Non-Destructive Test Methods

Nicole Wallace and Mark Goodson*
Goodson Engineering, 1500 Spencer Road, Denton, TX 76205

Abstract

We present testing methods that can be applied in forensics engineering toward the investigation of fires. There are five methods that are often used and are effective in obtaining analysis without damaging the object or material in question. One of the key standards important to fire investigations comes from ASTM 860, *Standard Practice For Examining and Testing Items That Are Or May Become Involved In Litigation*. Basically, this standard explains that potential parties involved in a fire investigation should be notified if any "testing, disassembly, or other action" that would "preclude or adversely limit additional examination and testing" of the object or material involved as evidence is to take place. Testing that is considered "destructive" could also be considered as "adversely limiting additional testing." This can lead to spoliation issues in fire cases. There are fire investigators that will lean toward little or no investigation being carried out until all parties are in attendance due to potential claims of spoliation. Our present research is appraising different test methods that will not affect the quality or integrity of the evidence being examined. Currently the test methods are not commonly used in fire investigations. However, the adoption of these methods will lead to better analysis techniques.

Optical Microscopy

Optical microscopy refers to the utilization of microscopes that use visible light and a system of lenses to magnify images. There are many types of light microscopes suited for many different tasks. Some examples are the stereo microscope, comparison microscope, and the phase contrast microscope. These types of microscopes are commonly used to magnify the images of small samples. Nowadays the configuration of lenses in these microscopes can be more complex and numerous leading to better contrast and illumination. One of the more useful techniques that can be done with optical microscopy is image splicing. Various images of a sample can be stitched together into a composite image that provides better depth of view. Photo #1 shows a modern type of stereo microscope with a CCD camera attached.

Photo #1 - Light Microscope

Endoscopy

Endoscopy is a term that refers to "looking inside." Endoscopic methods make use of instruments such as the borescope for situations where the line of sight is not readily accessible. The borescope is an optical instrument that consists either of a rigid or flexible tube with an eyepiece on one end and objective lens on the other, along with a fiber optic guide. The eyepiece and the objective lens are joined together by an optical relaying system. This optical device is used to look inside objects without the necessity of cutting them apart. The use of borescopes has led us to be able to examine the internal mechanisms of:

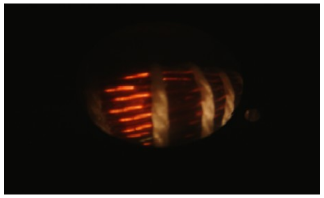
- Compressors
- Motor Windings
- Circuit breakers
- Water heaters
- Gas valves
- Televisions
- Fuel tanks
- Heat exchangers

Photo #2 and Photo #3 show both types of borescopes. Photo #4 shows the image of the inside of a refrigerator compressor taken with a rigid borescope. The CCD camera was used to capture this image. In this case, a sealed compressor had a 1/4" hole drilled in it in order to obtain the image.

Photo #2 - Flexible Borescope

Photo #3 - Rigid Borescope

Photo #4 – Inside of Refrigerator Compressor

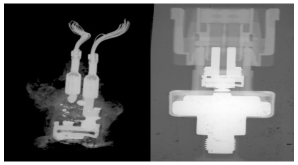


Radiography

In the process of radiography, materials are inspected using a type of penetrating radiation such as from an x-ray tube. This penetrating radiation helps to locate components or hidden flaws in materials that may not be seen otherwise. The theory behind radiography is that it has the ability to produce short wavelength electromagnetic radiation which is needed to penetrate the material. Photo #5 shows a typical x-ray machine used for engineering analysis with the control panel toward the bottom. Photo #6 shows the x-ray of a brake pressure switch that was damaged. The one to the right of it shows one that is not damaged. Both are used as points of comparison.

Photo #5 - X-Ray Machine

Photo #6 - X-ray of Brake Pressure Switches

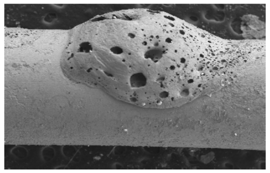


Electron Microscopy

Electron microscopy refers to another type of microscopy that makes use of a beam of electrons instead of visible light. This type of method is generally used when higher magnifications of the samples are needed. The theory behind this method is that the electrons help produce smaller wavelengths which are needed to produce a higher resolution. An example of an instrument in this type of method is the scanning electron microscope (SEM). This method provides a greater depth of view of the sample. Secondary electrons or back scatter electrons can be measured using two different detectors on the SEM. The SEM has proven to be very useful in the examination of the topography of metal surfaces. Fractures in materials can be located and seen at higher magnifications. Arcing and gouges in metal wires can be seen as well with great ease. Photo #7 shows the SEM setup with an EDAX detector attached. Photo #8 shows a SEM image of a copper wire damaged from arcing.

Photo #7 - SEM Setup

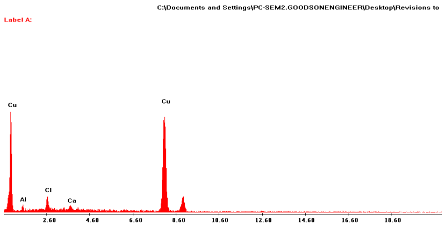
Photo #8 – Effects of Arcing on Copper Wire



EDS

Energy Dispersive X-ray Spectroscopy (EDS or EDX) is a type of spectroscopy that makes use mainly of x-rays or electrons to characterize the chemical make-up of samples. This type of analysis is qualitative; however quantitative analysis can be done as well with material standards involved. EDS detectors are most commonly integrated into a scanning electron microscope (SEM). It acts as a detector on the SEM. In this setup, the EDS uses electrons generated from the SEM to characterize samples. The SEM coupled with EDS detector provides an efficient way of obtaining an image of the sample along with a chemical emission spectrum. Photo #7 mentioned before for SEM contains a long cylindrical EDAX detector attached. Photo #9 shows the emission spectrum of the copper wire depicted in photo #8.

Photo #9 - Emission Spectrum of Copper Wire



Conclusion

The five techniques described in this paper have been shown to be very useful and quite remarkable for the task at hand. As mentioned earlier, these techniques are non-destructive ways to examine, analyze, and in some cases characterize the various materials or objects that come under investigation. The use of these methods facilitates investigative work and leads to more productive analysis.

References

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