Inspection Methods to Determine Potential Arc Flash

By Mark Goodman, VP of Engineering, UE Systems, Inc

Arc flash can be considered as a short circuit through the air: It produces tremendous stored up energy that will travel outward from electrical equipment. An arc flash produces temperatures as high as 35,000 degrees F, which is hotter than the sun, and produces a force that is equivalent to being hit by a hand grenade. The impact is so high it can cause hearing loss and memory loss. If it doesn't kill you, it will severely burn or injure you. In addition, the conditions that produce an arc flash, even when no arc flash occurs, will also lead to damage to electrical equipment causing unplanned outages and costly downtime. Worse, many victims are so badly burned they require treatment at special burn centers.

The Science Of Safety

In the U.S., the Occupational Safety and Health Administration (OSHA) has become aggressive in its attempts to reduce arc flash incidents and has begun to use the National Fire Protection Association NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces, 2005 edition, as the guide for compliance for worker safety. There are standards for arc flash assessment, various types of PPE (Personnel Protective Equipment), working around energized equipment, and opening enclosed equipment to name a few, all of which are geared towards worker safety.

Arc flash incidents can result from poor work habits, dropping of tools, or accidental contact with energized equipment. However, there are conditions that produce the potential for arc flash within enclosed cabinets that can be detected before creating flashover or arc flash incidents. These conditions are arcing, tracking, and corona.

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 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.

Portable Instruments

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. This enables inspectors to observe subtle problems that might be missed by just viewing a screen without sound.

Low Voltages

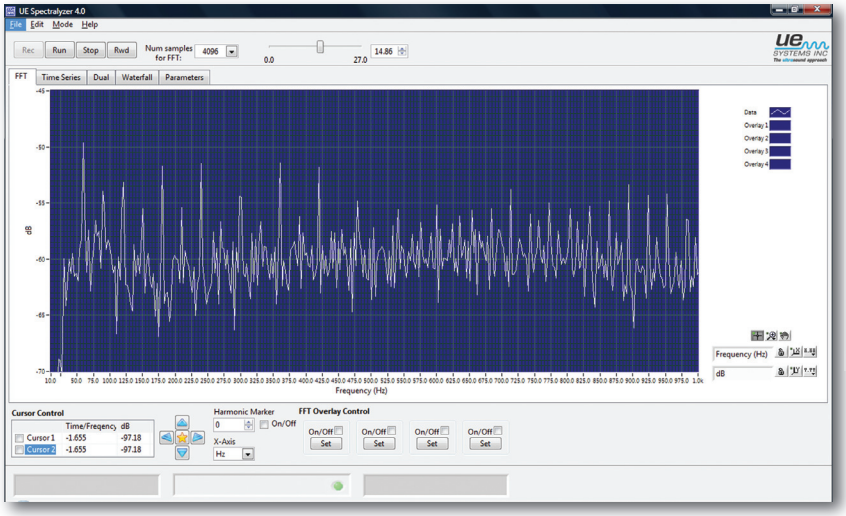
We are often asked at which voltages and on what type of equipment is ultrasound most effective. The answer is not simple. First of all, determining the definition of low, mid, and high voltages is relative.

The main concern in low voltage equipment is arcing. Typically 110, 220, and 440-volt systems are inspected with infrared imaging and/or spot radiometers for temperature changes. Hot spots, usually an indication of resistance, can be indicative of a potential for equipment failure or it could indicate a possible fire hazard. When arcing occurs, it is often accompanied by heat. However, it is not always possible to detect a hot spot if the equipment is covered. Ultrasound will hear arcing in circuit breakers, switches, contacts, and relays. In most instances, a quick scan of a door seal or vent will detect the ultrasound emission. Listening for internal arcing in circuit breakers and switches can be accomplished with the contact probe. For example, touch a circuit breaker switch with the contact probe to listen for internally generated arcing. The most effective method of low voltage inspection will be to combine infrared imaging with an ultrasonic probe.

Mid And High Voltages

Higher voltages often produce more potential for equipment out-

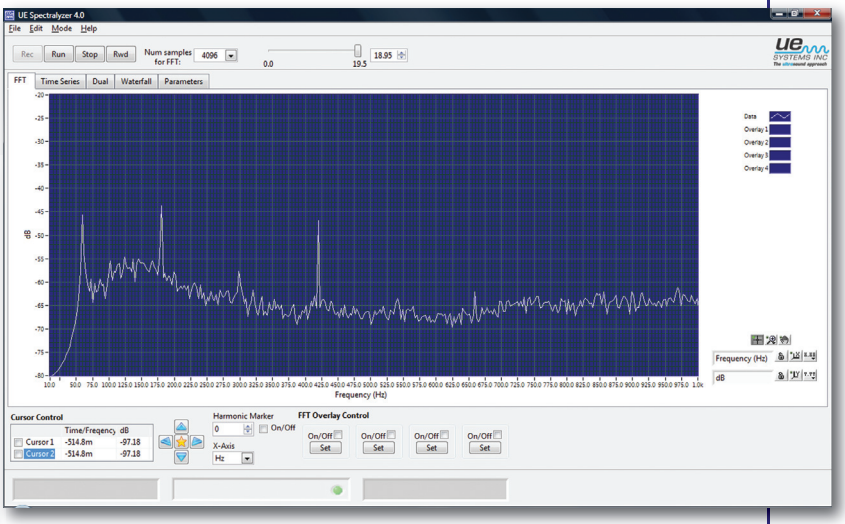
age. Problems such as arcing, destructive corona, or tracking (sometimes referred to as "baby arcing") and corona, as well as partial discharges and mechanical looseness, all produce detectable ultrasound that warn of impending failure. Detecting these emissions is relatively easy with ultrasound. The 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 build up 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.



Analysis of Recorded Signals

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 tools in analyzing electric emissions. Since all Ultraprobe instruments heterodyne ultrasound down into the audible range, either the headphone jack or the Instrument itself—Ultraprobe 10000 may be used to 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, or quality cassette 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 percent of full scale on the signal strength indicator. On the digital instruments, you should try to maintain the signal strength to between 4 to 6 segments 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. 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.



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. The advantage to on-line monitoring is obvious; it is not operator dependent and will continuously monitor.

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 alarm personnel of the presence of arcing, tracking, and corona in advance of an inspection. **IMPO**