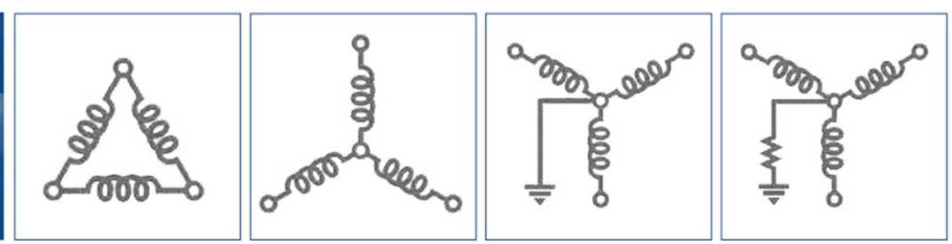
Unparalleled Protection

WHY HRG?

> www.i-gard.com



What do we Want from our Electrical System ?

Don't Wants		Wants
Unscheduled Process Interruptions	→	Process reliability
Damaged Electrical Equipment	→	Functioning Electrical Equipment
Unsafe work conditions	→	Safe work conditions

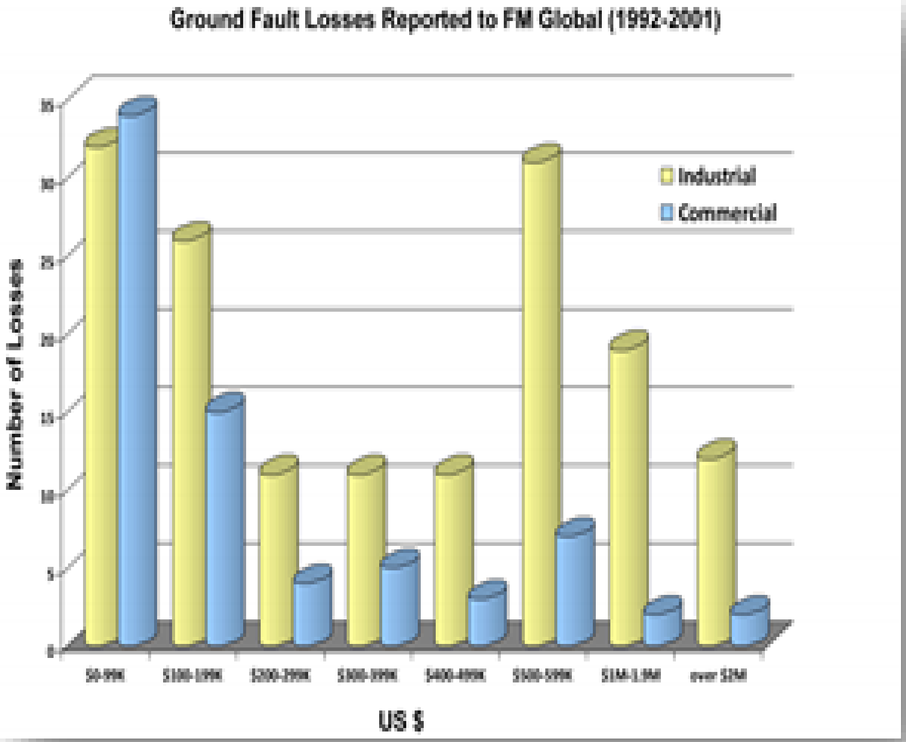
Absent ground faults, any electrical system will provide the Wants

But Ground Faults Happen !

One leading US based insurance company notes that over a 7 year period their clients reported 228 losses that were attributed to ground faults resulting in payments of $180 million.

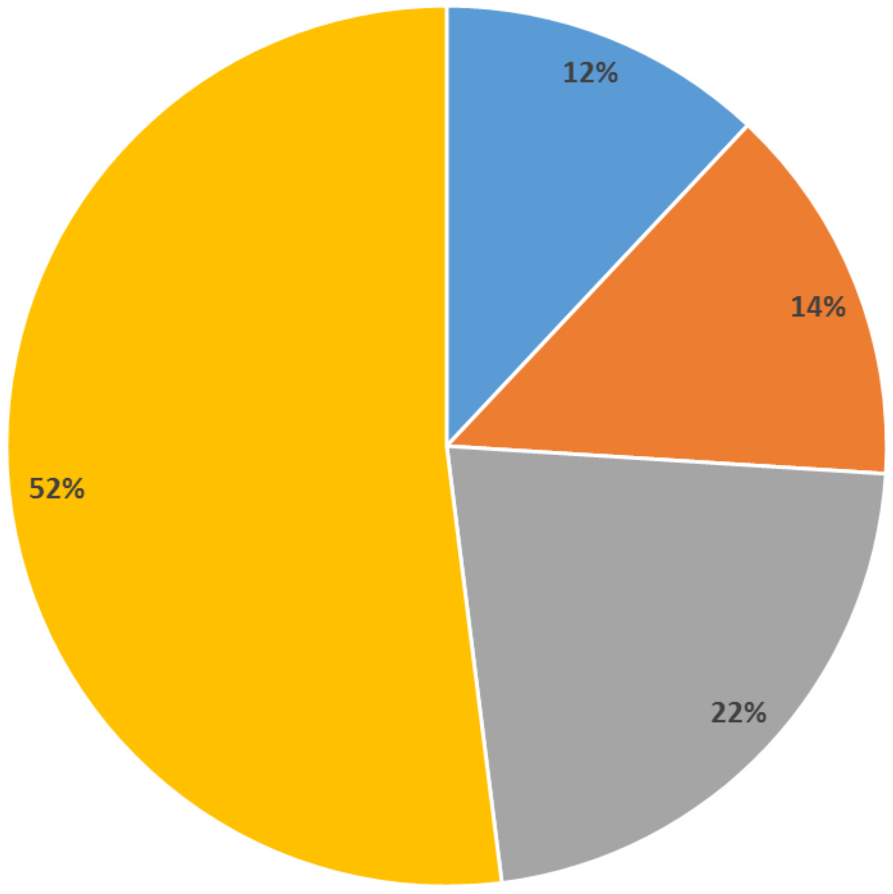
A review of the costs shows the impact of both direct and indirect costs.

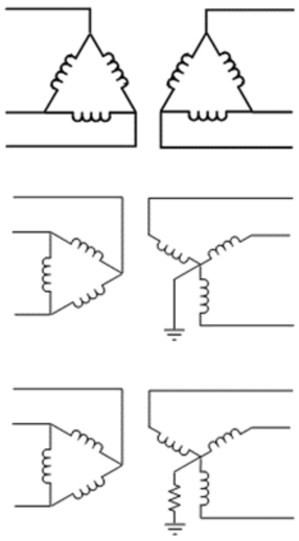
On the direct side are the costs associated with equipment repair and replacement as well as the direct medical costs associated with injuries.



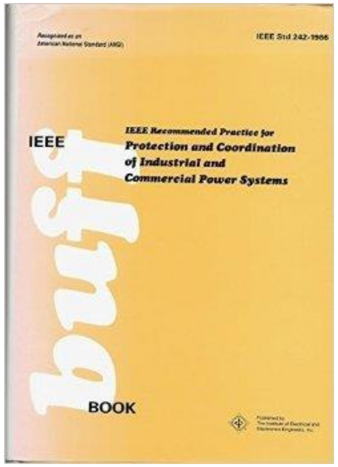
On the indirect side we see the cost of business interruption in terms of unscheduled delays, employee training and redeployment, accident investigation, legal costs and possible fines etc.

Type of Grounding System





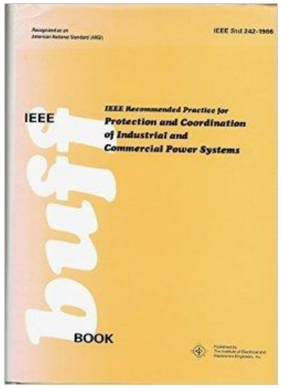
Ungrounded Systems



IEEE Standard 242-2001
Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

8.2.5 Ungrounded low-voltage systems employ ground detectors to indicate a ground fault. These detectors show the existence of a ground on the system and identify the faulted phase, but do not locate the ground, which can be anywhere on the entire system.

Ungrounded Systems

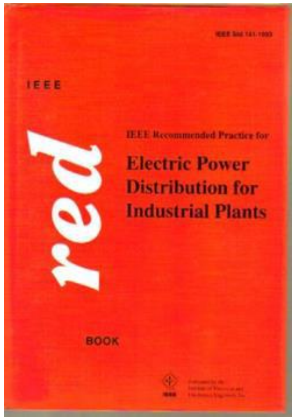


IEEE Standard 242-2001

Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

8.2.5 If this ground fault is intermittent or allowed to continue, the system could be subjected to possible severe over- voltages to ground, which can be as high as six to eight times phase voltage. **Such over-voltages can puncture insulation** and result in additional ground faults.

Ungrounded Systems



IEEE Std 141-1993

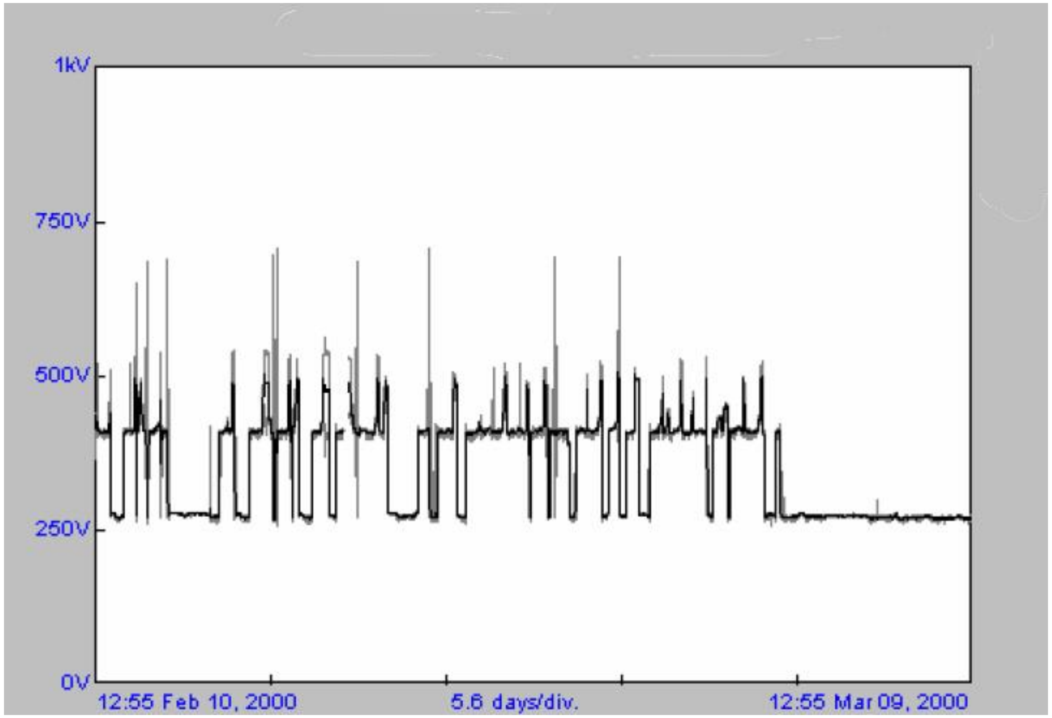
Recommended Practice for Electric Power Distribution for Industrial Plants

7.2.1 Accumulated operating experience indicates that, in general purpose industrial power distribution systems, **the over-voltage incidents associated with ungrounded operation reduce the useful life of insulation** so that electric current and machine **failures occur more frequently** than they do on grounded power systems.

Case Study

Automotive Facility **Troy Michigan**

Phase to Ground voltage monitored for 4 weeks ungrounded and 4 weeks high resistance grounded.



485 events with peak voltage above 700 volts due to intermittent ground faults.

Peak voltage 1050 volts

Transients lead to insulation degradation.

Impact of Transient Over-voltages

Insulation failure resulting in phase to phase fault and equipment damage in excess of $200k.

Ungrounded Systems

FM Global 5-18 Protection of Electrical Equipment Single Phase and Other Related Faults

- In ungrounded systems a phase to ground fault often produces dangerous overvoltage…
- Sustained arcing faults in low voltage apparatus are often initiated by a single-phase fault to ground which results in extensive damage to switchgear and motor control centers.

FM Global 5-10 Protective Grounding for Electric Power Systems and Equipment

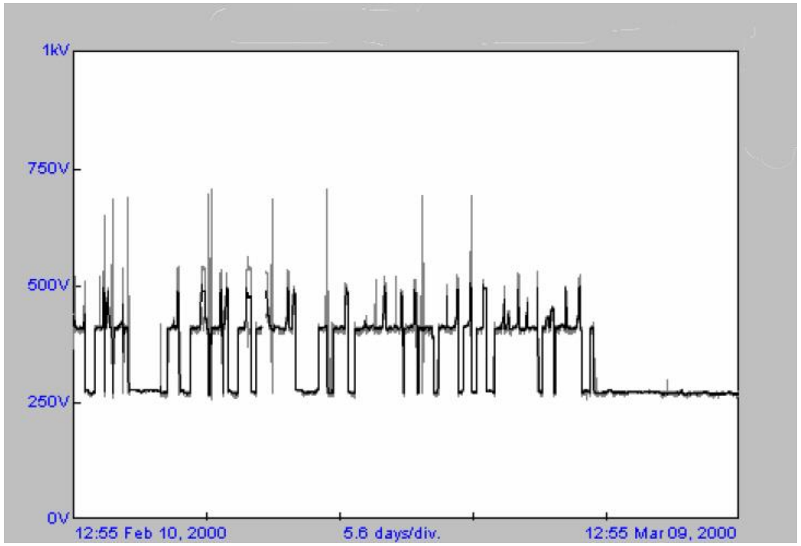
- 2.3.3.1 Unlike the ungrounded system the high resistance grounded system prevents transient overvoltage which can cause potential failure of insulation.
- 2.3.4.1 Convert ungrounded systems to high resistance grounded systems.

High Resistance Grounding

Automotive Facility

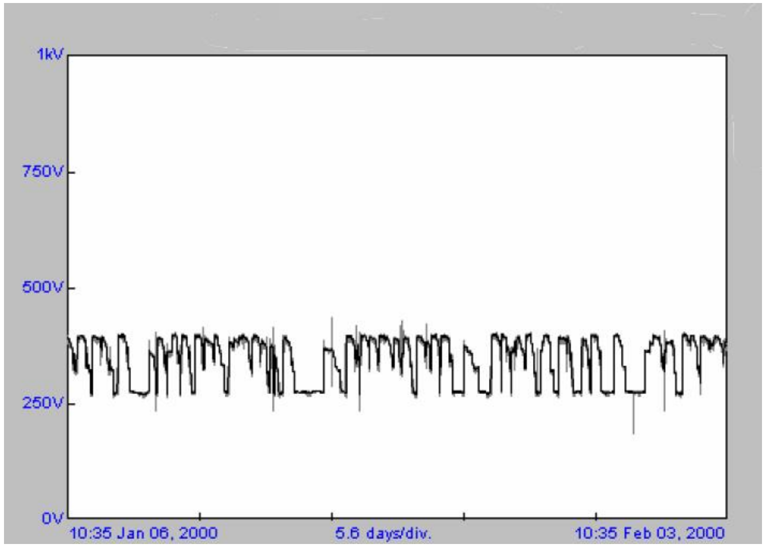
Troy Michigan

Phase voltage ungrounded



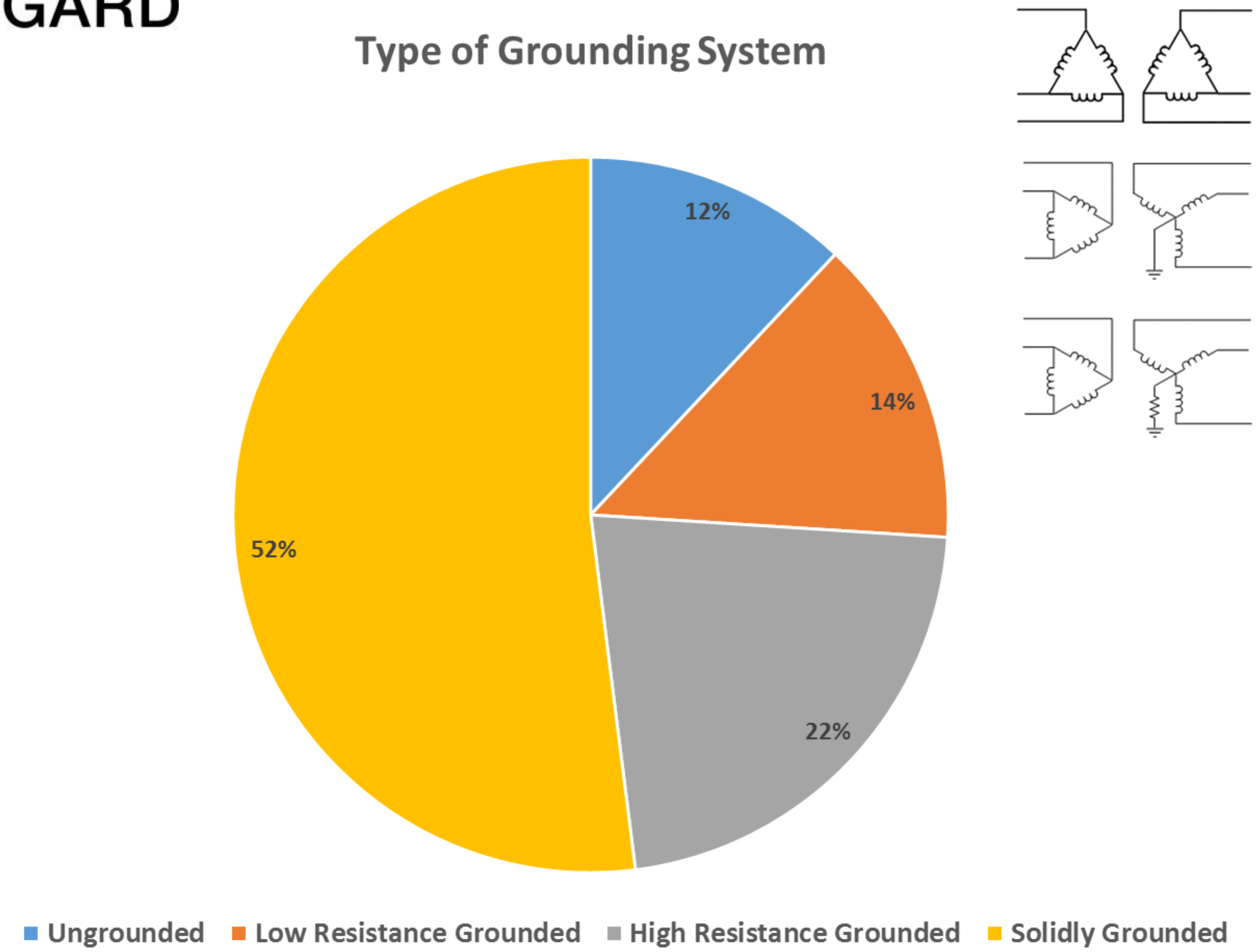
High level of transients
485 peak events over 700 volts
Peak voltage 1050 volts

Phase voltage HRG



Transients controlled
0 peak events over 700 volts
Peak voltage 660 volts

Type of Grounding System



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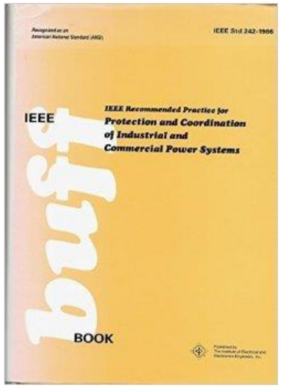
Solidly Grounded Systems

- Eliminates transient overvoltage problem
- Permits line-to-neutral loads (lighting, heating cables)
- Ground faults easy to locate, but cause unscheduled service interruption
- Danger from low-level arcing ground faults
- Since 1970s, ground fault protection mandatory for solidly grounded 600V services rated 1000A and higher by the CEC and the NEC

IEEE Color Books – Arcing Faults

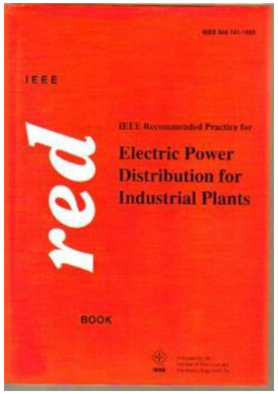
IEEE Std 242-2001

8.2.2. One disadvantage of the solidly grounded system involves **the high magnitude of destructive, arcing ground-fault currents** that can occur.



IEEE Std 141-1993

7.2.4. **The solidly grounded system has the high probability of escalating into a phase-to-phase or three-phase arcing fault, particularly for the 480V and 600V systems.** The danger of sustained arcing for phase-to-ground fault…is also high for the 480V and 600V systems, and low or near zero for the 208V system.



Arc Faults on Solidly Grounded Systems

There was a recent electrical fire at a recreational facility that resulted in consequential damages of $400,000, mostly in business interruption costs

During the course of the investigation a simple question was raised.

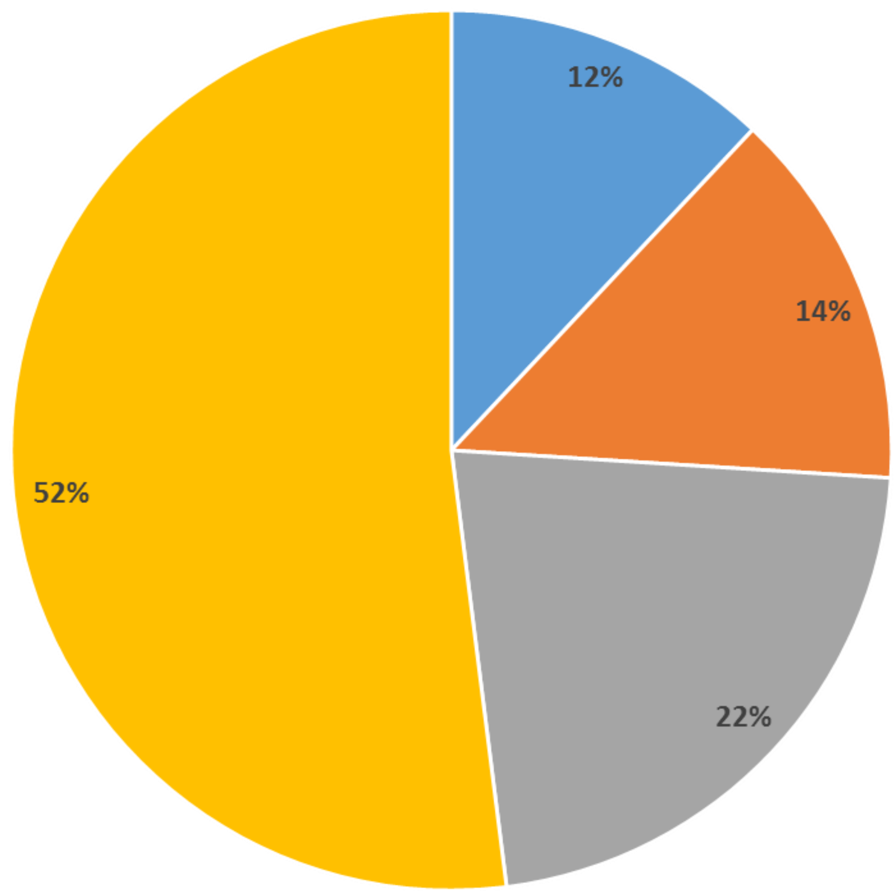
Was the grounding method chosen by the consulting engineer and the facility owner or operator a contributing factor?

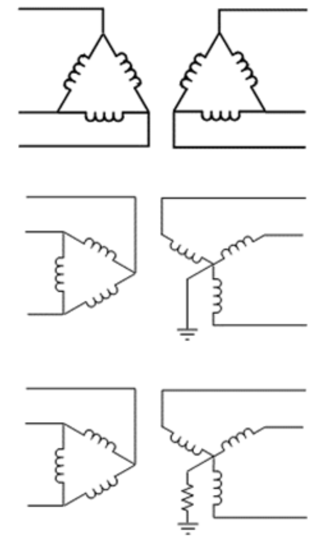
The simple answer is YES !

While solidly grounded systems are common and even the industry standard, they are known to be subject to arc flash hazards.

The fire and damage was not a result of IF but WHEN.

Type of Grounding System

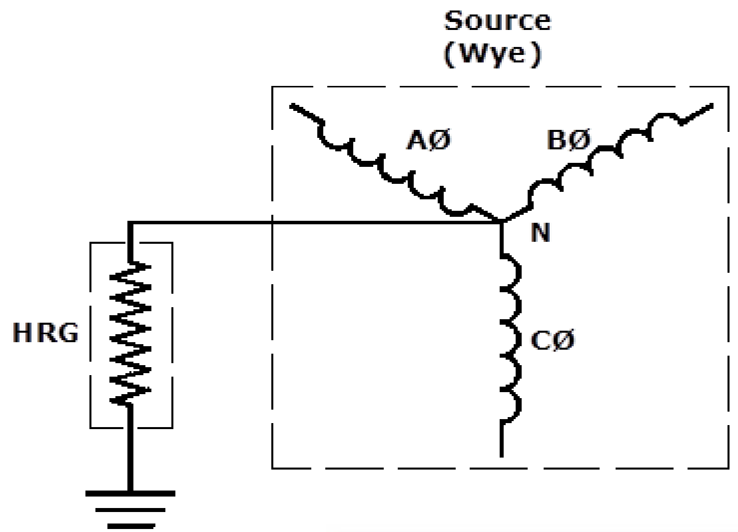




What is High Resistance Grounding?

High resistance grounding of the neutral limits the ground fault current to a very low level (typically from 1 to10 amps) and this is achieved by connecting a current limiting resistor between the neutral of the transformer secondary and the earth ground and is used on low voltage systems of 5000 volts or less, under 3000 amp.

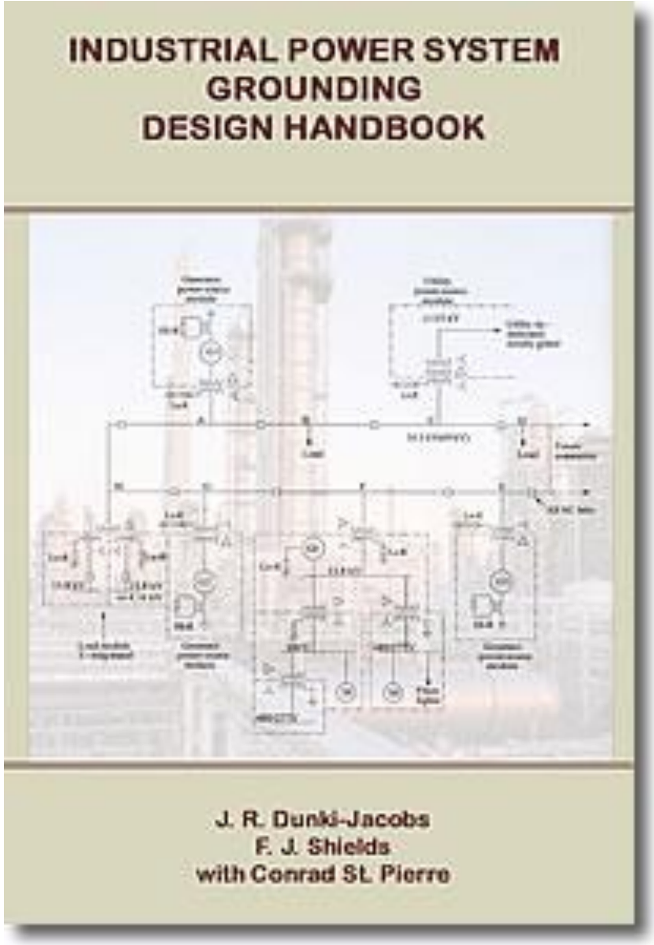
By limiting the ground fault current, the fault can be tolerated on the system until it can be located, and then isolated or removed at a convenient time.



How Does HRG reduce Arc Flash?

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.



High Resistance Grounding

IEEE Std 242-2001 (Buff Book)

- 8.2.4. High-resistance grounding helps ensure a ground-fault of known magnitude, helpful for relaying purposes. This makes it possible to identify the faulted feeder with sensitive ground-fault relays.

IEEE Std 141-1993 (Red Book)

- 7.2.2. High-resistance grounding provides the same advantages as ungrounded systems yet limits the steady state and severe transient over-voltages associated with ungrounded systems. There is no arc flash hazard *[for LV ground faults]*, as there is with a solidly grounded system, since the fault current is limited to approximately 5A.

IEE Std 242-1986 Recommended Practice for the Protection and Coordination of Industrial and Commercial Power Systems

- 7.2.5. Ungrounded systems offer no advantage over high-resistance grounded systems in terms of continuity of service and have the disadvantages of transient overvoltage's, locating the first fault and burn downs from a second ground fault. For these reasons, they are being used less frequently today than high-resistance grounded systems"

I GARD

NFPA 70E 2015 Comments

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:

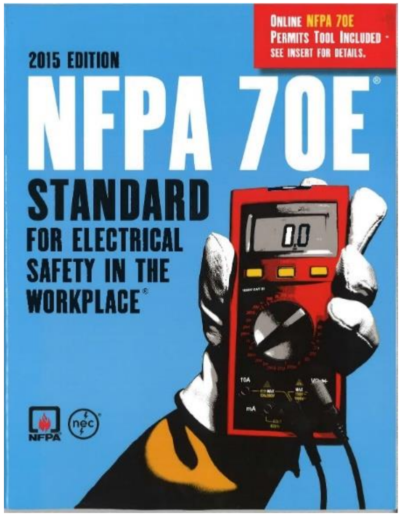
(1) Reducing the likelihood of exposure
(2) Reducing the magnitude or severity of exposure
(3) Enabling achievement of an electrically safe work condition

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. HRG will insert an impedance in the ground return path and will typically limit the fault current to 10 amperes and below, leaving insufficient fault energy and thereby helping reduce the arc flash hazard. HRG will not affect arc flash energy for line-to-line-to-line arcs.

I-GARD Installed Savings due to HRG System

- Case Study - $60MM Plant
  - Electrical Cost ~$2MM (7 Substations)

Savings from No Neutral	**+ $400,000**
Cost of (7) HRG systems w/ Feeder Protection	**- $ 97,500**
Cost of (14) 1:1 transformers	**- $ 21,500**
TOTAL SAVINGS	**$281,000**

(NOT INCLUDING Safety & System Benefits)

Grounding System Summary

	Ungrounded	Solidly Grounded	High Resistance Grounded	Advanced High Resistance Grounding
Process Continuity with 1 ground fault	✓	✗	✓	✓
Locate Ground Fault	✗	✓	✓	✓
Control Transient Over-voltages	✗	✓	✓	✓
Feeder Indication for quicker fault location				✓
2nd Fault Protection		✗		✓
Arc Detection to lower incident energy		✓		✓

Typical Excuses Given

I already have the most modern equipment for GF detection.
Ask to see the equipment, it probably isn't so modern.

We come in on weekends to find faults. No cost as production is down
How long does it take to find the ground fault at the weekend? What is the overtime cost? What else could maintenance be working on? How much damage was done to the insulation while waiting for the weekend to arrive?

Never had a ground fault, not an issue at this facility.
Ask if they have ever lost one motor continuously. If yes they blame the manufacturer of motor, the root cause is more likely to be a ground fault.

We ignore signal as too time consuming to find fault. Leave it and eventually we find it (2^{nd} phase fault). What was the cost of damage to the equipment of this wait and see approach?

Maintenance staff has been here years and know where the faults usually are.
How long does it typically take to find a fault? If it is more than 1 hour then they are not doing it right, don't know where to look or don't have I-Gard Advanced HRG.

Why HRG ?

Eliminates transient over-voltages that cause equipment failure :

Pulsing technology allows for quicker fault finding :

Limiting the ground fault to a low level prevents re-striking and lessens the likelihood of an arc flash:

Lower design and installation cost than solidly grounded:

GARD

STANDARD
HRG Offerings

Temporary
TURBO SLEUTH
Portable HRG with integral pulsing circuit that temporarily and quickly connects to an exisiting electrical system converting the faulted system to HRG.

starting from
$8,250 CAN
$6,848 US

Level 1
STOPLIGHT
Inexpensive, simple HRG that provides visual indication of ground fault.

$5,846 CAD
$4,842 US

Level 2
SLEUTH
Self-contained HRG system with integral pulsing circuit to aid in locating fault.

$8,236 CAD
$6,835 US

PREMIUM
Exclusive to I-Gard

LEVEL 3
GEMINI
Fail-safe HRG with integral pulsing, redundant resistor path and full-time monitoring.

$10,876 CAD
$9,027 US

Level 4
SENTINEL
Advanced HRG system that protects up to 50 feeders with critical process protection even under second ground fault.

$11,456 CAD
$9,508 US

LEVEL 5
GARDIAN
Combines the recognized safety and reliability benefits of HRG with the incident energy reduction capabilities of arc mitigation.

$12,830 CAD
$10,649 US

Why Advanced HRG ?

Feeder indication allows for even quicker fault finding:

Second fault protection ensures critical processes remain operational:

Adding arc detection module lowers incident energy levels:

HRG isn't PPE

HRG is PPPPPE

HRG :

Protects your People from electrical hazards like arc flash

Protects your Processes from costly unscheduled interruptions

Protects your Equipment from costly damage.