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



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

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Foreword

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. Procedures are outlined for measuring the trigger pull(s) of firearms 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.

This document was revised, prepared, and finalized as a standard by the Firearms and Toolmarks Consensus Body of the AAFS Standards Board. The draft of this standard was developed by the Firearms and Toolmarks (SCFT) Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science.

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All hyperlinks and web addresses shown in this document are current as of the publication date of this standard.

Keywords: *measurand, readings, measurement, trigger pull, dead weights, arsenal weights, static weights, spring gauges, dial gauges, digital force gauges, automated trigger pull, uncertainty of measurement, firearm, single action, double action, sear, cock.*

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

1 Scope

This document provides procedures for trigger pull measurements and for estimating uncertainties associated with trigger pull measurements.

2 Normative References

There are no normative reference documents. Annex C, Bibliography, contains informative references.

3 Terms and Definitions

For purposes of this document, the following definitions apply.

3.1 measurand

Quantity intended to be measured. VIM^{[1][9]},

3.2 pound-force/lbf

One pound-force, 1 lbf, is defined as the weight of a one pound, 1 lb, mass at standard gravity.

$$1 \text{ lbf (pound-force)} \approx 4.448 \text{ N (newtons)}$$

$$1 \text{ N (newton)} \approx 0.2248 \text{ lbf (pound-force)}$$

NOTE The SI unit of force is the newton, symbol N. In the U.S., it is customary to specify the trigger pull force in pound-force, symbol lbf.

3.3 trigger pull

The amount of force applied to a trigger of a firearm to cause sear release ^{[1][21],[1][6],[1][20]}. The direction of the applied force is parallel to the firearm barrel.

3.4 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 *Association of Firearm and Tool Mark Examiners, Glossary*^[8] and *Glossary-SAAMI* ^{[1][6],[1][20]}.

¹ International Vocabulary of Metrology:
https://www.bipm.org/utis/common/documents/jcgm/JCGM_200_2012.pdf

4 Recommendations

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 functionality of a firearm. It may also be used to assess the firearm for consistency with factory specifications.

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

4.2.3 The examiner shall ensure that the measurement device has a current calibration certificate that provides traceability to the International System of Units (SI) unit of force through an accredited calibration laboratory.

4.3 Setup

4.3.1 General

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 4.3.2 through 4.3.5.

4.3.2 Static Weights/Dead Weights/Arsenal Weights

In order to measure the trigger pull of a firearm using static weights/dead weights/arsenal weights, the following procedure should be followed.

- a) The muzzle of the firearm barrel is positioned vertically as shown in Figure 1.
- b) 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.
- c) The firearm is raised upward until the weighted base is no longer supported by the flat surface and if the sear does not release, the action is re-set for subsequent measurements.
- d) Additional weights are added to the weighted base and the previous measurement process is repeated until the sear releases.
- e) The combined weight at which the sear releases is recorded.

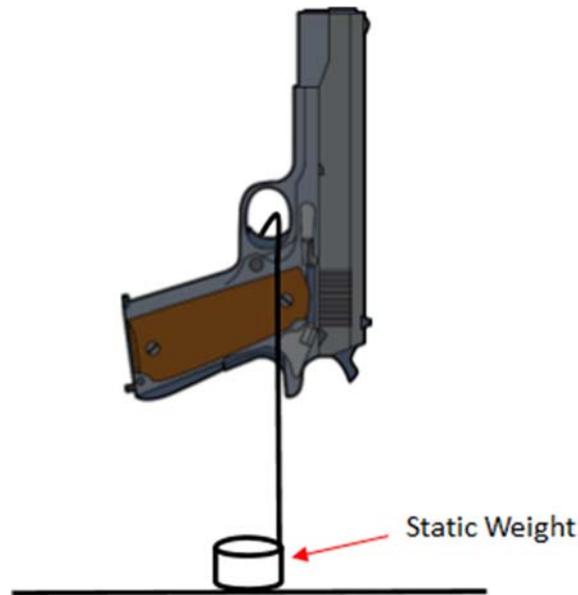


Figure 1—Static Weight/Dead Weight/Arsenal Weight Setup

4.3.3 Spring Gauges/Dial Gauges

In order to measure the trigger pull of a firearm using spring gauges/dial gauges, the following procedure should be followed.

- a) The barrel of the firearm is positioned horizontally and mounted for stability.
- b) The spring gauge/dial gauge hook is placed on the trigger where the shooter's index finger would typically rest.
- c) The spring/dial gauge or firearm should be pulled horizontally such that the exerted force is parallel to the barrel of the firearm until the sear releases.
- d) The force at which the sear releases is recorded.
- e) Alternate orientations are acceptable if the direction of force is maintained parallel with the axis of the bore.

4.3.4 Digital Force Gauges

In order to measure the trigger pull of a firearm using digital force gauges, the following procedure should be followed.

- a) The barrel of the firearm is positioned horizontally and mounted for stability.
- b) 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.
- c) The force gauge is zeroed and is pulled horizontally rearward such that the exerted force is parallel to the barrel of the firearm until the sear releases.

d) The force at which the sear releases is recorded.

NOTE Alternative methods are utilized according to manufacturer's user documentation.

4.3.5 Automated Trigger Pull System

In order to measure the trigger pull of a firearm using an automated trigger pull system, the following procedure should be followed.

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

4.4 Trigger Pull Measurement in Case Work

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 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 process study, it is best practice to select a revolver that has a similar double action trigger pull for each of the cylinder positions.

4.5.3 The process study should be performed in accordance with the procedures outlined in 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 case work, 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 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 case work a firearm is secured in a fixture, then the process study should be conducted in the same manner. After each set of at least three trigger pull measurements for the process study, the firearm should be removed from and re-secured in the fixture. This is done to account for variations in the experimental setup.

4.5.7 For each 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 in 4.5.8 a) through 4.5.8 d). This example is based on a laboratory with a single staff member who conducts three trigger pull measurements in case work. If more than three measurements are obtained in case work, the example below should be modified to reflect this change.

a) Single Action/Double Action Revolver (with 6 cylinder positions)

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

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

b) Pistols

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

c) Rifles

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

d) Shotguns

— (2 firearms) × (1 participant) × (10 sets × 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^[1]19], should be used to estimate uncertainty of measurement. Example spreadsheets of simulated data and analyses for a process study to establish measurement uncertainty are available via Annex A.

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 cylinder position with the highest standard deviation should be used for further analysis.

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.

4.6.5 The modified Levene's test^{[1]7], [1]19]} should be used to determine whether the standard deviations identified in 4.6.4 are significantly different from one another. This test is performed as outlined in 4.6.5.1 and 4.6.5.2.

4.6.5.1 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 lbf (pounds of force), and the median of the ten average values for that firearm class/action type is 7.75 lbf, then the corresponding difference is 1.25 lbf. Note that because an absolute value is involved, all computed difference values are non-negative.

4.6.5.2 Using the difference values from 4.6.5.1 for all five firearm classes/action types as data, perform a one-way analysis of variance^[1]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.

4.6.6 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 firearm classes and action types that have a significant difference in standard deviation.

4.6.7 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. Additional information regarding completion of the blank measurement uncertainty estimation^{[1]6], [1]19]} is contained in Annex A.

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 process study and uncertainty analysis described in 4.5.1 through 4.6.7 should be performed by participants at each laboratory location using the trigger pull measurement device utilized at that location. Each laboratory location should estimate the measurement uncertainty independently of the others.

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

4.7.5 The process study and uncertainty analysis described in 4.5.1 through 4.6.7 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.

4.7.6 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.

4.7.7 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 the uncertainty of measurement re-estimated.

4.7.8 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 the uncertainty of measurement re-estimated.

4.7.9 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. If the firearms selected for the process study cannot be maintained in their original condition, the process study should be repeated by all participants using a new set of firearms.

4.7.10 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 4.7.12 should be performed and the uncertainty of measurement should be estimated for that firearm.

4.7.11 For a firearm received into the laboratory caseload that exhibits large variation in trigger pull measurements, an abbreviated process study as described in 4.7.12 should be performed and the uncertainty of measurement should be estimated for that firearm.

4.7.12 For the abbreviated process study, 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. For the firearm, the average should be calculated for each set of three trigger pull measurements and the standard deviation of the five average values should be calculated. If the firearm is a double action revolver, the average of each set of three trigger pull measurements should be calculated for each cylinder position and the standard deviation of the five average values should be calculated for each cylinder position. An uncertainty of measurement should be estimated from these data.

5 Records [1][21]

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 and its calibration certificate);
- d) all uncertainty components considered;
- e) all uncertainty components 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 obtained.

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Annex A (informative)

Example Spreadsheets for Estimating Trigger Pull Uncertainty of Measurement

Spreadsheets, located at [\(link to be provided at time of publication\)](#), 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.

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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 the statistical analysis of series of observations (e.g., process study data). Type B uncertainty components are those that are evaluated by means other than the statistical analysis of series of observations ^{[1]4],[1]8]}.

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

- 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 barrel;
- rate at which the measurement device is engaged prior to sear release; and/or,
- different participants performing the measurements.

B.1.2 Type B sources of uncertainty may include the following:

- temperature and environmental conditions;
- sources described in documents from manufacturers of measurement devices and standards; and/or,
- sources described in documents from calibration laboratories that specify measurement quality, such as accuracy, precision, or uncertainty of measurement.

NOTE The calibration report of a static weight often states its mass in lb or kg. The weight or force exerted by a mass of 1 lb can be approximated as 1 lbf. The weight of a 1 kg mass can be approximated as 9.8067 N or 2.2046 lbf. The actual weight or force is determined by the acceleration due to gravity, which varies depending on geographical location and height. The force is furthermore slightly affected by the buoyancy of the static weight in air. Overall, the uncertainty due to both these effects can be modeled as a Type B uncertainty with a rectangular distribution equal to $\pm 0.35\%$ of the approximated weight.

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.

Example: $0.25 \text{ lbf} / \sqrt{3}$

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

Example: $(7.25 \text{ lbf} - 6.50 \text{ lbf}) / (2\sqrt{3})$

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

B.4.4 For the standard deviation from the process study, the divisor is 1.

B.5 The combined standard uncertainty is calculated as the root of the sum of the squared individual standard uncertainty components. See, for example, the imbedded formula within the "Blank Measurement Uncertainty Estimation" Template ^[11] spreadsheet in Annex A.

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%, that the true value lies within the uncertainty limits. Table G.2 ^[11] (t -distribution and degrees of freedom) 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 smallest number of sets of three trigger pull measurements that is used to calculate a standard deviation per the procedure in 4.6.2, minus 1. For example, if the process study is carried out per the examples in 4.5.8 with ten sets of three trigger pull measurement being taken by one participant for each firearm class/action type, then the degrees of freedom is $10 - 1$ (equal to 9). The more participants, the greater the degrees of freedom. For example, if eight (8) participants carried out the process study, each with ten sets of three trigger pull measurements for each firearm class/action type, then the degrees of freedom is $80 - 1$ (equal to 79).

Annex C (informative)

Bibliography

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