How Ultrasound Can Detect Electrical Discharge Non-invasively and Help Eliminate Arc Flash Incidents

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Abstract

Résumé:
While infrared thermography will detect heat generated by arcing and in most instances tracking, it will not sense corona. If cabinets are enclosed, unless there is an IR test port, it is highly unlikely that infrared will detect the presence of these emissions. In addition, to view components within enclosed electrical cabinets, it is necessary to conform to NFPA standards with regards to PPE, therefore in many situations in IR inspectors must wear cumbersome clothing and hoods and perform the required procedure to open cabinets for inspection. This can be very time consuming and, in hot weather, very uncomfortable. An integrated approach incorporating infrared and ultrasound is recommended for the detection of the potential of arc flash.

Arcing, Tracking and Corona emissions produce ionization. Ionization, is a process by which a neutral atom or molecule loses or gains electrons, thereby acquiring a net charge and becoming an ion; occurs as the result of the dissociation of the atoms of a molecule in solution or of a gas in an electric field2. Ionization has by-products: ozone and nitrogen oxides. These combine with moisture to produce nitric acid, which is destructive to most dialectics and certain metallic compositions, resulting in corrosion.

The object of electric condition monitoring is to detect the presence of these events before flashover* occurs or before they produce an arc flash incident when a cabinet is opened.
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I. INTRODUCTION
While infrared thermography will detect heat generated by arcing and in most instances tracking, it will not sense corona. If cabinets are enclosed, unless there is an IR test port, it is highly unlikely that infrared will detect the presence of these emissions. In addition, to view components within enclosed electrical cabinets, it is necessary to conform to NFPA standards with regards to PPE, therefore in many situations in IR inspectors must wear cumbersome clothing and hoods and perform the required procedure to open cabinets for inspection. This can be very time consuming and, in hot weather, very uncomfortable. An integrated approach incorporating infrared and ultrasound is recommended for the detection of the potential of arc flash. Arcing, Tracking and Corona emissions produce ionization. Ionization, is a process by which a neutral atom or molecule loses or gains electrons, thereby acquiring a net charge and becoming an ion; occurs as the result of the dissociation of the atoms of a molecule in solution or of a gas in an electric field. Ionization has by-products: ozone and nitrogen oxides. These combine with moisture to produce nitric acid, which is destructive to most dialectics and certain metallic compositions, resulting in corrosion.

The object of electric condition monitoring is to detect the presence of these events before flashover occurs or before they produce an arc flash incident when a cabinet is opened. Airborne/structure borne Ultrasound technology is ideally suited for detecting these emissions since the ionization process produces ultrasound. Ultrasonic instruments sense between 20-100 kHz and use heterodyning to translate the ultrasonic emissions into the audible range. These portable instruments provide information via headphones for the audio signal and on a meter to display intensity readings, usually as decibels. These hand-held devices usually contain two sensing heads containing piezoelectric transducers: a scanning module for airborne sounds and a contact probe/wave-guide for structure borne signals.

II. HOW ULTRASONICS PORTABLE INSTRUMENTS ARE USED TO DETECT POTENTIAL FAILURE AND ARC FLASH CONDITIONS
A. Ultrasonics Inspections Principles
Typically, an operator will scan around the door seams and air vents of enclosed electrical cabinets with the scanning module while listening through headphones and observing a display panel. Arcing, tracking and corona all have distinct sound qualities that can be heard. If there are no air paths, the inspector will use the wave-guide to probe around the cabinet wall. Due to a possible change in wave characteristics as the ultrasound moves from airborne to structure borne the operator will change the frequency from 40 kHz (effective for airborne scans) to 25 kHz. Should there be a need to analyze these patterns further, the sounds can be recorded and played back on spectral analysis software. Voltage will play a role in the diagnosis since corona will only occur at 1,000 volts and higher. High Voltage Electrical Cabinet Ultrasonic Inspection B. The advantage of spectral analysis There may be instances where it is difficult to determine the type of problem heard through the headphones. In these situations, a sound recording of the condition can be made (some instruments have on-board sound recording capability) and viewed on spectral analysis software. The sounds may be heard in real time as they are viewed on an FFT or time series screen for analysis. This enables inspectors to observe subtle problems that might be missed by just viewing a screen without sound. As an example, the following screen shows a transformer that had a typical transformer hum. By just observing the screen, the condition of loose windings might have been overlooked. The sound sample, showing a buildup and drop off of the sound along with movement on the screen highlighted this condition. III. MID AND HIGH VOLTAGE
Higher voltages often produce more potential for equipment outage. Problems such as arcing, destructive corona or tracking (sometimes referred to as “baby arcing”) and corona as well as partial discharges and mechanical looseness all produce detectable ultrasound that warn of impending failure. Detecting these emissions is relatively easy with ultrasound. The acoustic difference among these potentially destructive events is the sound pattern. Arcing produces erratic bursts, with sudden starts and stops of energy, while corona is a steady “buzzing” sound. Destructive corona has a buildup and drop-off of energy resulting in a buzzing sound accompanied by subtle popping noises. While scanning for these emissions, use a parabolic reflector. These accessories can more than double the detection distance of the standard scanning modules. High Voltage Line Ultrasonic Inspection Partial discharge (PD) which occurs inside electrical components such as in transformers and insulated buss bars, is another problem that can be detected with ultrasound. Partial discharge can be quite destructive. It is affected by and causes deterioration of insulation. This is heard as a combination of buzzing and popping noises. The contact probe is employed for PD detection. If your Instrument has frequency tuning, try 20 kHz. High Voltage Line Ultrasonic Inspection IV. ANALYSIS OF RECORDED SIGNAL
While it is relatively easy to determine arcing, tracking or corona by the sound pattern, there can be occasions where it may prove confusing. It may be possible that a strong buzzing sound related
to corona might in fact be nothing more than mechanical looseness. Spectral analysis and Time Domain can be a useful tool in analyzing electric emissions. Since all Ultraprobe instruments heterodyne ultrasound down into the audible range, either the headphone jack or the Instrument itself – Ultraprobe 15.000 may be used to view and record sounds. You must use a suitable recording device that has a suitable bandwidth in the lower frequencies. Digital Voice Recorders are not acceptable as they only can record signals above 300 Hz, which is not low enough to be useful for the 50 or 60 Hz peaks. Laptop Computers, MP3 Recorders work well for recording the signals in the field. When recording the signals, you need to make certain that the signal is not distorted. On the Analogue instruments, you should not let the signal go over 50% of full scale on the signal strength indicator. On the Digital Instruments, you should try to maintain the signal strength to between 40% to 60% of the bargraph. These sounds can then be downloaded to a PC with a sound card and viewed as a spectrum or time series for analysis. It is necessary to examine both the Spectrum and the Time Domain images when you are trying to evaluate what is going on. The main harmonic of an electrical emission (60 Hz in the USA, 50 Hz elsewhere) will be most prevalent in corona. As the condition becomes more severe, there will be fewer and fewer 60 Hz harmonics observed. As an example, arcing has very few 60-cycle components. Mechanical looseness will be “rich” in 60 Hz Harmonics and will have little frequency content between the 60 Hz peaks and will also demonstrate harmonics other than 60 Hz. Examining the Time Domain image can also be of help. In the case of Corona, you will have a uniform band of signal with very few peaks that extend above the average “band”. With Tracking, you will begin to see the peaks created by the discharges extend above the average “band”. With Arcing, you will see several “bursts” of energy which correspond with the discharges. In all cases, both the Spectrum and the Time Domain should be examined before the final determination is made. Time Domain Signal V. EXAMPLES OF BOTH THE SPECTRUM FFT AND TIME DOMAIN VIEWS FOR THE VARYING DEGREES OF SEVERITY OF DISCHARGE TO ATMOSPHERE A. Corona Effect Time Domain Signal FFT Signal B. Partial Discharge / Tracking Time Domain Signal FFT Signal C. Bad Tracking Time Domain Signal D. Arcing Time Domain Signal FFT Signal E. Vibrating Component / Mechanical Looseness FFT Signal VI. NEW ON-LINE CONDITION MONITORS While a great majority of the inspections around energized electrical equipment incorporates portable instruments, these inspections are limited in their ability to protect equipment from failure or from an arc flash potential from going undetected. The limitations are time based. If an inspector is testing at the time any of these incidents is occurring, there is a good chance they will be detected and reported for corrective action. But, unlike mechanical conditions which are usually detected first and then trended to specific action levels, once arcing, tracking or corona are present, there is a potential for failure and arc flash that can occur at any time. Therefore, there is need for continuous on-line monitoring of enclosed electrical equipment. An electrical cabinet monitor is mounted on the internal side of a door or wall facing the components. Utilizing an airborne scanner, a threshold level is set. Should an event of arcing, tracking or corona occur, the sound level will be above the ambient threshold and be detected. A 4-20 mA or 0-10 VDC output can be selected to carry the signal to an alarm mechanism or red light alert. In addition, these units contain a heterodyned signal to provide recording capability for record keeping and analysis purposes. The advantage to on-line monitoring is obvious, it is not operator dependent and will continuously monitor. Whenever a condition occurs to produce the potential for arc flash or flashover, it will be sensed and alarmed instantly. Conclusion Ultrasound inspection is an effective screening tool for detecting the potential for arc flash incidents. When hand- held ultrasonic instruments are used to scan enclosed electrical apparatus the procedure is fast, accurate and simple. It can help inspectors by eliminating the need for wearing cumbersome, uncomfortable PPE during a preliminary survey. On-line continuous monitors can alert personnel of the presence of arcing, tracking and corona in advance of an inspection. *Flashover (according to Merriam-Webster’s New Collegiate Dictionary) is an abnormal electrical discharge (as through the air to the ground from a high potential source or between two conducting portions of a structure). 1. *Preventing Arc Flash Incidents in the Workplace*, George Greggory: EC&M June 2003 2. National Fire Protection Association, 1 Battery March Park, Quincy, MA 02269-9101 3. www.hatch.com glossary of chemical terms

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