Using the SonicScan™ 7000 to Supplement Your Substation's Infrared Thermography Program

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With the help of CSI subsidiary M&D, a TVA (Tennessee Valley Authority) substation has developed a noteworthy maintenance system utilizing various emerging technologies, including ultrasonics. This system not only helps eliminate catastrophic failure, but gives substation maintenance personnel a means of tracking the status of the switchyard, transformer by transformer.

Current Practices

Most utilities operate time interval-based, preventive maintenance programs. These utility companies are under the impression that this approach is sufficient to understand the status of their utility at all times. But it is now evident, especially after recent efforts to optimize utility maintenance programs, that this approach may not be the most efficient. Instead of choosing a single approach, like preventive maintenance, some companies are benefitting from a program that combines two different types of maintenance. For example, a better overall picture of machinery equipment condition can be gained by integrating Reliability Centered Maintenance (RCM), which identifies critical equipment, and Predictive Maintenance (PdM), which assesses equipment condition to define what type of maintenance needs to be done and how often.

SonicScan in use, with aid of ParaScan parabolic sensor

In order for this integrated approach to be proven useful, some questions had to be asked about general maintenance practices in the utility industry. Initially, most of the efforts to design an efficient PdM program were targeted just at rotating equipment, but then were extended to include all main transformers and circuit breakers.

The first question that had to be answered was exactly which technologies would be effective in diagnosing substation problems. The answer turned out to be that the application of various technologies, such as vibration and oil analysis, is beneficial to maintaining the health of substation equipment, but that infrared thermography and ultrasonics encompass the most information, with the most benefit.

In addition to understanding which technologies reap the best rewards, the programmatic aspects of predictive maintenance need to be analyzed as well. It was discovered that in most utility maintenance departments, communication was the biggest downfall. Therefore, to truly understand how the newly acquired technology can benefit utilities some strategies must be implemented. These strategies must organize diagnostic with operational data, maintenance and design information, as well as a means of communicating the information extracted from the data gathered, to be efficiently implemented. Fortunately, due to the ability of thermography and the SonicScan 7000 ultrasonics package to output data in a format that can be electronically stored, this feat was not as insurmountable as initially thought.

Next, which medium was the most efficient? Currently, many organizations perform some equipment diagnostic tests. Also, many have computerized their maintenance work management functions, including retaining maintenance histories, logging significant operational activities, and maintaining a library of design information for substation equipment. Integrating this information is essential to success. Because the data gathered by each of these technologies easily downloads into CSI manufactured ODBC software (eliminating reentry of numerous amounts of information), this problem was easily remedied.

In conclusion, the proper communication, integration, and analysis of all of this information results in more accurate recommendations of when to perform maintenance and/or how to operate a specific piece of equipment. The main objective of this new philosophy is to reduce operation and maintenance (O&M) costs by implementing or enhancing the predictive maintenance (PdM) program for switchyard equipment, to better define what and when to perform the necessary maintenance. Ultimately, using such technologies as thermography and ultrasonics will result in a reduction in power loss due to unscheduled downtime or catastrophic failure in the switchyard. However, decisions like this require answering even more questions. Some of these questions will be answered in the following paragraphs; some will not. Ultimately, the decision is yours.

Why Couple Technologies?

The idea of coupling technologies is based on the same premise that you would use if you were diagnosed with a terminal illness. Rather than accepting one diagnosis, you would want the opinion of a second doctor before you began treatment. The same idea applies in substations. If you were provided with recent thermographic data on a transformer set in the switchyard and found a 120 degree delta temperature change, what questions would you as a manager ask? Is this delta severe enough to reroute power and repair the transformer, or will it continue to provide power until the next outage? How valid is this data? Is there any other supporting data? And finally, how can I be sure that the transformer is the location of the fault? Such appropriate questions validate the need for a "second opinion" in substation monitoring.

Ultrasonic detection devices provide this second opinion, and because of very distinct qualities of ultrasonic data, this information can be considered to be the most reliable second opinion available for substations. In order to truly understand how the SonicScan 7000 can be used to efficiently monitor substations such as those mentioned at TVA, it is necessary to first understand the types of problems that can be detected.

What Can Be Detected?

There are basically two types of faults or occurrences that can be accurately detected in substations: arcing and corona discharge. Arcing is defined as the flow of electricity through the atmosphere caused by an electrical excitation in the surrounding atmosphere. Some good examples of arcing are lightning and the event seen just as a light bulb burns out. Another form of arcing is known as "tracking" in which an excited electrical pattern follows the path of least resistance forming a small arc across an area. This type of arcing usually occurs in faulty insulation as well as other settings such as this in the switchyard.

The second occurrence, corona discharge, is a more common event in substations, and happens when the electrical conductor in the switchyard or substation exceeds the maximum allowed limit, which then causes the surrounding atmosphere to become ionized and carry an electrical charge. Discharge usually occurs in transformers and is easily detected visibly due to the blue-gray or purplish glow, and audibly from the emitted crackling or buzzing sound. In any case, both arcing and corona are main contributors to both equipment failure and energy loss.

Other areas in which these types of anomalies can be found (and should be monitored for such occurrences) are insulators, cable lines, switchgear, bus bars, relays, joints, junction boxes, and bushings. Although ultrasonic detection can be used in low, medium, and high voltage systems, the best results occur in medium and high voltage systems, making substation monitoring a natural choice for the use of this technology. With a quick scan of the lower voltage systems, the SonicScan 7000 can be used to pick up loose connections in bus bars, as well as checking junction boxes for arcing or tracking. In addition, in high voltage systems (2,000 volts and above), especially in enclosed switch-gear, the SonicScan 7000 is very useful in identifying corona problems due to its superb signal processing capability.

Thermographic Inspections Alone Aren't Enough

Thermography is extremely efficient in detecting problems as they occur, and more so after. Ultrasonics is a quick and inexpensive way to catch a lot of problems in their infancy because you can perform more ultrasonic inspections for the cost of one infrared thermography inspection. This is especially true of enclosed switchgear. Therefore, a truly proactive approach to substation maintenance must include both complementing technologies in order to achieve the desired result of reducing failures.

So How Does The SonicScan 7000 Detect These Anomalies?

Now that we understand the different types of occurrences in substations, how do we detect these events so that timely corrective action can be taken to avoid catastrophic failure? It is obvious that when these events occur there is a significant amount of energy being spent. This energy expenditure generates the ultrasonic signal that can be detected by devices such as the SonicScan 7000. However, because this signal is outside the audible range of the human ear (20 Hz to 20,000 Hz) the noise often goes undetected. To detect these occurrences, a device is needed to convert this signal or noise to the level in which the human ear can detect it, hence the use of the SonicScan 7000 and other ultrasonic detection devices. These devices take the signal from the air and filter them in such a way as to lower them into the audible range of the human ear. This is also known as "heterodyning".

How Are The Problems In The Substation Diagnosed?

Determining whether a problem exists is relatively simple once we understand what we are looking for. By comparing both the audible characteristics of the sound emissions and dB (decibel) levels among similar equipment in the switchyard and substation, it is easy to not only detect, but differentiate between good and bad equipment. Procedurally, scanning for ultrasonic emissions in a substation is done in much the same manner as a thermographic survey is done. This makes for an easy transition for long-time thermographers to adapt to using ultrasonic technology.

After you identify the critical equipment (mainly lines, switchgear, and transformers), then activate the SonicScan and walk from area to area listening for the types of audible occurrences mentioned earlier in this paper. As with leak detection, the signal intensity grows as the fault is approached, allowing the fault location to be pinpointed. However, if the fault is not approachable, i.e., power transmission lines, a parabolic dish can be used, which will double the effective range and tighten the directionality of the system.

What Are The Additional Benefits Of Using The SonicScan?

1. Continual Scanning Mode

By depressing the trigger on the SonicScan 7000 twice, the gun is put into continual scanning mode allowing effortless use of the gun. This enables a user to actively scan for occurrences in the switchyard without have to hold down the gun's trigger. Noting that switchyard scanning requires continual sweep of all equipment, this feature greatly minimizes strain on the user.

2. Signal Processing

SonicScan's signal processing has many distinct advantages over other ultrasonic instruments because SonicScan uses two internal signal paths. The first is heterodyned and its intensity in the headphones is directly affected by the volume and frequency controls. In the second path, the signal is surface sampled, measured, and the results are sent to the display. The signal is also enveloped and sent to a port on the bottom of the gun specifically designed for interfacing w/FFT analyzers, such as the CSI Model 2120.

3. Digital Readout

Ease of use is always important to end users; however, even more important is the accuracy of the information. In some ultrasonic detection devices, the ability to quantify and evaluate problems in the switchyard is severely hampered by the arduous task of having to estimate values from a fluctuating readout of the gun and then having to refer to additional materials to attain a quantifiable output. A digital display helps solve this problem by providing the information needed (dB level, frequency range, intensity, etc.) to diagnose the problem immediately, and in a form that is easy to read (numeric values) and quantify.

4. Integration

As has been discussed in the majority of this paper, the ability to store, as well as integrate both thermographic, vibration, tribological, and ultrasonic information is extremely important in having an overall understanding of the current state of your utility. The SonicScan 7000 is the only ultrasonic detection device on the market that has been designed with the express intent of integrating it with other PdM technologies through software. Built into the SonicScan is a direct, non-processed, voltage output that connects directly to the 21XX analyzers through a simple BNC connection, allowing for easy integration into any PdM program.

In addition, SonicScan has broadened this claim further by creating a dedicated platform for ultrasonic data collection that was designed solely with integration in mind.

By integrating the SonicScan with a Handheld Portable Computer (HPC) and SonicView, CSI's ultrasonics data collection software package, CSI has also eliminated the arduous task of logging data manually and transcribing notes later.

5. Temperature Reading

Using a contact probe, the SonicScan 7000 allows this second opinion to include not only the condition of the machine's ultrasonic emissions, but its temperature as well.

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Through its RBM programs, CSI offers not only the instrumentation and software, but also the support services, training and consulting needed for an easily implemented, profitable maintenance program.

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