

SUBSTATION MAINTENANCE

Improving best practices for greater success

BY BUDO MILOVIC, DV-Power

Currently, substation maintenance—regular or emergency—operations and best practices must fit the utility's goal of accomplishing more with less, in order to maximize assets and minimize outages. A caveat to this weighty goal is to accomplish more with less with a reduced workforce and under tight budgets. Field workers face this reality daily. Therefore, to overcome such challenges, maintenance crews have to be properly equipped and trained for these everyday demanding tasks.

In this issue's *Substation Channel, Electricity Today Magazine* and DV-Power aim to equip utility maintenance personnel with seven important facts that can help maximize testing efficiency for substation maintenance tasks.



Select testing procedure based on clear criteria

I CHOOSE CRITERIA-BASED TESTING PROCEDURES

Improvised tests and testing on the fly may save time and money, but results may not be accurate, thus introducing potential reliability issues and unexpected events. One of the most important elements to consider about time and efforts spent for testing is potential consequences for any unexpected event. Reliability-centered and performance-based maintenance are some of the methodologies currently used by utility maintenance crews. The goal is to have records of equipment conditions and to understand associated risks and consequences to determine an optimum maintenance strategy.

Every substation downtime could be expressed in terms of dollars and safety issues. As such, corresponding status of each element needs to be classified by readiness and maintenance requirements. Past records, as well as ability to examine trends for selected parameters, are becoming critical elements to select when, what, and how apparatus should be maintained on a regular, advanced, or exceptional basis.

Several basic test methods, such as dissolved gas analysis (DGA) for transformer condition assessment, or contact resistance for circuit breakers provide a basic status data. Furthermore, online monitoring provides continuous feed of data containing important information on operational activity of substation equipment. Finally, risk assessment of the substation, its criticality, and potential for economic, environmental, social, and public impacts are used to decide which maintenance program to apply.

Some utilities use a maintenance strategy based upon equipment condition criteria. Then, a failure mode effect analysis dictates the maintenance concept that combines condition measurement with small maintenance activities. The frequency of the concept applied depends on the type of equipment (SF6, oil, metal enclosed, mechanical, or hydraulic drive) and voltage level, but varies within a time span of several years. Overhaul or revision of maintenance tasks are not fixed, but dependent on the results of the measured condition such as contact resistance or oil analysis, which is then compared to a "typical" data set to create corresponding expert rules and support decisions used in various applications (for example, asset management systems such as Maximo or, for tracking preventive maintenance tools such as MaintenWorks).

For substations and associated apparatus requiring special test procedures, more advanced testing can provide insight into the condition of each component, starting from the premise that the weakest link in the chain defines the overall performance of the equipment.



Select testing tools fit for the task

II SELECT TESTING TOOLS FIT FOR THE TASK

No single magic test tool exists that can detect all apparatus problems and provide the equipment owner information on the expected life of the tested unit. Maintenance crews can improve their chances to identify problems using a larger toolbox that contain versatile instruments. Sheer number of manufacturers, numerous options, and different price ranges are contributing to difficulties in selecting the right tools for the job.

There is a significant difference between rugged field instruments and high precision laboratory instruments. Nowadays, field in-

FREE Subscription: ***www.electricity-today.com***

struments with increased accuracy are available. Decisions about required accuracy should fit the application, taking into consideration that increased accuracy may require longer testing times or more expensive tools.

Utilities need to determine the length of time that maintenance crews spend in the field completing condition assessments that usually consist of several test procedures. For example, does a utility worker need to know if humidity of the paper in a transformer is 3.2 or 3.5 percent? Is this precision required, or is a simple "wet" vs. "dry" enough to warrant a corrective action? On the other hand, when testing a transformer with 33 tap positions, maintenance personnel can shorten each test on automatic procedures by one minute, which saves time—especially if these tests are repeated for each phase.

One test method requiring higher instrument output is a transformer winding direct current resistance test. This procedure may take hours to obtain a required accuracy, as the total test time consists of charging plus stabilization time. The higher the voltage is, the faster the charging time.

On the other hand, stabilization may take hours. Saturation of the magnetic core significantly improves the stabilization time. A high current output from the instrument is required to saturate the core. Combining higher voltage and higher current outputs traditionally increases weight of the instrument. Power can be increased by using modern instruments with a very modest weight increase.

Instruments fit for substation apparatus testing should provide enough power, or voltage, or accuracy, to perform tests as quickly as possible. Service personnel safety and convenience are of utmost importance. Climbing up and down a transformer, even with all the safety gear in place, is a risk hazard. Selecting the tool that would require one setup for several test procedures is not only a convenience, but also a safety improvement. Taking into consideration relative long changeover times when replacing testing tools, the right choice is becoming even more critical.



III REVISIT SELECTION CRITERIA WHEN BUYING NEW TEST EQUIPMENT

Multiple vendors, diverse products, and a multitude of features make selection decisions challenging. Therefore, preparation to purchase becomes even more critical to prevent selection based on the best sales strategy rather than features to fit current and future maintenance needs.

Many combined instruments on the market provide two or three test procedures in a single box. Others provide several test procedures using the same test lead connection. If the utility's test teams have to perform several measurements in different substations, combined tools are disadvantageous.

This procedure would require duplication of test instruments, where simple single-task units may be shared. On the other side, failure of one test module makes the whole battery of tests impossible, where as an advantage, one box and one set of test leads makes work more convenient.

Manufacturers with a large installed base and established contacts may have easier access to a particular market. Still, fast changing technologies and newcomers with attractive pricing are some of the factors that make the utility test instrument marketplace more competitive.

Before selection criteria are fully established, keep up-to-date with the industry. Do the homework: (1) prioritize selection criteria, (2) investigate multiple resources, and (3) follow the expert advice, not just the preferred—or established—sales resources.

Initial selection criteria should be revisited at the later stage of a purchasing process ensuring the latest industry trends learned or identified are considered as well. Accuracy, simplicity, robustness, size, warranty, and price are some of the criteria.



GET CERTIFIED

AND IMPROVE YOUR FLEET PERFORMANCE

Fleet managers want fluid power certified mechanics, engineers, and technicians working on every one of their trucks because improved productivity, safety and efficiency are the bottom line.



FLUID POWER INTERNATIONAL SOCIETY

CERTIFICATIONS INCLUDE

- Mobile Hydraulic Mechanic
- Mobile Hydraulic Technician
- Connector & Conductor

For more information visit www.ifps.org or call 1-800-308-6005

Some of the current trends may become important. For example, more powerful instruments require lighter cables easier to work with in the field. Multitask test equipment versus simpler and smaller units may become an important selection factor, taking into account internal resources capability and focus. Generally, a selection criteria list should be established separately for each type of test equipment.



IV SELECT SMART TEST EQUIPMENT

One important selection criteria is to ensure purchased test equipment is based on Smart multiprocessor-based technology. Multitasking, but simplicity of use, remains the industry trend. Smart test equipment should collect and store comprehensive records from multiple tests with the capability to compare and analyze different test scenarios and procedures. Clear error code interpretations and access to help instructions are expected.

When working in the field, out of reach for additional help, smart test equipment with operating instructions and comprehensive error detections are a necessity. A well-designed quick guide placed on the instrument itself is an effective way of ensuring that the basic testing information is always and easily available. Safety warnings, connection schematics, and the basic operating instructions are typical examples.

Smart instruments are capable of recognizing incorrect or faulty connections. For example, open circuits or polarity reverse conditions are automatically alarmed. Smart instruments indicate other important conditions affecting operations or accuracy, for example, a transformer discharge indication for DC current tests on a power transformer or duty cycle durations.

The accompanied computer software for smart instruments provides additional testing information and graph options to simplify the results analysis and understanding. Sometimes, a problem that could be easily missed among the numerical results becomes immediately apparent in the graphical result presentation and comparative analysis.

Another effective analysis method is an automatic pass/fail criterion for tests with clearly defined limit conditions. Comparison between different phases in case of three-phase tests, or between different tests on the same test object, need to be simple and easily available.

Smart instruments are capable of recognizing incorrect or faulty connections.

In order to utilize the additional features that computer software provides, fully user-friendly, intuitive, and supported with comprehensive help options, built-in tips, and tutorials should be provided upon purchase. Moreover, a demo mode is expected, enabling the operator to explore the options provided by the software safely.



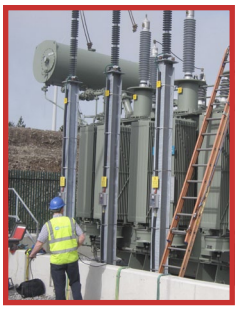
V SELECT DURABLE TEST EQUIPMENT

Probably one of the most frequent factors affecting operational readiness in the field is the durability of test equipment. Substation maintenance is about service calls under different weather conditions, in remote areas and transportation that involve dropping, banging, or rough handling of test equipment. Consequently, mobility, housing construction, material used including shock absorbers, and packing for the test equipment become the important selection criteria.

Resistance to vibrations is an often-underrated feature of test equipment, since the roads leading to test locations are often rough, and the equipment frequently needs to withstand several hours of being shaken or bounced in the back of a van or a pickup truck. If the instrument is packed in a waterproof plastic case, the device provides additional protection against mechanical impacts and elements. Additionally, the instrument accessories and cables need to be durable, since these fittings often bear the greatest mechanical tensions during the test.

Testing can be performed in temperature extremes and the equipment should be capable of withstanding both hot and cold conditions. Proper ventilation and cooling of the equipment is necessary in order to extend its lifetime and to avoid overheating problems. In case overheating does occur, the instrument should alarm and shut down the test automatically in order to avoid any permanent damage.

FREE Subscription: ***www.electricity-today.com***



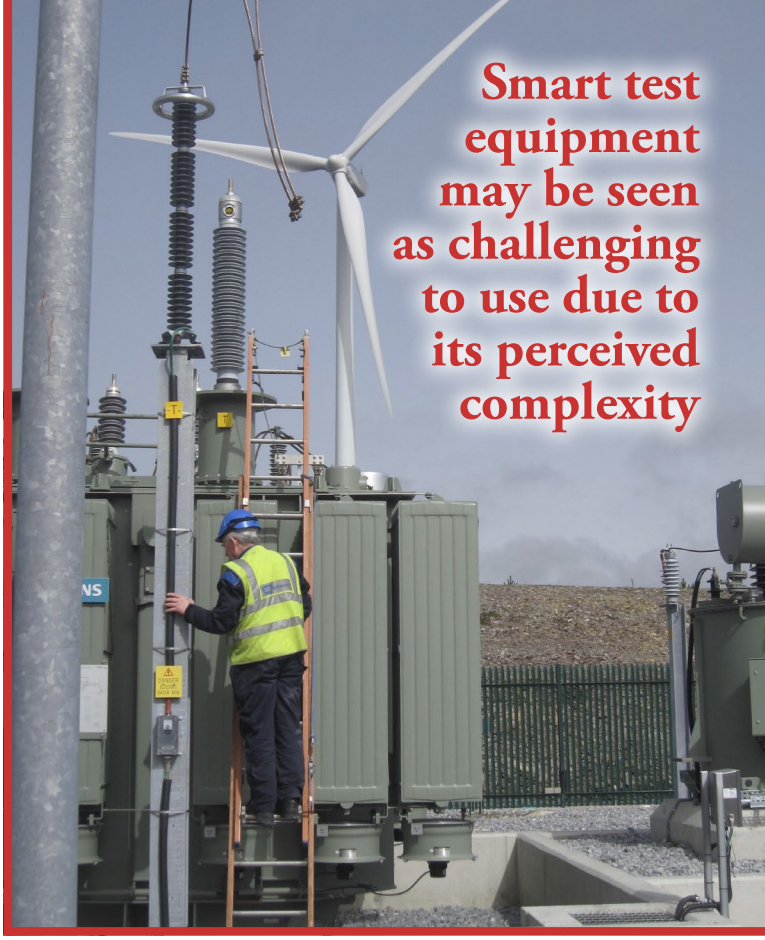
VI ENSURE PERSONNEL IS WELL TRAINED

Smart test equipment, usually with microprocessor and various software routines, may be seen as challenging to use due to its perceived complexity. The best test equipment in the field, even if considered as a black box in terms of operating principles, is easy to operate, with clear and simple connecting and operating instructions.

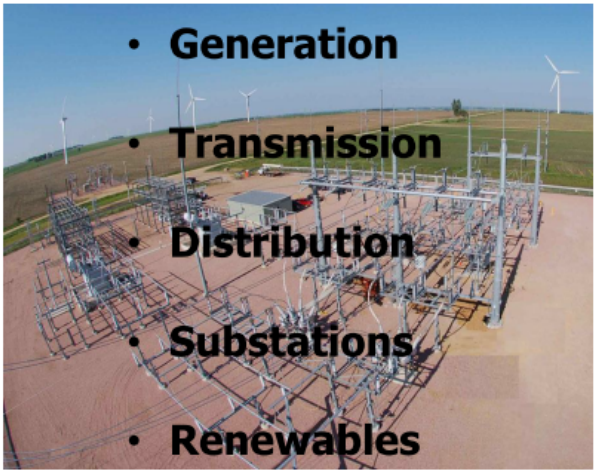
Test technicians are faced with many tasks during their daily routine. Using one particular test instrument may come once a month or even less frequently. Once trained, this knowledge has to be retained for a long period of time. Complex procedures are easy to forget or mix up. Continuous education and knowledge refreshments are essential. The process of learning is not finished after the first training session. The possibility to receive follow-up training either onsite, virtually via e-mail exchange or webinar, or a simple telephone contact should be the norm.

Providing timely reports on test data with indication of possible test procedure errors or deficiencies, explaining correct test procedures, parameters selection, and data evaluation are necessary for continuous education and experience gain. Such supports from both internally and from test instrument manufacturers should be regular and comprehensive.

Modern test instruments are operated via a built-in interface or external laptop/controller link. In addition to simple operations and supporting tools, such computerized interface requires some level of familiarity with information technologies. Specifically in cases of unexpected problems and troubleshooting, a technician is expected to have some IT proficiency to ensure productivity and self-sufficiency in the field. For example, a tech-







FACTORY REPRESENTATIVES OF ELECTRICAL EQUIPMENT MANUFACTURERS

KA Factor Group Inc. is the exclusive representative for leading manufacturers of electrical equipment in the Provinces of Ontario, Manitoba, Saskatchewan and Alberta. Our expertise lies in the application of equipment with the focus being on innovative and cost efficient solutions.

Dedicated to serve Electric Utilities, Consultants, Contractors, Renewable Developers and Industrial Customers.

For more information, please call or visit our website for complete manufacturer and equipment listing.

905-453-0044 **www.kafactor.com** **info@kafactor.com**

nician should be able to find a backup file of the test results in case of a computer crash.

While training and proper education are of utmost importance, clear instructions readily available with the instruments plus application notes helping with specific routines should essentially be a part of any true smart test equipment purchase.



VII CONSIDER WARRANTY & TECHNICAL SUPPORT

Manufacturers of equipment with reputable maintenance records usually provide extended warranties. The manufacturer's bottom line is affected each time equipment is returned under the warranty. As such, warranty conditions and, specifically, warranty lengths are clear indications of test equipment readiness and quality. Availability of a manufacturer's technical support must be timely, comprehensive, and substantiated in terms of tests functional specifics and test result interpretations.

On-time technical support services remain an important part of field testing successes. Test and measurement equipment complexity continues to increase. Multiple application modes and routines reside within a single unit. In addition to all preparation work, unexpected events in the field may need urgent support. Software issues and recovery of lost data after several hours of testing are typical examples where reliable manufacturer support makes a difference in such unexpected events.

The last step in substation testing is to create reports including test results analysis and interpretation. Technical and process expertise for such supports is becoming critical. A solid manufacturer keeps knowledge databases and expertise in-house with an ability to assist in those final testing steps to determine the condition of assets. As the result, quite often, direct assistance during operation procedures—via telephone assistance or desktop controlled software—is expected and necessary. ET

Budo Milovic is an application engineer at DV-Power, a global manufacturer of substation test equipment. Mr. Milovic is an electrical engineer with strong background in power electronics. His experience includes dynamic contact resistance measurements and best test equipment manufacturing practices.

VISIT: www.DV-Power.com

Related Articles



POWER TRANSFORMERS

Aluminum or copper: the truth about cast-resin transformers



FREE Subscription: ***www.electricity-today.com***