Incorporation of Materials Properties Enhances Forensic Electrical Investigations

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OBJECTIVE: An exploration of the properties of materials relevant to three areas of interest: electrical fire cause and origin, shocks/electrocutions, and electrical product defects, will show the effectiveness of an interdisciplinary approach to forensic electrical analysis.

All too often a fire investigator will produce an isolated box of burned electrical wires, components and housings and expect the electrical engineer to declare whether or not the fire was caused by electricity. Fires often occur in a cacophony of inharmonious materials and must be analyzed in a context that accounts for the entire local environment of that electrical equipment just before ignition. This presents the forensic electrical analyst the opportunity to exercise a wide range of diverse knowledge and skills regarding the properties of materials.

The solubility of gases in molten metals can provide clues to the cause of an electrical fire. An arc bead in its molten state will absorb the elements from the surrounding atmosphere and preserve that record for later recovery and interpretation.

Thermal conductivity considerations may indicate whether the electrical component could have started the fire or the fire merely penetrated into the component, causing its destruction. The available thermal energy of a spark may bolster or quash a proposition as well. Several types of clues may be gleaned from the plasma properties of conducting gases. The presence of metallic vapor will increase the arc's available energy and leave metallic deposits as "shadows" on surrounding materials that show failure mechanisms and indicate the direction of the arc origin. Ignition limits, burn rates and combustion energies can all sink or save a theory of causation based on arcing.

Although pure water is an impressive electrical insulator, the "conductivity" of water-based solutions contributes to the explosion of trees and power poles from lightning, and the efficacy of earth as an electrical "ground," even in the face of a National Electrical Code (NEC) proscription against the use of earth as a "grounding conductor." Though a versatile fire suppressant, water in equipment could actually start a fire if it caused excess leakage current to flow in under-protected wires.

The effects of electrical stress, especially on human tissue, may help determine the validity of a claim of electric shock, or confirm the viability of an assertion of electrocution. Properties of contacting surfaces may be used to show that internal injury from electric shock doesn't always require an entry or exit wound.

A material's mass, friction, surface tension, hardness, acceleration, strength, conductivity, reactivity, elasticity and almost any other property may be called upon for the analysis of electrical product design and manufacturing defects. The primary purpose of many electrical machines and devices involves rotation or vibration. The resulting mechanical forces and stresses can modify the material properties of the conductors, insulators and supporting structures creating electrical failures that manifest in fires, floods, shocks and lost production.

Material properties underlie many edicts of the National Electrical Code (NEC). For example, electrical failures most commonly entail a breakdown of insulation either from excess voltage related electrical stress or excess current related overheating. The electrical current carrying capacity of wires, mandated by the Code, is determined not by the failure modes of the metallic conductor but by the material limitations of its insulation. These include its tolerance not only to heat but to all anticipated environmental exposures, as well.

Conductivity of conductor connections is affected by the presence of ambient chemicals and may require special treatment, often with anti-oxidants or additional sealers. If you add thermal or security considerations, include an array of encapsulation polymers. Connections are particularly susceptible to thermal stress, "cold flow" or "creep," resulting from ductility and malleability, and the frictions associated with the "stacking properties" of various shapes.

Thus Forensic Electrical Engineering cannot be conducted in disciplinary isolation and its results are enriched by incorporating knowledge of the properties of materials.

Electrical Fires, Electrical Shocks, Material Properties