Various works related to Green Ammunition at FFI

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Over the last decennium, FFI – Norwegian Defence Research Establishment, has undertaken a number of projects in which the environmental effects of ammunition has been the issue. Several of the works have been presented in EDA or AVT-forums. This paper presents briefly the content of some of these projects.

Emission of gas and dust from small arms

After the Norwegian Army had introduced lead-free ammunition for their small arms, a number of health related issues turned up. At several occasions, a number of soldiers suffered from various symptoms like fever, headache, nausea, chills, etc. and had to be temporarily taken out of service. The symptoms were suggested to be due to some kind of metal fever.

In order to find the source of these problems, the emissions of gas and dust from various combinations of ammunition and weapon were measured. The gun was placed inside a flexible container, and the dust emitted from all parts of the weapon was sampled. In addition, the concentrations of the three most poisonous gases, CO, NH_3 and HCN were also measured.

The measurements showed that there were great variations in metal emission depending on the kind of ammunition that was used. However, there were also variations when using the same ammunition, but with different guns. Thusn there were both an ammunition factor and a weapon factor determining the emission rate. It was found that the unleaded ammunition, which has a steel core and an elongated shape, gave the highest amount of metal emission, more than twice that measured for leaded ammunition. It was also found that gun barrels that had the smallest cross section area emitted more than those with a normal or high cross section. The amount of poisonous gas varied much less compared to metal emission.

[1] FFI, Kjeller, Norway

Based on these firings, the ammunition manufacturer modified the design of the bullet in a way that minimized the contact area between the jacket and barrel. That resulted in an emission rate that was just slightly higher than the previous leaded ammunition.

Clinical test of users of small arms

Based on the tests mentioned above, a clinical test was undertaken in order to see whether the differences in metal dust emission could affect the frequency of metal poisoning, and affect certain physiological indicators related to the symptoms that the soldiers reported. 55 adult male persons took part voluntarily in the tests. Three types of ammunition were used; a leaded type, the original unleaded type, and the modified unleaded one. All used the same type of gun, a 5.56 mm HK416. Each person used one type of ammunition only. The test was blind, as the test persons did not know what kind of ammunition they were firing.

The test persons were individually placed in a small, and almost airtight tent made of a transparent polyethylene sheet for one hour. During this time they should fire the gun through the tent wall at rate that kept the concentrations of CO at a certain level. Typically 10 – 20 shots were fired in that interval.

Subsequent to the test, a great majority of the volunteers suffered from several of the symptoms. Typically the symptoms started 5 – 8 hours after the exposure and could last 6 – 10 hours. On the average those who fired the leaded ammunition reported 3.6 symptoms, those who used the original unleaded one reported 5.2 symptoms, and those with the modified one reported 4.1 symptoms. These numbers are quite well in accordance with the emission of copper dust. The results for the physiological indicators were not that clear, as the error margin for those tests were quite high. The trend, however, was the same as for the symptoms reported.

Mechanical cause of the emission

An explanatory model for the emission was established based on our measurements. It seems that friction between the bullet jacket and the bore, combined with the high acceleration of the projectile, creates an abrasion of metal from the bullet surface. The model also shows that the abrasion can be substantially reduced if the contact area between the bore and the bullet is made as small as possible.

Contamination of heavy metals and HE residues in firing ranges

A series of measurements of residues from explosives, pyrotechnics and propellants has been made in various areas and over time. High concentrations of explosives have been found at certain firing points and at demolition areas due to incomplete detonation of the explosive. Large concentrations of propellants are found at firing posts caused by incomplete combustion. Bullet catchers contain large amounts of lead, copper, antimony and tungsten, and finally lumps of pyrotechnics have cause injuries to local fauna.

Ways and means to remediate the soil has been studied with quite promising results. By stimulating chemical and biological process in soil, the contamination could be significantly reduced in a few weeks.

Other works

Several other works that have been conducted by FFI in the recent years in this field are:

- Gas concentrations near the soldier during small arms firing indoor and outdoor
- Alternatives to white phosphorous as an illuminating agent
- Measurement of CO-concentrations in armoured vehicles
- Effects of TNT-contamination in sheep forage
- Metal contamination in fish from lakes in a firing range

Finally, the audience is encouraged to take part in the AVT-244 specialist meeting on Munitions-Related Contamination in Prague in October 2015.