Measurement 43 (2010) 415–420

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

# Validation of piezoelectric measurement system for weapon firing pin percussion energy

Jorma Jussila *

*National Bureau of Investigation, Forensic Laboratory, Jokiniementie 14, FI-01300-Vantaa, Finland*

ARTICLE INFO

*Article history:*
Received 25 August 2009
Received in revised form 19 October 2009
Accepted 7 December 2009
Available online 4 January 2010

*Keywords:*
Firearms
Percussion
Primer

ABSTRACT

Functional reliability of a service firearm is essential. A failure to fire at a critical moment could lead to disastrous consequences. The firing pin of a weapon must hit the primer hard enough to ascertain reliable detonation of the primer which then ignites the powder. Depths of firing pin created indent on an inert primer and on a copper cylinder are the two methods conventionally used to estimate this percussion energy. In this study the copper cylinder method was compared with piezoelectric measurement. It was found out that both systems give reliable readings. Eight pistols of calibre 9 mm were measured. Although the majority of the measured weapons seemed to provide sufficient percussion energy, there were some surprisingly low readings with seemingly perfect weapons. This discrepancy shows the necessity of an industrial standard and of using a reliable percussion energy measurement system for monitoring the condition of service weapons. Further research on firearm and ammunition primer compatibility is required.



## 1. Introduction

A modern small-arms percussion primer contains a primer compound consisting mainly of impact sensitive initiator explosive, oxidizer and fuel. The ignition is caused by the weapon firing pin impacting the percussion primer. The impact compresses the explosive between the primer cup and anvil thus detonating the initiator. The resulting flame then ignites the powder. The firing pin must have sufficient kinetic energy to cause a deep indent on the primer cup.

NATO standards [1,2] are generally used by the ammunition manufacturers as a guideline on defining and measuring primer sensitivity. For 9 mm pistol primers they specify dropping a 55 g steel sphere on the firing pin requiring 100% fire at drop height of 305 mm (12 in.). The standards, however, do not define the mass of the firing pin, which is essential for defining the actual impact energy (percussion energy) of the firing pin. They, however, do define a firing pin diameter of 1.98 mm whereas the diameter used for instance by SIG-Sauer and Heckler and Koch pistols is 1.8–1.6 mm respectively [3]. Primer sensitivities are tested using different drop heights to obtain a sensitivity distribution, 50% ignition height ($H$) and standard deviation ($S$). The primer manufacturers ordinarily announce sensitivity as $H + 5S$ and $H - 2S$ values as “all fire” and “no fire” heights. The $H + 5S$ drop height is usually between 10 and 12 in.. These drop heights must, however, be expressed in resulting impact energies to be able to compare primer sensitivities with percussion energies of weapons.

International organizations Commission Internationale permanent Pour l’Epreuve des Armes à Feu portatives (CIP) and Sporting Arms and Ammunition Manufacturers’ Institute (SAAMI) have standardized cartridge chamber and ammunition minimum and maximum dimensions as well as maximum chamber pressures. German police technical guideline [4] specifies measuring the percussion energy of a pistol with a cylinder of pure copper inserted into a measurement cartridge whose length corresponds to the maximum case length allowed by CIP and SAAMI

* Tel.: +358 40 5691408.
*E-mail address:* jorma.jussila@poliisi.fi

0263-2241/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.measurement.2009.12.011

**Fig. 1.** Measurement cartridge and copper crusher cylinder.

(Fig. 1). These copper cylinders are actually made for the crusher method measurement of chamber pressure. When measuring percussion energy, the intention is to press the copper cylinder tightly against the weapon breech face. The firing pin impact causes an indent on the copper cylinder (Fig. 2). The depth of the indent is then measured and the result used for estimating the sufficiency of the percussion energy of the weapon. The German technical guideline specifies the minimum indent depth as 0.3 mm. Mil-Std spec of 9 mm pistol [6] requires that the pistol shall produce 0.03–0.043 mm indent on a copper cylinder. Based on discussions with weapon manufacturers an indent of 0.26 mm is often used as a requirement.

National Institute of Justice [5] specifies a similar method. Instead of using a copper cylinder it recommends using a headspace gage modified to allow insertion of an unfired primer. This assembly is then used to verify the sufficiency of the percussion energy. The problem with this method is that the hardness of the unfired primers must be verified and thus the indent be calibrated. The system can neither be used to check the concentricity of the firing pin impact as the headspace gages are typically cylindrical instead of conical allowing the gage head to move slightly.

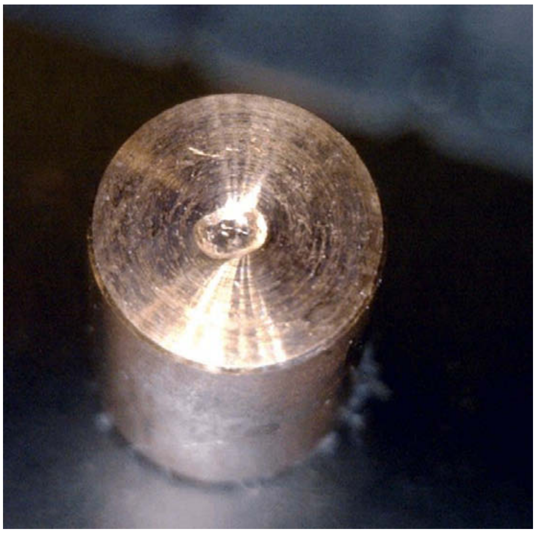

**Fig. 2.** Indent made by Glock-pistol firing pin on a copper cylinder head.

A percussion mechanism of a firearm consists in principle of a percussion spring, percussion mass ("hammer") and a firing pin. Firearms employ two major percussion mechanism modes. In single action mode the hammer is under spring tension resting on a retaining lever called sear. A pull on the trigger moves the sear releasing the hammer. It hits the firing pin which then strikes the primer. In double action mode pulling the trigger will first cock the hammer before releasing it. Usually the double action strike is slightly shorter producing less percussion energy than single action. All weapons do not use both modes.

Piezoelectricity is the ability of some materials to generate an electric field or electric potential in response to applied mechanical stress. This method is used in the Firing Impulse Tester (FIT), made by the Italian company STAS. The transducer assembly consists of an impact anvil against which the firing pin strikes, a pressure transducer and an elastic element in between. These components are assembled inside a stainless steel body with the external dimensions of a cartridge in each calibre to be measured. The assembly, later in the text referred to as the transducer, should therefore fit snugly into the cartridge chamber of a firearm.

Published scientific reports relevant to the issue of percussion primer sensitivity and shedding additional light on the subject of this study could not be found. The purpose of this study was to compare two measurement systems and to shed light to the problem of measuring percussion energy.

## 2. Materials and methods

In the copper cylinder method a special chamber gage of 19.14 mm length was used. The length is close to the maximum case length 19.15 mm of a 9 mm $\times$ 19 cartridge [7,8]. The difference can be considered negligible in this case. A cavity to hold a 6 mm copper crusher cylinder flush with the gage base had been milled in it. Crusher cylinders made by Wilhelm Handke GmbH were used. The depth of indent made by the impacting firing pin was measured using a digital gage on a measurement bench. Fig. 3 shows a similar arrangement used at the NBI Forensic Laboratory. The tip of the measurement head was placed in the centre of the indent and the gage was zeroed. The copper cylinder head height was then measured at four places around the indent and the mean value was used as the depth of the indent. This measurement method reduces the effect of possible imperfections of the cylinder head surface.

The piezoelectric system (Fig. 4) made by STAS was to some extent still on a prototype stage. For example, the gage did not fit in the chamber of a Glock 17 pistol.

Both systems were calibrated using a NATO specified drop test device [1,2] where a steel sphere weighing 55 g is dropped at specified heights onto a firing pin. To obtain