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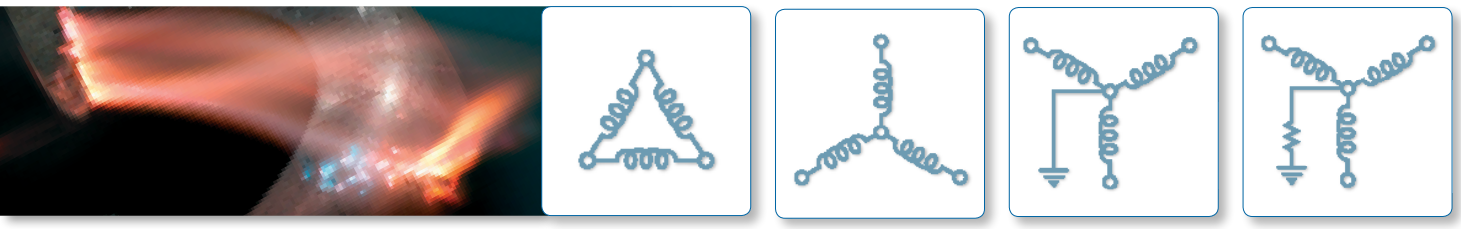
WHY HRG IS CONSIDERED AN ARC FLASH MITIGATION TECHNOLOGY BY NFPA 70E AND CSA Z462

Q&A



Webinar Q&A, April 2020

ARC FLASH MITIGATION USING HRG

Thank you for attending our webinar titled ***Why HRG is Considered an Arc Flash Mitigation Technology by NFPA 70E and CSA Z462;*** it was a pleasure sharing decades of experience with you. We are happy you had the opportunity to participate in this webinar as many people are confused about this technique because it is the only technique that does not lower incident energy. It reduces the likelihood of having a single phase to ground fault propagate to multi-phase fault and initiating an arc flash event.

HRG is the only mitigation technique that, once in place, protects the entire electrical system on the secondary of the transformer. It is also the only technique that does not sacrifice coordination when implemented.

For those of you who missed it, or would like to watch it again, both the PDF and webinar recording is available on our website. Please find the link below or visit www.i-gard.com. As always, if you have any further questions, please email support@i-gard.com and one of our support team members will gladly assist.

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QUESTIONS AND ANSWERS

Q-1. If I want to install a ground fault relay to a resistance of a transformer from 200A 10 seconds 12 Ohm, which is tripping time of the relay?

A. i. In this particular application, a duty cycle of 10 seconds is stated. This means that the relay must trip within 10 seconds of the occurrence of a ground fault. This is done to ensure that the NGR elements used do not exceed the maximum temperature rise (as per IEEE-C57.32 or CSA 295) when limiting the ground fault current.

ii. Consideration may be given to the possibility that the fault is on the line side of the secondary main. If the fault current persists after the tripping the main breaker, the primary breaker must be opened.

Q-2. Will a drive cause a false ground fault?

A. A drive will not cause a false ground fault. Most drives should be compatible with ground fault systems.

Q-3. Is HRG compatible with VFD's applications? Is there anything specific to watch for?

A. VFDs are compatible with HRG applications. One thing to watch out for is the voltage isolation to ground - which shows that a phase to ground fault will increase the voltage on the two unfaulted phases with respect to ground. Ensure that the drive manufacturer has taken the necessary precautions to allow for the extra voltage rating on the two unfaulted phases.

Q-4. Are there any considerations on sizing the NGR when ASD are present?

A. Drive manufacturers like to add capacitors to the phases to ground to filter high frequency noise caused by PWM. This will add to the distributed capacitance of the system. Although unlikely, in some cases it may require changes to the sizing of the NGR.

Q-5. Does an HRG work if we have VFD and the phase to ground fault happens at the VFD output?

A. i. Yes - With a properly executed design that protects the entirety of the motor circuit, the addition of a VFD does not change the effectiveness of the protective system in place.

ii. The drive is not a separately derived source. Any ground fault on an HRG system will return to the source. If the source is HRG then the fault will be limited to a low value. The frequency and magnitude of the ground fault will depend on the output of the VFD at the time of the fault.

Q-6. How does HRG affect cable insulation specification? (133%)

A. Table 310.1049(E) 2018 shows voltage levels between 2000-35000 V, however look under the heading for 2000-5000 V, only the 100 % is indicated. For 5001-8000V, you will note the 100% 133%, and 173%.

Table 310.104(E) Thickness of Insulation for Shielded Solid Dielectric Insulated Conductors Rated 2001 to 35,000 Volts

Conductor Size (AWG or kcmil)	2001–5000 Volts		5001–8000 Volts						8001–15,000 Volts						15,001–25,000 Volts					
	100 Percent Insulation Level [1]		100 Percent Insulation Level [1]		133 Percent Insulation Level [2]		173 Percent Insulation Level [3]		100 Percent Insulation Level [1]		133 Percent Insulation Level [2]		173 Percent Insulation Level [3]		100 Percent Insulation Level [1]		133 Percent Insulation Level [2]		173 Percent Insulation Level [3]	
	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils
8	2.29	90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6–4	2.29	90	2.92	115	3.56	140	4.45	175	—	—	—	—	—	—	—	—	—	—	—	—
2	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	—	—	—	—	—	—
1	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260	8.13	320	10.67	420
1/0–2000	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260	8.13	320	10.67	420

2021 NEC Reference

Table 311.10(C) Thickness of Insulation for Shielded Solid Dielectric Insulated Conductors Rated 2001 Volts to

Conductor Size (AWG or kcmil)	2001–5000 Volts		5001–8000 Volts						8001–15,000 Volts						15,(	
	100 Percent Insulation Level		100 Percent Insulation Level		133 Percent Insulation Level		173 Percent Insulation Level		100 Percent Insulation Level		133 Percent Insulation Level		173 Percent Insulation Level		100 Percent Insulation Level	
	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils	mm	mils
8	2.29	90	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6–4	2.29	90	2.92	115	3.56	140	4.45	175	—	—	—	—	—	—	—	—
2	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	—	—
1	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260
1/0–2000	2.29	90	2.92	115	3.56	140	4.45	175	4.45	175	5.59	220	6.60	260	6.60	260

311.10(C)(1) 100 Percent Insulation Level.
Cables shall be permitted to be applied where the system is provided with relay protection such that ground faults will be cleared as rapidly as possible but, in any case, within 1 minute. These cables are applicable to cable installations that are on grounded systems and shall be permitted to be used on other systems provided the above clearing requirements are met in completely de-energizing the faulted section.

311.10(C)(2) 133 Percent Insulation Level.
Cables shall be permitted to be applied in situations where the clearing time requirements of the 100 percent level category cannot be met and the faulted section will be de-energized in a time not exceeding 1 hour. Cable shall be permitted to be used in 100 percent insulation level applications where the installation requires additional insulation.

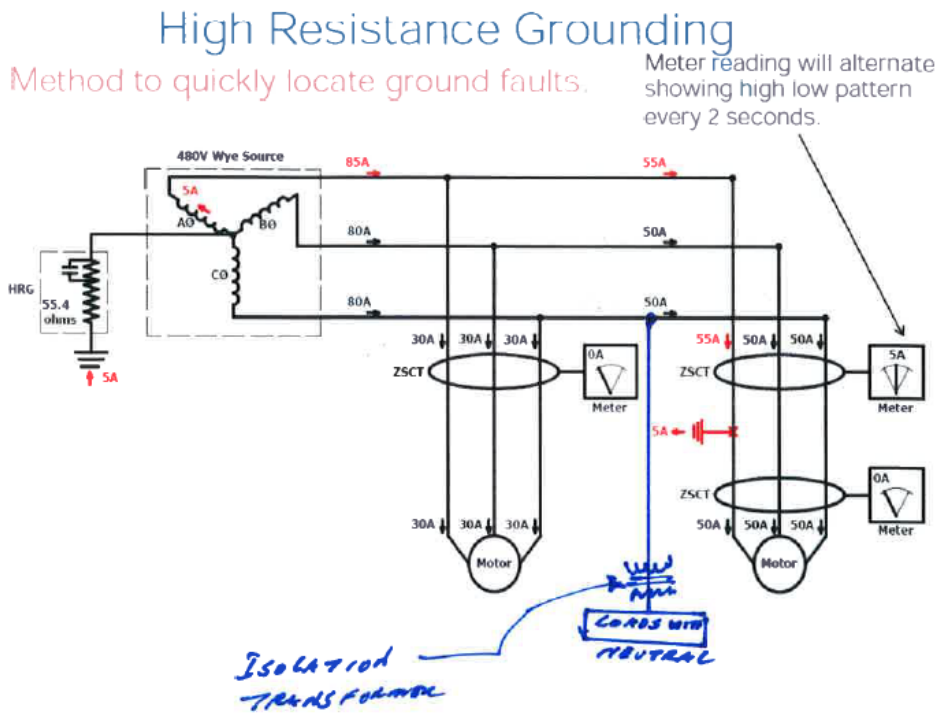
311.10(C)(3) 173 Percent Insulation Level.

Cables shall be permitted to be applied under all of the following conditions:

1. In industrial establishments where the conditions of maintenance and supervision ensure only qualified persons service the installation
2. Where the fault clearing time requirements of the 133 percent level category cannot be met
3. Where an orderly shutdown is required to protect equipment and personnel
4. Where the faulted section will be de-energized in an orderly shutdown

Q-7. What result does switching from solidly grounded to HRG have on distributing the neutral? One slide mentioned that this cannot be used on a system where the neutral is used to serve a load. Does this mean this cannot be used on 480/277V systems if there is 277V loads?

A. In the USA, the neutral will be disconnected from the system and any loads that require the neutral should be isolated for the grounded system through an isolation transformer. Refer to diagram below.



In Canada the system is permitted to remain energized on HRG if

- The system is operating at 5kV or less
- The system serves no neutral load
- The ground fault current is controlled at 10A or less and
- The impedance grounding device is rated for continuous use

In both cases, the HRG is considered as

- Arc flash mitigation system
- Reduce mechanical stresses in circuits and apparatus carrying fault currents
- Reduce electric-shock hazard to personnel caused by stray ground fault currents in the ground return path
- Reduce the momentary line-voltage dip occasioned by the occurrence and clearing of a ground fault.
- Reduce burning and melting effects in faulted electric equipment, such as switchgear, transformers, cables and rotating machines

Q-8. Please share the relationship between solidly grounded systems and motor repair requirement. What is the impact of HRG on motor's fault? How were motor repair costs reduced so substantially using a retrofitted HRG system?

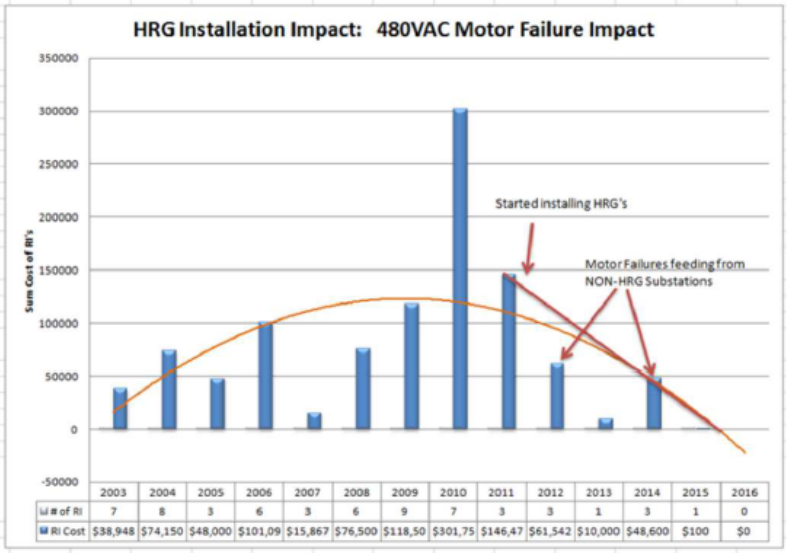


Figure 1 Motor Repair costs. [4]

A. On a solid grounded system during a ground fault, 100% ground fault current may flow through the stator & damage it, where as you are limiting ground fault current to a low level in impedance grounding resulting in less or no damage to motor. Please see advantage observed decrease in motor failures as shown. HRG limits ground fault current to a low value as such fault current may not damage motor or have limited damage

Q-9. What is referred by "line to neutral loads are not served"? Which types of loads can be classified? This seems be a major hindrance in considering NGR for our system.

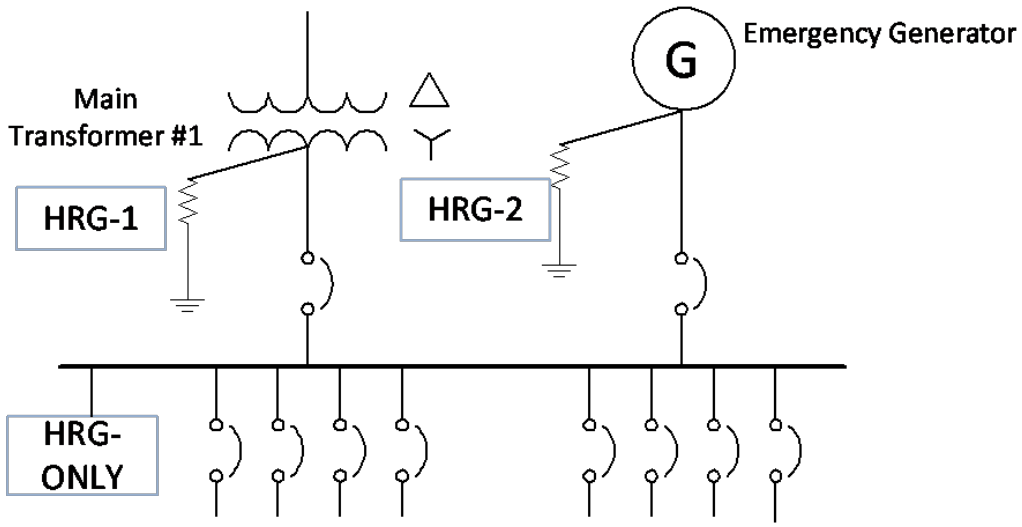
A. For the first portion of this question, see answers to questions 7 and 8. The second question is whether this is a hindrance or not. This is a good question because the isolation transformer that is used to derive the neutral for the line to neutral loads also reduces the incident energy at the ballast where the electricians would most likely repair with the most frequency. This can be seen as an added benefit.

Q-10. Can you comment on HRG applied to Data Centres?

A. Our HRG systems are applied to many dada centres to list a few

i. TD Canada Trust
ii. Ontario Provincial Police
iii. Telus Communications
iv. Rogers Communication
v. AT&T
vi. Bank of America
vii. Amazon
viii. Microsoft
ix. Apple

Our HRG systems can be used to economically benefit to datacenters. Traditional HRG Systems for multiple sources must use 2 HRG systems to monitor the NGR on each source. Our HRG system can monitor the bus independently of which source is used. This not only saves money, but is a safer system to use because the maintenance staff only need look at 1 area to see if a fault is present or not.



Q-11. Does pulsing not require relays for each feeder load?

A. Pulsing does not require any additional relays at feeders. It would help to assist where the fault is, but it is not necessary. The added benefit will provide advantages like individual feeder protection, second fault trip…

Q-12. What is the incremental cost to add the pulse detection unit into each feeder cell

A. Pulsing is not added to each feeder unless you want individual feeder protection. This can be done for very little in fee. Pulsing is added to the resistor and the entire system can use it.

Q-13. Do you always need pulsing system to locate fault? Why not just ZSCT connected to meter or ground fault meter can find the fault as well?

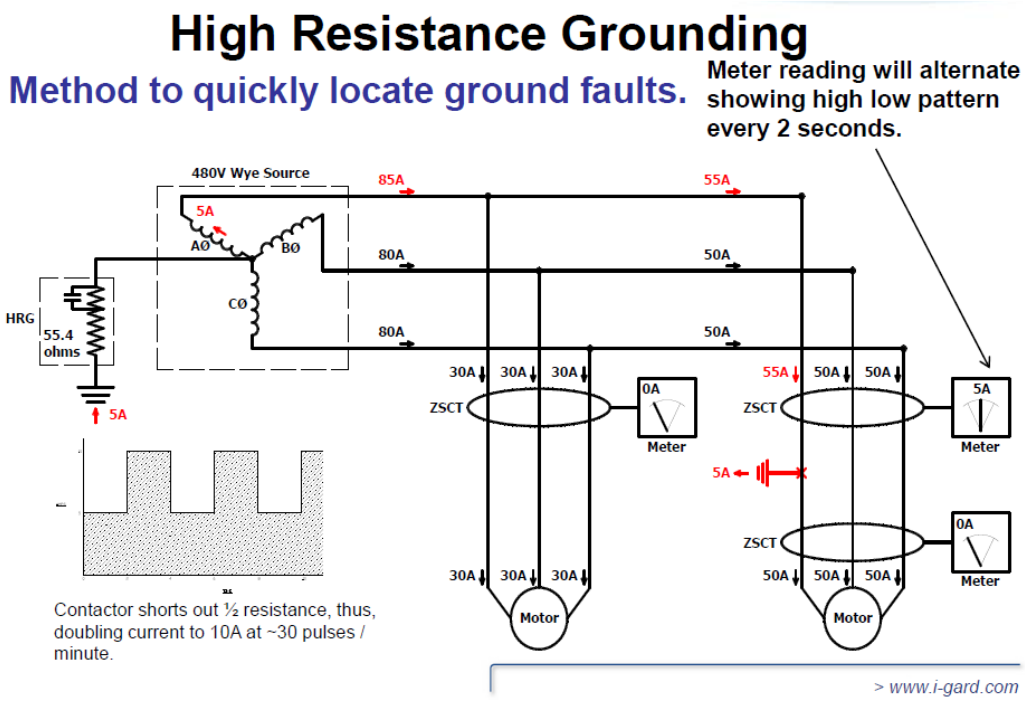
A. One can use only a ZSCT to detect where the fault is on very small systems. Once the system becomes more complex with many loads it would be extremely difficult to distinguish a fault with higher capacitive charging currents. This is why pulsing is used to separate the fault from charging current. The fault current will vary with the pulsing and the charging current will not. So Pulsing makes it far easier to find the fault.

Q-14. The picture showed the current sensor over a conduit. Will that work? Or does the sensor need to be over the cable without conduit?

A. There is a misconception in this field that current takes the path of least resistance. This is not true, current takes all paths to return to the source. This is why the signature can be observed around conduit.

Q-15. When searching for a ground fault on a system with a pulse functionality what sort of measurement do you take? Current on the system conductors, or voltage on bonded components?

A. We are looking at zero sequence currents. There is no voltage on bonded components.



Q-16. When there is not a maintenance switch available on a circuit breaker, is it acceptable to adjust the instantaneous dial to a lower setting to perform the same mitigation?

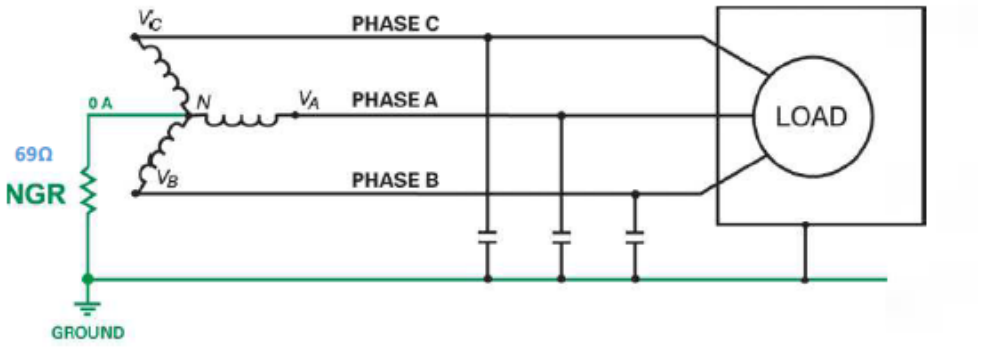
A. This is not considered a mitigation technique. It may work as an approved equivalent method , but you would have to seek approval.

Q-17. The implication of HRG is an elevation on the voltage of healthy phases. What kind of voltage protection should be used simultaneously with the HRG method?

A. Ground fault current flowing through HRG when single-phase faults to ground will increase the phase-to-ground voltage of the remaining two phases. SPD must be rated line to line with respect to ground and lightning arrestors rated line to line with respect to ground.

Q-18. So I understand the benefit of HRG as an arc flash mitigation. By doing so and allowing fault current to flow without overcurrent tripping don't you then increase the likelihood of electrical shock hazard?

A. With a HRG system, the fault current is limited to approximately 5A/10A (depending on the charging current calculation of the system). Therefore, by limiting the ground fault to 5A/10A, you have avoided the hazard



Normal 600V system

Q-19. If the NGR is open, can the sensing resistor still detect ground faults and trigger a GF alarm?

A. The ground fault relay measures ground faults by measuring the current through the NGR, this current is measured using the zero sequence current sensor (ZSCS). If the NGR is open, ground fault cannot be detected. However, our DSP system measures voltage and current, so even if the resistor is open, the DSP system will detect the presence of a ground fault by observed the neutral increase in voltage above ground and by observing the two healthy phases increase above ground thereby detecting the presence of a fault without measuring any current. We also have the Gemini system that has twin resistance paths in combination with the integrity monitoring relay. The parallel resistance circuit protects against the damaging effect of a ground fault and should the integrity of either resistor path be compromised, the second path continues to provide the necessary protection while an alarm is activated.

Q-20. Describe what happens with double ground faults on HRG

A. A double ground fault on different phases is a line-to-ground-to-line fault. In effect it is a double line fault. It will be extremely difficult to say what will open first. It could be the breaker feeding the first line to ground fault, the second line to ground fault or the breaker feeding both. With our DSP system , one can assign priorities to the feeders so that the feeder with the lowest priority will open first.

Q-21. Would this be a preferred system for natural gas compression stations in the oil field? If so what are the main advantages.

A. Resistance grounding provides the highest level of reliability and safety, especially with the volatile nature of materials used in this application; With the fault current being limited to a low level, the probability of arc flash hazards is reduced, burning and melting effects in faulted electrical equipment is minimized, and transient overvoltages are controlled.

Q-22. Are companies installing this method in their gear at this point?

A. Yes, companies across different industries and applications are implementing resistance grounding as the preferred method, because of the advantages it offers, including arc-flash hazard probability reduction, the control of transient overvoltages, and detection of faults (High Resistance Grounding).

Q-23. How common is the use of HRG in commercial applications (involving offices/retail spaces) as compared to industrial establishments where single line to ground faults still operate? Is it based primarily on the load profile? Is there any added benefit of The HRG to commercial buildings?

A. Yes load profile is one reason HRG in not as common in commericial establishments, as there is a need to service line to neutral loads present. In this case, the user would have to either provide an isolation transformer to feed these loads, or trip on a ground fault to comply with the electrical code. HRG provides the highest level of reliability and safety once these criteria have been met.

Q-24. Which rule in CEC says you have to trip on an open resistor in Canada? Would you be able to share this as we only see a 'resistor fault' LED turn on in our plants?

A. 10-300-10-308 of the 2018 CEC

Q-25. If you have a 600V system (HRG) having a 69ohm NGR and for eg the NGR faults, burns. How long can we operate without an NGR till we replace it? Is there a rule in the code that talks about the need to have an NGR on 600V? only see a 'resistor fault' LED turn on in our plants?

A. If you follow the Canadian Electrical Code the unit must trip immediately; It cannot operate with an open resistor. If you follow the NEC , there is no rule.

Q-26. Once the fault occurs, what is the maximum time in which fault should be cleared?

A. There is no time limit for the fault to be cleared on the system as per the code.

Q-27. Why we insert an NGR in the secondary neutral (lv part)of a transformer?
can we put it also in the principal part(HV)?

A. NGR is typical used to reduce fault current during line to ground fault condition. Line-Ground fault current goes back to source, which is the secondary of a step-down isolation power transformer. You can place it in the primary neutral of a step up transformer.

Q-28. Why does the HRG fault ground has to be higher than the capacitance charge current?

A. HRG let-through current should be higher than the system charging current so NGR can effectively discharge stored energy. Therefore, your system will act like an ungrounded and your system is susceptible to transient over voltage when you have an arching fault.

Q-29. Very basic question how you size or select the HRG for the system?

A. For sizing NGR, it should be higher than the charging current (3Ico) of the system. I-Gard have different line-up HRG system. It depends your requirements such pulsing or non-pulsing; feeder monitoring; second fault protection, etc. See attached brochure for different type of HRG and its features.

Q-30. If the HRG system has less damage than solid grounded on a 3PH fault doesn't that mean it has less energy?

A. If the word “energy” referred to in this question is the arc flash energy, therefore HRG system will not affect the arc flash energy for line-to-line or line-to-line-to-line arcs. HRG System limit the fault current during line to ground fault condition. During line to ground fault condition the fault current, return to the source. By inserting a resistor between the Xo (Neutral) and G (Ground), you are limiting the fault current. While line-to-line or line-to-line-to line fault, the fault current will flow between phase bypassing the resistor. Therefore, the magnitude of the fault current is higher depending on the impedance of the system where the fault occurred.

Q-31. On a transformer supplying 3 wire PDC with a 250 HP VFD, is an HRG recommended?

A. Yes this is a good place to use HRG.

Q-32. Is there a table that compares each of these strategies, against clearing time and general costs?

A. There are too many variable to consider for a table to be implemented.

Q-33. Why does the HRG fault ground has to be higher than the capacitance charge current?

A. HRG let-through current should be higher than the system charging current so NGR can effectively discharge stored energy. Therefore, your system will act like an ungrounded and your system is susceptible to transient over voltage when you have an arching fault.

Q-34. How does the arc flash maintenance switch works in switch gear?

A. Maintenance switch as defined by NFPA 70E, Clause 3 – An energy reducing switch allows a worker to set a circuit breaker trip unit to operate faster while the worker work within an arch flash boundary. Maintenance Switch is an arch flash mitigation technic, it lowers the incident energy by bypassing breaker coordination to trip faster (reducing clearing time) thereby reducing the magnitude or severity of exposure.

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