Analyzing Electronic Control Device (TASER) Wire to Determine Duration of Short Circuit

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ABSTRACT

When the trigger of an Electronic Control Device (ECD) such as a TASER is activated, a timed cycle of pulsed electrical energy (usually five seconds) is automatically delivered. This cycle is designed to temporarily incapacitate the subject through involuntary muscle contraction, to reduce escalation of force and injury potential to all parties involved. However in some field applications, the situation may dictate multiple cycles from the device.

In the post incident analysis, it may necessary to determine the time that the individual was exposed to the discharge. Although the cycle duration is recorded within the TASER unit, the data does not necessarily equate to energy delivered to the subject. The ECD output will take the path of least resistance to complete a circuit between the positive and negative poles. Occasionally, the electrical path will short circuit across the wires, and not through the intended subject. The area through the wire becomes damaged/burned as a result of the passing current. Microscopic examination of the burned wire can determine the site of the wire to wire arc, and the duration of the short circuit can be approximated. Discharge cycles of 1, 5, 10, and 20 seconds in duration were evaluated to determine the size of the wires' burned area. This technique can prove useful to help verify and reconstruct the circumstances surrounding an incident. For the purposes of controlling experimental conditions, the probe was arced through the wire on the opposing side. The damaged area of the wire was measured. Based on the data, durations of the short circuit in the field can be approximated.

Introduction

In the late 1960's, John Cover introduced the concept of a "conductive energy weapon" to assist law enforcement in dealing with increasing civil unrest within the United States. The idea was to create a less-lethal weapon that would incapacitate a person without permanently injuring them. The TASER, or "Thomas A. Swift's Electrical Rifle," was designed to send an electric shock through a person for temporary incapacitation. When the first TASER was introduced in 1974, this less-lethal weapon was considered a firearm since it used gunpowder as a propellant.

In 1993, TASER International introduced the Air TASER based on the concept of the original model. These new models were considered non-firearms since they used compressed nitrogen as the propellant. Since then, TASER International has introduced additional generations of the TASER. Two of these models, the Advanced TASER M26 and TASER X26, are currently used in numerous law enforcement agencies around the nation. Both of these devices are designed to override the normal muscle control of the subject through involuntary muscle contraction. Although they differ in size and power output, the cartridge that they fire is identical and interchangeable.

The TASER system (Figure 1) is composed of the main unit

Figure 1: TASER X26, TASER X26 with cartridge and TASER CAM

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and a removable cartridge. The cartridge contains the probes, lightly insulated wires, and compressed nitrogen propellant (Figure 2). When the trigger is pulled, a spark from the unit initiates an electrically fired primer. This releases the compressed nitrogen which propels the probes and wires. The probes and wires leave the cartridge at approximately 180 feet per second and are separated by an angle of 8 degrees of trajectory, allowing them to spread as they travel through air. When the probes come into contact with the subject, pulsed electricity flows between the two probes through the subject. This cycle mimics signals to the skeletal muscle system, causing contractions. The levels of incapacitation will vary depending on the amount of muscle mass affected by the spread of the probes.

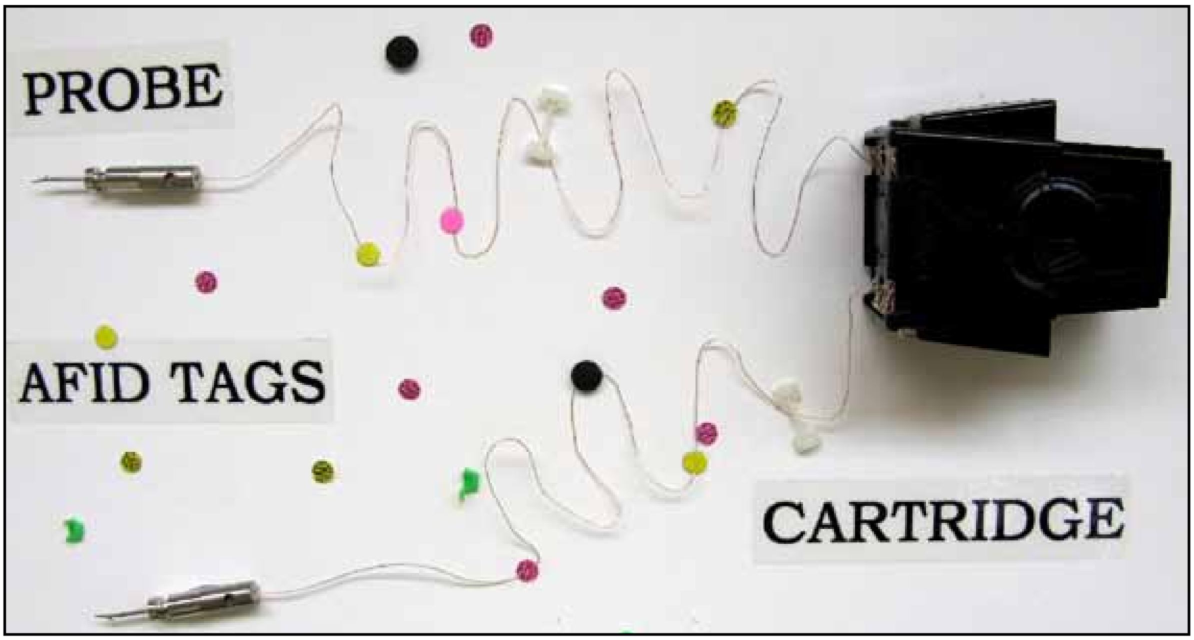


Figure 2: Cartridge components

Depending on the circumstances surrounding an incident, it is possible that a probe may either come loose or miss the subject. When this occurs, a circuit can still be created if a probe or wire comes in close contact with the opposing probe, wire or the subject (conductive material) the other probe is imbedded in. The electrical energy may arc to the opposing wire and burn through the insulation, creating a short circuit. If this occurs, the incapacitating effect may diminish or be absent all together.

The objective of this study was to determine if the time of a discharge cycle corresponds to the size of the visible change to the exposed wire due to short circuiting. This would be key information in reconstructing an event involving this type of circumstance.

Methods

Short circuits across the wires with TASER deployments have occurred in the field. However, preliminary results demonstrated that a wire to wire short circuit was rare in the experimental setting. It is speculated that short circuits in the field are due to a breach of the wire insulation (struggle, etc). To simulate a breach of the wire insulation in the field, the experiment focused on probe to wire interaction. A TASER X26 and six cartridges were used, each with approximately 25 feet of wire per probe. Each wire was tested thereby giving twelve results for each duration. The TASER cartridge was insulated with neoprene to prevent completion of the circuit/ unintended short circuit at the cartridge and force the electrical energy where desired (Figure 3).

Each wire was positioned with the intent to create a controlled arc distance. The tip of one probe was placed 90 degrees, approximately 2.5mm from the opposing wire (Fgure 4 and 5). This forces the electrical discharge to complete the electrical circuit in a pre-determined area. Discharge durations of 1, 5, 10, and 20 seconds were tested in different areas along a wire and tagged. For the 10 and 20 second intervals, multiple trigger activations with pauses between cycles were tested as well as continuous discharges to determine any differences.

Results and Discussion

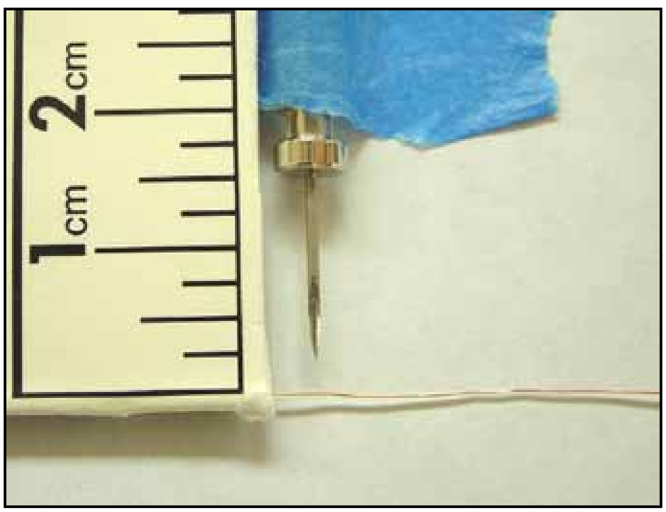
Short circuiting occurred with probe-to-wire arrangements only. Wire-to-wire interactions were also tested by contacting the opposing wires at designated areas (reliable data was not obtained due to the high impedance of the insulation on the two interacting wires). For the 10 and 20 second intervals, a total of 12 results were not obtained due to difficulty in creating a consistent short circuit for the duration of the cycle.

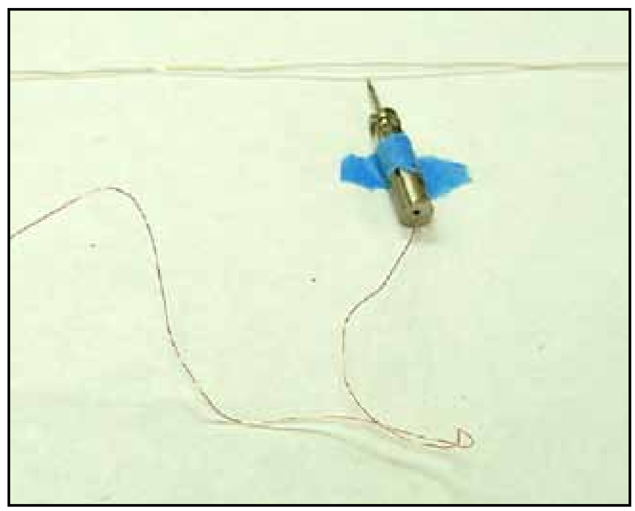
A Leica UFM4 comparison microscope was used to examine the areas of melted insulation and exposed wire. Using the air-gap method, an electronic digital micrometer was used to measure the exposed wire and averages were calculated for each time interval (Figure 6 and 7).

For 1 second, an average of 0.104mm was measured, while for 5 seconds 0.139mm was measured. For 10 seconds, 0.193mm and 0.200mm were measured for intervals containing pauses and without pauses, respectively. The greatest differences were observed for 20 seconds with averages of 0.236mm and 0.251mm for intervals containing pauses and without pauses, respectively.

Figure 3: Insulated cartridge

Although the average data showed distinct differences in burn area size between intervals, there was variability in the data which caused an overlap in the time intervals. This was expected due to the dynamics of electricity. Therefore, it would be difficult to place a single wire into a specific time interval in most circumstances, although comparative approximations are possible.





Figures 4 and 5: Set up of probe-to-wire interaction

The differences in sizes resulting from the pauses and no pauses could be due to the ionized/energized air around the circuit between trigger pulls or the cooling of the wire from the delay in activation. When the trigger is held down constantly a larger area will is more likely to be exposed.

Conclusions

Based on the average measurements, it is possible to identify and document arcing locations where ECD pulsed energy is short circuited away from the intended target across insulated cartridge wire. There is a noticeable difference in the size of the hole created from the burning of the insulation between the different time intervals. However, a single measurement would be difficult to place with any degree of accuracy due to some overlapping of data at some intervals.

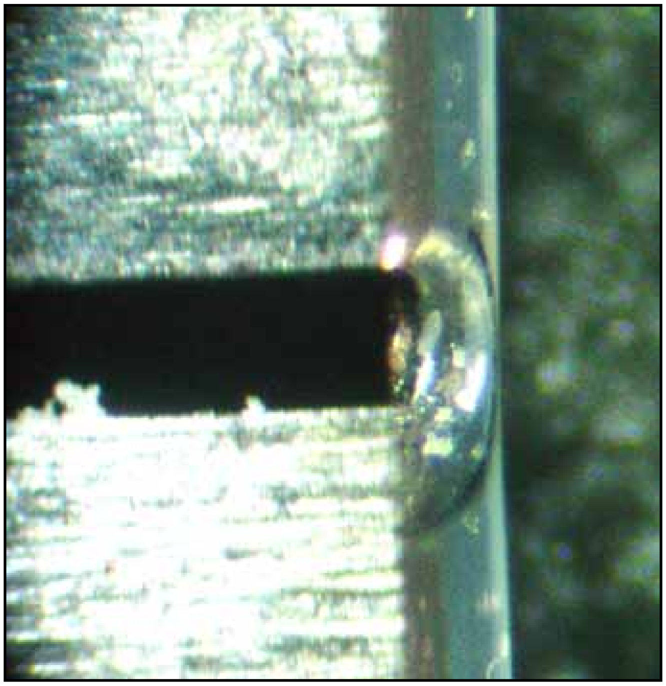


Figure 6: Air-gap measurement; Left- micrometer, right- exposed wire

For the 10 second interval, it can be presumed that there is no significant difference between multiple cycles or continuously cycling the device. As the time interval increases, a more significant difference will be observed with pauses between trigger pulls. By knowing the size of an exposed wire/melted insulation, an approximation can be made to the amount of time of a short circuit with a limited amount of certainty.

Future Study

We currently have a study underway evaluating the wire-probe junction with a scanning electron microscope (SEM). Preliminary data indicates that the duration of cycle delivered to the probe, and therefore to the conductive subject at the probe, can be determined. This is useful to determine if an electrical circuit was completed, and can provide context to the memory download obtained from the device memory.

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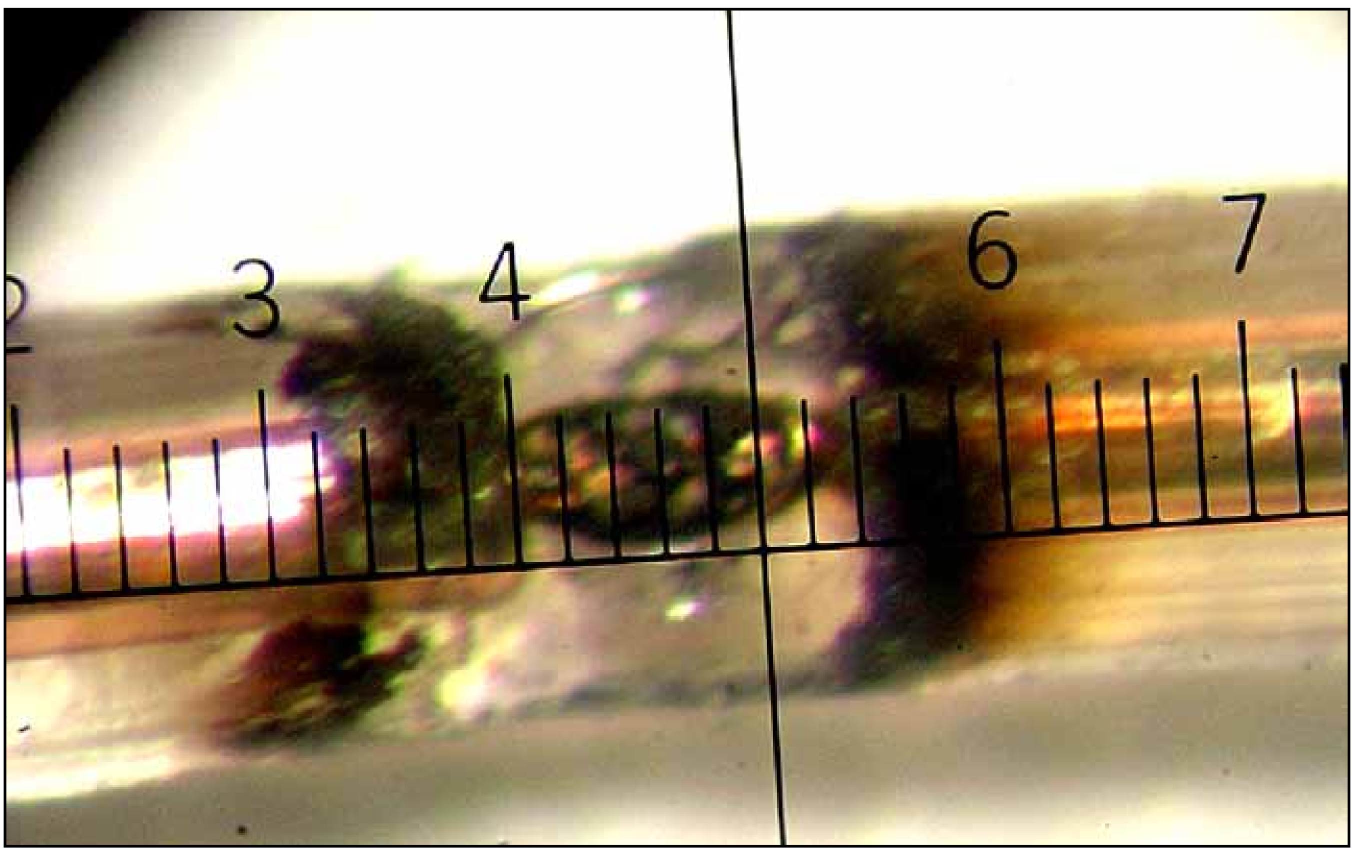

Figure 7: Direct wire measurement under stereoscope

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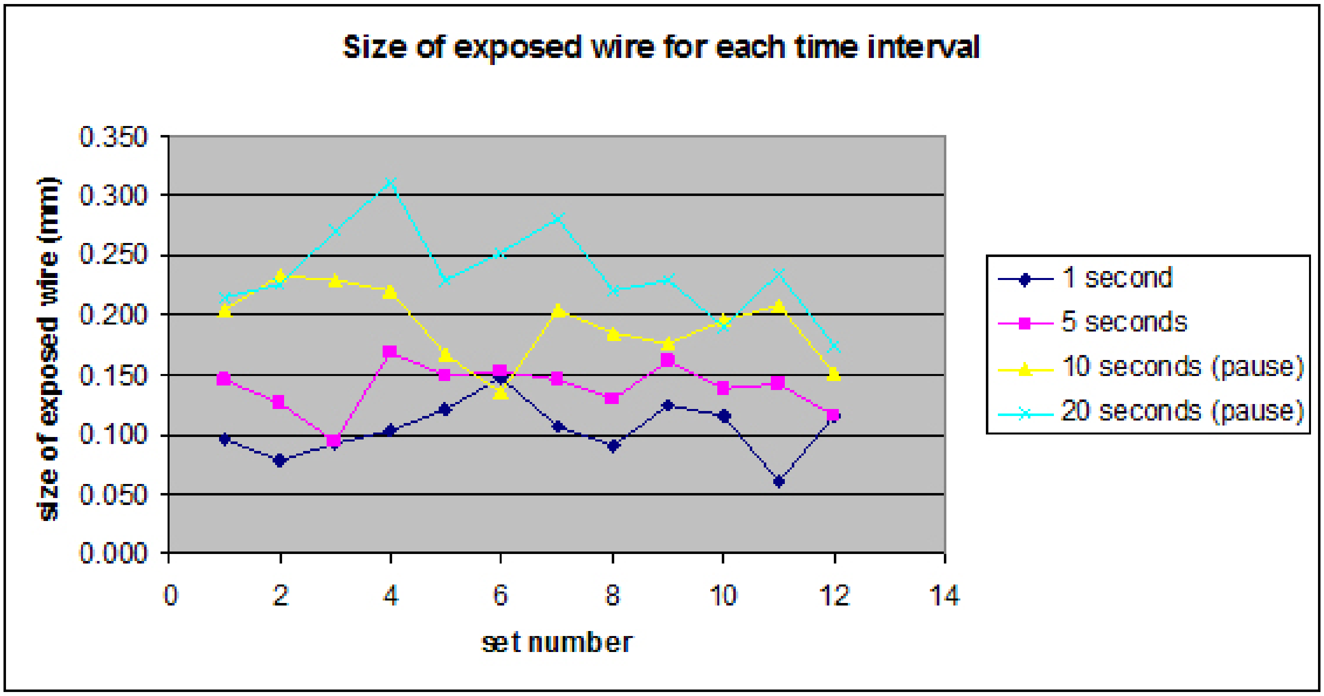

Figure 8: Summary of data, n=12 for each set

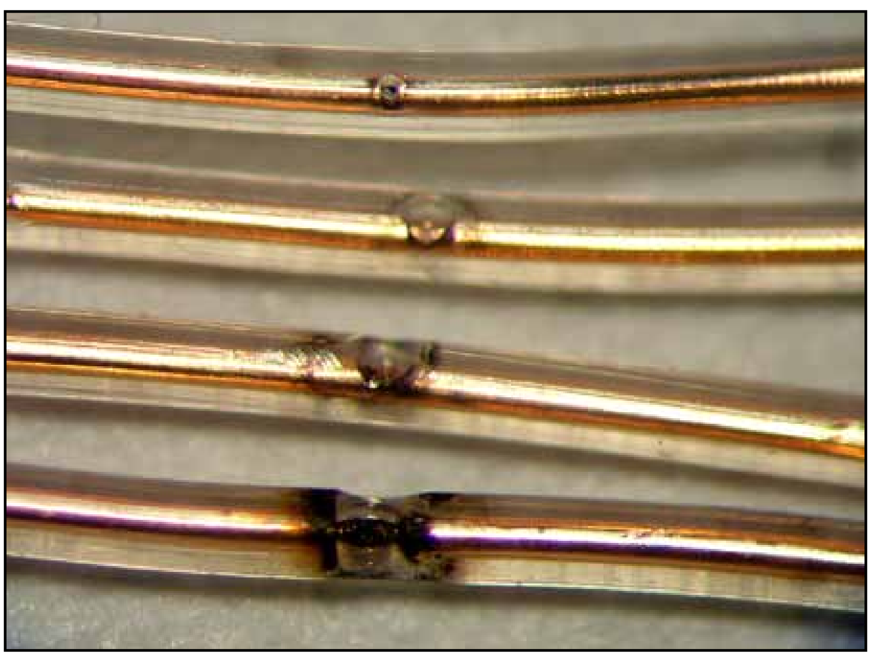

Figure 9: (top to bottom) 1, 5, 10 and 20 second intervals

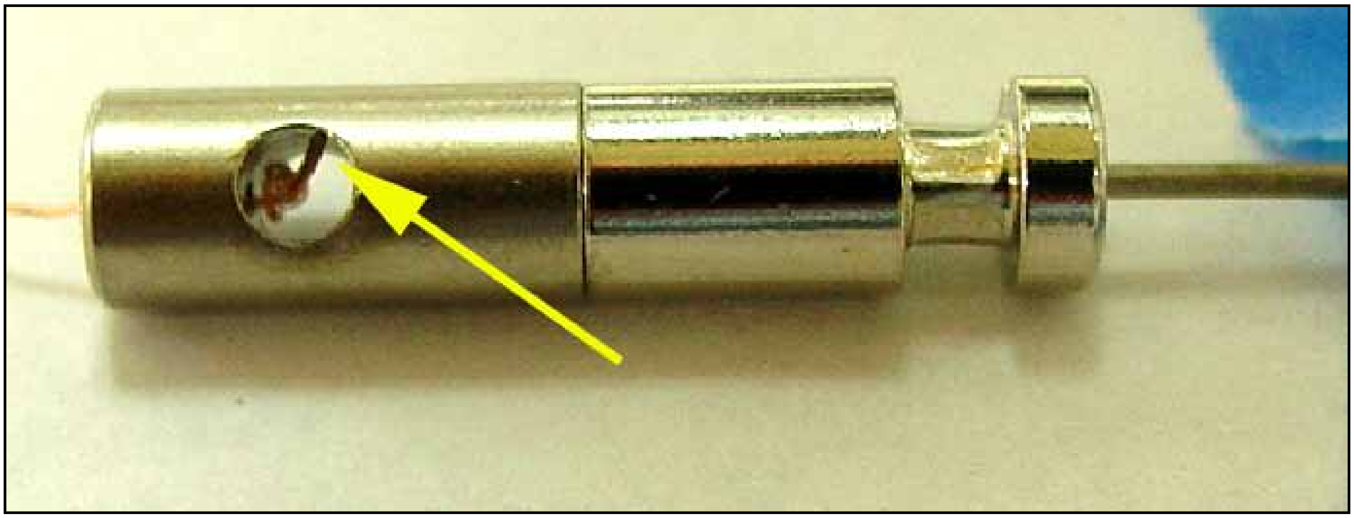

Figure 10: Wire / probe junction