Risk characterization of electromuscular incapacitating devices: literature survey and description of a safe test arrangement

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Electrical non-lethal weapons, in particular electric shock and electromuscular incapacitating devices, have high potential to meet requirements of modern police and armed forces. A discharge of a pulsed dose of electrical energy at high peak voltage causes muscle contraction and pain and temporarily incapacitate a human subject. Especially commercial products like TASER® have been tested in case studies [1-3], among others with animals (pigs) [4] and no report directly related to their risk of inducing ventricular fibrillation has been issued. Therefore it has been concluded that the risk to the life of human subjects will be extremely low. However, casualties in relation with the use of these non-lethal weapons are known. At the same time, a lack of scientifically convincing studies about the behaviour and the effect of these devices on humans is still felt. Also, a standard of comparison is desired for the evaluation of the different medical effects which are very much dependent on the subject's actual condition and the situation it has been hit.

In the paper, activities to overcome these limitations are reported. Existing anatomic and physiologic human body models, incorporating electrically relevant properties of tissue and organs, are collected from the literature, and achievements to assess medical effects of high-voltage pulses on various parts of the human body are described. Also, investigations of bioelectric phenomena in human bodies and related methods, such as the bioelectrical impedance analysis to monitor cardiac functions are of interest.

As a consequence, a concept of a safe measurement test arrangement is presented, which is capable to give repeatable outcomes for adjustable parameters, from which statistically meaningful conclusions can be drawn. Such a test arrangement would be comprised of three parts: (1) a stimulation waveform simulator with adjustable parameters like pulse shape and length, pulse train length, period, overall discharge, active current, (2) a humanesque surrogate model, being essentially an equivalent electrical circuit (R-L-C-network) representing the relevant parts of the body on the propagation path of the electrical pulse, and (3) a processing and storing device. On behalf of such a test arrangement together with an observer model which describes the relation between input and output, the factors having the most critical influence on the initiation of a lethal outcome can be derived and safety margins for the use of electromuscular incapacitating devices under every circumstance can be established.

Keywords: electromuscular incapacitating device, medical effects, risk assessment, artificial measurement test arrangement

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