NEUTRAL GROUNDING RESISTORS

NGR

I-Gard offers a complete range of Neutral Grounding Resistors from 277V to 69,000 volts and these are used for resistance grounding of industrial power systems and are usually connected between earth ground and the neutral of power transformers, power generators or artificial neutral transformers.

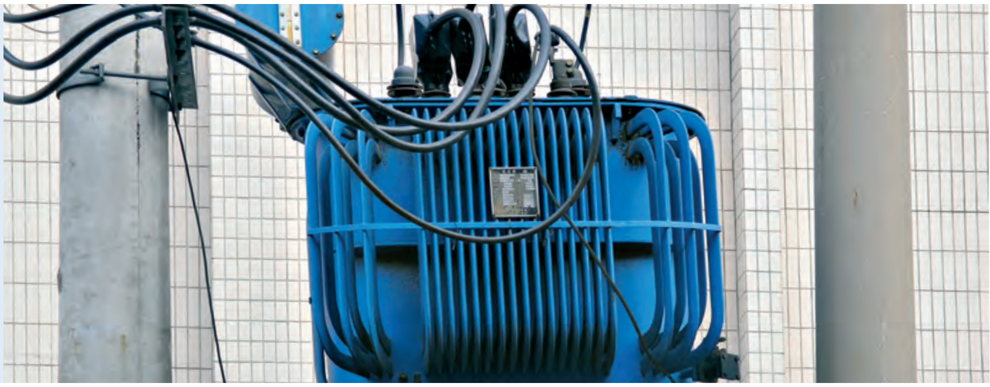
Neutral Grounding resistors are similar to fuses in that they do nothing until something in the system goes wrong. Then, like fuses, they protect personnel and equipment from damage. Damage comes from two factors, how long the fault lasts and how large the fault is. Ground fault relays trip breakers and limit how long a fault lasts. Neutral grounding resistors limit how large the fault is.

the power to protect

Neutral Grounding resistors limit the maximum fault current to a value which will not damage generating, distribution or other associated equipment in the power system, yet allow sufficient flow of fault current to operate protective relays to clear the fault.

There are two broad categories of resistance grounding: low resistance and high resistance. In both types of grounding, the resistor is connected between the neutral of the transformer secondary and the earth ground and is sized to ensure that the ground fault current limit is greater than the system's total capacitance-to-ground charging cur rent.

Low resistance grounding of the neutral limits the fault current to a high level (typically 50 amps or more) in order to operate protective fault clearing relays. These devices are then able to quickly clear the fault, usually within a few seconds.



The key reasons for limiting the fault current through resistance grounding are:

- To reduce burning / melting effects in faulted electrical equipment, such as switchgear, transformers, cables and rotating machines
- To reduce mechanical stresses in circuits and apparatus carrying fault currents
- To reduce electric shock hazards to personnel caused by stray ground fault currents in the ground return path
- To reduce arc blast or flash hazard to personnel who may have accidentally caused or who happen to be in close proximity to the fault current
- To secure control of transient over voltages

what does IEEE say about Low Resistance Grounding?

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

Clause 1.4.3 Resistance Grounding

The low-resistance method has the advantage of immediate and selective clearing of the grounded circuit, but requires that the minimum ground-fault current be large enough to positively actuate the applied ground-fault relay

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

Clause 7.2.3 Low-Resistance Grounding

The magnitude of the grounding resistance is selected to allow sufficient current for ground-fault relays to detect and clear the faulted circuit

why consider low resistance grounded over solidly grounded?

While solidly grounded systems are an improvement over ungrounded systems, and speed the location of faults, they lack the current limiting ability of resistance grounding and the extra protection this provides. The destructive nature of arcing ground faults in solidly grounded systems is well known and documented and are caused by the energy dissipated in the fault.

A measure of this energy can be obtained from the estimate of Kilowatt-cycles dissipated in the arc: Kilowatt cycles = V x I x Time/1000

100 Kilowatt Cycles	Fault location identifiable at close inspection-spit marks on metal and some smoke marks
2000 Kilowatt Cycles	Equipment can usually be restored by painting smoke marks and repairing punctures in insulation
6000 Kilowatt Cycles	Minimal amount of damage, but fault more easily located
10,000 Kilowatt Cycles	Fault probably contained by the metal enclosure
20,000 Kilowatt Cycles	Fault probably burns through single thickness enclosure and spreads to other sections
Over 20,000 Kilowatt Cycles	Considerable destruction

Comparison of Damage

2000 kvA, 480 Volt system, single phase fault current available	30,000 amps.
Solidly Grounded Assumes breaker opens in 10 cycles or 0.16 seconds	100 x 30,000 x 10 / 1000 = 30,000 KWC
Resistance Grounded	100 x 400 x 60 / 1000 = 2,400 KWC

All I-Gard's low resistance grounding products are standardized on the edgewound element design. Because of the rapid heating and very high temperatures encountered, this design has been proven superior for the NGR application.

The edgewound element material is mounted on porcelain supports, which are not affected by the high temperature or high voltages. The sturdy, helically coiled element is free to expand and does not deform when heated and offers consistent current density.

The element material is critical in ensuring high operating performance of the neutral grounding resistor. The element material is a special grade of electrical alloy with a low temperature coefficient of resistance. This prevents the resistance value from increasing significantly as the resistor operates through a wide temperature range. It also ensures a stable value of the fault current for proper metering and relaying.

Some manufacturers offer stamped and cast alloy grids resistors for low resistance grounding applications but the mica paper insulation they incorporate limits the temperature at which they can operate. The mica paper insulation can also absorb moisture and fail while the flat grid stampings may severely warp when rapidly heated. Also, the grids have hot spots which may burn when overloaded by the fault.

Typical NGR 8000 Volts, 1000 Amps 10 seconds, 760 C temperature rise as per IEEE 32.

	Material 1 AISI 304 Nickel Chrome	Material 2 Aluminum Chrome Steel 1JR (Ohmalloy)
Temp Coefficient of Resistance	0.001 ohms / C	0.00012 ohms / C
Ohms at Ambient	8000 / 1000 = 8 ohms	8000 / 1000 = 8 ohms
After 10 Seconds	8 * (1+0.001 * 760) = 14.08 ohms	8 * (1+0.00012*760) = 8.7 ohms
Operating Fault Current	8000 / 14.08 = 568 amps	8000 / 8.7 = 919 amps
Change	43.2%	8.1%

To ensure sufficient fault current is available to positively actuate the over-current relay and that the fault current does not decrease by more than 20% between ambient and the full operating temperature, it is recommended that the NGR element material to be specified to have a temperature coefficient not greater than 0.0002 ohms / C.

the power to protect

Neutral Grounding Resistors are rated in line-to-neutral voltage, initial current in amps and allowable on time. They must be capable of carrying rated current for the allowable on time without exceeding the allowable temperature rise established by IEEE 32. All I-Gard Neutral Grounding resistors are designed, rated, manufactured and tested in strict compliance with IEEE 32.

time rating and permissible temperature rise (IEEE 32)

Time Rating (on time)	**Permissible Temp.** Rise (above 30°C)
Ten Seconds (Short Time)	760°C
One Minute (Short Time)	760°C
Ten Minutes (Short Time)	610°C
Extended Time	610°C
Steady State (Continuous)	385°C*

*(CSA permissible rise is 375°C over 40°C ambient on a continuous duty)

I-Gard Neutral Grounding Resistors are CSA category certified to 8000 volts. For resistors to be certified by CSA, they must meet the following sections of the Canadian Electrical Code:

a) CAN/CSA-C22.2 No. 0-M91 - General Requirements Canadian Electrical Code, Part II

b) C22.2 No. 0.4-M1 982 - Bonding and Grounding of Electrical Equipment (Protective Grounding)

c) CAN/CSA-C22.2 No. 14-M91 Industrial Control Equipment

d) CAN/CSA-C22.2 No. 94-M91 – Special Purpose Enclosures

For resistors to be listed by UL, they must meet the following criteria:

a) UL 508 Industrial Control Equipment

b) UL 50 Enclosures for Electrical Equipment

c) UL 347 High Voltage Industrial Control Equipment

In addition, factory tests must be conducted at the conclusion of manufacture and before shipment of each resistor assembly. I-Gard is licensed by CSA, and supplies CSA certified equipment when specified by the customer.

GARD

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