Best Practice Recommendation for Measuring Trigger Pull of a Firearm and Estimating its Uncertainty

Firearms & Toolmarks Subcommittee
Physics/Pattern Interpretation Subcommittee
Organization of Scientific Area Committees (OSAC) for Forensic Science

OSAC Proposed BPR

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Prepared by
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This document has been developed by the Firearms & Toolmarks Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science through a consensus process and is *proposed* for further development through a Standard Developing Organization (SDO). This document is being made available so that the forensic science community and interested parties can consider the recommendations of the OSAC pertaining to applicable forensic science practices. The document was developed with input from experts in a broad array of forensic science disciplines as well as scientific research, measurement science, statistics, law, and policy.

This document has not been published by a SDO. Its contents are subject to change during the standards development process. All interested groups or individuals are strongly encouraged to submit comments on this proposed document during the open comment period administered by the Academy Standards Board (ASB) (www.asbstandardsboard.org).

Keywords: measurand, readings, measurement, trigger pull, uncertainty of measurement, rifle, shotgun, pistol, revolver, firearm, single action, double action, sear, cock

This best practice recommendation describes procedures for measuring the trigger pull(s) of evidence firearms and for estimating the uncertainty associated with those trigger pull measurements. Estimation of uncertainty is achieved through repeated measurements by all laboratory personnel responsible for trigger pull measurements over multiple days. Annex A provides an example illustrating trigger pull measurement data, components of uncertainty, and calculations for estimating trigger pull uncertainty of measurement.

Foreword

Trigger pull measurements are one aspect of a Firearm and Toolmark Examiner's evaluation of an evidence firearm. Trigger pull is defined as the amount of force that must be applied to the trigger of a firearm to cause sear release [4,9,13]. Procedures are outlined here for measuring the trigger pull(s) of four classes of firearms: rifles, shotguns, pistols, and revolvers utilizing four types of trigger pull measurement devices; static weights (also referred to as dead weights or arsenal weights), spring gauges/dial gauges, digital force gauges, and automated trigger pull systems. Procedures for estimating uncertainty of trigger pull measurements are also described here.

This best practice recommendation was proposed by the Subcommittee on Firearms and Toolmarks (SCFT) of the Organization of Scientific Area Committees (OSAC) by submitting a request to the American Academy of Forensic Sciences (AAFS) Academy Standards Board (ASB). It is based on a guideline [22] describing the trigger pull measurement procedures originally developed by the Scientific Working Group for Firearms and Toolmarks (SWGGUN). Several research articles also provide useful background information [1,11,17,18,21]. SCFT has added procedures for the estimation of uncertainty, a crucial component for establishing measurement traceability.

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Table of Contents

1 Scope

This best practice provides recommendations for crime laboratory procedures for trigger pull measurements and for estimating uncertainties associated with trigger pull measurements.

2 Normative References

There are no normative references.

3 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1

Measurand
Quantity intended to be measured
VIM, Sec. 2.3 [14,16]

3.2

Trigger Pull
The amount of force which must be applied to the trigger of a firearm to cause sear release [4,8,12].

3.3

Terms Specific to Firearms
Other terms specific to firearms, such as rifle, shotgun, pistol, revolver, firearm, single action, double action, sear, and cock are described in [8,12].

4 Requirements

4.1 Background

This document details the procedure for conducting trigger pull measurements and estimating trigger pull uncertainty of measurement.

4.2 General

4.2.1 Trigger pull measurement is one component of a process for assessing the overall safety, condition, and factory specifications of a firearm.

4.2.2 When handling a firearm, safety is paramount. Always verify that the firearm is unloaded prior to conducting a trigger pull measurement.

4.2.3 When measuring trigger pull, ensure that the firearm is free from movement and stable for measuring and is located in an area with proper lighting.

4.2.4 Ensure that the measurement device has a current calibration certificate that provides traceability to the international unit of force through accredited calibration laboratories.

4.3 Setup

4.3.1 Common devices used to measure the trigger pull(s) of evidence firearms include static weights (also referred to as dead weights or arsenal weights), spring gauges/dial gauges, digital force gauges, and automated trigger pull systems. The setups differ depending on the device used to measure trigger pull and are described in Sections 4.3.2, 4.3.3, 4.3.4, and 4.3.5.

4.3.2 Static weights/dead weights/arsenal weights

The muzzle of the firearm barrel is positioned vertically as shown in Fig. 1. The weighted base is supported on a flat surface and the elbow of the attached bar is placed on the trigger where the shooter's index finger would typically rest. The firearm is raised upward until the weighted base is no longer supported by the flat surface. Additional weights are added to the weighted base in increments until the sear releases. The combined weight at which the sear releases is recorded.

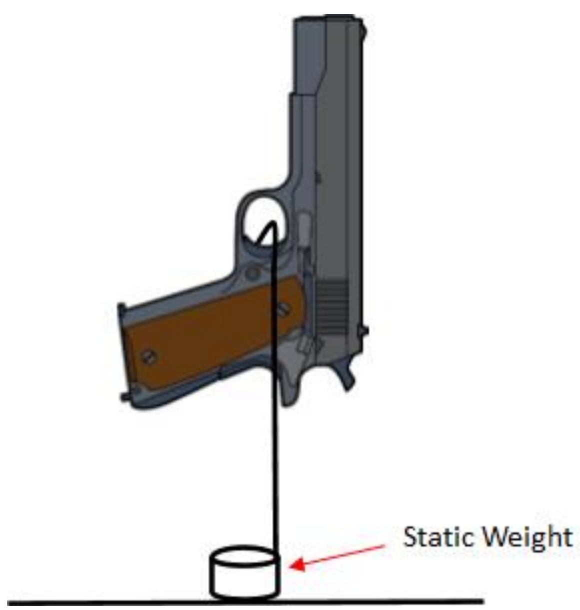

Figure 1. Static Weight/Dead Weight/Arsenal Weight Setup

4.3.3 Spring gauges/dial gauges

The barrel of the firearm is positioned horizontally. The spring gauge/dial gauge hook is placed on the trigger where the shooter's index finger would typically rest. The spring/dial gauge is pulled horizontally rearward until the sear releases. The force at which the sear releases is recorded.

4.3.4 Digital force gauges

The barrel of the firearm is positioned horizontally. The digital force gauge hook is aligned, but not in contact with, the region on the trigger where the shooter's index finger would typically rest. The force gauge is zeroed and is pulled horizontally rearward until the sear releases. The force at which the sear releases is recorded.

4.3.5 Automated Trigger Pull System

The firearm and automated trigger pull system are positioned and operated according to manufacturer's user documentation. The force at which the sear releases is recorded.

4.4 Trigger Pull Measurements in Casework

4.4.1 When trigger pull is measured in case work, a minimum of three measurements should be obtained for each firearm when possible. For revolvers in double action, at least three measurements should be obtained for each cylinder position.

4.4.2 In case work, the individual measurements, the average of the measurements, and the laboratory's uncertainty of measurement for a firearm should be documented.

4.5 Process Study for Estimation of Uncertainty

4.5.1 A laboratory's trigger pull uncertainty of measurement should be estimated with data from a process study of repeated measurements of several firearms by all those in the laboratory responsible for measuring and/or reporting trigger pull measurements. These repeated measurements should be obtained over several days to account for operator fatigue and environmental variation.

4.5.2 Firearms chosen for the process study should represent the make, model, and caliber of firearms routinely submitted to the laboratory and consist of at least two pistols, two rifles, two shotguns and one single action/double action revolver. Additional firearm classes/action types may be added to the process study, as appropriate. For the single action/double action revolver(s), prior to beginning the process study verify that the double action trigger pull measurements are consistent between cylinder positions.

4.5.3 The process study should be performed in accordance with the procedures outlined in Sections 4.3.2, 4.3.3, 4.3.4, or 4.3.5 and the laboratory's standard operating procedures (SOPs).

4.5.4 For laboratories that utilize a spring gauge to conduct trigger pull measurements in casework, humidity and temperature should be monitored during the process study.

4.5.5 Ten sets of at least three trigger pull measurements should be obtained for each striker fired pistol, rifle, shotgun, and revolver in single action. Ten sets of at least three trigger pull measurements should be obtained at each cylinder position for revolver(s) in double action.

4.5.6 If in casework, a firearm is secured in a fixture, then during the process study, after each set of at least three trigger pull measurements, the firearm should be removed and re-fixtured. This is done to account for variation due to re-fixturing.

4.5.7 For each striker fired pistol, rifle, shotgun, and revolver in single action, the average should be calculated for each set of at least three trigger pull measurements. For the revolver(s) in double action, the average of each set of at least three trigger pull measurements should be calculated for each cylinder position.

4.5.8 An example for the process study is shown below. This example is based on a laboratory with a single staff member who conducts three trigger pull measurements in casework. If more than three measurements are obtained in casework, the example below should be modified to reflect this change.

<u>Single Action / Double Action Revolver (with 6 cylinder positions)</u>

Single Action
(1 firearm) × (1 participant) × [(10 sets x 3 measurements in single action)] = 30 measurements (10 averages recorded)

Double Action
(1 firearm) x (1 participant) x [(10 sets x 3 measurements in double action at each cylinder position) x (6 cylinder positions)] = 180 measurements (6 x 10 averages recorded)

<u>Striker Fired Pistols</u>

(2 firearms) x (1 participant) x (10 sets x 3 measurements) = 60 measurements (20 averages recorded)

<u>Rifles</u>

(2 firearms) x (1 participant) x (10 sets x 3 measurements) = 60 measurements (20 averages)

<u>Shotguns</u>

(2 firearms) x (1 participant) x (10 sets x 3 measurements) = 60 measurements (20 averages)

Total Number of Measurements = 390 measurements (130 averages)

4.6 Estimation of Uncertainty for Trigger Pull Measurements

4.6.1 The "Blank Measurement Uncertainty Estimation Template," a spreadsheet available from [9], may be used to estimate uncertainty of measurement.

4.6.2 The standard deviation of the ten average values should be calculated for each firearm. For revolver(s) operating in double action, the standard deviation of the ten average values should be calculated at each cylinder position.

4.6.3 The firearm in each class and action type with the highest standard deviation shall be identified and its standard deviation used for further analysis. For revolver(s) in double action, the position with the highest standard deviation should be used for further comparisons.

4.6.4 If there is no significant difference between the highest standard deviations for each firearm class and action type, then the highest standard deviation across all firearm classes and action types can be selected for estimating a single uncertainty of measurement. In this scenario, one measurement uncertainty budget should be completed using that highest standard deviation across all firearm classes and action types.

4.6.4.1 The modified Levene's test [10,19] may be used to determine whether the standard deviations identified in 4.6.4 are significantly different from one another. This test is performed as follows:

4.6.4.1.1 Compute the absolute value of the difference between each average value and the median of all average values recorded for that firearm class/action type. For example, if the average value of three measurements is 6.5 lbsf (pounds of force), and the median of the ten average values for that firearm class/action type is 7.75 lbsf, then the corresponding difference is 1.25 lbsf. Note that because an absolute value is involved, all computed difference values are non-negative.

4.6.4.1.2 Using the difference values from 4.6.4.1.1 for all five firearm classes/action types as data, perform a one-way analysis of variance [20]. A *p*-value of less than 0.1 is often interpreted as evidence that the standard deviations associated with the firearm classes/action types are significantly different.

4.6.5 If, on the other hand, there is a significant difference between the highest standard deviations for each firearm class and action type, then the uncertainty of measurement should be estimated separately for each firearm class/action type. In this scenario, a measurement uncertainty budget should be completed for each of the following firearm classes and action types: striker fired pistol, rifle, shotgun, revolver in single action, and revolver in double action.

4.6.6 The laboratory should identify and estimate the other components contributing to the trigger pull uncertainty of measurement in addition to the standard deviation calculated in 4.6.2 and 4.6.3.

4.6.7 Example spreadsheets of simulated data and analyses for a process study to establish measurement uncertainty is available via a link from Annex A.

4.6.8 Additional information regarding completion of the "Blank Measurement Uncertainty Estimation Template" [9] is contained in Annex B.

4.7 Process Study Special Considerations

4.7.1 If a laboratory utilizes more than one type of trigger pull measurement device, a separate uncertainty budget should be developed, and a separate uncertainty of measurement should be estimated for each measurement device.

4.7.2 If a laboratory utilizes more than one trigger pull measurement device of the same manufacturer/model, a validation study should be conducted using each device to determine if there is a significant difference in trigger pull measurements between devices. If no significant differences are observed, the uncertainty of measurements may be estimated using data from one device.

4.7.3 For forensic organizations that have multiple laboratory locations, the procedure outlined in Sections 4.5.1 to 4.5.7 should be performed by participants at each laboratory location using the trigger pull measurement device utilized at that location. Each laboratory location should calculate the measurement uncertainty independently of the others.

4.7.3.1 If the reproducibility standard deviations, as compared by Levene's test for example, are not significantly different between laboratory locations, then the highest calculated uncertainty of measurement may be used by all laboratory locations.

4.7.4 The process study described in Section 4.5.1 - 4.5.7 should be repeated when a change occurs in the laboratory procedure for measurement of trigger pull, such as the acquisition of a new measurement device.

4.7.5 If a change occurs in the laboratory procedure for reporting of trigger pull, the process study does not need to be repeated, but the uncertainty of measurement should be re-estimated using the combined data from the original process study.

4.7.6 If new laboratory personnel responsible for measuring and reporting trigger pull measurements are hired by the laboratory, the process study should be repeated by the new participants, their data combined with the data from all other participants, and uncertainty of measurement re-estimated.

4.7.7 If a participant responsible for measuring and reporting trigger pull measurements permanently leaves the laboratory, their data should be removed from the combined laboratory data and uncertainty of measurement re-estimated accordingly.

4.7.8 The firearms selected for the process study should be maintained in their original condition and should not be utilized for other laboratory purposes that may alter the firearms' mechanical integrity.

4.7.9 For a firearm received into the laboratory caseload that falls outside the categories from which the uncertainty of measurements was estimated, an abbreviated process study as described in 4.7.11 should be performed and the uncertainty of measurement should be estimated for that firearm.

4.7.10 For a firearm received into the laboratory caseload that exhibits large variation in trigger pull measurements, an abbreviated process study as described in subclause 4.7.11 should be performed and the uncertainty of measurement may be estimated for that firearm.

4.7.11 At least five sets of three trigger pull measurements should be obtained by the laboratory personnel assigned to the case, using the evidence firearm and the trigger pull measurement method being used in the case. An uncertainty of measurement should be estimated from these data.

5 Records [2,3,5]

The laboratory should maintain the following records for each estimation of trigger pull measurement uncertainty:

a) Statement defining the measurand;
b) Statement of how traceability is established for the measurement;
c) The equipment (e.g. measurement device used);
d) All uncertainty components considered;
e) All uncertainty components of significance and how they were evaluated;
f) Data used to estimate repeatability, intermediate precision, and/or reproducibility;
g) All calculations performed; and`
h) The combined standard uncertainty derived from the process study.

Annex A
(informative)

Example Spreadsheets for Estimating Trigger Pull Uncertainty of Measurement

A.1 General

Spreadsheets, located at [url to be determined], provide example data, calculations, and component estimates for a process study to estimate uncertainty of trigger pull measurements. Because errors can find their way into such documents when data are added or substituted, users must verify for themselves that the numerical formulas do not contain omissions or errors and that the calculated results are accurate.

Annex B
(informative)

Supplemental Information for Estimating Trigger Pull Uncertainty of Measurement

B.1 There are two categories of uncertainties. Type A uncertainty components are those that are evaluated by statistical analysis of process study data. Type B uncertainty components are those that are evaluated by means other than statistical methods of series of observations [6,13].

B.1.1 Type A uncertainties include observed variations in trigger pull measurement resulting from such possible factors as:

- Position/alignment of the measurement device with the region on the trigger where the shooter's index finger would typically rest,
- Manner by which a firearm is secured/positioned,
- Angle at which the measurement device is engaged relative to the axis of the firearm,
- Rate at which the measurement device is engaged prior to sear release,
- Different participants performing the measurements.

B.1.2 Type B sources of uncertainty may include:

- Sources described in documents from manufacturers of measurement devices and standards,
- Sources described in documents from calibration laboratories that specify measurement quality, such as accuracy, precision, or uncertainty of measurement,
- Temperature and environmental conditions

B.2 The variations in trigger pull measurements from the process study are assumed to be consistent with a normal distribution.

B.3 If specifications from an outside laboratory or manufacturer are used to estimate a Type B uncertainty component, a rectangular distribution is typically assumed.

B.4 Because the various uncertainty components arise from different sources, a divisor is required to convert each component to a standard uncertainty [6]. The values of these divisors may vary depending on the scenarios below.

B.4.1 For a rectangular distribution where the uncertainty component is represented as a +/- specification (e.g. +/- 0.25 lbf), the divisor is the square root of three.

B.4.2 For a rectangular distribution where the uncertainty component is represented as a range of specifications (e.g. 6.50 lbf - 7.25 lbf), the divisor is twice the square root of three.

B.4.3 If the expanded uncertainty of measurement is provided by a calibration laboratory at a coverage factor k=2, the divisor is 2.

B.4.4 For the standard deviation from the process study, the divisor is one.

B.5 The combined standard uncertainty is calculated as the root mean sum of squares of the individual standard uncertainty components. See, for example, the imbedded formula within the Blank Measurement Uncertainty Estimation Template [9].

B.6 In order to determine the expanded uncertainty, the combined standard uncertainty is multiplied by the coverage factor (k). The coverage factor is dependent upon the number of degrees of freedom associated with the Type A uncertainties. The coverage factor can be determined by specifying a level of confidence, typically 95 percent, that the true value lies within the uncertainty limits. Table 1 (t-distribution and degrees of freedom) contained in [6,15] may be used to determine the coverage factor from the degrees of freedom and the specified level of confidence.

B.7 The degrees of freedom is calculated as the total number of sets of three trigger pull measurements minus the total number of firearms used in calculating the uncertainty. For example, if the process study is carried out per the example in 4.5.8 with ten sets of three trigger pull measurement being taken for one firearm class/action type, then the degrees of freedom is 10 minus 1 (equal to 9).

Annex C
(informative)

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