NETA

TRAINING TALK

Electrical Power Systems Industry Resource on Technical and Professional Training

SUMMER 2020: VOL. 5. NO. 1

NETA

TRAINING TALK

SUMMER 2020

A *NETA World Journal* Special Publication

A publication dedicated to disseminating information on technical and professional training for the advancement of the electrical power systems industry

AUTOMATED vs MANUAL TESTING:

BENEFITS AND CONSEQUENCES

BY RALPH PARRETT,
AVO Training Institute

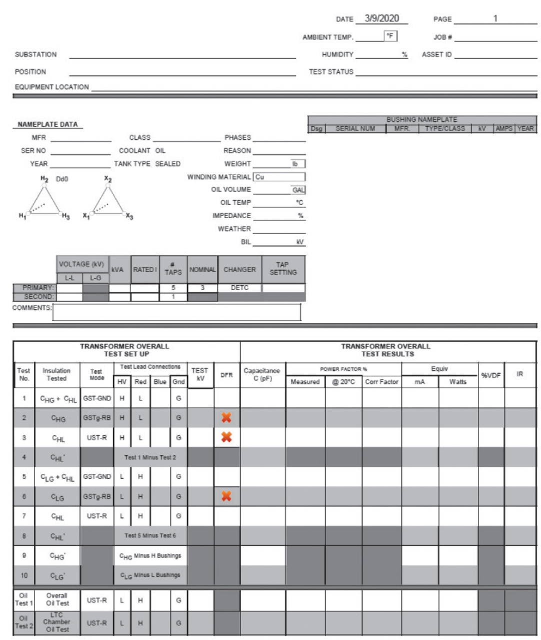
The importance of obtaining data for the purpose of trending equipment life expectancy is a well-established topic. Today's challenge is with the testing techniques and equipment used to obtain that data.

Organizations such as the InterNational Electrical Testing Association (NETA), the National Fire Protection Association (NFPA), and the Institute of Electrical and Electronic Engineers (IEEE) all release testing standards that must be followed. NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance* provides general requirements such as testing the function of a protective relay, but does not get into the detail of which tests are to be conducted for each type of protective element. NETA standards provide a foundation for the tests that should be conducted including such as insulation resistance, high-potential testing, digital low-resistance ohmmeter testing, pickup, timing, differential, etc. However, these publications do not provide detail on how to use the tests to obtain optimal results. This article looks at opportunities presented by today's test equipment capabilities.

Given today's technology, it is no surprise the automation capabilities of modern electrical test equipment have spoiled us. Automated testing has proven to be more cost and time effective and, due to its repeatability, has proven viable for creating the trending data required to foresee equipment issues. It is easy to see the benefits of automated testing, but we need to take a closer look to see where we might be left vulnerable to our dependency on the test equipment and its operating software capabilities.

TRANSFORMER TESTING

The first example is a test form that can be used when performing power factor testing on a two-winding transformer. The test form does a remarkable job at providing an interface between the user and the tests to be conducted (Figure 1). It takes approximately 20 minutes to set up the piece of equipment and 5 minutes to conduct all required tests on a two-winding transformer. Three tests on the high-side winding — high-to-ground, high-to-ground (guard low), and high-to-low — are conducted with a common, one-time connection setup and are cycled through automatically. The test set automatically switches the measurement method to obtain each reading. The technician next follows safety precautions to verify the circuit is de-energized and grounded, switches the high-voltage and return (guard) leads, and performs the same evolution for the low-side winding.



DATE 3/9/2020 PAGE 1
AMBIENT TEMP. °F JOB #
SUBSTATION HUMIDITY % ASSET ID
POSITION TEST STATUS
EQUIPMENT LOCATION

NAMEPLATE DATA
MFR CLASS PHASES
SER NO COOLANT OIL REASON
YEAR TANK TYPE SEALED WEIGHT lb
WINDING MATERIAL Cu
OIL VOLUME GAL
OIL TEMP °C
IMPEDANCE %
WEATHER
BIL kV

BUSHING NAMEPLATE						
Dsg	SERIAL NUM	MFR.	TYPE/CLASS	kV	AMPS	YEAR

	VOLTAGE (kV) L-L	VOLTAGE (kV) L-G	kVA	RATED I	# TAPS	NOMINAL	CHANGER	TAP SETTING
PRIMARY:					5	3	DETC	
SECOND:					1			

COMMENTS:

TRANSFORMER OVERALL TEST SET UP									TRANSFORMER OVERALL TEST RESULTS							
Test No.	Insulation Tested	Test Mode	Test Lead Connections HV	Red	Blue	Gnd	TEST kV	DFR	Capacitance C (pF)	POWER FACTOR % Measured	@ 20°C	Corr Factor	Equiv mA	Watts	%VDF	IR
1	$C_{HG} + C_{HL}$	GST-GND	H	L		G										
2	C_{HG}	GSTg-RB	H	L		G		✖								
3	C_{HL}	UST-R	H	L		G		✖								
4	C_{HL}'		Test 1 Minus Test 2													
5	$C_{LG} + C_{HL}$	GST-GND	L	H		G										
6	C_{LG}	GSTg-RB	L	H		G		✖								
7	C_{HL}	UST-R	L	H		G										
8	C_{HL}'		Test 5 Minus Test 6													
9	C_{HG}'		C_{HG} Minus H Bushings													
10	C_{LG}'		C_{LG} Minus L Bushings													
Oil Test 1	Overall Oil Test	UST-R	L	H		G										
Oil Test 2	LTC Chamber Oil Test	UST-R	L	H		G										

Figure 1: *Insulation Tests on Two-Winding Transformer*

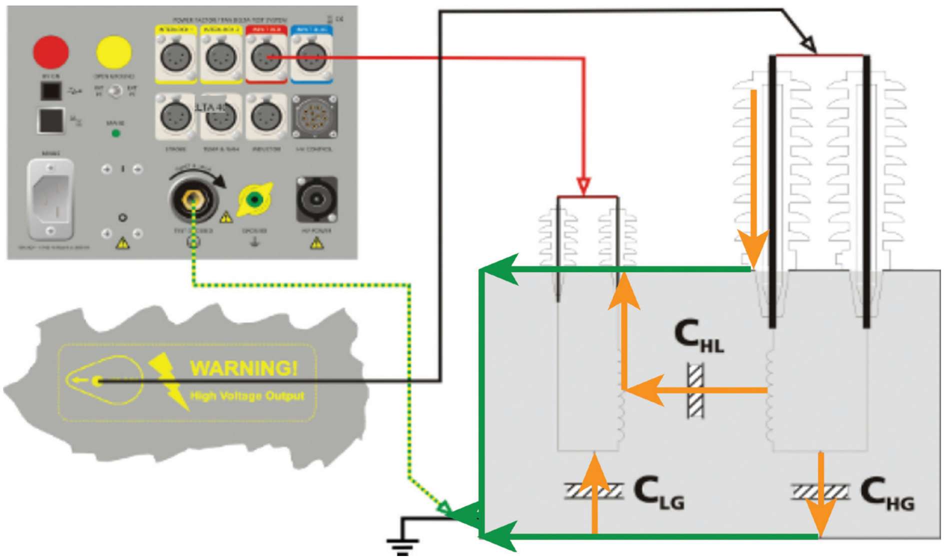


Figure 2: *High-to-Ground Test Using GST Mode*

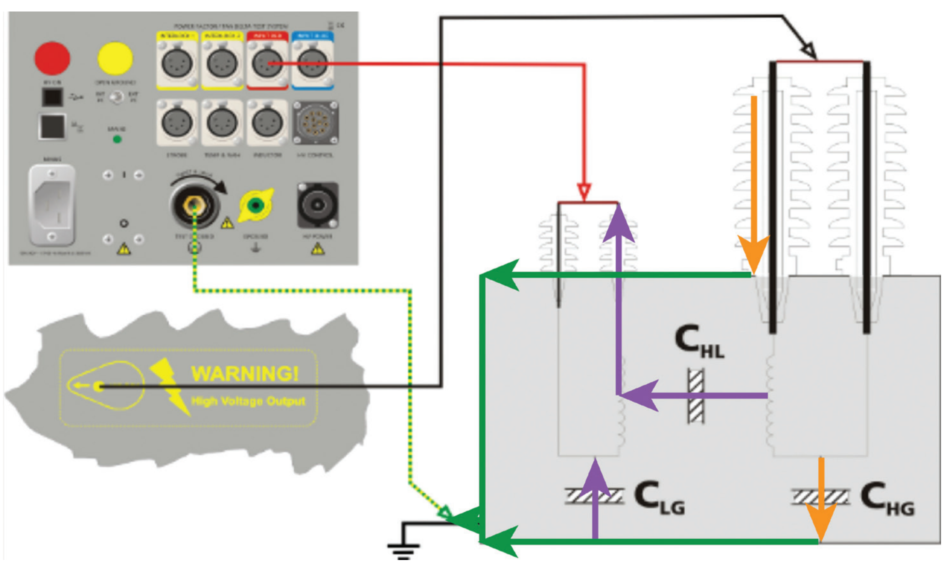


Figure 3: *Grounded Specimen Test Using Guard Terminal (GSTg) and Ungrounded Specimen Test (UST) Mode*

One downside could be that the technicians performing the tests are no longer required to have a deeper understanding of how the tests are conducted, especially the importance using various measuring methodologies to obtain each reading.

First, the high-to-ground test uses the grounded specimen test (GST) mode, which measures all leakage current found to ground (Figure 2). All leakage current sources, indicated with amber arrows, are from the high-side bushings, high-to-ground, and high-side-to-low-side-to-ground. When a GST is conducted, all currents returning to ground will be measured as indicated by the green arrows.

The second test, high-to-ground (guard low), uses the grounded specimen test using a guard terminal (GSTg); any leakage current found on the guard terminal will be subtracted, ignored, or not measured in relation to the current measured on the ground terminal (Figure 3). All leakage current sources, indicated with amber and purple arrows, are again from the high side bushings, high-to-ground, and high-side-to-low-side-to-ground. However, the leakage current measured at the guard terminal, indicated with purple arrows, will be ignored by the test equipment and removed from the leakage current measured during the GST mode used in the first test. The GSTg mode removes leakage currents associated with the low-side winding.

The final high-to-low test uses the ungrounded specimen test (UST) measurement mode; any leakage current found on the ground terminal will be subtracted, ignored, or not measured in relation to the current measured on the guard terminal (Figure 3). All leakage current sources are again from the high side bushings, high-to-ground, and high-side-to-low-side-to-ground, indicated with amber and purple arrows. However, the test equipment measures the leakage current measured at the guard terminal, indicated with purple arrows, thus providing the leakage current between the high- and low-side windings. The leakage current measured at the ground terminal is now removed from the leakage current measured during the GST and GSTg modes used in the first and second tests.

Using the GST, GSTg, and UST modes results together, it is possible to determine whether there is an internal issue due to winding shifting, for example, versus degrading or dirty bushings. Prior to development of the test forms, technicians were

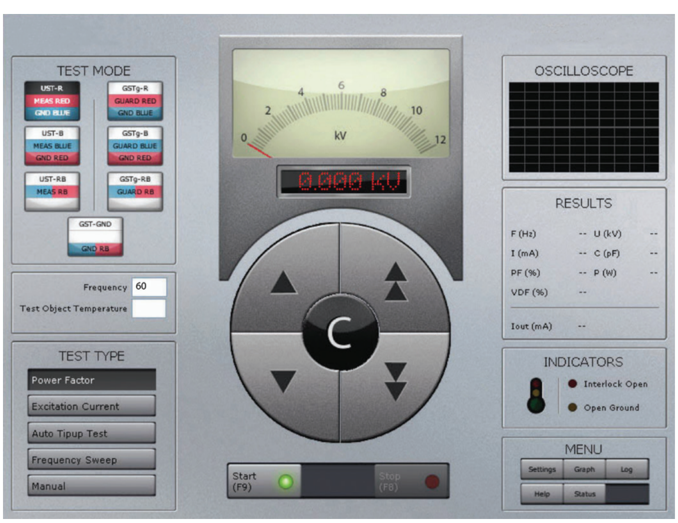


Figure 4: *Example of Software with Manual Testing Interface*

required to understand the required test modes for each test or depend on operating procedures that detailed the test methods step-by-step. In comparison, automated versus manual testing should give the same results given environmental conditions and test connections are consistent.

For some readers, this merely reviews prior knowledge and understanding. In some cases, however, it is difficult to convey this information to new up-and-coming technicians. This is where manual testing can benefit technicians new to power factor testing, and various companies offer a manual testing interface that can be used by technicians (Figure 4). Operating in manual mode requires a technician to understand which measurement mode is required based on the equipment being tested. While the manual method requires more time to accomplish the same measurements, a technician is able to exercise his or her knowledge and put skills into practice.

PROTECTIVE RELAY TESTING

Microprocessor-based protective relays can be tested using manual or automated methods that present multiple opportunities for technicians to exercising their knowledge and skills. This is due to the relay's inherent flexibility through different settings dependent on system configuration. NETA recognizes the efficiency of these relays by making the protective element testing optional, but there is value in manual single-element testing because it exercises a technician's knowledge of the element and the ability to test the element characteristics. It also keeps the industry following standardized tests for all relays regardless of their technology or application.

COMTRADE TESTING

Comtrade testing as a replacement for standardized testing may not be valid because Comtrade files only present a single scenario previously captured during a fault condition that most likely caused undesirable or nuisance tripping. However, one benefit of testing based on a Comtrade file is that it will prove that the given settings will operate accordingly.

Comtrade file testing can present negative consequences in certain instances. While a Comtrade file presents a real event, a fault characteristic is based on a number of uncontrollable factors such as weather. For example, if a Comtrade file was captured in a very dry area, the same fault would present different values if the ground was saturated due to rain. This could cause the protection scheme to operate differently.

It is also possible to edit a Comtrade file with additional characteristics to further improve the file. However, this is no longer a real event, which takes away from the major benefit or selling point that the test is from a true event.

Finally, if a Comtrade file or automated element test does not result in desired relay operation, the technician is faced with a several questions: What could have caused the undesirable operation? The relay? The test method? The connections? The test equipment? I have personally encountered each of these options and had to revert to manual testing to find the underlying issue. When a relay testing technician is trained to rely solely on automated tests — whether Comtrade file or single element — they will not be equipped to provide efficient reporting or correction when it does not perform as expected. This will require the organization to bring in a technician with higher knowledge, skills, and pay rate to resolve the issue. If the original technician had been trained on manual single-element testing and test equipment operation, perhaps they could have found and corrected the issue.

The best way to build up workforce knowledge for technicians is to ensure they understand what they are testing, the test method(s) being used, and the function of the test equipment.

CONCLUSION

Manual and automated testing must go hand in hand. The best way to build up workforce knowledge for technicians is to ensure they understand what they are testing, the test method(s) being used, and the function of the test equipment. Nothing supports the growth of that knowledge and skills like manual testing. On the other hand, manual testing in general cannot compete with the efficiency of automated testing, which saves time for the company and provides test data that is retrieved the same way every time — no matter who is operating the test equipment.

RALPH PARRETT *is a United States Navy veteran with over 13 years of professional experience relating to electrical safety and maintenance training. During his time at AVO Training Institute, his proven dedication to training led to his position as Manager of Content & Delivery. His passion has always been to provide a topnotch training experience to ensure his students are more effective and safer when they return to the workplace. Ralph has extensive knowledge of maintenance, repair, and troubleshooting of control and instrumentation, relay logic systems, ABB control systems, central control station programs, power system equipment testing and maintenance, and other various types of equipment. He has developed and taught theory, operation, maintenance, and safety of various engineering systems.*

HOW TO TEST LOW-VOLTAGE CIRCUIT BREAKER GROUND FAULT PROTECTION

PART 1

BY DANIEL CARREÑO and VOLNEY NARANJO, Megger

Selective coordination of a power system to ensure that the system is protected and power is maintained properly can be a large investment. Part of commissioning standards and maintenance procedures for low-voltage circuit breaker testing is to determine whether the circuit breaker is able to respond correctly to the faults and/or overloading conditions set in the coordination study.

When the coordination study includes ground fault (GF) as a part of the low-voltage circuit breaker protection scheme, the best approach to test these elements is to use primary injection. Techniques for detecting a ground fault in low-voltage circuit breakers include residual earth-fault, zero sequence, neutral protection, and earth leakage. Testing with primary injection ensures the applicable current transformers (CTs), main contacts, wiring, and trip unit are tested together as one complete circuit.

This paper covers the testing procedures and the challenges of ground fault testing low-voltage molded-case and power circuit breakers using primary injection such as cable length, power sources, breaker configurations, CT polarity, CT sizing, as well as why primary injection is specified by NEC standards and NETA.

NFPA 70 REQUIREMENTS

NFPA 70–2017, National Electric Code includes an update to Article 230.95(C) Performance Testing stating that the ground fault protection system shall be tested using a process of primary current injection for newly installed ground-fault protection systems. Previously, NFPA 70–2014 Article 230.95(C) stated that the test shall be conducted in accordance with instructions that shall be provided with the equipment. This often left the testing method up to an installer who may or may not be familiar with how to properly test or install the ground fault protection system. Thus, prior to 2017, it would have been acceptable to use a secondary injection method or press the trip button to test the circuit breaker.

Testing a circuit breaker with the primary injection method will ensure all circuit breaker elements are tested, including breaker contacts, current sensors, wiring, and trip unit.

GROUND FAULT DETECTION METHODS

Methods of detecting ground faults on LV systems (Figure 1) include residual sensing 3-pole (3P) or 4-pole (4P), residual sensing 3-pole with external neutral CT, zero sequence, and source ground return. Note that manufacturers may use different terminology for similar methods.

Residual sensing is known as integral ground fault sensing. It can be set up as 3P, 4P, or 3P with an external neutral CT. Residual sensing uses vectorial summation of the currents on each phase and neutral (if applicable) using separate CTs to determine a possible path to ground. If the system has a balanced load, the resulting current flow through the GF protection circuit would be equal to 0 ($I_a + I_b + I_c + I_n = 0$ = No operating current). This method detects faults downstream of the circuit breaker.

Zero sequence is similar to residual sensing where the vectorial summation of the currents is monitored, but instead of multiple CTs, there is only a single CT that encompasses all phases including the neutral (if applicable) and is external to the circuit breaker.

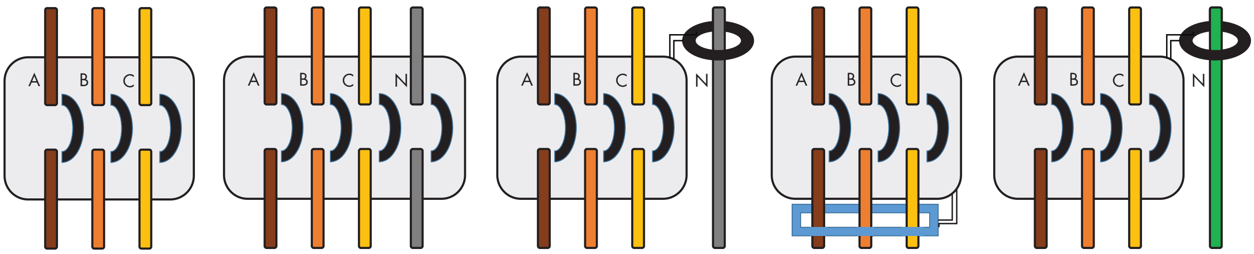


Figure 1: *Ground Fault Detection Methods on Low-Voltage Circuit Breakers: 3-Pole Residual, 4-Pole Residual, 3-Pole Residual with External Neutral CT, Zero Sequence, and Source Ground Return.*

Source ground return utilizes a CT on the ground conductor and monitors for any ground current returning to the source.

GROUND FAULT TESTING PROCEDURES

In this article, the two most common GF configurations — 3P residual sensing and 3P residual with external neutral CT — are explained in detail. These are general guidelines for ground fault testing. Please refer to the manufacturer's recommended procedures for specific testing sequences. As in any test, field challenges may be encountered that require additional actions to be able to complete the tests successfully. Examples of these challenges are related to the power source, breaker configurations, and testing leads.

Type of Tests

- **Trip test.** A trip test ensures that pickup (PU) and timing of the GF element in the trip unit is operating correctly in accordance with the manufacturer's time current curve (TCC). When the current flow direction properly replicates that of an actual ground fault, the GF element will trip the breaker if the current is high enough to be within the setting parameters.

- **No-trip test.** A no-trip test ensures the trip unit will not give a false trip, the CTs are phased and sized correctly, and the GF element is working correctly. When current flow direction is representative of load current, and the setting parameters are exceeded, the GF element will not trip the breaker because the currents have vectorially canceled each other out.

- **External neutral CT phasing and sizing (ratio verification).** Units equipped with external neutral CTs may require additional testing if those elements are activated in the trip unit. CT phasing is used to determine that the CT and connections are terminated correctly and that the polarity is correct. CT sizing is used to ensure the CT is sized to match the breaker CTs.

PROCEDURES

Prior to performing the measurements, follow the steps below to first ensure a safe test environment, and then set the circuit breaker settings. These tests are to be conducted on de-energized equipment only.

1. **Circuit breaker lockout/tagout.** Isolate the power source from the circuit breaker and follow all safety and lockout/tagout protocol before connecting any test equipment.

2. **Nameplate.** Record the circuit breaker nameplate information.

3. **Circuit breaker settings check.** Record the trip unit pickup and delay settings of all the protection elements before making any adjustments.

4. **Zone interlocking.** If the breaker is equipped with zone interlocking, it may need to be defeated before testing. Refer to the manufacturer's manual.

5. **Circuit breaker settings adjustment.**
   a. Set all long, short, and instantaneous settings to the maximum value.

b. Set GF pickup to the minimum value.
c. Set GF delay = 0.2 or 0.3. Setting to minimum may cause a nuisance trip, as a slightly higher setting may be required for better timing accuracy depending on test equipment.

Trip Test

For 3P breakers with external neutral CT, perform CT phasing and the sizing test first.

1. Test set connections (Figure 2)
a. Connect the output lead (polarity lead) to the Phase A line side.
b. Connect the return lead (common lead) to the Phase A load side.

2. GF pickup
a. The pulse method is recommended over the run-up method.
b. Apply current starting at 70% of the expected trip value in 10-,15-, or 20-cycle pulses depending on the GF delay setting.
c. Pulse up the current until the breaker trips or exceeds the accuracy percentage of the maximum trip current on the TCC.
d. Reset the breaker and decrease the current per pulse if further accuracy is needed.

3. GF delay
a. Inject a current with a magnitude of 150% of the GF pickup value.
b. Inject the current for longer than the GF delay setting. This can be accomplished by applying current in a continuous mode.

4. Verification
a. Compare the trip time against the TCC .

5. B and C phase tests: Reset the breaker and repeat this process on Phase B and then Phase C.

No-Trip Test

This procedure applies to 3P residual configurations. For 3P external neutral CT, this verification is conducted in the CT polarity test.

1. Test lead setup (Figure 3)
a. Connect the output lead from the test instrument to Phase A line side.
b. Connect a jumper from Phase A load side to Phase B load side.
c. Connect the return lead to Phase B line Side.

2. Apply current
a. Identify GF pickup setting and delay.
b. Apply 125% to 150% of GF pickup setting for longer than the delay time. Example: GF PU = 500A and GF delay = 0.3 seconds. The test could be conducted at 750A for 1.0 second.

3. Test result: Breaker SHOULD NOT trip. This confirms CT phasing is correct and the trip unit is operating correctly.

4. Repeat for other phases
a. Run test for Phase B: output lead to Phase B line side, jumper from Phase B load side to Phase C load side, return lead to Phase C line side.

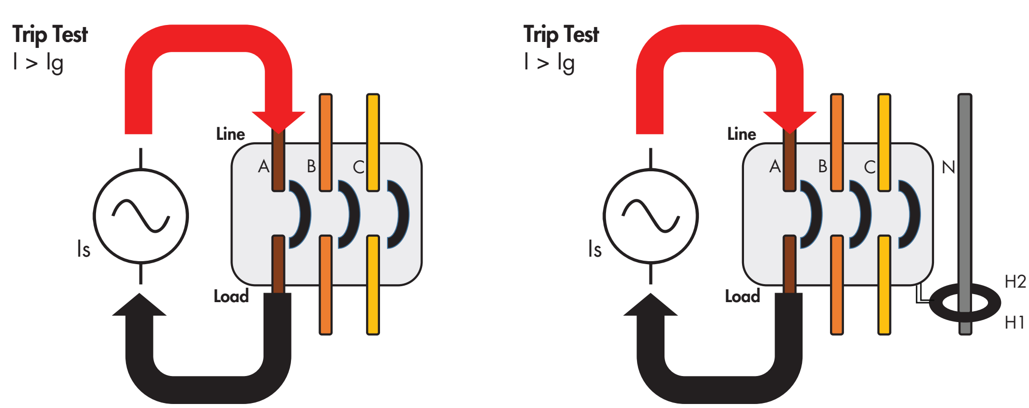


Figure 2: *Trip Test Connections*

b. Run test for Phase C: output lead to Phase C line side, jumper from Phase C load side to Phase A load side, return lead to Phase A line side.

EXTERNAL NEUTRAL CT RATIO AND POLARITY

This stage of the testing verifies that the CT polarity and ratio are appropriate for the application. Each ratio and each polarity is verified separately.

Neutral CT Polarity

The polarity marking is on H1 side of the neutral CT and may be noted with a white or red dot to help identify the side. The test verifies the orientation of the CT and the line/load termination configuration.

1. Identify marking

a. Locate the line side of the breaker.
b. Locate the polarity marking of the neutral CT.
c. Test current flow should enter through line side and follow to the polarity marking of the CT.

2. Setup test lead (Figure 4)

a. Connect the output lead from the test instrument to Phase A line side.
b. Connect a jumper from Phase A load side to neutral CT H1 side.
c. Connect the return lead to neutral CT H2 side.

3. Apply current

a. Identify GF pickup setting and delay.
b. Apply 125% to 150% of GF pickup setting for longer than the delay time. Example: GF PU = 500A and GF delay = 0.3 seconds. The test could be conducted at 750A for 1.0 second.

4. Test result

a. Breaker SHOULD NOT trip. This confirms correct phasing of the breaker and neutral CT.
b. If the breaker trips, verify and correct: Test lead setup, line/load termination configuration, neutral CT orientation, trip unit settings, and/or wiring.

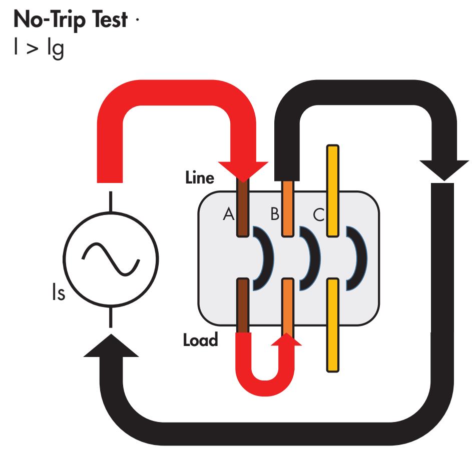


Figure 3: *No-Trip Test*

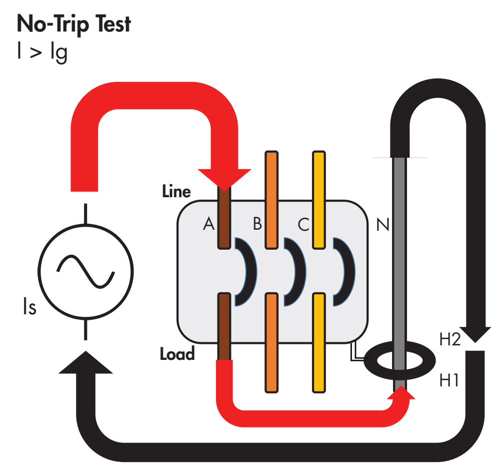


Figure 4: *Neutral CT Polarity*

Neutral CT Ratio

CT ratio should be performed to ensure the external neutral CT is properly sized with the internal breaker CTs for correct ratio.

1. Identify marking

a. Locate the load side of the circuit breaker.
b. Locate the polarity marking of the neutral CT.
c. Test current flow should enter the load side and follow to the polarity marking of the CT.

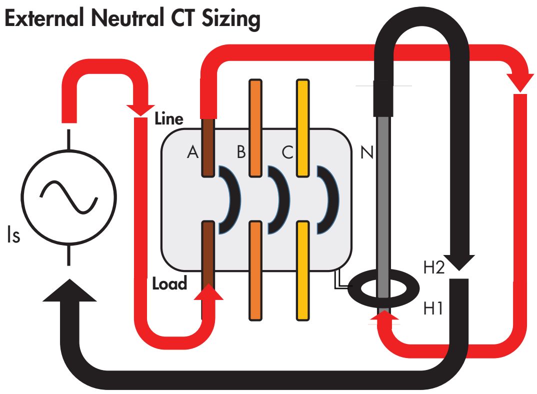


Figure 5: *External Neutral CT Sizing (Ratio Verification)*

2. Set up test lead (Figure 5)

a. Connect the output lead from the test instrument to Phase A load side.

b. Connect a jumper from Phase A line side to neutral CT H1 side.

c. Connect the return lead to neutral CT H2 side.

3. Apply current

a. Identify GF pickup setting and delay.

b. Set the instrument to pulsing method and set current at around 40% of the pickup setting.

c. Apply current and ramp up the current in small increments toward 50% of the pickup current. Example: GF PU = 500A. Start current: 200A, increments of 5A up to 250A.

4. Test Result

a. The current being sensed by the trip unit should appear as double the injected current.

b. The circuit breaker should trip at half of the trip unit setting if the ratios are matched between the external and internal CTs. Example: The injected current approaching 250A will look like 500A to the trip unit, which should pick up or trip.

CONCLUSION

These steps are the general framework to test the most common ground fault detection systems for low-voltage protection. Adapting these to each specific condition and documenting the results will comply with NEC –2017 230.95(C) requirements.

There will be challenges to overcome when implementing these steps in each case. These will be covered in Part 2 of this article in the next issue of *NETA World*. Aspects such as power source requirements, breaker configurations, trip units, connection methods, and test leads will provide a thorough resource to achieve efficient and effective testing and compliance.

DANIEL CARREÑO *is an Applications Engineer with Megger specializing in transformer testing, batteries, and high-voltage circuit breakers. His previous experience includes working for power transformer manufacturers in the United States and Mexico. Daniel is an IEEE-PES member and actively participates in substation equipment condition assessment and applications development. He graduated from Instituto Politécnico Nacional in Mexico City, with a BS in mechatronic engineering.*

VOLNEY NARANJO *has been with Megger for over eight years as an Application Engineer focusing on power transformers, high-voltage circuit breakers, battery, and power quality testing. He has over 17 years of experience working in the power engineering industry, providing professional services for design, and testing and commissioning of power systems as a Field Engineer and Project Manager. Volney is a member of IEEE-PES. He graduated from the University of Valle in Cali, Colombia, with a BS in electrical engineering.*

HOW DO YOU START TRAINING YOUR TEAM?

BY CHUCK BAKER, SDMyers

Jim worked in the field as an electrical test technician for 16 years before he was promoted to operations coordinator. He filled that role for three years and eventually became the operations manager. He has been in this role for more than four years and is considered excellent at what he does.

The company Jim works for provides electrical testing, breaker and relay services, base transformer services, and an electrical system maintenance inspection service. Jim manages seven senior technicians, three technicians in their last year of apprenticeship, and three technicians in their first two years of apprenticeship — and as of this spring, four new hires… total newbies.

Phillip, a senior technician, is teamed with Eric, one of the newbies. This is the historic method of training newbies: Team them with an expert. Phillip is an eighteen-year veteran and a true expert in this business. Eric is only a year into the program, but he enjoys working with Phillip.

Jim paired Phillip and Eric to ensure good cross-training during the apprenticeship. After 6 months, Jim sits down with Phillip to see how Eric is doing and how he is reacting to the challenges in the field.

Phillip explains some of the highlights of this working relationship and Eric's growth:

- Intelligent, learns quickly and retains
- Good initiative, self-motivated
- Still in the early stages with breaker servicing and testing
- Still in the early stages with testing relays and transformers
- Hasn't started providing the maintenance inspection services

Jim says thank you, keep me posted; they shake hands and head their separate ways.

The problem is Jim and Phillip are both falling short on training Eric… and it is not going to get any better. Jim forgets that during his 16 years in the field, he learned the hard way, trial and error in a business where we can't make mistakes. He was average but slowly learned by observing and doing.

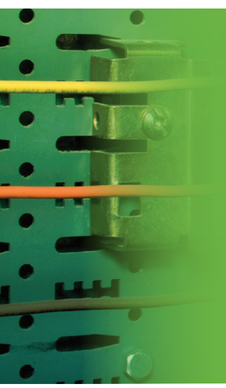
Today, Jim is getting work done by counting on the seven senior technicians on all key projects. What he hasn't taken the time to think through is that over the next four years, two of these seven will retire, one will be promoted into ops management, and one will leave the company. These four vacancies will not be filled with equally experienced candidates — they represent an average of 21 years of experience. The apprentices won't be near where they need to be to fill in. This is going to happen, and there is no natural way to prevent or manage it.

In the 70s, 80s, and 90s, we had steady growth on new hires being trained by experience and exposure. Most averaged 8 to 10 years to secure the fundamentals. Training regulations, work hours, DOT hours, and annual training were much less stringent than they are today. Over the last 20 years, we have had such strong expertise we could just tackle things as they come. Today, we have high rates of retirement that can't be replaced by the natural field experience training we had in the past.

Now back to the story.

Kevin is a senior technician. Wednesday morning, Kevin's wife called to let Jim know that Kevin was in the hospital with appendicitis; surgery was scheduled for later today. Jim asked her to keep him posted and let her know he would help wherever possible.

Jim checked the schedule board. In two weeks, a 36-hour outage at a customer's site included servicing a large number of low-voltage breakers. Kevin was scheduled to perform the high-current breaker testing during the second of the three 12-hour shifts. No one else was available. The rest of the crew were the newer guys, and they were assigned to remove the breaker, clean the contacts and arc chutes, torque test the connections, and move the breaker to the test stand. The schedule is so tight Jim doesn't have an alternative lead test tech to meet the schedule.



Today, we have high rates of retirement that can't be replaced by the natural field experience training we had in the past.

At 1:15 AM two weeks later, Jim stood on the factory floor with breakers lined up for testing. He wiped the sweat off of his brow, took a deep breath, and determined that things were going to get worse before they got better unless he made some changes.

He headed into the office and started one of the best projects to help the company: He assembled an aggressive training program. He acknowledged his shortfalls and the fact he was going to lose expertise faster than it could be generated through traditional means, and he developed an alternative program.

He researched and mapped out some key points:

1. Current and future market demands and the required manpower to accomplish this work:
   a) Lead test person
   b) Lead mechanical person
   c) Laborer
2. He looked at the trends of workflow, typical scheduled outages, frequency, and required manpower.
3. He set up an outline of the ideal number of workers that would be needed and the level of expertise that would be required.
4. He did some industry research and determined the impact of worker retirement and worker turnover.
5. He put the numbers together and determined the best scenario he could create to make the program work and combat the reality they faced.

Next, he called a meeting with Otto, Vice President of Operations, and Karen, President. The meeting started out with an interesting approach. He explained he had mapped out the direction they were heading with work steadily increasing and expertise steadily decreasing. He explained that the traditional learning-by-doing couldn't keep up with this pace. He jumped to the bottom line when he said, "And I need $90,000 over the next 6 months to turn this around." Karen's left eyebrow slowly lifted, and Otto cleared his throat and asked for some explanation on why this money was needed and what was going to be accomplished.

Jim had their attention and began to walk through what this investment would do.

1. We will send the three technicians in their last year of apprenticeship to two weeks of training on breaker testing and services.
2. We will send three of our senior technicians to two weeks of relay testing (currently only three of the seven have this expertise).
3. We will purchase a variety of used breakers and relays and set up a test training station in the shop. He explained that 25% of the time 25% of their crews are unapplied. With this investment, every available minute would be used to aggressively have our experienced techs train our less experienced techs. This training would be proactively scheduled, performed, and recorded, and everyone would be tested for expertise.
4. We will send two of our senior techs and two of our newbie techs to transformer maintenance training, levels 1–3.
5. Everyone who attends formal training will work with Cindi to walk through our current SOPs and make sure all are up to date. We will create quarterly refreshers on all SOPs for every technician.

6. Most important — and it's included in the $90,000 budget — unscheduled crews will be sent to jobs that would further their training goals. They will shadow the experts and perform work under the direction of the senior technicians.
7. The $90,000 budget is for the first year and includes the purchase of used equipment. Jim estimated that a continual and aggressive training program would average about $25,000 per year thereafter.

Jim showed Otto and Karen the various training programs he wanted to use for the specialized training, walked through each technician, and explained which technicians would best be sent to the various training options.

When he finished, he added one more key summary they needed to hear before discussion opened. He explained that, on average:

- A fully trained technician would provide:
  a) Additional adders on site because he will see other problems outside the scope.
  b) Scheduling flexibility because if the tech can handle whatever opportunities pop up, then additional work will be quoted, won, and performed.
  c) The unplanned loss of a technician due to attrition will have reduced impact.
  d) The quality and margin on field jobs will increase due to expertise and efficiency.
- The company's preventive maintenance inspection business could grow with the increased expertise, and it was a great business to fill in openings between key jobs
- Jim would find himself in the steel mill wiping his brow at 1:15 AM a lot less often.

The most inefficient method of training is during a normal field job.

"Any questions?" he asked. Otto smiled, and Karen said, "Let's do it; we should have started years ago."

CONCLUSION

The most inefficient method of training is during a normal field job. When techs have to work a 12-hour day, there are endless trips to the truck, splitting up the work between the two techs, the senior tech having to do the high-tech work, and traveling between jobs… you get the point. You have to take a step back, evaluate what you want, where you are, and how you are going to close the gap.

Because of the strong need for advanced technical training, the market has responded, and fantastic training is available. The more we train, the more secure and profitable our services businesses will be. We are losing expertise faster than we can create it, and we need outside help from training experts. If you think about it, this is an exciting time for our business, and our growth over the last 36 months has been fantastic. Let's match that with the growth of our expertise and provide more opportunities for our field crews.

CHUCK BAKER *is the General Manager of the SDMyers Electric IQ Division, which offers a variety of training courses related to transformer maintenance. Chuck entered the world of substation and power maintenance 36 years ago and has spent a majority of that career on the operations side of power and distribution system maintenance and the development of power system maintenance programs.*

COMPUTER-BASED TRAINING: PLEASE STEP INSIDE

BY JAMES R. WHITE, Shermco Industries

How does computer-based training (CBT) fit into the training plan? CBT includes video tape, YouTube or anything like it, computer interactive programs, and satellite training. The advantages of CBT are obvious: lower per-person cost, ability to train whenever employees are available, more employees can participate, and ease of running CBT. All these make CBT desirable.

Using CBT poses several problems, however:

- It has been proven to be the least effective methodology, which is why NFPA 70E has not approved of it in past editions.
- Initial costs to develop interactive training can be quite high.
- OSHA does not accept CBT for initial training where employees have high-risk tasks.

> *Use of computer-based training by itself would not be sufficient to meet the intent of most of OSHA's training requirements.*

Back when nuclear power stations were first coming on line, I taught at several (36, in fact). I noted they all had extensive video training libraries. I asked one training manager why they would bring me in if they had such an extensive video library. He answered that they had found video training was okay for refresher training or sometimes basic training, but it was inadequate for technical training. They could only bring in an outside trainer once; then they had to do the training in-house. I was also told that the Nuclear Regulatory Commission (NRC) would not approve of CBT as the only method. The impression I got from my conversations was that the video tapes mostly sat on the shelf.

OSHA's Letter of Interpretation dated November 22, 1994, states:

Question 1. *What is OSHA's position on computer-based training programs for cognitive training?*

Answer: *In OSHA's view, self-paced, interactive, computer-based training can serve as a valuable training tool in the context of an overall training program. However, use of computer-based training by itself would not be sufficient to meet the intent of most of OSHA's training requirements, in particular those of HAZWOPER. Our position on this matter is essentially the same as our policy on the use of training videos, since the two approaches have similar shortcomings. OSHA urges employers to be wary of relying solely on generic, "packaged" training programs in meeting their training requirements. For example, training under HAZWOPER includes site-specific elements and should also, to some degree, be tailored to workers' assigned duties.*

Safety and health training involves the presentation of technical material to audiences that typically have not had formal education in technical or scientific disciplines, such as in areas of chemistry or physiology. In an effective training program, it is critical that trainees have the opportunity to ask questions where material is unfamiliar to them. In a computer-based program, this requirement may be providing a *telephone hotline so that trainees will have direct access to a qualified trainer.*

Equally important is the use of hands-on training and exercises to provide trainees with an opportunity to become familiar with equipment and safe practices in a non-hazardous setting. Many industrial operations, and in particular hazardous waste operations, can involve many complex and hazardous tasks. It is imperative that employees be able to perform such tasks safely. Traditional, hands-on training is the preferred method to ensure that workers are prepared to safely perform these tasks. The purpose of hands-on training, for example in the donning and doffing of personal protective equipment, is two-fold: first, to ensure that workers have an opportunity to learn by experience, and second, to assess whether workers have mastered the necessary skills. It is unlikely that sole reliance on a computer-based training program is likely to achieve these objectives.

Thus, OSHA believes that computer-based training programs can be used as part of an effective safety and health training program to satisfy OSHA training requirements, provided that the program is supplemented by the opportunity for trainees to ask questions of a qualified trainer, and provides trainees with sufficient hands-on experience.

OSHA's LOI applies not only to hazardous waste operations and emergency response (HAZWOPER) workers, but to all workers who face the types of hazards and risk that can cause serious injury or death. Essentially, it says that initial training must have an instructor to answer questions directly and perform hands-on lab sessions, such as doffing and donning PPE. CBT is not prohibited by OSHA; it can be used to augment refresh training.

NFPA 70E states in Section 110.2(A)(4):

Δ (4) Type of Training. *The training required by 110.2(A) shall be classroom, on-the-job, or a combination of the two. The type and extent of the training provided shall be determined by the risk to the employee.*

The triangle indicates a new section was added to the 2018 edition. NFPA 70E agrees with the OSHA LOI that CBT can be used for refresher training, but if you review the requirements for initial training in 110.2, it should be readily apparent that these requirements cannot be achieved by CBT.

Years ago, I was part of a team that looked at satellite training, which seemed to meet all of OSHA's requirements. The problem was that the equipment to conduct such training was so expensive only community colleges were able to implement it, and it was therefore available to only a small group of community colleges that had this equipment. On the plus side, the instructor could present almost any hands-on subject by providing students with the equipment in front of them and the instructor performing hands-on exercises over video. He could also solicit and answer questions immediately. Very neat and effective, but also very expensive, and I'm not certain whether it is used any more. An alternative available today is web-based training, where interaction is also possible.

If a technician knows he has to perform a test he hasn't done in a while, he can quickly bring himself up to speed on his cell phone.

Our company conducts hands-on, instructor-led initial training. For refresher training, we use a dedicated YouTube channel so our technicians can get training and company updates as well as a quick refresher for a test they may not have done. This over-the-air (OTA) type of training adds a new depth to the training experience. If a technician knows he has to perform a test he hasn't done in a while, he can quickly bring himself up to speed on his cell phone. Each week, a new safety program is offered to all technicians, and they are encouraged to get together and discuss it with each other and their supervisors. If there is an incident, all employees are notified and warned about what they should or should not do to avoid a repeat. Technical issues are also addressed, such as problems we have found with the installation of underground cables at wind-generation sites.

The list of uses goes on, and we are discovering ways to increase the effectiveness of our technicians. Yes, initial training for electrical technicians should almost always be instructor-led. Questions are going to be asked and need to be answered, as OSHA implies, "immediately." One thing to keep in mind is that retraining — not refresher training — is required by NFPA 70E every three years. Refresher training can occur any time between those three-year intervals, but every three years, technicians must receive training that allows them to ask questions and get them answered. That is difficult using CBT.

CONCLUSION

Training is not just optional or something to get behind you. It's an important part of keeping technicians safe and growing their expertise. Of course, it is not the only part. Good procedures, safe work practices, and the ability to get technicians involved in the process all enhance worker safety. Be certain you provide effective training that meets both OSHA regulations and NFPA 70E standards.

JAMES (JIM) R. WHITE, *Vice President of Training Services, has worked for Shermco Industries Inc. since 2001. He is a NFPA Certified Electrical Safety Compliance Professional and a NETA Level 4 Senior Technician. Jim is NETA's principal member on NFPA Technical Committee NFPA 70E®,* Standard for Electrical Safety in the Workplace®, *NETA's principal representative on National Electrical Code® Code-Making Panel (CMP) 13, and represents NETA on ASTM International Technical Committee F18,* Electrical Protective Equipment for Workers. *Jim is Shermco Industries' principal member on NFPA Technical Committee for NFPA 70B,* Recommended Practice for Electrical Equipment Maintenance *and represents AWEA on the ANSI/ISEA Standard 203* Secondary Single-Use Flame Resistant Protective Clothing for Use Over Primary Flame Resistant Protective Clothing. *An IEEE Senior Member, Jim received the IEEE/IAS/PCIC Electrical Safety Excellence Award in 2011 and NETA's Outstanding Achievement Award in 2013. Jim was Chairman of the IEEE Electrical Safety Workshop in 2008 and is currently Vice-Chair for the IEEE IAS/PCIC Safety Subcommittee.*

Megger's Testing Tactics Webinar Series 2020

Learn valuable testing tips and tricks from Megger application engineers and product managers. In this webinar series, our experienced staff will show you how to make your testing more efficient by sharing their lessons learned in the field. You will find answers to frequently asked questions, learn how to avoid the most common mistakes, and accelerate your testing.

Upcoming Webinars

- **An Insight into End to End Testing Philosophy**
  May 22, 2020 | Presenter: Sughosh Kuber
- **Off-line Partial Discharge Testing of Rotating Machines**
  June 19, 2020 | Presenter: Charles Nybeck
- **Feeder Protection in Power Distribution Systems**
  July 17, 2020 | Presenter: Abel Gonzalez
- **Narrow Band Dielectric Frequency Response – Application on HV and EHV OIP Bushings**
  August 21, 2020 | Presenter: Diego Robalino
- **MV and HV Circuit Breaker Testing beyond Timing and Travel Measurements**
  September 18, 2020 | Presenter: Volney Naranjo
- **State-of-the-Art Diagnostics Technologies for Proactive Cable Condition Assessment**
  October 23, 2020 | Presenter: Robert Probst
- **Fundamentals of Motor Protection**
  November 20, 2020 | Presenter: David Beard
- **LV Circuit Breaker Ground Fault Protection Utilizing Primary Injection Test Method**
  December 18, 2020 | Presenter: Daniel Carreno

Previous Webinars

- **Best Field Practices for Testing Instrument Transformers: CTs, VTs, CVTs**
  November 15, 2019 | Presenter: Daniel Carreno
- **Tan Delta Testing on Medium Voltage Cables**
  December 20, 2019 | Presenter: Javier Ruiz
- **Fundamentals of Partial Discharge Measurements**
  January 24, 2020 | Presenter: Charles Nybeck
- **DC Insulation Resistance Testing: Effective Use of Guard Terminal**
  February 21, 2020 | Presenter: Nick Rees
- **Understanding Sweep Frequency Response Analysis and Best Field Practices**
  March 20, 2020 | Presenter: Sanket Bolar
- **MV and HV Cable Fault Location Utilizing ARM Method**
  April 17, 2020 | Presenter: Javier Ruiz

How to Join Megger Webinar Series

- **Megger Webinars are held on the 3rd Friday of every month.**
- **Time: 10:00 AM Central Time**
- **Sessions are FREE**
- **Earn 1 NETA CTD and 1 PDH or 0.1 CEU**
- **us.megger.com/webinars**

Earn Credits

Megger has partnered with NETA (InterNational Electrical Testing Association) in North America to present **Testing Tactics**, a special monthly webinar series that allows webinar registrants to receive NETA CTDs (Continuing Technical Development Credits) for attending the live webinar.

- Only attendees of the live **Testing Tactics** webinar sessions are eligible to receive 1 NETA CTD (Continuing Technical Development Credit) and 0.1 CEU (Continuing Education Units) or 1 PDH (Professional Development Hour) for each webinar attended.
- Live attendees of the webinar will also receive a PDF copy of the PowerPoint presentation.

Shermco Industries: Your Electrical Safety Experts

CEUs available from IEEE

Shermco is a leader in electrical power systems maintenance, repair, and testing, and for years, we have trained others in those skills. Offering onsite, classroom, and hands-on training, Shermco conducts a wide variety of courses covering Electrical Systems Maintenance, Electrical Safety, and Electrical Technical Skills. Some of the most influential leaders in electrical safety work at Shermco Industries, and now you have direct access to that experience and expertise! Shermco offers technical and electrical safety programs year-round and at multiple locations in the U.S. and Canada. **NETA CTDs and CEUs through IEEE are available for most courses where applicable. Train with the experts. Train with Shermco.**

Shermco University Distance Learning Courses

- **Electrical Safety Refresher**
- **Electrical Safety for Qualified Electrical Workers**
- **Electrical Safety for Managers**
- **Electrical Safety for Non-Electrical Personnel**
- **Electrical Safety for Utilities**
- **National Electrical Code**
- **Company Custom Courses**

How Does Distance Learning Work?

Teleconference courses are taught face-to-face and allow live interaction between instructor and students even though they may be in different geographic locations. Synchronous tools such as text chat, audio chat, or video chat will provide students with real-time access to the instructor while the class is in session.

Class size limited to twenty (20) participants.

Call and reserve your seat today.

Shermco industries

Enroll today by visiting www.shermco.com/training or call 888-Shermco.

For more information, to download our current course catalog, or to register online, go to www.shermco.com/training or email trainingservices@shermco.com

SHERMCO.COM • 888-SHERMCO

NETA ACCREDITED COMPANY