Annex K – HUMAN EFFECTS OF ELECTRO-MUSCULAR DEVICES (EMD)

K.1 ELECTRICAL FENCE HISTORY

The Underwriter Lab Investigation [1] of electrical fences extended over three years and included a survey of medical electric shock research, special shock tests, and field investigations of the use of fences and accidental contacts. As a result, electrified fences were approved as safe provided they operated in bounds of current level and time duration specified for both continuous and pulsed modes. The levels specified are comparable in value to the TASER® output for the pulsed mode but of lower frequency so that a person making accidental contact can free himself between pulses.

K.2 ELECTRONIC GUN INJURIES

In a study titled "Electronic Gun (Taser) Injuries" 218 patients who had been "tasered" by the police were compared with 22 shot with conventional handguns [2]. The long-term morbidity rate was significantly less for tasered individuals (0 %) that for those with bullet wounds (50 %) ($P < .05$). The mortality rate was also significantly lower for tasered persons (1.4 %) that for gunshot wound victims (50 %) ($P < .05$). Possible complications associated with Taser wounds included contusions, abrasions, and lacerations (38 %), mild rhabdomyolysis (1 %), and testicular torsion (0.5 %).

K.3 CARDIAC SAFETY OF HIGH VOLTAGE TASER X26 WAVEFORM

This section is based on a report by Max Nerheim, Robert Stratbucker, M.D., Ph.D., & P.E., as modified by Dr. Dieter Reimann.

K.3.1 Introduction

The use of any device as a less-lethal weapon carries with it some degree of risk to the subject being controlled. This risk, however, must be compared to the risk associated with the use of traditional weapons including firearms, batons, impact weapons, chemical sprays, and physical restraint techniques. With the application of an electrical incapacitation weapon, the principal risk had been thought to be the induction of ventricular fibrillation in the subject [3]. In this study, the authors purposely attempted to create the highest risk scenarios they could envision in real-life field settings and still failed to induce ventricular fibrillation with the external application of high voltage emissions in experimental animals of body habitus comparable to adult humans with stimulating waveforms up to 15x the intensity of the commercial TASER X26.

K.3.2 Methodology

Following approval of the Animal Use Committee, ten domestic swine of several breeds and both sexes, were randomly selected from a much larger pool to span a spectrum of weights (30 and 117 Kg, (66 to 258 pounds)) and ages (9 months to 5 years). Unassisted endotracheal ventilation under 2% Halothane anaesthesia was supplemented with 3 litre/minute oxygen. Most pigs occupied a full day of testing.

The high voltage pulses were administered using carefully controlled "maximum susceptibility" experimental scenarios in every animal. To accomplish this goal, the pulse delivery probes were placed on the previously identified sensitive areas of the thorax.

K.3.3 Ohmic vs. Arcing Contact with the Skin

In the measurements, they found that the peak currents in arcing mode were not substantially higher than in direct contact. In fact, the measurements showed that the total charge per pulse delivered in arcing mode was less than the charge per pulse using direct contact. Specifically, they found no significant difference in cardiac electric *safety margin* between arcing (plasma coupling) and non-arcing (ohmic coupling) cutaneous contact conditions. In order to quantify a *safety margin*, the stimulation waveform was adjusted to 100% of the electrical output of the standard, commercially available TASER X26.

K.3.4 Application

During the application of the TASER X26 waveform in the standardized electrode configuration the heart rate and blood pressure remain unaffected.

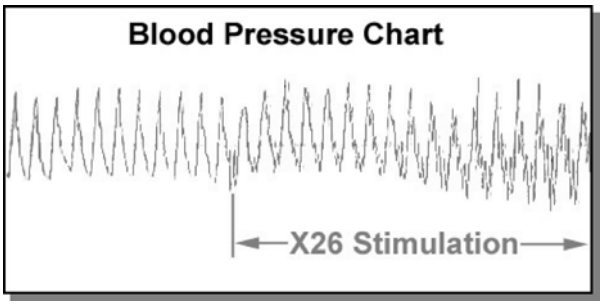

Figure K-1: Blood Pressure following X26 TASER Stimulation.

From the recording, it can be seen that the heartbeat continues completely unchanged during the stimulation. The tiny, hash-like fluctuations in the reading of the blood pressure that abruptly appear with the activation of the high voltage excitation are caused by the mechanical contractions of the skeletal muscles, reinforcing that the high voltage pulses from the TASER X26 were indeed emitting supra-threshold neuromuscular stimuli. Proof is provided that the stimulation intensity is below that of the ventricular fibrillation threshold. Moreover, the TASER X26 stimulation intensity is below the pacing threshold level. Supra-threshold pacing pulses would likely evoke an occasional paced beat of the heart.

Other physiologic variables being equivalent, paced beats have a significantly lower stimulus threshold than does the induction of ventricular fibrillation.

K.3.5 Fibrillation Threshold

To find the actual fibrillation threshold of pulses similar to the TASER X26® pulse, the stimulation intensity of the TASER test pulses was then increased step-wise from 2x (two times) to a maximum of 48x of the baseline until fibrillation was induced. The tests were run with a 5-second duration of 19 pulses per second discharge across the chest.

The safety margin was calculated using the threshold measurement methodology of Werner Irnich [4], namely the threshold was calculated using the arithmetically averaged value of the lowest fibrillatory and the highest non-fibrillatory pulse. The safety margin is expressed as a multiple of the standard TASER X26 stimulation in terms of the value of the stimulating capacitors. Hence, a 42x safety margin indicates a threshold of

fibrillation was found at 42 times the simulating capacitance of the standard TASER X26. There was a consistent increase in safety margin associated with increased body mass (Figure K-2).

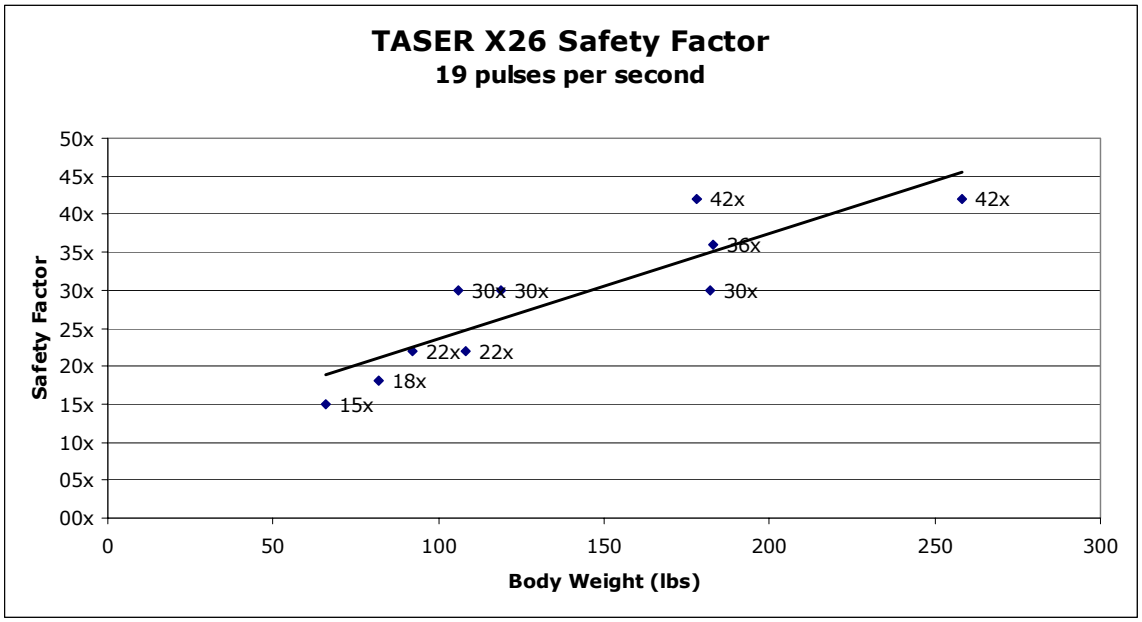

Figure K-2: Safety Factor of TASER X25 Related to Body Weight of Subject.

Recalling that the electrodes were always placed in the "most sensitive" positioning for cardiac stimulation, a safety margin of 20x would therefore exist for normal human adults of bodyweight greater than 100 pounds. The safety margin appears to be even greater than 20x for field applications because the "most sensitive" precordial electrode positioning would be extremely unlikely to occur as an accident of usage.

K.3.6 Safety Margin

As noted, the stimulation rate used in the cardiac safety margin experiments employed a constant pulse rate of 19 pulses per second. We were subsequently able to establish that decreasing the pulse rate further increased the safety margin as shown in Table K-1.

Table K-1: Safety Margin vs. Pulse Rate per Second (pps) in Pigs

Body Weight [lbs]	**19 pps** Safety Margin	**15 pps** Safety Margin	**10 pps** Safety Margin
66	15x	34x	
82	18x	52x	
92	22x	32x	95x
106	30x		80x
108	22x	26x	66x
119	30x		53x

The commercial version of the X26 generates a variable pulse rate that drops from 19 to 15 pulses per second after 2 seconds of operation, a design feature that promises to further increase the TASER X26 safety margin for routine field use.

Finally, the pulse characteristics of the TASER X26 were compared to those of the ADVANCED TASER M26, a popular unit currently in use at over 3,000 police agencies. The output current comparison in Table K-2 shows the TASER X26 output current is significantly less than the ADVANCED TASER M26.

Table K-2: Current Output Characteristics of X26 vs. M26

	Current per Pulse [microcoulombs]	Typical Pulse Frequency [pulses/second]	Average Current [milliamps]
ADVANCED TASER M26	182	20	3.6
TASER X26	112	19	2.1

K.3.7 Conclusion

An animal model for assessing the cardiac safety factor of an emerging class of high voltage, short duration, pulse train transcutaneous stimulators as incapacitation weapon has been developed and tested using pulse train induced ventricular fibrillation as the critical end point.

Of the various technical factors associated with electrical pulse train characteristics and their physiological consequences in a reasonable humanesque porcine surrogate model, the factors having the most critical influence on the initiation of a potentially lethal outcome of the application of such electrical pulse train to an anaesthetised animal are the pulse waveform intensity and pulse repetition rate.

By judicious selection of the electronic circuits and the various parameters controlling such circuits, it is possible to maximize a numeric safety factor for the use of such devices in beneficial ways and at the same time ensure that the *safety margin* is not less than that of other acceptable risks. In the analysis of the data from these experiments, the *safety margin* exceeds 20x for a normal human adult. Further, a safety margin of 15x was found for subjects with body weights similar to children and adolescents.

The risk of inducing ventricular fibrillation by the surface application of a TASER X26® to a human subject is highly improbable.

K.3.8 Some Remarks

In a ©1999 TASER® International folder the table of specifications name for the M26, Model No. 44000 an Amperage of 162 mA and a Pulse Energy of 1.76 J. Compared with Table K-2 above the value "162 [mA]" compares better with 182 [micro coulombs] Current per Pulse. But what about the Average Current of 3.6 mA? So presentation and interpretation of data and effects is confusing and difficult.

"The Air TASER® has the highest, measurable, real voltage of any stun device on the market, 50.000 Volts. Voltage tells how far the spark will jump and how much clothing the stun device can penetrate, if the spark must jump through fabric. This is the only true benefit from high voltage. Amperage and power determine how strong the pulse feels." Power in this text is used for "voltage"!

In order to measure the peak voltage of a stun device, simply measure the distance that the spark jumps when you activate the stun gun into the air. The thumb rule is 30.000 volts per inch. For example, the distance is 0.3 inches, so the maximum voltage is 0.3 inches x 30.000 Volts = 9.000 Volts. The Air TASER® actual peak voltage is given with 50.000 Volts, so the spark will jump over a distance of 1.66 inches (4.2 cm).

"The intrinsic pulse repetition rate was fixed at 19 pulses per second for all experiments. This is for the critical reason that our earlier muscle tension efficiency tests repeatedly showed the TASER X26® waveform achieving complete tetanus of pig skeletal muscle at repetition rates as low as 19 pulses per second. In other words, little was to be gained in strength of contraction, and something could be lost in cardiac safety margin when using pulse repetition rates in excess of 20 pps."

"Some older TASER® model was programmed with a pre-programmed timing cycle in light of the potential for respiratory interruption. The unit automatically provides four one second pauses during each 30 second discharge to allow the subject to breathe. Hence, the four one second breaks allow the target to take four full breaths every 30 seconds, minimizing the risk of anoxia. However, interruption of respiration for a full 30 seconds poses little health risk."

The new TASER® models are programmed with a pre-programmed timing cycle limited to 5 seconds each. The trigger has to be down again for another cycle.

Huge amounts of subcutaneous fatty tissue may deter the electric impact of the incapacitating device on the neuro-muscular groups of a body, even if the probes have made proper contact on the thorax and the trigger is pulled for 30 seconds. This could result in failure of complete incapacitation [5]. Subject may be affected, but still able to stand and move.

K.3.9 Suicide Bombers

The growing frequency of suicide bomb attacks not only in the Middle East raises the question, how explosives would react when exposed to an electro-incapacitating device. This might be the desirable weapon,

especially in crowded areas like market places, bus stops, cafés, or inside tubular structures such as aircraft, trains, or buses, where handguns cannot be fired without endangering bystanders or the vehicle. Explosives are often concealed in hand-tailored vests, prostheses, or carried in handbags or backpacks. Because of self-protection purposes it is important for police and military personnel to know, how the explosives carried by suicide bombers will react when tasered.

The following information was developed by Setracon Inc. [6] and presented at the 2003 TASER Tactical Conference, Orlando, May 10 & 11. Before applying the M26 Taser in this mode agencies and individuals should conduct their own testing to confirm this results. The paper intends to demonstrate the effect of the M26 Law Enforcement Taser when utilized against a person carrying explosives for malevolent purposes such as suicide bombers. This research is intended to substantiate that an M26 Taser can be used successfully against an individual packing explosives. Other explosive situations where a Taser may be utilized are limitless, however, they will result from First Responder reactions to a situation where utilization of a firearm may cause detonation, for example the inability of the First Responder to place a precision shot eliminating the ability of a terrorist to depress an actuator or inadvertently setting off the explosive through the shock of bullet impact. A suspected belt bomber will use commercial or military explosives for reasons of explosive stability with an electric initiation system. The Taser M26 will always produce 50,000 volts, 26 watts, at 162 milliamps if it is functioning correctly.

The author has proven with his video-taped experiments that tasering commercial explosives probably used by suicide bombers with the M26 Taser is possible without endangering the police or military user or the bystanders.

K.4 REFERENCES

[1] Underwriters Laboratory: Electric Shock as it pertains to the electric fence. Bulletin of Research, Number 14, December 1939.

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[3] Dalziel C.F.: “Electric Shock Hazard,” IEEE Spectrum, pp. 41-51, February 1972.

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[5] Yohe, Sgt. Michael: TASER Deployment Case Study – Ronald Jackson, male/35 yoa, 5’6”/204 lbs. Akron Police Department. 615 Morgan Ave, AKRON, OHIO. TASER Tactical Conference & Master Instructor School, Hosted by the Orange County Sheriff’s Department, Rosen Centre Hotel, Orlando, May 10-11, 2003.

[6] Slotnick, Jeff: Suicide Bombers – The Effects of the M26 on Explosives. Executive Director, Setracon, Inc. TASER Tactical Conference & Master Instructor School, Hosted by the Orange County Sheriff’s Department, Rosen Centre Hotel, Orlando, May 10 & 11, 2003.