

EVALUATION OF DATA COLLECTED BY A SURVEILLANCE SYSTEM FOR GUN PROPELLING CHARGES UTILIZING CONSCRIPT PRACTICE TROOP FIRINGS

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Abstract. The Finnish Defence Forces have implemented a surveillance system for gun propelling charges utilizing conscript practice troop firings. In this study the muzzle velocity data collected during troop firings of a 155-mm weapon system have been statistically evaluated. The elimination of the first round fired of each series of collected muzzle velocity data was found to reduce the variation in the data. For one charge zone, the study determined a need to verify the validity of standard muzzle velocity values in the firing tables. The muzzle velocity data collected in conscript troop firings were found to be suitable for the estimation of lot-to-lot and gun-to-gun variances if the data is not too unbalanced. The methodology for identifying and removing erroneously marked observations and outliers in the muzzle velocity data collected by conscripts has been developed and the evaluation of the results connected to each studied charge lot/zone has been conducted. The muzzle velocity data collected was found to be usable for numerous purposes, as long as the characteristics of the data are taken into consideration.

INTRODUCTION

The Finnish Defence Forces (FDF) have implemented a surveillance system for gun propelling charges utilizing conscript practice troop firings. The system is based on data collected on the muzzle velocity for each round fired. The system supplies the user and maintenance staff with information about deviations from the relevant firing table values for a specific charge/cartridge lot. The background and implementation of the system data have been presented in [1].

The muzzle-velocity data collected by this surveillance system for propelling charges can be applied in the recognition of possible changes of interior ballistics as a result of aging of the propelling charges [2–5]. The natural chemical and functional aging of the nitrocellulose propellants of gun propelling charges can be accelerated for example, if an imperceptible chemical compatibility problem and/or spontaneous opening of cartridge closing covers or their inner packages have occurred. There may also be fractures in propellant grains or damages in charges due to handling and transportation. The fractures and/or brittleness in propellant grains can lead to propellant grain breakage during the internal ballistic cycle. Pressure fluctuations may at first lead to diminished porosity of the propellant bed and then enlargement of the burning surface. This phenomenon can lead to the maximum pressures defined during propelling charge development being exceeded and even cause a breech blow [6,7]. It would be beneficial to organize the monitoring of muzzle velocity values in troop firings during international operations conducted in hot climatic conditions, where aging of propelling charges is faster than in Finnish storage conditions.

There are also several other reasons to collect and monitor the muzzle velocity results in troop firings. In the case of defects discovered in the quality of the propelling charge determination or of the production of propelling charges [8] it is possible to assess the propelling charge lot specific deviations of specified muzzle velocities. Furthermore, because the muzzle velocity results collected in conscript troop firings are stored in a database, a prompt gun-specific picture of fired projectile/charge combinations and realized muzzle velocities is conveniently available in situations such as damage to the barrel or a firing accident.

The muzzle velocity data collected may be suitable for the analysis of round-to-round, gun-to-gun, lot-to-lot, and occasion-to-occasion variations in data. Round-to-round variation comes from, among other things, the variation of loading of the projectile and from the difference in muzzle velocities of the first rounds and later rounds in a fired series. One source of round-to-round variation is the variation of projectile weight, present despite the projectile weight class-based projectile weight correction of muzzle velocity. Gun-to-gun variation comes mainly from the variation of the dimensions of each gun barrel and from barrel wear. One phenomenon peculiar to barrel wear is ballistic hump, a rise in muzzle velocity and chamber pressure taking place typically before firing of 200–300 rounds from a gun barrel [9]. The accurate evaluation of the magnitude of ballistic hump by carrying out test firings is an expensive study, for which several new barrels are needed. For the 155-mm gun dealt with in this paper, ballistic hump is a demonstrated phenomenon. Occasion-to-occasion variation is a result of many elements, like variation of ground or weather conditions and changes in the gun, projectile, or propelling charge during maintenance or storage.

The aim of this study was to use statistical methods to evaluate muzzle velocity data collected by a surveillance system for gun propelling charges utilizing conscript practice troop firings. Another aim was to develop a methodology to define muzzle velocity deviations from firing table values for gun propelling charge lots and zones.

EXPERIMENTAL

The sequence of the surveillance system for gun propelling charges utilizing conscript practice troop firings is shown in Scheme 1. The definition of muzzle velocity and the definitions of muzzle velocity value terminology and procedures to calculate the projectile muzzle velocities are given in STANAGs 4114 and 4500 [10,11].

The muzzle velocity values in field firings are measured by Weibel MVRS 700-SCD muzzle velocity Doppler radars mounted either permanently or temporarily on the guns. The radars are robust and it is convenient to type the data even in Finnish winter conditions. The radar dimensions are 195×187×67 mm and the weight is 5 kg. The radar has a built-in acoustic detector for starting the microwave

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