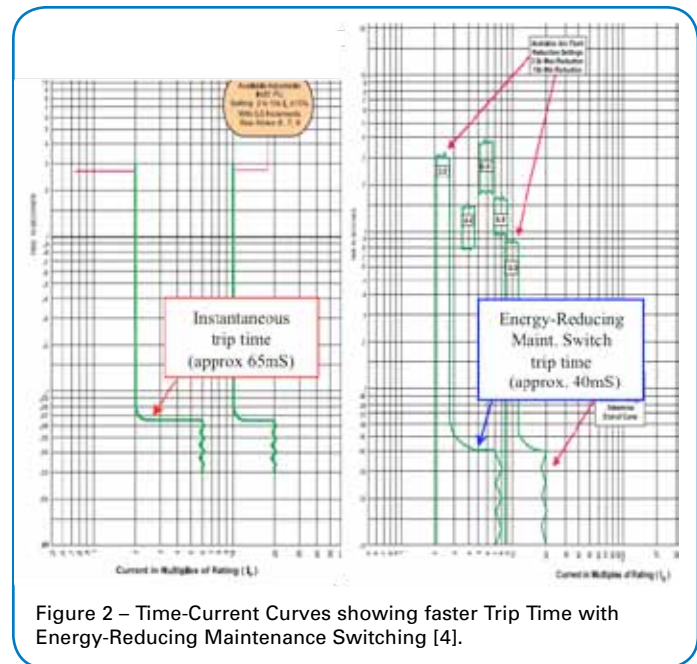


Figure 2 – Time-Current Curves showing faster Trip Time with Energy-Reducing Maintenance Switching [4].

Switching scheme is switched ON or OFF as needed, with the local indicator present as required by the 2011 NEC. This design does not provide a means separate from the protection settings for selecting a pick-up level for the Energy-Reducing Maintenance Switching. Instead, it uses the existing Short-time delay pick-up setting on the trip unit. For Energy-Reducing Maintenance Switching, the Short-time current pick-up setting must be set below 85% of the calculated minimum arcing current at the system location where it is expected to provide "fast" interruption [5]. At the completion of the energized electrical work, in addition to switching OFF the Energy-Reducing Maintenance Switching scheme, this short time pick-up setting must be also returned to its previous protection setting [5]. When activated, this type of Energy-Reducing Maintenance Switching design also provides a faster tripping time (approximately 80mS) than normal short delay tripping, but will not be faster than the normal instantaneous trip time of the circuit breaker [5].

### Are all Energy-Reducing Maintenance Switching devices Equal?

Since the primary purpose of an Energy-Reducing Maintenance Switching device is to provide very fast tripping times during an arc flash incident, a key parameter for selecting between manufacturers of these devices, is the device's total clearing time in the event of an arcing fault. While several manufacturers offer Energy-Reducing Maintenance

Switching designs that meet the 2011 NEC requirements, the performance of their designs are not all equivalent – the total clearing times of the various design solutions are different. For some manufacturers, the total clearing time provided by their Energy-Reducing Maintenance Switching device is even faster than the normal "no intentional delay" instantaneous trip time. For some other manufacturers, their total clearing time may be slower than their instantaneous trip times. To ensure that the device with the fastest total clearing time is chosen for an arc flash reduction application, the electrical system designer should consult the manufacturer's published data to identify and verify the total clearing time performance of each Energy-Reducing Maintenance Switching device option.

### References

- [1] National Fire Protection Association, NFPA 70, National Electrical Code, 2011 Edition
- [2] NFPA 70E, Standard for Electrical Safety in the Workplace, 2009 Edition
- [3] Jud Meyer, "Arc Flash Mitigation with Entellisys"; GE Industrial Solutions White Paper, October 2009.
- [4] Eaton Corporation, "Arc-Flash Reduction Maintenance Switch Application and Installation," Instruction Literature, May 2005.
- [5] SQUARE-D by Schneider Electric, "Alternate Maintenance Setting (AMS) Switch," Instruction Bulletin, Sept 2009.

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