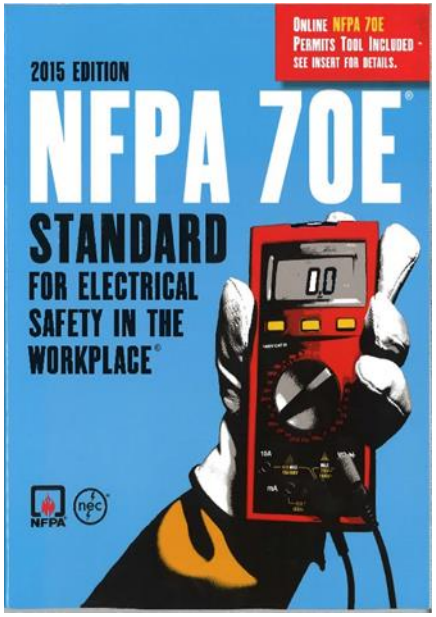
GARD

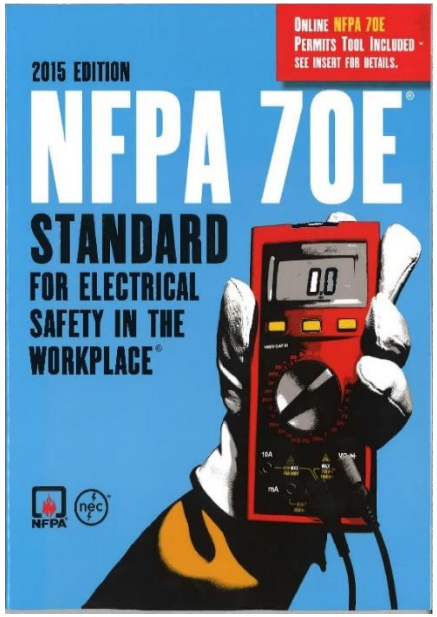
Unparalleled Protection

HIGH RESISTANCE GROUNDING

THE ONLY TECHNOLOGY THAT PREVENTS ARC FLASH



What is an Arc Flash?



According to NFPA 70E:

A dangerous condition associated with the release of energy caused by an electric arc.

A hazard beyond shock and electrocution.

What does an Arc Flash Do?

What does it do?

It hurts people !

It destroys equipment !

It Results in Penalties from OSHA

It Causes outages !

It Affects morale !

Informative Annex O Safety-Related Design Requirements

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

O.1 Introduction. This informative annex addresses the responsibilities of the facility owner or manager or the employer having responsibility for facility ownership or operations management to perform a risk assessment during the design of electrical systems and installations.

O.1.1 This informative annex covers employee safety-related design concepts for electrical equipment and installations in workplaces covered by the scope of this standard. This informative annex discusses design considerations that have impact on the application of the safety-related work practices only.

O.1.2 This informative annex does not discuss specific design requirements. The facility owner or manager or the employer should choose design options that eliminate hazards or reduce risk and enhance the effectiveness of safety-related work practices.

O.2 General Design Considerations.

O.2.1 Employers, facility owners, and managers who have responsibility for facilities and installations having electrical energy as a potential hazard to employees and other personnel should ensure that electrical hazards risk assessments are performed during the design of electrical systems and installations.

O.2.2 Design option decisions should facilitate the ability to eliminate hazards or reduce risk by doing the following:

(1) Reducing the likelihood of exposure

(2) Reducing the magnitude or severity of exposure

(3) Enabling achievement of an electrically safe work condition

O.2.3 Incident Energy Reduction Methods. The following methods have proved to be effective in reducing incident energy:

(1) Zone-selective interlocking. A method that allows two or more circuit breakers to communicate with each other so that a short circuit or ground fault will be cleared by the breaker closest to the fault with no intentional delay. Clearing the fault in the shortest time aids in reducing the incident energy.

(2) Differential relaying. The concept of this protection method is that current flowing into protected equipment must equal the current out of the equipment. If these two currents are not equal, a fault must exist within the equipment, and the relaying can be set to operate for a fast interruption. Differential relaying uses current transformers located on the line and load sides of the protected equipment and fast acting relay.

(3) Energy-reducing maintenance switching with a local status indicator. An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to operate faster while the worker is working within an arc flash boundary, as defined in NFPA 70E, and then to set the circuit breaker back to a normal setting after the work is complete.

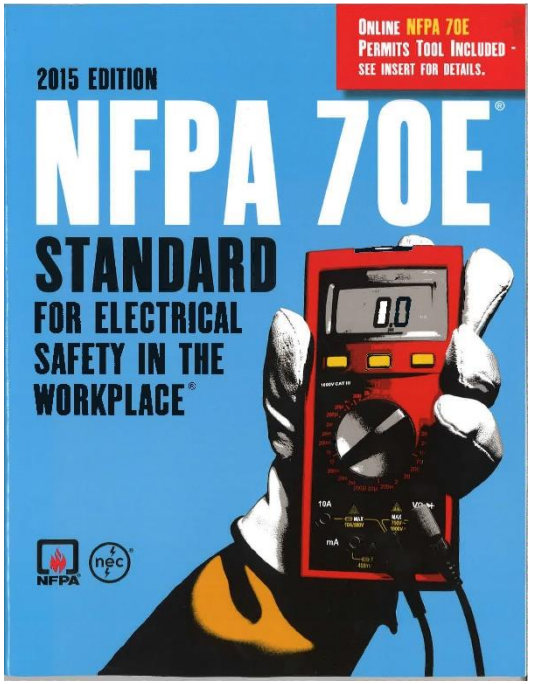
O.2.4 Other Methods.

(1) Energy-reducing active arc flash mitigation system. This system can reduce the arcing duration by creating a low impedance current path, located within a controlled compartment, to cause the arcing fault to transfer to the new current path, while the upstream breaker clears the circuit. The system works without compromising existing selective coordination in the electrical distribution system.

(2) Arc flash relay. An arc flash relay typically uses light sensors to detect the light produced by an arc flash event. Once a certain level of light is detected the relay will issue a trip signal to an upstream overcurrent device.

(3) High-resistance grounding. A great majority of electrical faults are of the phase-to-ground type. High-resistance grounding will insert an impedance in the ground return path and will typically limit the fault current to 10 amperes and below (at 5 kV nominal or below), leaving insufficient fault energy and thereby helping reduce the arc flash hazard level. High-resistance grounding will not affect arc flash energy for line-to-line or line-to-line-to-line arcs.

(4) Current-limiting devices. Current-limiting protective devices reduce incident energy by clearing the fault faster and by reducing the current seen at the arc source. The energy reduction becomes effective for current above the current-limiting threshold of the current-limiting fuse or current limiting circuit breaker.



O.2.2 <u>Design option decisions should</u> facilitate the ability to eliminate hazards or reduce risk by doing the following:

(1)Reducing the **likelihood** of exposure

(2) Reducing the **magnitude or severity** of exposure

(3) Enabling achievement of an electrically safe work condition

Informative Annex O Safety-Related Design Requirements

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

O.1 Introduction. This informative annex addresses the responsibilities of the facility owner or manager or the employer having responsibility for facility ownership or operations management to perform a risk assessment during the design of electrical systems and installations.

O.1.1 This informative annex covers employee safety-related design concepts for electrical equipment and installations in workplaces covered by the scope of this standard. This informative annex discusses design considerations that have impact on the application of the safety-related work practices only.

O.1.2 This informative annex does not discuss specific design requirements. The facility owner or manager or the employer should choose design options that eliminate hazards or reduce risk and enhance the effectiveness of safety-related work practices.

O.2 General Design Considerations.

O.2.1 Employers, facility owners, and managers who have responsibility for facilities and installations having electrical energy as a potential hazard to employees and other personnel should ensure that electrical hazards risk assessments are performed during the design of electrical systems and installations.

O.2.2 Design option decisions should facilitate the ability to eliminate hazards or reduce risk by doing the following:

(1) Reducing the likelihood of exposure

(2) Reducing the magnitude or severity of exposure

(3) Enabling achievement of an electrically safe work condition

O.2.3 Incident Energy Reduction Methods. The following methods have proved to be effective in reducing incident energy:

(1) Zone-selective interlocking. A method that allows two or more circuit breakers to communicate with each other so that a short circuit or ground fault will be cleared by the breaker closest to the fault with no intentional delay. Clearing the fault in the shortest time aids in reducing the incident energy.

(2) Differential relaying. The concept of this protection method is that current flowing into protected equipment must equal the current out of the equipment. If these two currents are not equal, a fault must exist within the equipment, and the relaying can be set to operate for a fast interruption. Differential relaying uses current transformers located on the line and load sides of the protected equipment and fast acting relay.

(3) Energy-reducing maintenance switching with a local status indicator. An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to operate faster while the worker is working within an arc flash boundary, as defined in NFPA 70E, and then to set the circuit breaker back to a normal setting after the work is complete.

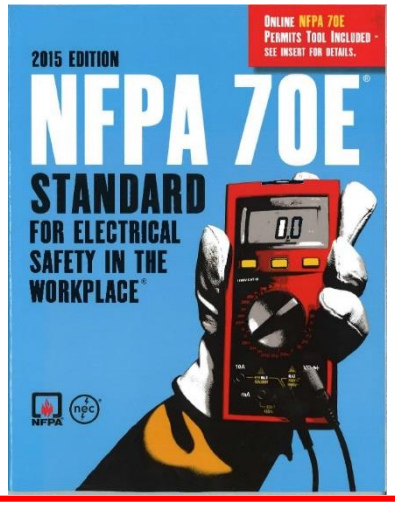
O.2.4 Other Methods.

(1) Energy-reducing active arc flash mitigation system. This system can reduce the arcing duration by creating a low impedance current path, located within a controlled compartment, to cause the arcing fault to transfer to the new current path, while the upstream breaker clears the circuit. The system works without compromising existing selective coordination in the electrical distribution system.

(2) Arc flash relay. An arc flash relay typically uses light sensors to detect the light produced by an arc flash event. Once a certain level of light is detected the relay will issue a trip signal to an upstream overcurrent device.

(3) High-resistance grounding. A great majority of electrical faults are of the phase-to-ground type. High-resistance grounding will insert an impedance in the ground return path and will typically limit the fault current to 10 amperes and below (at 5 kV nominal or below), leaving insufficient fault energy and thereby helping reduce the arc flash hazard level. High-resistance grounding will not affect arc flash energy for line-to-line or line-to-line-to-line arcs.

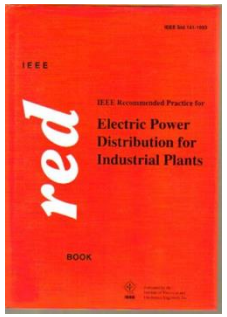
(4) Current-limiting devices. Current-limiting protective devices reduce incident energy by clearing the fault faster and by reducing the current seen at the arc source. The energy reduction becomes effective for current above the current-limiting threshold of the current-limiting fuse or current limiting circuit breaker.



(3) **High-resistance grounding**. A great majority of electrical faults are of the phase-to-ground type. High-resistance grounding will insert an impedance in the ground return path and below (at 5 kV nominal or below), **leaving insufficient fault energy and thereby helping reduce the arc flash hazard level**. High-resistance grounding will not affect arc flash energy for line-to-line or line-to-line arcs.

Reducing the Likelihood of Exposure

High Resistance Grounding



IEEE Std 141-1993 Recommended Practice for Electric Power Distribution for Industrial Plants

7.2.2 (High Resistance Grounding) **There is no arc flash hazard, as there is with solidly grounded systems,** since the fault current is limited to approximately 5A.

Another benefit of high-resistance grounded systems is the limitation of ground fault current to prevent damage to equipment. **High values of ground faults on solidly grounded systems can destroy the magnetic core of rotating machinery.**

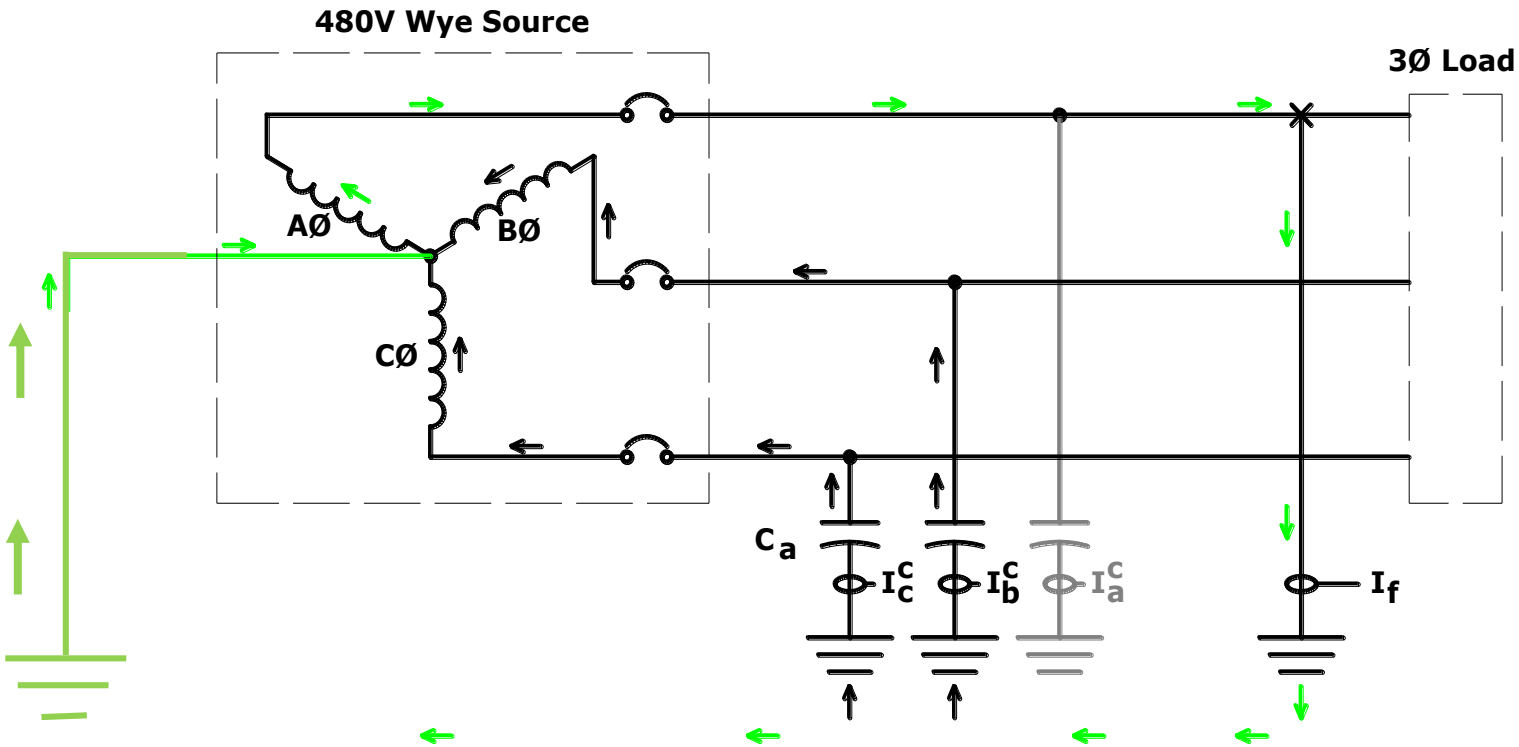
IEEE Std 142 – 1991 Recommended Practice for Grounding of Industrial and Commercial Power Systems

1.4.3 The reasons for limiting the current by resistance grounding may be one or more of the following.

1. To reduce burning and melting effects…
2. To reduce mechanical stresses….
3. **To reduce electric-shock hazards to personnel…**
4. **To reduce the arc blast or flash hazard to personnel…**
5. To reduce the momentary line-voltage dip..
6. To secure control of transient over-voltages while at the same time avoiding the shutdown of a faulty circuit**...**

Likelihood of Exposure

Solidly Grounding



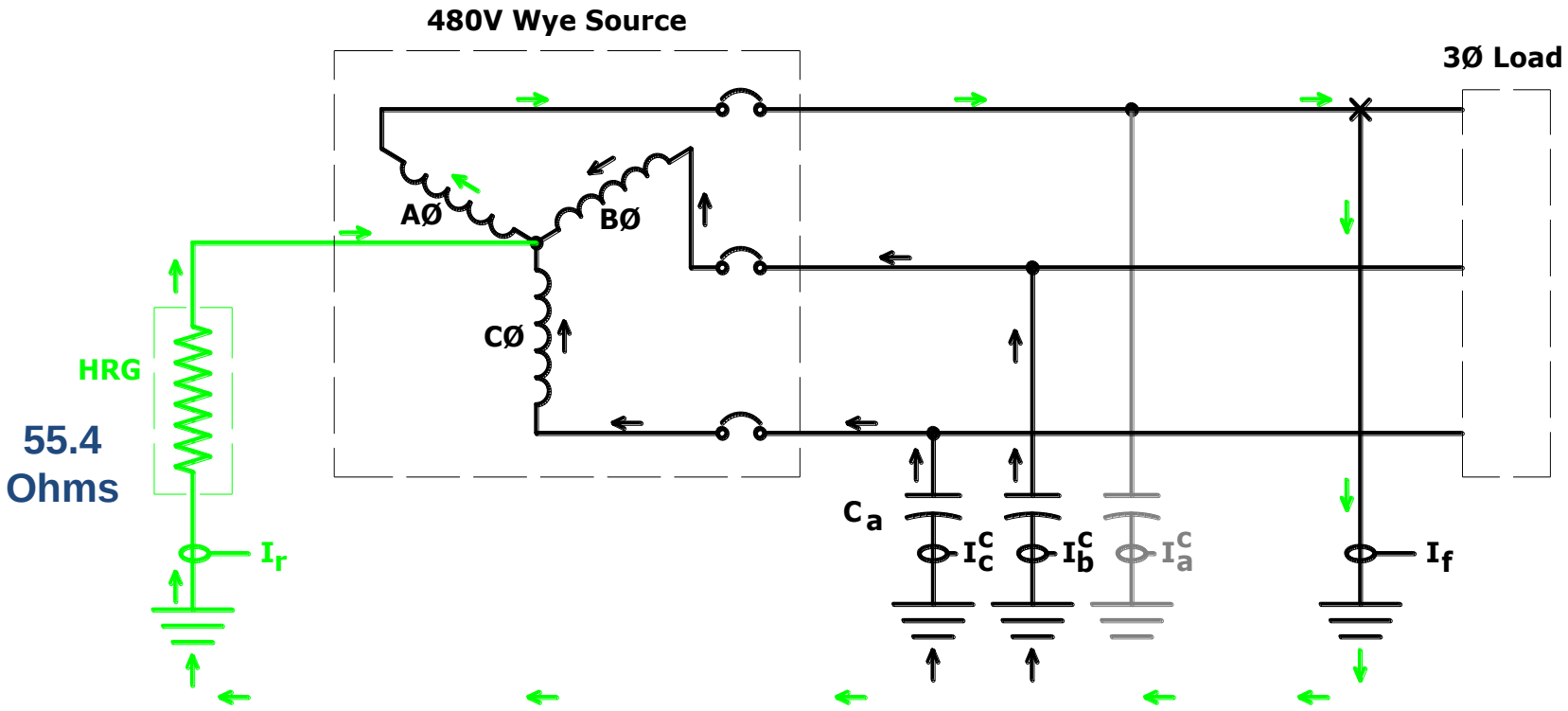
Resistance of the ground fault current path is very low

I = V / R

Ground Fault Current is very **HIGH (> 1,000 A)**

Reducing the Likelihood of Exposure

High Resistance Grounding



I = V / R → I = 277 / 55.4 = 5 Amps

Ground Fault Current is very low

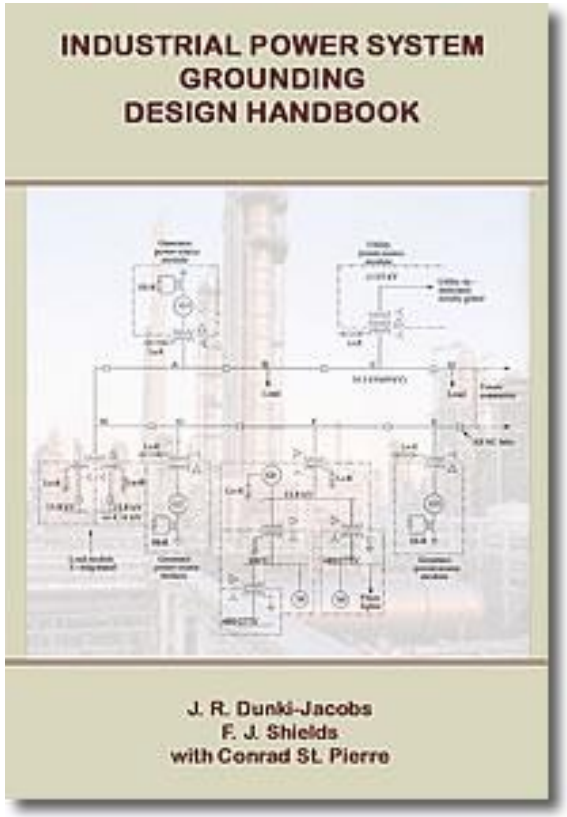
Reducing the Likelihood of Exposure

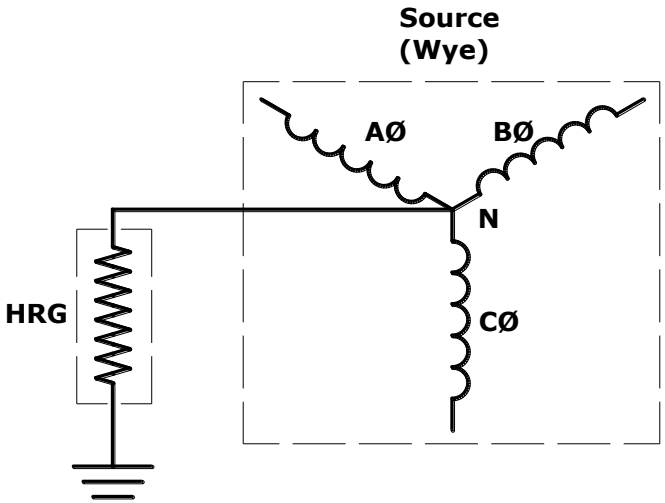
High Resistance Grounding

How Does HRG reduce Arc Flash?

According to Industrial Power System Grounding Design Handbook - 95% of all electrical faults are phase to ground faults.

By limiting the fault current to a low level, 10 amps or less, there is insufficient current for the arc to re-strike and it self-extinguishes.





HRG reduces LIKELIHOOD

Reducing the Likelihood of Exposure

High Resistance Grounding

I-GARD HRG PRODUCT FLOW

I-Gard is pleased to offer nine levels of high-resistance grounding protection to meet your specific requirements. If your specific requirements are not covered by one of the solutions below, then our in-house team will customize a solution that matches your specific needs and budget.

		PULSING	SMART
STANDARD HRG Offerings	Level 1 **STOPLIGHT** Inexpensive, simple HRG that provides visual indication of ground fault. 	Level 3 **SLEUTH** Self-contained HRG system with integral pulsing circuit to aid in locating fault. 	Level 7 **SENTINEL** Advanced HRG system that protects up to 50 feeders with critical process protection even under second ground fault. 
MONITORING	Level 2 **STOPLIGHT–M** Stoplight with an integral monitoring relay that continuously monitors the integrity of the grounding circuit. 	Level 4 **SLEUTH–M** Sleuth that provides all process continuity and fault location properties with the added monitoring relay that continuously monitors the integrity of the grounding circuit. 	LEVEL 8 **SENTINEL–M** Sentinel with an integral relay that continuously monitors the integrity of the grounding circuit. 
PREMIUM Exclusive to I-Gard FAIL-SAFE	LEVEL 5 **GEMINI** Fail-safe HRG with redundant resistor path and full-time monitoring relay. 	LEVEL 6 **GEMINI–PS** Fail-safe HRG with integral pulsing, redundant resistor path and full-time monitoring. 	LEVEL 9 **GARDIAN** Combines the recognized safety and reliability benefits of HRG with the incident energy reduction capabilities of arc mitigation. 

Informative Annex O Safety-Related Design Requirements

This informative annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

O.1 Introduction. This informative annex addresses the responsibilities of the facility owner or manager or the employer having responsibility for facility ownership or operations management to perform a risk assessment during the design of electrical systems and installations.

O.1.1 This informative annex covers employee safety-related design concepts for electrical equipment and installations in workplaces covered by the scope of this standard. This informative annex discusses design considerations that have impact on the application of the safety-related work practices only.

O.1.2 This informative annex does not discuss specific design requirements. The facility owner or manager or the employer should choose design options that eliminate hazards or reduce risk and enhance the effectiveness of safety-related work practices.

O.2 General Design Considerations.

O.2.1 Employers, facility owners, and managers who have responsibility for facilities and installations having electrical energy as a potential hazard to employees and other personnel should ensure that electrical hazards risk assessments are performed during the design of electrical systems and installations.

O.2.2 Design option decisions should facilitate the ability to eliminate hazards or reduce risk by doing the following:

(1) Reducing the likelihood of exposure

(2) Reducing the magnitude or severity of exposure

(3) Enabling achievement of an electrically safe work condition

O.2.3 Incident Energy Reduction Methods. The following methods have proved to be effective in reducing incident energy:

(1) Zone-selective interlocking. A method that allows two or more circuit breakers to communicate with each other so that a short circuit or ground fault will be cleared by the breaker closest to the fault with no intentional delay. Clearing the fault in the shortest time aids in reducing the incident energy.

(2) Differential relaying. The concept of this protection method is that current flowing into protected equipment must equal the current out of the equipment. If these two currents are not equal, a fault must exist within the equipment, and the relaying can be set to operate for a fast interruption. Differential relaying uses current transformers located on the line and load sides of the protected equipment and fast acting relay.

(3) Energy-reducing maintenance switching with a local status indicator. An energy-reducing maintenance switch allows a worker to set a circuit breaker trip unit to operate faster while the worker is working within an arc flash boundary, as defined in NFPA 70E, and then to set the circuit breaker back to a normal setting after the work is complete.

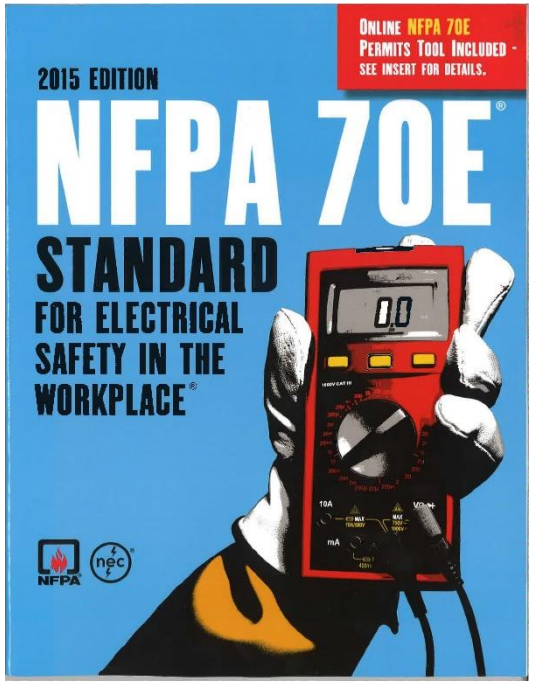
O.2.4 Other Methods.

(1) Energy-reducing active arc flash mitigation system. This system can reduce the arcing duration by creating a low impedance current path, located within a controlled compartment, to cause the arcing fault to transfer to the new current path, while the upstream breaker clears the circuit. The system works without compromising existing selective coordination in the electrical distribution system.

(2) Arc flash relay. An arc flash relay typically uses light sensors to detect the light produced by an arc flash event. Once a certain level of light is detected the relay will issue a trip signal to an upstream overcurrent device.

(3) High-resistance grounding. A great majority of electrical faults are of the phase-to-ground type. High-resistance grounding will insert an impedance in the ground return path and will typically limit the fault current to 10 amperes and below (at 5 kV nominal or below), leaving insufficient fault energy and thereby helping reduce the arc flash hazard level. High-resistance grounding will not affect arc flash energy for line-to-line or line-to-line-to-line arcs.

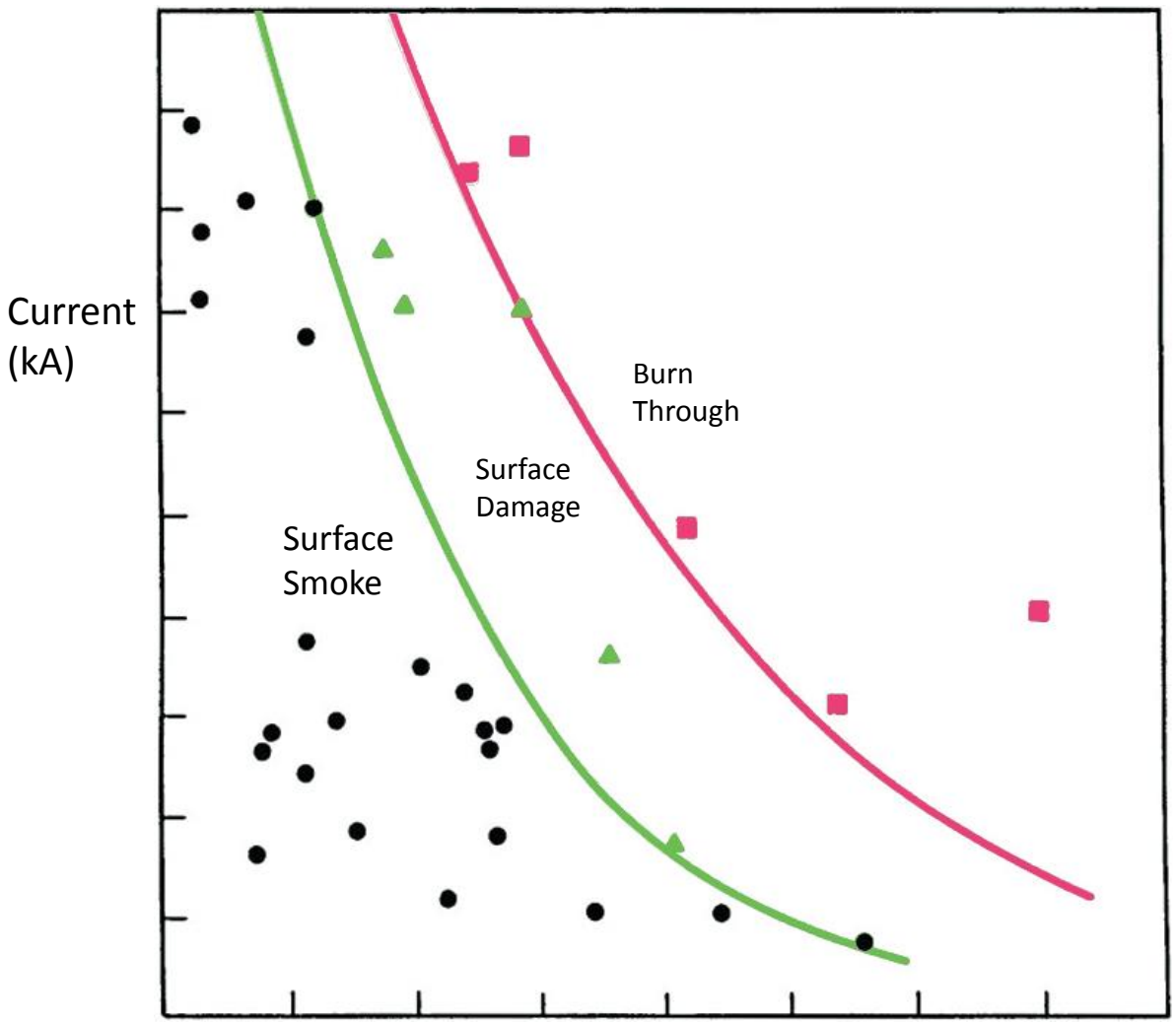
(4) Current-limiting devices. Current-limiting protective devices reduce incident energy by clearing the fault faster and by reducing the current seen at the arc source. The energy reduction becomes effective for current above the current-limiting threshold of the current-limiting fuse or current limiting circuit breaker.



(2) **Arc flash relay**. An arc flash relay typically uses **light sensors** to detect the light produced by an arc flash event. Once a certain level of light is detected the relay will issue a trip signal to an upstream overcurrent device.

Reducing the Magnitude of Exposure

Arc Flash Relay



Arc damage curve showing arc current versus arc time

An arc is developed within milli-seconds and leads to the discharge of enormous amounts of destructive energy. The energy in the arc is directly proportional to the square of the short-circuit current and the time the arc takes to develop.

Reduce the Time,

Reduce the Damage,

Reduce the Incident Energy.

Reducing the Magnitude of Exposure

Arc Flash Relay

Protection at the Speed of Light

ARC-i-TEC: Optical Sensing Technology

- Sense and initiate trip in 1ms
- Use current and light inputs – 12 optical sensors
- Simultaneously trip up to 4 breakers
- ModBus Communication
- BIT: Built in tester – checking integrity at all times

SENTRi :Optical Sensing Technology

- Arc flash 1ms speed
- 3 light sensors with optional pressure sensors
- Simultaneously trip up to 3 breakers
- ModBus Communication

Reducing the Magnitude of Exposure

Arc Flash Relay

Incident Energy Comparison

PROTECTION TYPE	CLEARING TIME (SECONDS)	INCIDENT ENERGY (CAL/CM^2)
51 Overcurrent	2.00	211
50 Instantaneous	0.450	47
I-Gard ARC-I-TEC	0.084	9

- Assumes breaker clearing time of 5 cycles
- 480V and 65kA bolted fault current, 18 inches

Arc Flash Relays lower Magnitude

Who is I-Gard Eh!

- Founded in 1982, all manufacturing and engineering conducted in North America
- For over thirty years, I-Gard has been committed to quality. ISO registered since 1994, I-Gard, is currently the only resistor company in North America registered to ISO 9000:2008. This acknowledges the high level of in-house design capabilities in addition to manufacturing expertise and custom focus.
- All Low Voltage products are CE approved and all products are CSA certified and UL recognized and listed.
- Active on various UL, IEEE and NFPA committees.

Industry's most extensive and advanced line of High Resistance Grounding Products.