C24 Modern Equipment Control Affects Electrocution Risk

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After attending this presentation, attendees will be able to identify some work place electrical hazards, to expose the elements of electrocution, and provide a comparison of SCR switching and rheostat control to an electrocution.

This presentation will impact the forensic community and/or humanity by demonstrating how to identify some electrical hazards in the workplace, and how the use of modern electrical design techniques may contribute to these hazards.

Proposition/Hypothesis: A fatal industrial accident involving a hotwire foam cutter indicates a potential increase in electrocution hazard resulting from the use of modern switched-mode techniques in industrial control design.

A salesperson at a foamed plastic plant was using a hot wire cutter to cut to size a stack of three 2" thick panels of structural foamed plastic. It was an extra order which the person was performing alone on a very hot night. He had been working for 17 hours when he was found positioned as though he had tumbled awkwardly into the frame of the cutting table. The coroner reported a cauterized lateral burn on the decedent's face, with charring on the interior of lip and a superficial burn on the thigh corresponding to the frame height. Cause of death was noted as positional asphyxia.

The knob controlling cutting wire heat was found rotated to the zero position; the power switch was on, but the switches controlling cutting wire carriage movement were off.

With the controls in this position, the potential from the cutting wires to ground was measured to be 120 v.

It was surmised that the decedent was sighting the cutting wires to position the work piece when he contacted the topmost of three cutting wires with his sweaty face. This sent an electric current from his head though his neck and torso to his right thigh.

Measurement of the electrical resistance of the body of other subjects demonstrated that an electrical impulse sufficient to affect the heart would have been generated by that contact.

Muscles are electrochemical in nature and, as such, produce characteristic electrical waveforms but can also be influenced and controlled by electrical signals. Muscles and nerves generally reside in a polarized state, poised for action. Once a muscle or a nerve is activated it "depolarizes" thus transmitting the intended signal (for a nerve) or performing a physical contraction (for a muscle). When they recover, by redistributing metallic ions in the body-fluid electrolytes, they are said to repolarize.

Electricity follows the path of least resistance. In living tissue the paths of least resistance are the nervous system, the lymphatic system, and the circulatory system. With regard to the heart and the cardiac cycle, there is significant sensitivity at one particular place in the cardiac cycle referred to as the T wave. The normal cardiac cycle exhibits an atrial depolarization demarking the contraction of the right atrium; this is identified as the P wave. After a variable 125-300 millisecond delay, another depolarization referred to as the QRS-complex, demarks the contraction of the ventricles of the heart. Following the QRS complex by 50 to 150 milliseconds is the T wave, which demarks the repolarization of the cardiac muscle.

Modern defibrillator technology uses IGBT, Insulated Gate Bipolar Transistor, similar to the SCRs used in industrial control, in switchedmode controlled circuitry to produce a stream of pulses between 50 and 60 Hertz to perform cardiac conversion. The term "conversion" in the context of cardiology refers to converting a chaotic or fibrillating rhythm to a regular pacing rhythm. The same stream of pulses can convert a regular cardiac rhythm into fibrillation or from fibrillation to a regular rhythm.

Modern semiconductor components have increased in performance such that with modern pulse-width and frequency-modulation control techniques, the use of rheostats, iron core inductors and transformers which limit the controlled circuit voltage is being supplanted. Such techniques are good in that they decrease the size, weight, and cost of industrial controls; however, the control waveforms bear a significant resemblance to the waveforms intentionally used by cardiac defibrillators.

In conclusion, there is a particular electrical hazard present in the modern industrial environment due to the use of the modern electronic design techniques afforded by improvements in silicon devices.

Other factors in this case are (1) failure to turn off the machine's main switch; (2) two red warning lights were burned out; (3) required warning signs were absent or obliterated; (4) decedent was doing work he was told not to do; (5) decedent was probably affected by the long hours and high heat; (6) decedent was not a regular operator of the machine.

Electrocution, Cardiac, Switched-Mode Control

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