

Resistance Grounding System Basics

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Resistance Grounding Systems

Resistance Grounding Systems are used in industrial electrical power distribution facilities to limit phase-to-ground fault currents. IEEE Standard 142-1991 states: "The reasons for limiting the current by resistance grounding may be one or more of the following:

1. To reduce burning and melting effects in faulted electrical equipment, such as switchgear, transformers, cables, and rotating machines.
2. To reduce mechanical stresses in circuits and apparatus carrying fault currents.
3. To reduce electrical-shock hazards to personnel caused by stray ground fault currents in the ground return path.
4. To reduce the arc blast or flash hazard to personnel who may have accidentally caused or who happen to be in close proximity to the ground fault.
5. To reduce the momentary line-voltage dip occasioned by the occurrence and clearing of a ground fault.
6. To secure control of the transient over-voltages while at the same time avoiding the shutdown of a facility circuit on the occurrence of the first ground fault (high-resistance grounding)."

Generally speaking, there are two types of resistors used to tie an electrical system's neutral to ground: low resistance and high resistance.

Ground fault current flowing through either type of resistor when a single phase faults to ground will increase the phase-to-ground voltage of the remaining two phases. As a result, conductor insulation and surge arrester ratings must be based on line-to-line voltage. This temporary increase in phase-to-ground voltage should also be considered when selecting two and three pole breakers installed on resistance grounded low voltage systems. Many 480/277V three-pole breakers, for example, carry single-pole interrupting ratings that are based on 277V phase-to-ground. Once the phase-to-ground voltage increases to 480V, the breaker's performance is not guaranteed.

The increase in phase-to-ground voltage associated with ground fault currents also precludes the connection of line-to-neutral loads directly to the system. If line-to-neutral loads (such as 277V lighting) are present, they must be served by a solidly grounded system. This can be achieved with an isolation transformer that has a three-phase delta primary and a three-phase, four-wire, wye secondary.

Neither of these grounding systems (low or high resistance) reduce arc-flash hazards associated with phase-to-phase faults, but both systems significantly reduce or essentially eliminate the arc-flash hazards associated with phase-to-ground faults. Both types of grounding systems limit mechanical stresses and reduce thermal damage to electrical equipment, circuits, and apparatus carrying faulted current.

Low Resistance Grounding Systems

Neutral Grounding Resistors (NGR's) limit the fault current when one phase of the system shorts or arcs to ground. In the event that a ground fault condition exists, the NGR typically limits the current to 200-400A, though most resistor manufacturers label any resistor that limits the current to 25A or greater as low resistance. A particular resistor may be specified as 2400V L-N, 400A, 10 seconds, meaning that the impedance of the resistor is such that 2400V applied across it will result in 400A of current through it, and that the unit can only carry this current for 10 seconds before overheating. As a rule of thumb, NGR's are designed with a continuous current rating equal to approximately 10% of its rated current. A unit that is rated 400A for 10 seconds may carry 40A (10% of 400A) continuously. In order to prevent the NGR from overheating, overcurrent protective devices must be designed to trip before the resistor's damage curve is breached. Additional GE Neutral Ground Resistor product specifications can be found on-line at http://www.geindustrial.com/cwc/Dispatcher?REQUEST=PRODUCTS&id=ngr&lang=en_US

High Resistance Grounding Systems

High Resistance Grounding (HRG) systems limit the fault current when one phase of the system shorts or arcs to ground, but at lower levels than low resistance systems. In the event that a ground fault condition exists, the HRG typically limits the current to 5-10A, though most resistor manufacturers label any resistor that limits the current to 25A or less as high resistance. HRG's are continuous current rated, so the description of a particular unit does not include a time rating. Unlike NGR's, ground fault current flowing through a HRG is usually not of significant magnitude to result in the operation of an overcurrent device. Since the ground fault current is not interrupted, a ground fault detection system must be installed. These systems include a bypass contactor tapped across a portion of the resistor that pulses (periodically opens and closes). When the contactor is open, ground fault current flows through the entire resistor. When the contactor is closed a portion of the resistor is bypassed resulting in slightly lower resistance and slightly higher ground fault current. A hand held pulsing current detector can then be used to track the ground fault to its source. A one-line diagram of the GE High Resistance Pulsing

Ground Detection System is included in Publication GEI-72116. This publication can be found on-line at [http://www.geindustrial.com/publibrary/checkout/Installation and InstructionGEI-72116PDF](http://www.geindustrial.com/publibrary/checkout/Installation%20and%20Instruction%20GEI-72116%20PDF)

To avoid transient over-voltages, an HRG resistor must be sized so that the amount of ground fault current the unit will allow to flow exceeds the electrical system's charging current. The charging current for an electrical distribution system can be measured or estimated. As a rule of thumb, charging current is estimated at 1A per 2000KVA of system capacity for low voltage systems and 2A per 2000KVA of system capacity at 4.16kV. These estimated charging currents increase if surge suppressors are present. Each set of suppressors installed on a low voltage system results in approximately 0.5A of additional charging current and each set of suppressors installed on a 4.16kV system adds 1.5A of additional charging current. A system with 3000KVA of capacity at 480 volts would have an estimated charging current of 1.5A. Add one set of surge suppressors and the total charging current increases by 0.5A to 2.0A. A standard 5A resistor could be used on this system. Most resistor manufacturers publish detailed estimation tables that can be used to more closely estimate an electrical system's charging current.

Grounding System Comparisons

Low Resistance Grounding:

1. Limits phase-to-ground currents to 200-400A.
2. Reduces arcing current and, to some extent, limits arc-flash hazards associated with phase-to-ground arcing current conditions only.
3. May limit the mechanical damage and thermal damage to shorted transformer and rotating machinery windings.
4. Does not prevent operation of overcurrent devices.
5. Does not require a ground fault detection system.
6. May be utilized on medium or high voltage systems. GE offers low resistance grounding systems up to 72kV line-to-line.
7. Conductor insulation and surge arrestors must be rated based on the line-to-line voltage. Phase-to-neutral loads must be served through an isolation transformer.

High Resistance Grounding:

1. Limits phase-to-ground currents to 5-10A.
2. Reduces arcing current and essentially eliminates arc-flash hazards associated with phase-to-ground arcing current conditions only.

3. Will eliminate the mechanical damage and may limit thermal damage to shorted transformer and rotating machinery windings.
4. Prevents operation of overcurrent devices until the fault can be located (when only one phase faults to ground).
5. Requires a ground fault detection system to notify the facility engineer that a ground fault condition has occurred.
6. May be utilized on low voltage systems or medium voltage systems up to 5kV. IEEE Standard 141-1993 states that "high resistance grounding should be restricted to 5kV class or lower systems with charging currents of about 5.5A or less and should not be attempted on 15kV systems, unless proper grounding relaying is employed".
7. Conductor insulation and surge arrestors must be rated based on the line-to-line voltage. Phase-to-neutral loads must be served through an isolation transformer.

Conclusion:

Resistance Grounding Systems have many advantages over solidly grounded systems including arc-flash hazard reduction, limiting mechanical and thermal damage associated with faults, and controlling transient overvoltages. High resistance grounding systems may also be employed to maintain service continuity and assist with locating the source of a fault.

When designing a system with resistors, the design/consulting engineer must consider the specific requirements for conductor insulation ratings, surge arrester ratings, breaker single-pole duty ratings, and method of serving phase-to-neutral loads.

Additional Reference Material:

IEEE Standard 141-1993, "Recommended Practice for Electrical Power Distribution for Industrial Plants" (Red Book)

IEEE Standard 142-1991, "Recommended Practice for Grounding of Industrial and Commercial Power Systems" (Green Book)

GE Publication GEI-72116, "High Resistance Pulsing Ground Detection System"