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TRAINING TALK

Electrical Power Systems Industry Resource on Technical and Professional Training

FALL 2021: VOL. 6, NO. 2

NETA

TRAINING TALK

FALL 2021

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

THE TECHNICIAN'S APPROACH TO $\sqrt{3}$ × LINE = LINE TO LINE

BY RALPH PARRETT, AVO Training Institute

Over my 10 years as a technical instructor, students have voiced a common question regarding this topic. For years, this same question was somewhat difficult for me to explain other than simply taking the math for what it was.

Over time, however, I have developed a consolidated and simplified method of explaining and demonstrating the relationship between phase-to-neutral versus phase-to-phase voltage through visual representation. While this explanation is based on trigonometry, it is straightforward when the technician draws or graphs the values stated below. To easily identify the different values in this explanation, three different colored pens plus a ruler and a protractor are utilized along with "1 inch is equivalent to 1 voltage."

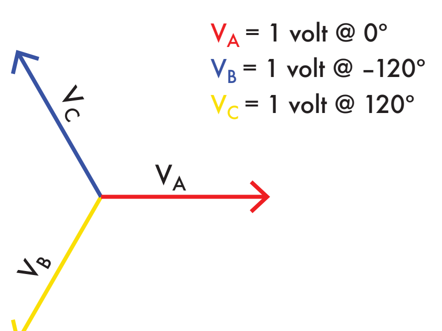


Figure 1: *Step 1*

To begin, a simple system to use is a balanced 3-phase system with magnitudes equal to 1 volt (1 inch) and 120 degrees of separation between the phases (Figure 1). To determine the value of V_{AB}, place the vector of V_B on the end of the V vector.

V_B will be used as a reference point for another voltage at its non-polarity node. Thus, it will cause the vector representing V_B to be 180 degrees from its polarity vector (Figure 2).

Note: The length of the non-polarity vector of V_B is equal to its polarity reference.

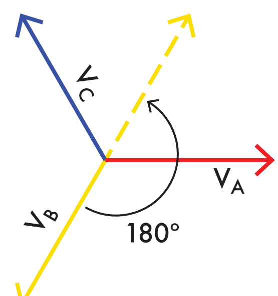


Figure 2: *Step 2*

The angular relationship of the non-polarity VB to VA becomes 60 degrees V_B leading V_A. Then, by moving the resultant V_B vector to the end of V_A, finding V_{AB} becomes easier (Figure 3).

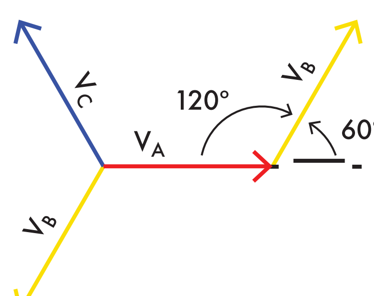


Figure 3: *Step 3*

Then, measure the distance from the point of origin to the end of the non-polarity V_B, which measures out to approximately 1.732, given that 1 inch is equal to 1 volt (Figure 4). Then measure the angular displacement from V_A and find that V_{AB} leads V_A by 30 degrees.

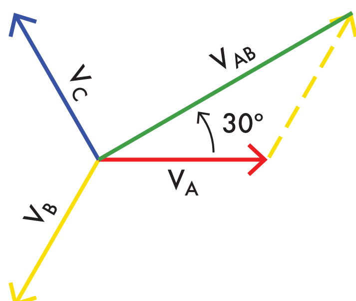


Figure 4: *Step 4*

USING TRIGONOMETRY

If measuring the angle and voltage manually is not precise enough, find the magnitude of the resultant vector V_{AB} using trigonometric functions. To begin, take the triangle shown in Figure 4 and create two right triangles, as shown in Figure 5. Now, it is clear that the 1-volt vectors form the hypotenuses of both right triangles.

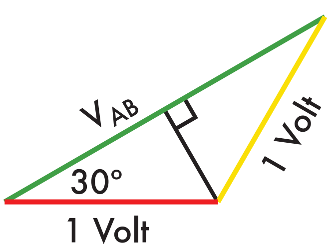


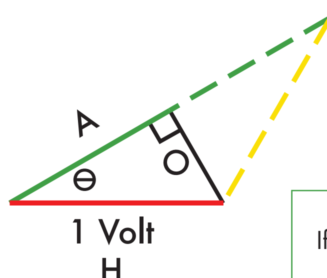
Figure 5: *Using Trig*

As shown previously, the angular separation between V_{AB} and V_A is 30 degrees. However, suppose the angle is still unknown. Refer to Figure 3 and look at the two marked angles: one being 60 degrees, which demonstrates the relationship of non-polarity V_B from V_A; the other being 120 degrees, which demonstrates the opposite angle. Now look at Figure 5 where the 120-degree angle is split in half, creating two 60-degree angles. Knowing that the sum of the angles of any triangle is 180 degrees, combine 60 degrees with 90 degrees (as the triangle is a right triangle) and subtract the sum from 180 degrees. This provides a result of 30 degrees as the angular separation between V_{AB} and V_A.

While this explanation is based on trigonometry, it is straightforward when the technician draws or graphs the values.

At this point, use the information gathered to find the length of the final side. The 30-degree angle can serve as the focus of the trig function. As that angle is θ (theta), the 1-volt magnitude of V_A serves as the hypotenuse (H) of the triangle.

The unknown magnitude of the resultant vector V_{AB} then becomes the adjacent (A) side of the right triangle. See Figure 6 for an illustration of the right triangle as well as equations for the three main trig functions. Using the cosine function, the adjacent side can be found using the available information.



$$\text{SIN } \Theta = \frac{\text{Opposite}}{\text{Hypotenuse}}$$

$$\text{COS } \Theta = \frac{\text{Adjacent}}{\text{Hypotenuse}}$$

$$\tan \Theta = \frac{\text{Opposite}}{\text{Adjacent}}$$

If $\cos \Theta = \frac{A}{H}$

then $H \cos \Theta = A$

Next, insert the known values to make:

$1 \cos 30° = A$

The end result is:

$A = \cos 30° \approx 0.8660254038$

Figure 6: *Right Triangle and Equations*

Remember that the value found through the above calculations is only half of the length of the vector representing V_{AB}.

Therefore, multiply it by two and the answer becomes:

$$\sqrt{3}$$

or approximately 1.732

Therefore, through the evidence above, it can be inferred that θ to θ = θ × √3.

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SELECTING SAMPLE CONTAINERS FOR INSULATING LIQUIDS

LANCE R. LEWAND and DAVID KOEHLER,
Doble Engineering Company

Any commercial laboratory performing insulating liquid analysis receives a myriad of sample containers through the course of a year. Not all of these containers are compatible with the liquid they are storing, nor do they maintain the properties to be tested intact.

The selection of a sample container is a specific science with the ultimate goal of not impacting the sample in any way. Thus, the insulating liquid in the sample container must reflect the insulating liquid in the electrical apparatus whether it be a transformer, load tap changer (LTC), oil circuit breaker (OCB), or some other device.

The requirements for a sample container are:

- Large enough to hold the volume of liquid necessary for analysis.
- Does not impart any contamination (chemical or particles) to the sample.
- Seals the sample from external contamination.
- Shields the sample from direct sunlight to prevent photo-degradation either by having a dark container or by using a covering for the container after the sample is taken.
- Prevents the loss or gain of gases or water when testing for these properties.

SOURCE: LEWAND & KOEHLER

Changes in an insulating liquid's properties while in the sample container can yield lab results that do not reflect the bulk oil in the apparatus and can yield a faulty diagnostic assessment of the apparatus or insulating liquid. Tests such as dissolved gas-in-oil analysis (DGA), water content, and methanol/ethanol analysis are critical tests that can easily be impacted in a negative way and can lead to a faulty condition assessment of the apparatus.

DISOLVED GAS ANALYSIS

DGA is used to determine the operational condition of an electric apparatus and is considered the most important insulating liquid test. If the sample container retaining the DGA sample is not completely sealed, gases such as hydrogen and carbon monoxide are easily lost. Because of their poor solubility in insulating liquids, these gases easily diffuse to the atmosphere, typically in a matter of minutes to hours.

Hydrogen is usually reflective of partial discharge, and carbon monoxide is most often due to paper degradation in the transformer. The loss of these gases would indicate that a faulty condition does not exist when, in fact, it may. In addition, additional concentrations of oxygen, nitrogen, and even carbon dioxide can be dissolved into the oil from the external atmosphere. The presence or absence of oxygen and nitrogen helps one understand the condition of the transformer's preservation system and whether the gaskets, O-rings, and/or conservator bladder are performing their intended functions. Elevated oxygen and nitrogen concentrations may indicate there is a leak, where the apparatus may be perfectly sealed resulting in unneeded costly maintenance.

For free-breathing LTCs and OCBs, a high amount of oxygen that is commensurate to the amount of oxygen in the air is expected. When oxygen levels fall low, it usually indicates that advanced aging of the oil is occurring or that the apparatus breathing mechanism is plugged. If the incorrect sample container is used or the sample is not taken properly, atmospheric oxygen will be present, and these types of conditions cannot be determined.

WATER CONTENT

Accurate water content values help determine the wetness or dryness of the entire insulation system including the paper or solid insulation. It must be remembered that most transformers are dry and are intended to stay that way to minimize aging of the solid insulation. Aging of solid insulation is directly proportional to water content. As paper ages, it produces water as one of the byproducts, so the amount of water in the transformer will gradually increase over time. Samples must properly reflect those conditions.

Selecting the correct sample container is imperative for keeping the properties of the samples intact and reflective of the properties of the bulk insulating liquid in the electrical apparatus.

The best time to take samples in the northern hemisphere is usually the summer months when most transformers are operating at highest load and warmest environmental temperatures. This condition will provide the best estimate of the water condition existing in the solid insulation of the apparatus. However, the summer months are also the most humid months, and contact of the insulating liquid with the humid atmosphere can increase the water content of the sample both dramatically and quickly, so this must be guarded against.

Thus, samples for water content must only be taken in enclosed systems such as DGA glass syringes. Even taking samples in metal bottles that can be filled to overflowing can be impacted, as the humid air in the bottle during filling will increase the water content by several ppm(mg/kg). A difference in a few ppm(mg/kg) can make a dramatic difference in calculating the water in paper content.

Environmental humidity will also negatively impact dielectric strength, especially in plastic bottles, as plastic is not a solid barrier against the ingress of water into the sample. Dielectric strength is reduced by increasing water content and particles. Plastic bottles allow water to diffuse across the plastic and can increase the water content substantially in just a few hours due to the natural physical process of the humidity outside the sample container trying to reach equilibrium with the humidity of the insulating liquid inside the sample container. This may result in lower dielectric strength of a sample when tested in a laboratory as compared to the insulating liquid that exists in the actual apparatus. Thus, plastic containers are not advisable for use when water content or dielectric strength measurements are going to be conducted.

METHANOL/ETHANOL

Methanol and ethanol concentrations are chemical aging markers that are produced from degradation of cellulose inside the transformer. They are better suited than furanic compounds in transformers where thermally upgraded paper is present and are commonly found in 65°C rise-rated transformers. However, furanic compounds are light alcohols and very volatile, so sampling for them must be treated in the same way as DGA samples and taken in glass syringes so they are not lost to the atmosphere.

These are but a few examples of how sample analysis can be negatively impacted by choosing the incorrect sample container. A variety of plastic, glass, and metal bottles have been used over the years along with glass syringes and steel cylinders. ASTM D923, *Standard Practice for Sampling Electrical Insulating Liquids* provides a list of sample containers and the advantages and disadvantages of each and should be consulted before drawing a sample. Lewand & Koehler provide a very detailed commentary on proper sampling technique and sample containers.

SAMPLE CONTAINERS FOR WATER CONTENT

To illustrate some of this information, research was performed to determine which types of containers are best at maintaining the quality of the sample for water content analysis. Four types of sample containers were evaluated in this nine-week testing: high-density polyethylene (HDPE), glass bottles, glass syringes, and aluminum bottles.

Table 1: *Water Ingress into Different Containers*

Average of Three Determinations per Measurement, ASTM D1533, mg/kg (ppm)				
Sample	**HDPE**	**Glass Bottle**	**Glass Syringe**	**Aluminum Bottle**
Initial Bottle 1	3.8	3.4	3.4	4.8
Initial Bottle 10	5.0	5.7	5.9	9.8
Week 1	14.4	7.6	5.5	5.7
Week 2	20.9	5.5	4.4	4.6
Week 3	30.4	9.5	9.7	7.1
Week 4	29.2	8.7	7.5	5.2
Week 5	37.8	21.4	5.9	5.4
Week 6	40.9	29.6	7.7	6.3
Week 7	44.7	27.3	7.2	7.3
Week 8	45.0	17.1	8.0	7.3

Transformer oil (22 liters) was dried with nitrogen to a water content of less than 5 mg/kg. This dried oil was transferred to 40 containers representing 10 each of four different container types: 1-liter HDPE bottle, 1-quart glass bottle with a hard plastic cap and paper liner, 50-ml glass syringe, and 1-liter aluminum bottle with sure-lock cap fitted with an aluminum liner. The containers were uncapped and aspirated with compressed air to remove unwanted particles and then transferred to a glove bag previously filled with nitrogen. All containers were filled with oil inside the glove bag.

Each container was filled to overflowing with oil and capped. Syringes were filled to the 40-ml mark, and all gas bubbles were expelled. The stopcocks and caps were then checked for tightness on each container. After filling, the first and last samples of each category were tested for water content within 1 hour. The rest of the samples were maintained in a glove bag under conditions of room temperature (approximately 22.5°C) and high humidity (83% to 88%). One sample for each category was tested weekly and the results recorded. The results are presented in Table 1.

The graph in Figure 1 summarizes the results from Table 1.

Results over the eight-week period indicate that HDPE bottles are not suitable for long- term storage

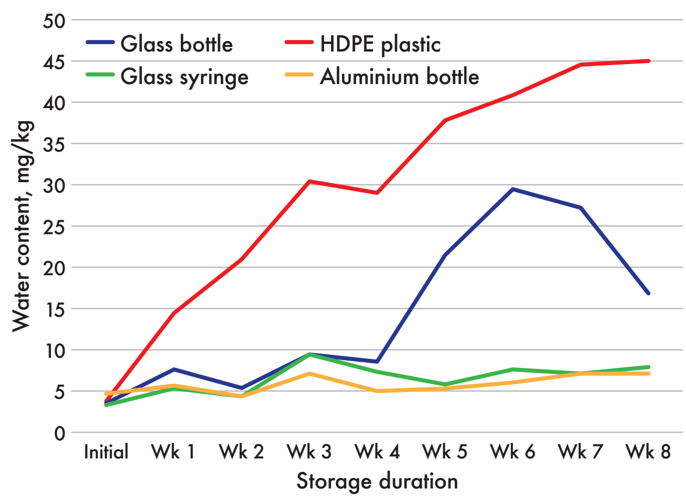

Figure 1: *Water Ingress into Various Containers under Controlled Conditions*

when a water content test is to be performed. As Figure 1 indicates, the maximum water content at the end of the experiment was 45 ppm for the HDPE bottle; the other containers were much lower. In addition, the caps worked loose on both the HDPE and glass bottles over time. If sample integrity is to be maintained for a long time, then periodic resealing of the caps is necessary.

Figure 1 depicted how the oil in each container fluctuated in water content in relation to the maximum

Table 2: *Suggested Sampling Container Applications*

Tests	Container Type
DGA, water, methanol/ethanol	Glass syringes, aluminum bottles for water only
Furanic compounds, oil quality	Particle-free glass bottles, aluminum bottles

water content that could be dissolved in oil using 88% relative humidity and a laboratory temperature of 22.5°C. At 22.5°C, 100% saturation of water in oil is about 61.2 ppm. Eighty-eight percent of 61.2 ppm is 53.9 mg/kg. Those were the concentrations used to calculate to what percentage the oil in each container rose in relative saturation over time. As shown in Figure 1, the HDPE plastic container was almost 84% (45 ppm/53.8 ppm) of that value by experiment's end, whereas the glass bottle rose to 32%, and the syringe was only about 15%. The aluminum bottle stayed fairly constant at 10 to 12%.

It is obvious that external relative humidity impacts the water content of the sample in certain containers, specifically HDPE plastic bottles. Testing the sample quickly and keeping the relative humidity in the laboratory low would negate some of these effects. However, keeping the relative humidity in the laboratory too low may also have the opposite effect. Equilibrium with the relative humidity of the ambient environment would also tend to dry the sample if the concentration of water on the outside of the sample container was less than the water in the oil in the sample container.

These effects do not seem to manifest themselves in either syringes or aluminum bottles. Therefore, syringes and aluminum bottles are the best containers to store oil for determining water content in transformer insulating liquid samples (Figure 2).

Because glass bottles cannot be filled to the top because of possible breakage due to expansion and contraction, some atmosphere exists inside the bottle. The external atmosphere can definitely affect the final water content of the sample prior to analysis, especially if that atmosphere is really humid.

Figure 2: Bottles and Syringes for Water Ingress Test

CONCLUSION

Selecting the correct sample container is imperative to keeping the properties of the samples intact and reflective of the properties of the bulk insulating liquid in the electrical apparatus. Evaluating the laboratory test data of such samples may yield incorrect or incomplete diagnostics. Remember that the analysis is only as good as the sample taken.

It has been our experience that the only compatible plastic bottle is high-density polyethylene (HDPE) plastic. However, we have moved away from plastic bottles almost completely because of the particles present in plastic bottles from the manufacturing process and the speed in which water can move through the plastic into the sample. Table 2 provides suggestions on which containers to use for particular applications.

Lastly, the caps for glass bottles must also be selected carefully. The only acceptable types are those caps with foil, polyethylene, polypropylene, or PTFE liners.

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HIRE EARLY— TEAM TRAINING AND HR

BY CHUCK BAKER, SDMyers

The good training manager has some form of a current training program that they inherited, inherited and modified, or created themselves. This training manager understands the applicable laws and regulations and makes sure each person is properly trained to fulfill their job responsibilities. They have a thorough, regular, and repetitive program.

Regulations are covered, everything is compliant, and it looks like you have a solid program and just need to maintain, watching for possible changes in the future. But what else can you do to increase the availability of qualified candidates for positions you are trying to fill and at the same time decrease the impact of resignation or termination?

Why do I ask? Well, I would say that having a goal to maintaining as-is today can be dangerous. Ladders.com recently reported that:

- In the last eight years, the number of HR professionals reporting problems finding qualified employees has gone up from 50% to 68%. This increases the challenge and requires additional creativity.
- The challenge of requiring the appropriate expertise to replace a seasoned employee complicates the process even more, as there are ever fewer properly experienced candidates.
- It has been predicted that this decrease in qualified candidates will continue to degrade over the next 10 years.

HR AND TRAINING TEAM UP

So let's look at training from another perspective: HR and training teaming up to meet the challenge. In the last article, we talked about working with each employee to help understand their individual interests, their goals, and what training could benefit them. If you do this, you will begin to see similar interests through each group or department, and you will see common goals and desires. This provides you with the ability to begin to build up the expertise of these individuals, teams, divisions, etc. for their next step. You know — the desired next step of quality employees.

What if you were to meet this challenge by building a training program to handle the dilemma of lack of experienced candidates and acknowledge these discovered goals of your current employees? This means your responsibilities (as well as HR's) would include understanding job functions and the talent required. This includes all positions, from simple to complex. By doing this, HR's in-depth understanding of each position would allow them to more accurately evaluate candidates who don't have full experience but might cover 50% or 60% of the key functions…and with your training program that can be a functional option.

If you understand the needs of each position and the desires of each employee, you can begin to forecast what will happen in the future. You have the statistics on turnover for each employee position. To tackle the challenge of finding qualified employees, let's start to cross-train individuals for their desired next step before opening the position. The reason this typically doesn't happen is lack of resources. But combining these problems by having HR search and hire candidates prior to the opening allows you to train the new hire and, at the same time, cross-train the person who is going to be promoted in their desired next step. Some excess labor, but this is an approach that handles the challenge of finding employees without hesitation in your business and production process.

HIRE EARLY

When you get some resistance to the idea of hiring early for cross-training, communicate the cost of the unplanned loss of an employee including the cost of finding the right employee. According to *Employee Benefit News*, employers spend around 33% of a worker's annual salary during the replacement process.

Hiring early will accomplish two things:

- You can cross-train the new employee with sufficient time built in to spend with the person still holding the position.
- The person who currently holds the position will have extra time to begin to train for their next desired position.

When you hire a good candidate early and have an effective cross training program, you are training the new hire for their eventual position, and that person will contribute along the way. Not only do you eliminate the 20%, but the training of the new employee is much better, and they will contribute as you direct them on learning the new position(s). If your company endorses hiring when you find the right match (with justification), you have reduced the impact of unexpected resignations or terminations.

This certainly isn't easy, but it is an approach that can be built over time and deepens your training program by allowing candidates to have more expertise when they take the next step. Using this strategy is an advantage to the company not just financially, but in increasing employee satisfaction because they know cross-training to their desired next step is a normal part of the company culture.

Preparing a training program for a person who is going to cross-train on their desired position requires the trainer to assemble a detailed training plan. To define each key component of each position, work with the people currently in that position on how to train, and then set up a repetitive schedule for this cross-training. Work with the department hosting the cross-trainer from another department to set up schedules, key areas to be taught/learned, and select the right person to host the trainee. Two hours a week or one day a week would both be beneficial in achieving the goal.

As a training manager, your responsibilities in this process will include tracking the progress of each person's training, which is a critical factor that is sometimes missed. Test employees throughout the training process to track their progress and pace, confirm their desire to eventually move to this position, and evaluate how effective the training process was. You will find that the training for each position will improve through experience as the program advances. This is a result of your involvement in setting goals for the trainee and establishing the time required to learn each function.

CONCLUSION

With this approach, you have the HR department doing an aggressive search based on the predictability of need and hiring those who are not 100% qualified. You have an established program of using available time during the pre-hiring training of new employees upon arrival. Finally, excess time is used to train a qualified existing employee for their desired next step.

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  December 18, 2020 | Presenter: Daniel Carreno
- **Fundamentals of Motor Protection**
  November 20, 2020 | Presenter: David Beard
- **State-of-the-Art Diagnostics Technologies for Proactive Cable Condition Assessment**
  October 23, 2020 | Presenter: Robert Probst

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 the special monthly webinar series Testing Tactics 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.

An Engineer's Playground

OMICRON Academy

"Amazing! 10 out of 10. This was very very helpful and knowledgeable...
...Many thanks to OMICRON..."

- M. Shaik, webinar participant

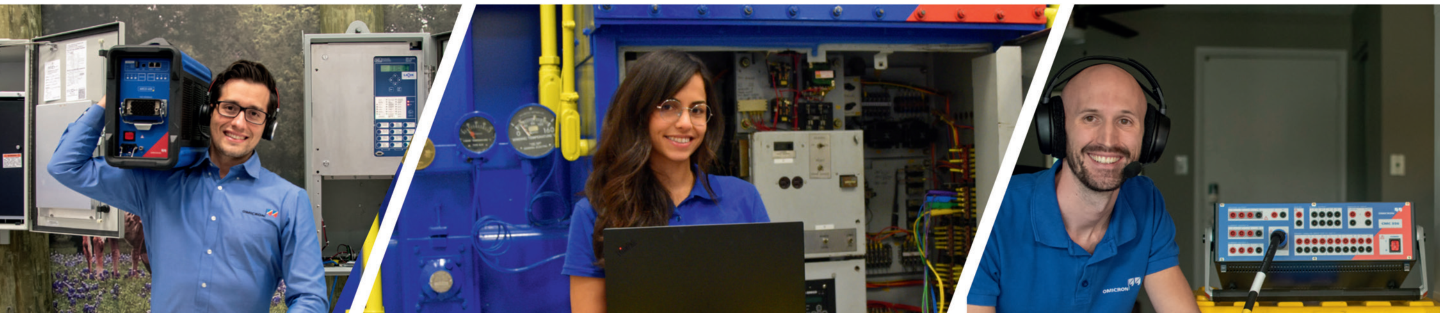
Excellence Through Education

Many people refer to the OMICRON Academy in Houston as "An Engineer's Playground." This is because, in addition to classrooms, we also have a state-of-the-art indoor substation with a variety of apparatus to perform hands-on testing, including transformers, circuit breakers, protective relays, PD testing area, and our recently installed distribution automation wall. Our instructors also use this playground for our virtual training courses.

Training Topics

- Protection Relays and Meters Testing
- Digital Substations and IEC 61850
- End-to-End Testing
- Generator Protection
- Protection Theory
- Reclosers and Distribution Automation
- Power Transformer Testing & Diagnostics
- Circuit Breaker/Switchgear Testing
- Instrument Transformer Testing
- Partial Discharge Testing
- And More...

See our full list of courses at **omicronenergy.com/na-training**



SDMyers: In electrical system maintenance and management, knowledge means powe

Effective power system management requires special skills acquired from years of hands-on experience. Today's diminishing number of experts is causing a growing need for specialized training to ensure these skills are not lost. SDMyers offers Electric Power IQ training, giving you and your team the opportunity to benefit from our 55+ years of electric power maintenance expertise. Study online using our pre-recorded e-learning sessions, participate in live, online courses, or host a private virtual training session for your team with our instructors. We cover everything you need to know to keep your system reliable.

E-learning

- **Transformer Management 1—Modules**
  Comprised of 32 prerecorded modules, these courses lay a strong foundation for those who are in any way responsible for transformer maintenance. Each module can be taken on demand within one year of first access.

- **Dry-Type Transformers**
  This is a 3-part series that covers design comparison and purchasing considerations, the selection process, and the maintenance of dry-type transformers.

- **Electrical Skills Series**
  These electrical training courses cover the fundamentals of electricity and cover how to safely maintain, troubleshoot, and repair industrial electrical equipment. This series consists of 8 Learning Plans and 30 Courses.
  *These courses are eligible for PDH credits only

- **Basic Skills Series**
  The basic skills training courses will empower your workplace with the knowledge, skills, and support to perform their jobs comfortably, safely, and effectively. This series consists of 2 Learning Plans and 13 Courses.
  *These courses are eligible for PDH credits only

- **Safety Skills Series**
  This course educates and empowers you on how to recognize and prevent at-risk conditions or behavior before they lead to an incident. This series consists of 1 Learning Plan and 10 Courses.
  *These courses are eligible for PDH credits only

Live online—Foundational

- **Transformer Management 1**
  This 9-session course provides a foundational understanding of the internal and external elements of the transformer, the essentials of transformer operation and maintenance implementation, and related industry standards. It covers the chemical, mechanical, electrical, and reliability components of transformer management. Training sessions include case studies, Q&A sessions, and interactive activities. This course is presented in both English and Spanish.

- **Inspection & Sampling of Transformers**
  In this 3-hour course you will learn the safe procedures needed to obtain a representative sample of dielectric fluid for more accurate lab analysis.

Live online—Advanced

- **Transformer Management 2**
  This 3-day course is for the person who understands the individual components of transformer maintenance–oil testing, electrical testing, and maintenance standards–and is responsible for applying this knowledge. Attendees will explore the importance of determining what maintenance to perform and when, based on Reliability Centered Maintenance Procedures, through practical exercises, breakout groups, discussion groups, and more.

- **Transformer Management 3**
  This 3-day course examines the transformer lifecycle, including new equipment purchasing, disposal of old transformers, transportation, installation and start-up, and reliability management. We review each step, from factory testing to final energization. This course is the summation of the technical training process and includes a working case study so attendees can apply each topic to a real-world situation. Level 3 is for the Lead or Manager of transformers and substations.

- **Dissolved Gas Analysis (DGA) Workshop**
  This 3-hour workshop takes a deep dive into fault gases and what causes their formation. Learn how to use DGA interpretation tools and how to apply your results to managing and increasing the life of the transformer. Attendees will work through real-life case studies using various DGA interpretation tools, discuss their findings, and make recommendations for corrective action.

SDMyers courses are eligible for the NETA CTD units that are required of NETA Certified Technicians, Professional Development Hours (PDH), and Continuous Education Credits (CEU) via Kent State University.

For information or to register online: courses.sdmyers.com

To contact a Training Advisor:
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SDMyers ACTS 4:12 Electric Power IQ SERIOUS RELIABILITY TRAINING

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

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