TOWARDS UNDERSTANDING POPULATION BEHAVIOUR OF CONDUCTED ENERGY WEAPONS IN CANADA

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Objective

Our long term goal is to develop an understanding of the performance characteristics of Conducted Energy Weapons (CEW's) which might have an effect on safety for subject or operator. In this paper we present results of the analysis of the electrical output of over 200 Conducted Energy Weapons taken over a three year period from the inventory of weapons of different police services in Canada. These results are first compared to the manufacturer's performance specifications and then presented more broadly with respect to general electrical characteristics.

Introduction

Conducted Energy Weapons (CEW's), the most common known by the trademarked name "Taser", are in widespread use by law enforcement in Canada and elsewhere in the world. CEW's are increasingly accepted as a less lethal option in the use of force spectrum by police and the military despite some public uncertainty about these weapons. Electrical characterization and regular testing of CEW's in Canadian jurisdictions are becoming established as a means to validate performance of these weapons and to effectively manage their physical and operational lifecycle, including indications of failure modes. We present performance data from testing of 819 emissions which were sampled at 2 MS/s, 10 MS/s and 50 MS/s and we have developed, in collaboration with Canadian industrial partners, a standardized testing procedure specifying minimum testing parameters, performance reporting and data requirements.[1]

Methods

Weapons**:**

We examined the 819 emissions from X26 Tasers because this has been the most common weapon in use in Canada over the past 10 years. An earlier model, the M-26, was being withdrawn from service when we began testing CEW's in 2009 and is no longer in use in Canada. The ages of the weapons we examined varied from less than one year to about 10 years old. The age is difficult to determine but the serial number order (X00-nnnnnn) is a rough proxy for date of manufacture. The owners of the weapons we examined were all active police services in Alberta, Ontario and Nova Scotia. In the process of analyzing the electrical performance data, all the identification of ownership has been blinded.

Some weapons were fired a number of times in succession to determine fatigue and wear characteristics of the power supply. Still other weapons were tested repeatedly over a 3 year period. Some weapons were tested on a one-time basis. In all, the emissions of over 200 weapons provided the raw data for our analysis.

Data Collection:

We used two protocols for examination and electrical characterization. The protocols are similar and vary only in sampling rate and equipment for signal capture. For about half of our work we captured the signals on a NI PXi-5122 scope sampled at the rate of 2 MS/s with 14 bit quantization. Data was analysed using custom software in MatLab and Octave. In late 2010 we began capturing CEW signal data with a Picoscope 4224 at a sampling rate of 10 MHz with 12 bit quantization and analysing it with MatLab. This change in protocol was driven by the creation and adoption of a Test Standard for CEW Testing in Canada which was published in August 2010.

Data files are in binary format and ranged in size from 27 MB to 500 kB. We successfully reduced the size of the data file in 2011 to achieve memory efficiency by not sampling the quiet periods in between the pulses of energy. Data was stored at Carleton University in the Systems and Engineering Department laboratories.[2]

Pulse characterization:

A five second burst of energy was captured from the CEW discharged into a 600 ohm load. The voltage was measured using a Tektronix 6015A high voltage probe and quantized. Between 85 and 100 pulses were captured in a 5 second interval. Analysis of the pulse train provided the parameters which are considered performance standards by the manufacturer of the X-26.[3] In addition, our analysis provided absolute maxima and minima of voltage, current, pulse duration and charge, average maxima and minima of voltge, current, pulse duration and charge, and other parameters such as interpulse time and absolute charge.

Statistical:

Our analysis of the test data was done using MatLab and standard analysis and presentation tools such as Excel. While we observed the manufacturer's method of computing the 5 parameters based on an average of the last 8 pulses in a train of approximately 100 pulses, we also evaluated every pulse in the pulse train. Standard deviations, averages, minima and maxima were computed based on the entire pulse train. Histograms were created to show the distribution by parameter and by serial number order of the CEW's.

Results

Our results show that the five Taser performance parameters have significant variance as a function of serial number order. The distribution of the five performance parameters in the earlier SN orders (X00-0nnnnn to X00-3nnnnn) is noticeably broader. The standard deviation of each parameter based on SN order is presented in Table 1.

Table 1: Standard Deviations by Serial Number Order

Standard Deviation						
	X00-1nnnnn	X00-2nnnnn	X00-3nnnnn	X00-4nnnnn	X00-5nnnnn	X00-6nnnnn
Peak Voltage	213	144	228	118	176	92
Peak Current	0.369	0.243	0.384	0.199	0.297	0.155
Net Charge	9.257	6.136	7.166	3.495	3.433	2.585
Pulse Duration	5.653	2.863	5.038	2.466	2.93	2.393
Pulse Repetition Frequency	1.377	1.795	1.398	0.718	0.074	0.025

Two parameters, net charge and pulse repetition frequency are the most significant parameters in terms of prevalence of out-of-tolerance occurrences. Older CEW`s (X00-1nnnnn to X00-3nnnnn) show net charges with standard deviations two to three times that of later generations of CEW`s. The standard deviation of pulse repetition frequencies is seventy times greater in older weapons than it is in later generations. A pulse repetition frequency lower than 16.5 pulses per second is outside the tolerance set out in the manufacturer`s performance specification. This is the most common out of tolerance condition in all of the weapons we have tested.

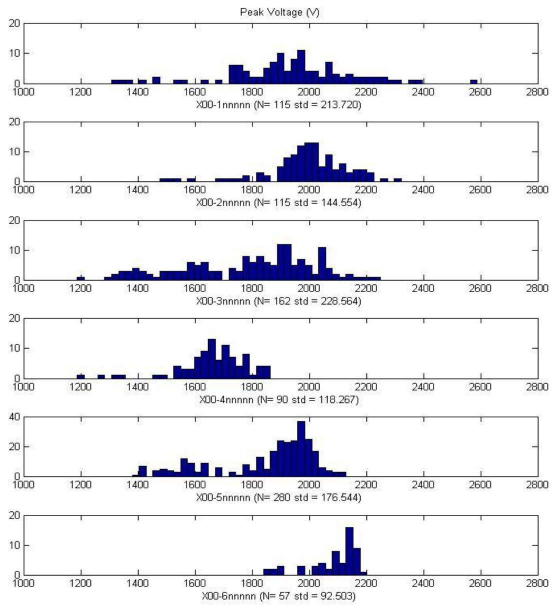

Figure 1: Voltage distribution by serial number

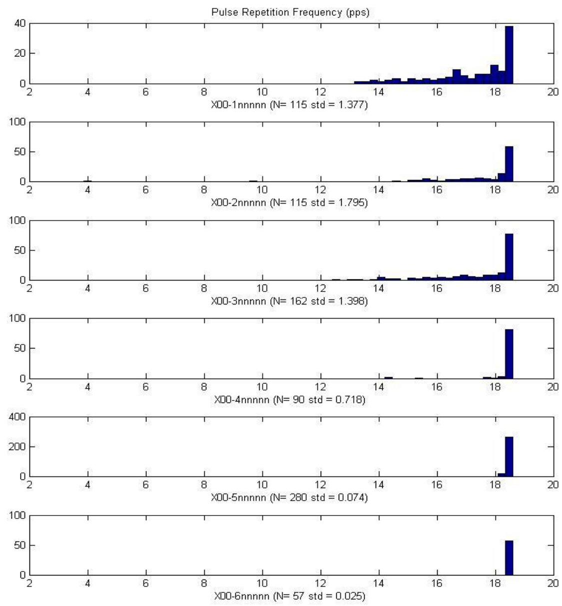

Figure 3: Pulse repetition frequency by serial number

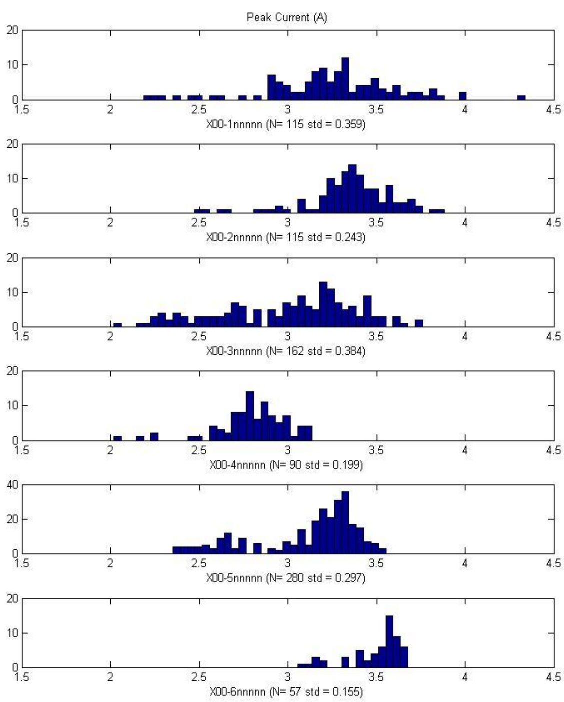

Figure 2: Current Distribution by serial number

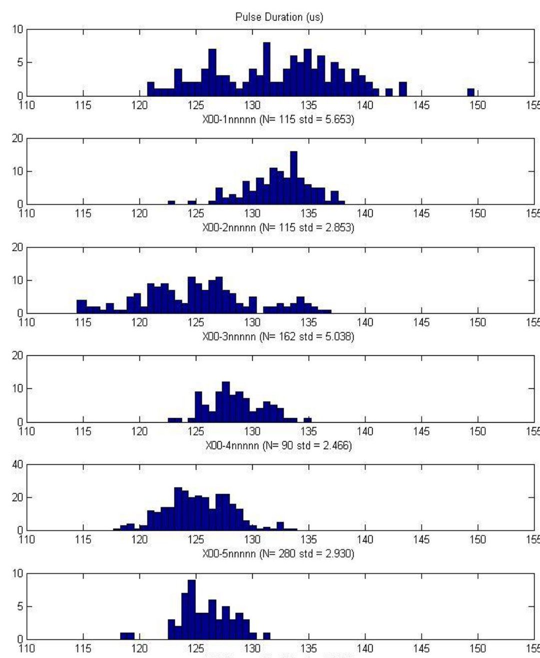

Figure 4:Pulse duration by serial number

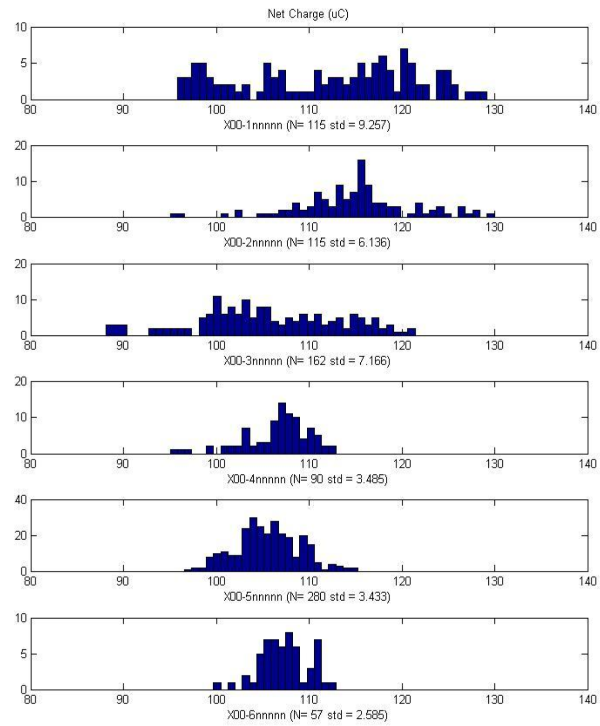

Figure 5: Net Charge by serial number

Discussion and conclusion

Testing of CEW's in Canada is becoming more regular as more jurisdictions require police services to regularly test weapons in their inventory. Alberta, British Columbia, Quebec and Nova Scotia have such regimes in place. From our work it is apparent that police officers have developed an understanding of the electrical characteristics and maintenance requirements from a regular testing regime.

For researchers, the more regular testing regime has increased the field of available data. Test data is not regularly shared between testing organizations but some attempts to aggregate the data from different testing organizations have been successful on a one-time basis with the permission of the data owners. It remains to be seen if a more open data sharing regime will be possible in the face of concerns for commercial exclusivity which have hampered data sharing to date.

The newest CEW's in our testing experience show the most consistent performance characteristics. While this may be attributable to less wear and tear on the weapon than on older weapons, it is more likely that the newer weapons reflect better performance because of improved design or manufacturing.

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[1] http://curve.carleton.ca/papers/2010/CEW-Test-Procedure-2010-ver1.1.pdf

[2] Peyman Rahmati, David Dawson, and Andy Adler, "Towards a portable, memory-efficient test system for conducted energy weapons," Canadian Conference on Electrical and Computer Engineering (CCECE 2011), Niagara Falls, Canada, May 8-11, 2011

[3] http://www.ecdlaw.info/outlines/EC_02-01-09_%20X26_Elec_Char.pdf