Firearms Section

Trigger Pull Uncertainty Validation Study and Determination of Uncertainty of Measurement

Validation Approval for use on Casework:

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Analyst Signature	**Date**	**Analyst Signature**	**Date**
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Trigger Pull Uncertainty Validation Study and Determination of Uncertainty of Measurement

This second validation study was conducted using the second Imada DST-44 digital force gauge identified as TP#5 (serial number 384427). The study was conducted to validate the Imada DST-44 digital force gauge for use in conducting trigger pull measurements of casework firearms and to calculate the uncertainty of measurement for the main firearm types/actions, to include, single-action rifles, single-action shotguns, single-action semiautomatic pistols, double-action pistols, single-action revolvers, and double-action revolvers.

The traceability for this measurement process was established through the calibration of the trigger pull gauges by Imada, Inc., an external vendor accredited to ISO/IEC 17025 **(calibration certificates are attached).**

Uncertainty of Measurement Contributing Factors:

The measurand (Y) in this process is the pulling force of the firearm determined by a trigger pull gauge and its associated uncertainty.

Y = y (trigger pull measurement) $\pm$ U (expanded uncertainty)

Type B* uncertainty *sources

The following components were identified as contributing the most to the combined standard uncertainty of measurement; the accuracy and the expanded measurement uncertainty of the Imada DST-44 digital force gauge (Type B uncertainty component determined by Imada Inc.) and the third component, the variability of the participant and / or the procedure (Type A).

Type A* uncertainty *sources

Type A uncertainty was calculated using the relative standard deviation from repeatability studies conducted in-house. The independent variables in the study were the analyst, firearm, and the environment; the dependent variable was the force gauge reading.

Procedure:

Eleven (11) analysts measured six (6) firearms from the Houston Forensic Science Center (HFSC) reference collection over multiple days using the Imada Digital Force Gauge TP#5 (serial number 384427). Measurements were divided into two (2) sets of five (5) readings. These readings were measured and recorded during different times a day (AM and PM). The six (6) selected firearms were representative of firearms commonly received as evidence by HFSC. The Firearm types included rifles, shotguns, revolvers and semiautomatic pistols representing a range of calibers and action types. The reference firearms used in this study are listed in **Table #1.**

Each firearm was placed in a vise with the barrel positioned horizontally, parallel to the floor. One end of the hook is placed on the trigger where the shooter's finger would typically rest. The opposite end of the hook is attached to the gauge. The peak button was pressed on the gauge so that "Peak" was visible on the display screen. After pressing the "Zero" button, the gauge is pulled rearward and horizontally, the peak force is measured and recorded in the computer spreadsheet in the WinWedge configuration file after pressing the “Send” button. A series of five measurements were recorded for each action type for the selected reference firearms per day per analyst, for a total of ten readings. A summary of the recorded trigger pull measurements are recorded in the tables listed as **Uncertainty of Measurement Workbook** located on the Firearms S:drive.

The short hook was used for all the handguns and the long hook was used for the rifles and shotgun.

For those firearms that could be fired in single-action by either manually cocking the hammer or by pulling the slide rearward, the trigger pull was measured by pulling rearward on the slide. The analysts measured the single-action and / or double-action trigger pulls at each cylinder position at least once for the revolver.

Conclusion:

The data from the eleven analysts was used to calculate the mean force, standard deviation and the relative standard deviation for each firearm type and action. HFSC chose to determine uncertainty of measurement values for the main firearm type and actions with the largest relative standard deviation, as it represented firearms with the greatest variability in trigger pull measurements. This information will be recorded on the HFSC Trigger Pull Gauge Excel worksheet.

After reviewing the data obtained and calculating the uncertainty of measurement for Trigger Pull #5, it was determined that it fits its intended use (casework only).

Trigger Pull Excel Worksheet

HFSC will conduct a series of five trigger pull force gauge measurements for each firearm and firearm action submitted as evidence using the Trigger Pull Excel Worksheet. The analyst will fill in the required data fields (Forensic Case Number, analyst name, Item designator, Trigger Pull Gauge number) and select in the dropdown menu the firearm type/action and the force gauge reading is sent from the Imada DST-44 digital force gauge to the excel spreadsheet. The mean is automatically calculated in pounds (lbs) using an embedded formula.

When reporting out the trigger pull data, the total expanded uncertainty of measurement will be reported along with the force gauge calculated mean reading in the following format:

$$\text{Mean of 5x measurements} \pm U_{total}$$

The total expanded uncertainty will be calculated using a coverage factor of k=2 for a 95.45% confidence level.

Other comments:

During the validation study of the Imada DST-44 digital force gauge, several issues were encountered with higher than acceptable levels of variation when the digital force gauge was operated by the various analysts. The variation was due in part of the inability of the analyst to hold the gauge with the attached hook in consistent horizontal position on the trigger of the firearm while pulling rearward on the gauge. Additionally, there was a tendency for the analyst to pull through the sear release, resulting in a higher than expected force gauge measurement reading on the display screen of the gauge. Setting the sensitivity selection on the “Middle” resulted in fewer higher gauge readings. This was verified with recording the trigger pull measurements using the NRA Static Weights with the two selected reference firearms (#551 and #758) during the first validation study.

The Imada DST-44 digital force gauge comes with SW1X-V2 data acquisition software and WinWedge software with a customizable Excel spreadsheet designed to capture the real-time force gauge measurements. The software records each measurement, and, from a series of measurements, it calculates and records the minimum force reading, maximum force reading, mean (average), median, standard deviation, average deviation and graphs the readings.

The embedded formula for the mean was verified on the first validation study.

Imada Inc. reports the accuracy of the Imada DST-44 digital force gauge as 0.2% F.S. ± 1 LSD on the calibration certificate. F.S. stands for Full Scale and refers to the capacity of the Imada DST-44 digital force gauge, which is 44 pounds of force (lbf). LSD stands for Least Significant Digit and refers to two decimal places on the Imada DST-44 digital force gauge LCD display screen (0.2% x 44 lbf = 0.088 lbf).

The limited second validation study values were higher for the reported uncertainty for the double-action revolver. This value will be used in the reporting of the uncertainty of double-action revolver trigger pulls.

References:

(1) Gamboe, T., "MAFS Firearms Workshop: Trigger Pull Methods," AFTE Journal, Vol. 18, No. 3, p. 77.
(2) Rios, F. and Thorton, J., "Static vs. Dynamic Determination of Trigger Pull," AFTE Journal, Vol. 16, No. 3, p. 84.
(3) AFTE Training and Standardization Committee, AFTE Glossary 6th Edition Ver. 6.030317 (2013).
(4) Scientific Working Group for Firearms and Toolmarks (SWGGUN), “Guidelines for Trigger Pull Analysis,” AFTE Journal, Vol. 40, No. 2, Spring 2008, pp. 219-220.
(5) Wilson, W.H., and Turbok, R.D., “Trigger Pull Data,” AFTE Journal, Vol. 35, No. 4, Fall 2003, pp. 400-430.
(6) Lawrence G.R., “The Effect of Hand Grip Angle on the Measurement of trigger Pull Forces,” AFTE Journal, Vol. 43, No. 2, Spring 2011, pp. 154-161.
(7) Avarez Bacha, C., “Imada DS2-44 Digital Force Gauge: Trigger Pull Measurements and Associated Uncertainty of Measurements,” prepublication AFTE Journal, 2018.
(8) Personal communication with C. Alvarez Bacha, Firearm and Toolmark Examiner, Aurora Police Department Crime Laboratory, Aurora, Colorado.

Table # 1

Reference #	Type	Action	Make	Model	Serial #
H042	Revolver	SA/DA	Smith & Wesson	Airweight 37	J993623
H573	Semiautomatic Pistol	DA	Glock	22	AFW656US
H673	Semiautomatic Pistol	SA/DA	Bersa	Thunder 380	286819
H778	Semiautomatic Pistol	SA	Hi Point	C9	P1326275
L134	Shotgun	SA	Winchester	1300 Defender	L2226676
L163	Rifle	SA	DPMS	A-15	FH30302