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Guidelines for Barrel and Overall Length Measurements of Firearms

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This document may be downloaded from: www.asbstandardsboard.org

Foreword

Barrel lengths and overall lengths are dimensional specifications of firearms that can be used as descriptors or that can be mandated by law. This document describes procedures for measuring the barrel length and overall length of firearms and for estimating the uncertainty of those measurements. Procedures are outlined for different types of firearms to determine their conformance to the specifications. Estimation of uncertainty is achieved through the analysis of possible sources of measurement uncertainty and includes repeated measurements by all lab personnel responsible for barrel length and overall length measurements. Annex A provides an example illustrating measurement results and uncertainty evaluation.

This document was revised, prepared, and finalized as a best practice recommendation by the Firearms and Toolmarks Consensus Body of the AAFS Standards Board. The draft of this Best Practice Recommendation was developed by the Firearms and Toolmarks 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 document.

Keywords*: barrel, bore, firearm, integral chamber, length, measurand, revolver, rifle, shotgun, uncertainty*.

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Guidelines for Barrel and Overall Length Measurements of Firearms

1 Scope

This document provides guidelines for measuring and reporting barrel length and overall length (BL-OL) of firearms, including guidelines for measurement traceability and estimating uncertainty of BL-OL measurements. This document does not apply to descriptive measurements of firearms.

2 Normative References

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

3 Terms and Definitions

Terms specific to firearms, such as muzzle, bore, bore axis, forcing cone, breech face, action, chamber, barrel, firing pin, and bolt (breech bolt) are described in the Sporting Arms and Ammunitions Manufacturers' Institute (SAAMI) *Glossary* [15] and Association of Firearm & Tool Mark Examiners (AFTE) *Glossary* [8].

3.1
measurand
Quantity intended to be measured (see Section 2.3 of *International Vocabulary of Metrology (VIM) — Basic and General Concepts and Associated Terms* [10].

3.2
metrological traceability, traceability
Property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of comparisons, each contributing to the measurement uncertainty (see 2.4.1 of *International Vocabulary of Metrology (VIM) — Basic and General Concepts and Associated Terms* [10]).

4 Recommendations

4.1 Background

Federal and State laws of the United States of America, and international laws contain requirements for the minimum barrel lengths and minimum overall lengths of rifles, shotguns and other firearms not classified as handguns. These requirements may vary for different jurisdictions. Examples of minimum length requirements in federal law [17] include: 16 in. barrel length for rifles, 18 in. barrel length for shotguns, and 26 in. overall length for rifles, shotguns and other firearms not classified as handguns. This document provides procedures for measuring barrel and overall length (BL-OL), information on measurement traceability, and procedures for calculating measurement uncertainty.

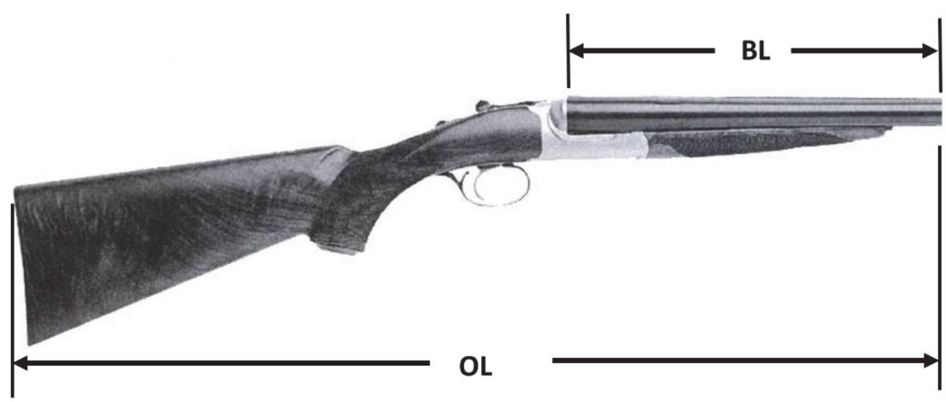
4.2 General

4.2.1 When handling any firearm, even for the purposes of measuring, safety is the first concern. Ensure the firearm is unloaded before conducting measurements. If there is any doubt about the operation of a firearm, consult with a qualified firearms instructor (if available), protocols, or manufacturers' literature before handling a firearm for measuring.

4.2.2 When measuring barrel or overall length, ensure that the firearm is free from movement, stable for measuring, and is located in an area with proper lighting. The measuring devices and/or reference length standards used to calibrate the measuring device shall have current calibration certificates that provide traceability to the international unit of length through accredited calibration laboratories.

4.2.3 Devices used to measure barrel and overall lengths (BL-OL) may include, but are not limited to, measuring tapes, measuring squares, rulers, measuring rods, and caliper devices. Some of these devices may have digital readouts. The unique identifier(s) for the device(s) used should be recorded in the examination record.

4.2.4 Measurands: The quantities to be measured for BL-OL are described elsewhere [11, 12, 17] and illustrated in Figure 1. These measurements include the forwardmost point of the muzzle and the rearmost point of the stock when those areas are uneven or have been altered. The forwardmost point of the muzzle may include fixed and/or non-readily removable parts.



Additional provisions and highlights are described in 4.3, 4.4, and 4.5.

Figure 1—Illustration of Barrel Length (BL) and Overall Length (OL) Measurands
(adapted from [17])

4.3 Barrel Length Measurements

4.3.1 Revolvers

4.3.1.1 The length of a revolver barrel is the distance from the rear of the forcing cone to the forwardmost point of the muzzle, measured parallel to the bore axis.

4.3.1.2 Ruler/Measuring Tape: A revolver barrel may be measured by placing a ruler/measuring tape on the exterior of the barrel, parallel to the bore axis, to determine the barrel length. The ruler marks should then be perpendicular to the bore.

4.3.1.3 Measuring Rod: A measuring rod may be used to measure barrel length; however, consideration should be taken to determine how the starting point can be accurately achieved. A block may be held in contact with the muzzle or forcing cone end of the firearm, perpendicular to the bore axis, to align the end of the measuring rod with the starting point of the barrel. The material of the measuring rod should be soft enough that it does not scratch the barrel. Test firing should be completed prior to barrel measurements made with a measuring rod.

4.3.1.4 Caliper: A revolver barrel may be measured by placing a caliper on the exterior of the barrel, with the main scale parallel to the bore axis (and the jaw surfaces perpendicular to the bore axis).

4.3.2 Integral Chamber Barrels

4.3.2.1 When measuring the barrel of a firearm that has an integral chamber, the length is defined as the distance from the breech face (with the action closed) to the forwardmost point of the muzzle, measured parallel to the bore axis.

4.3.2.2 Ruler/Measuring Tape: A barrel with an integral chamber can be measured by placing a ruler/measuring tape on the exterior of the barrel, parallel to the axis of the bore. An external measurement method may not be suitable for firearms that have recessed breechfaces or external parts that may make it difficult to determine the location of the breechface for alignment of the exterior measurement device.

4.3.2.3 Measuring rod: Before measuring a barrel with an integral chamber, ensure that no components or bolt contours are preventing the measuring rod from making contact with the breech face. It may be necessary to cock the firearm in order to withdraw a protruding firing pin. In the case of a fixed firing pin, be certain it is not reducing the barrel length measurement. Ensure that the measuring rod, when inserted in the barrel, is parallel to the bore axis. The material of the measuring rod should be soft enough that it does not scratch the barrel. Test firing should be completed prior to barrel measurements made with a measuring rod.

4.4 Overall Length Measurements

4.4.1 The overall length of a firearm is the distance between the forwardmost point of the barrel and the rearmost portion of the firearm measured on a line parallel to the bore axis.

4.4.1.1 Since the rearmost point of a firearm rarely falls directly along the bore axis, it is particularly important to make sure that it is accurately represented in the measurement, e.g., using a square to ensure that the line between the rearmost point of the firearm and the measurement scale is perpendicular to the axis of the measurement, or using a caliper surface of sufficient size to contact the rearmost point when the bore axis and measurement axis are parallel.

4.4.1.2 Due to the sometimes complicated geometry of the rear of a firearm, misalignment of the bore axis and the measurement axis can cause additional measurement error due to misjudging what is the rearmost point.

4.4.2 An alignment device such as a square should be used to ensure that the line between the rearmost point of the firearm and the measurement device is perpendicular to the axis of the measurement device as illustrated in Figure 1.

4.4.3 For firearms with folding or retractable stocks, multiple measurements may be taken to encompass the shortest and the longest lengths of the firearm.

4.5 Uncertainty and Measurement Traceability for Barrel and Overall Length Measurements

4.5.1 Estimating the uncertainty of length measurements is essential to achieving traceability of the measurements to the international unit of length. This section provides essential steps for laboratory studies to estimate the uncertainty of those BL-OL measurements that are reported by the laboratory to external parties.

4.5.2 Measurement traceability shall include the calibration certificate of the measuring device or reference length standard. The uncertainty of a laboratory's BL-OL measurements should be estimated with data from a study of repeated measurements of several firearms by all those in the laboratory responsible for measuring and reporting BL-OL. It is recommended that the study employ firearms similar to those found in casework and which are close to the relevant statutory minimum lengths, such as 16 in., 18 in., and 26 in. [17], required by applicable laws. The same type of measuring device should be used for all measurements for a given uncertainty study.

4.5.3 Measurements of BL-OL should be performed in accordance with the procedures outlined in 4.2, 4.3, and 4.4.

4.5.4 Key factors, which may affect the uncertainty of measurement, are as follows.

— Different lengths to be measured (for example 16 in., 18 in., and 26 in. [a]).

— Different models of firearms, which may need to be handled or fixtured differently.

— Different participants performing the measurements.

— Inherent uncertainty associated with the measurement device. A different uncertainty budget shall be developed for each type of device used for these measurements.

— Uncertainty in any physical standards used to calibrate the device with respect to the international unit of length.

— Misreading the demarcations on a length scale during a manual measurement. Participants responsible for manual measurements should be trained to avoid this error. In addition, the laboratory should have a clear policy for identifying and dealing with outlier data points which result from this type of error.

NOTE The first two items relate to the measurand and the last four relate to the measurement.

4.5.5 For each type of measurement, at least 70 measurements should be obtained in the study, with at least two measurements of each barrel length and overall length by each participant. The measurements should be taken on more than one day. The firearms measured should have slightly different lengths, close to the relevant statutory minimum lengths.

[a] Based on federal law, barrel and overall length measurements must be reported in inches. Therefore, SI units are not used in this document.

For example, if there are five participants in the laboratory, the number of measurements taken to estimate the BL or OL measurement uncertainty might be:
(4 models of firearm) × (5 participants) × (4 repeated measurements) = 80 measurements.

4.5.6 For laboratories with fewer participants, the number of models or the number of repeated measurements should be increased so that at least 70 measurements are taken altogether.

4.5.7 Recorded data not included in the estimation of uncertainty of measurement should be clearly identified.

4.5.8 To complete the analysis, the measurement data should be recorded, their pooled standard deviation should be calculated, and uncertainty components from all sources should be estimated and combined. The "Blank Measurement Uncertainty Estimation Template" [14], an online spreadsheet, may be used for this purpose.

4.5.9 A spreadsheet of simulated data and analysis results is available via a link in Annex A.

4.5.10 Once uncertainties for BL-OL measurements are established, at least two measurements should be obtained for barrel length and at least two measurements should be obtained for overall length in casework. The mean value of the measurements should be reported. Any difference between the measurements should be consistent with the uncertainty as assessed above.

4.5.10.1 If the differences between the measurements are greater than the uncertainty, the source for the differences should be assessed and corrective measures made based on laboratory policy.

4.5.10.2 The initial measurements and the corrective measures should be documented.

4.5.11 The stability of the measurement process should be monitored by control chart(s) [3, 8] of measurements of the laboratory's physical check standard(s), guided by its quality procedures.

4.5.12 The process described in 4.5.2 to 4.5.8 or an equivalent process should be repeated when a change occurs for measurement of barrel length or overall length, such as the acquisition of a measuring device, a change in participants, or a change of methods.

5 Records

The laboratory should maintain [4,5,6,14]:

- an uncertainty budget;
- control charts;
- a data log;
- records of calibration of physical standards used for these measurements;
- records of calibration procedures and maintenance of measurement devices used for these measurements.

Annex A
(informative)

Example Spreadsheet for Calculating Uncertainty for Measurement of Overall Length and Barrel Length

NOTE This annex is intended to provide useful working examples and is not intended to be construed as the only valid approach to calculating uncertainty.

A.1 General

A spreadsheet, which may be obtained at (http://www.asbstandardsboard.org/wp-content/uploads/2021/09/060_BPR_e1_AnnexA_Spreadsheet.xlsx), provides example data (Sheet 1) and component estimates from a simulated laboratory study to estimate uncertainty of measurement for overall length (OL) (Sheet 2) and barrel length (BL) (Sheet 3). Copies of the data shown in the spreadsheet are duplicated as Table A.1 to Table A.3. The spreadsheet is an example only and was adapted from a previously developed template [14].

The example spreadsheet begins on Sheet 1 (Table A.1) with simulated data involving 80 measurements each for barrel length and overall length, shown in columns D and E. The 80 measurements include five participants taking four measurements each on four firearms. The calculations here yield a mean value for the overall length and barrel length of each firearm and a Type A standard uncertainty (Stdev) calculated from 80 measurements by all participants. The four values of standard uncertainty are pooled to yield a value of statistical reproducibility for OL and BL measurements, shown in yellow. These values are carried onto Sheets 2 and 3, respectively, as one component of a summary uncertainty budget tabulated in a format originally described by ASCLD/LAB.

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. It is recommended to lock cells that contain formulas to avoid unintentional modification.

A.2 Introduction

The spreadsheet is designed for calculating the expanded measurement uncertainty for Overall Length (OL) and Barrel Length (BL). The expanded uncertainty defines an interval about the measurement result that may be expected to encompass a large fraction of the values that could reasonably be attributed to the measurand [9]. Typical values for this fraction, often referred to as the level of confidence, are 95% or 99%. To obtain the expanded measurement uncertainty, we need to evaluate and combine the significant components of measurement uncertainty.

For most scenarios, Sheet 2 and Sheet 3 provide a list of the uncertainty components that may significantly affect the OL or BL measurement uncertainty. For each uncertainty component, the tables provide an evaluation of the respective standard uncertainty, i.e., uncertainty expressed as a standard deviation [9]. Here, Type A uncertainty components are those that are evaluated by a statistical analysis of repeated observations [9]. Type B uncertainty components are those that are evaluated by other means, typically scientific judgement [9].

The combined standard uncertainty of the measurement is obtained as the square root of the sum of the squared component standard uncertainties. The expanded uncertainty is then obtained by multiplying the combined standard uncertainty with a coverage factor k. The value of the coverage factor can, in principle, be determined by specifying the desired level of confidence. However, the respective value of k is affected by the probability distributions of the various uncertainty components and the degrees of freedom associated with the estimates for the standard uncertainty. In practice, it is often reasonable to assume that the combined measurement errors have a normal distribution with a standard deviation equal to the combined standard uncertainty. In that case, $k = 2$ can be adopted for a level of confidence of approximately 95%, and $k = 3$ for a level of confidence of approximately 99%.

A.3 Measurement Process Reproducibility

This component describes the uncertainty resulting from non-reproducible errors in the measurement process. Examples of such errors are random errors in scale readings and firearm alignment. Sections 4.5.5 through 4.5.8 describe the data required to evaluate the respective standard uncertainty, an example of which is provided in Sheet 1.

For each firearm, Sheet 1 first calculates the standard deviation of each OL or BL measurement obtained by all participants. Next, a pooled standard deviation for OL or BL is obtained as the root mean square of the standard deviations obtained for the various firearms. As shown in Sheet 2 and Sheet 3, the standard uncertainty for measurement process reproducibility equals the standard deviation, obtained in Sheet 1.

A.4 Length Scale Readability

The length scale readability component describes the uncertainty due to the limited resolution of the measurement system. It is determined by the smallest change ΔL_r in measurement value that can be observed. For a measuring tape or scale that is read without interpolation, this would be the nominal distance between the scale hash marks. For a measurement system with a digital readout, this would be the smallest change in the readout value that is reported. To evaluate the respective standard uncertainty, we assume that the resulting length measurement error can take any value in the interval $\pm\ 0.5\ \Delta L_r$ with equal probability. For this rectangular distribution, the respective standard uncertainty is obtained by dividing the width of the distribution, ΔL_r, by $\sqrt{12}$.

Note that this standard uncertainty occurs twice in the uncertainty estimation form if the length is obtained as the difference between two scale or device readings.

A.5 Measuring Scale Calibration Uncertainty

The measuring scale calibration uncertainty describes the uncertainty due to errors in the length measuring device or scale. The uncertainty can be obtained from the calibration report of the device. Often, the uncertainty is reported as $\pm$ an expanded uncertainty. The standard uncertainty is obtained by dividing this expanded uncertainty by the respective coverage factor k, which is often specified in the calibration report. Typical values for k are 2 and 3 for levels of confidence of 95% and 99%, respectively, assuming a normal distribution.

In some cases, a forensic lab may choose to perform its own calibration of the length measuring device using a calibrated length artifact with a length close to the OL or BL to be measured. In this case, there are three standard uncertainties to consider:

1) the standard uncertainty of the calibrated length,

2) the standard deviation of repeated measurements of the calibrated length by the measuring device during its calibration, and

3) the length scale readability (similar to Section A.4).

If the mean value of N repeated measurements is used to estimate the error of the scale, the standard deviation in 2) is divided by the square root of N to yield the standard deviation of the average. Additional uncertainty components may have to be included due to thermal expansion (A.6) and misalignment (A.7). If the estimated scale error is not corrected, its absolute value can be conservatively included in the uncertainty evaluation as a standard uncertainty.

A.6 Thermal Expansion

Lengths are defined at a reference temperature of 20°C. If measurements are performed at a different temperature, small errors may occur because the firearm and measuring scale may have a different coefficient of thermal expansion. Additional errors may occur if the firearm and measuring scale do not have the same temperature.

For a conservative estimate of the possible error due to thermal expansion, we assume:

— a stainless steel measuring scale with a coefficient of thermal expansion of 0.0016 %/°C,

— a firearm whose length does not change with temperature,

— a measured length of 29 in.,

— a temperature anywhere between 15°C and 25°C.

Under these conditions, the maximum error in length measurement equals (0.0016 %/°C) × (5°C) × (29 in.) = 0.00232 in. Assuming a rectangular distribution for the temperature, we obtain the standard uncertainty as 2 × 0.00232 in. × $1/\sqrt{12}$ = 0.0013 in.

A.7 Alignment Errors

This section explains how to calculate potential errors in measurement of overall length due to small misalignments. Two types of misalignment are described.

Figure A.1 shows a schematic diagram of an OL measurement. In this diagram, the measurement datum at the firearm stock is misaligned by an angle α, i.e., it is not square to the bore axis. This misalignment causes an error ΔL in the measured length that is proportional to the distance d between the scale and the contact point between stock and datum:

$$\Delta\mathrm{L} = -d \cdot \tan(\alpha) \approx -d \cdot \frac{\alpha \cdot \pi}{180^{o}}, \qquad \text{A.1}$$

where:

α is expressed in degrees.

Here it is assumed that the misalignment does not change the position of the contact point on the stock. A similar error occurs at the muzzle end of the firearm. In general, both errors are sampled during the reproducibility study, and are therefore already addressed by the uncertainty analysis. It may therefore be good practice to include in the reproducibility study a firearm with a large offset in the position of the stock contact point relative to the barrel center line.

For some measurement setups, the fixturing may be such that the misalignment angle is the same for every measurement. For these setups, the resulting error in OL may not be adequately sampled during the reproducibility study. Similar to the procedure for thermal expansion, the standard uncertainty can be estimated by assuming a rectangular distribution for the squareness error α.

Figure A.2 shows a different alignment error during an OL measurement. Here the firearm is misaligned by an angle β relative to the scale and datum. In this scenario two errors occur. The first error, labeled ΔL_1, is proportional to the offset distance D between the barrel center line and the contact point between stock and datum:

$$\Delta \mathrm{L}_1 = -D \cdot \tan(\beta) \approx -D \cdot \frac{\beta \cdot \pi}{180^o}, \qquad \text{A.2}$$

If the barrel is rotated clockwise ΔL_1, is positive, if the barrel is rotated counterclockwise, ΔL_1 is negative. A similar error, now proportional to half the diameter of the barrel, occurs at the muzzle end.

The second error is a so-called cosine error that describes the foreshortening effect of the misalignment β between the measurement direction of the scale and the bore axis:

$$\Delta \mathrm{L}_2 = OL \cdot (\cos(\beta) - 1) \approx -\frac{1}{2} \cdot OL \cdot \left(\frac{\beta \cdot \pi}{180^o}\right)^2 \qquad \text{A.3}$$

If we assume that there are no systematic errors in the misalignment angle, most of these errors vary and are included in the standard uncertainty due to measurement process reproducibility, discussed in Section A.3. However, because the sign of the cosine error is always negative, the cosine error also introduces a small negative bias that is not characterized by this reproducibility. In general, the cosine error is not significant. Suppose, for example, that we are measuring an OL of 29 in. If we assume a large misalignment of 0.2 in. between the measurement scale and the barrel center line, the angle β can be estimated as $\beta = \text{arc}\sin(0.2/29) \approx 0.4^o$. The resulting cosine error equals approximately –0.00069 in.

A similar cosine error can occur during barrel length measurements. It can usually be neglected for reasonably small misalignment angles.

Figure A.1—Misalignment or Squareness Error Between the Measurement Datum and Scale (adapted from [17])

Figure A.2—Misalignment of the Firearm in the Measurement Setup (adapted from [17])

Table A.1—Example Spreadsheet for Calculating Uncertainty for Measurement of Overall Length and Barrel Length

All dimensions in inches

Participant	EntryDate	SerialNumber	Overall	Barrel
Al	01-Jan-15	11	20.4375	9.6875
Al	01-Jan-15	22	28.6875	11.875
Al	01-Jan-15	33	18.5	12.25
Al	01-Jan-15	44	20.1875	13.625
Betty	01-Jan-15	11	20.4375	9.75
Betty	01-Jan-15	22	28.6875	11
Betty	01-Jan-15	33	18.5	12.25
Betty	01-Jan-15	44	20.25	13.5625
Carl	01-Jan-15	11	20.4375	9.6875
Carl	01-Jan-15	22	28.6875	11
Carl	01-Jan-15	33	18.6875	12.25
Carl	01-Jan-15	44	20.1875	13.625
Denise	01-Jan-15	11	20.4375	9.75
Denise	01-Jan-15	22	28.5625	10.9375
Denise	01-Jan-15	33	18.6875	12.25
Denise	01-Jan-15	44	20.25	13.625
Ed	01-Jan-15	11	20.4375	9.75
Ed	01-Jan-15	22	28.6875	11
Ed	01-Jan-15	33	18.6875	12.25
Ed	01-Jan-15	44	20.1875	13.625
Betty	02-Jan-15	44	20.25	13.625
Betty	02-Jan-15	11	20.4375	9.6875
Betty	02-Jan-15	22	28.6875	11
Betty	02-Jan-15	33	18.6875	12.25
Carl	03-Jan-15	44	20.25	13.625
Carl	03-Jan-15	11	20.4375	9.75
Carl	03-Jan-15	22	28.6875	11
Carl	03-Jan-15	33	18.75	12.25
Denise	04-Jan-15	44	20.25	13.625
Denise	04-Jan-15	11	20.5	9.75
Denise	04-Jan-15	22	28.6875	11
Denise	04-Jan-15	33	18.75	12.25
Ed	05-Jan-15	44	20.25	13.625
Ed	05-Jan-15	11	20.4375	9.6875
Ed	05-Jan-15	22	28.6875	10.9375
Ed	05-Jan-15	33	18.75	12.25
Al	06-Jan-15	44	20.25	13.625
Al	06-Jan-15	11	20.4375	9.75
Al	06-Jan-15	22	28.6875	10.9375
Al	06-Jan-15	33	18.75	12.25
Al	08-Jan-15	33	18.75	12.25
Al	09-Jan-15	44	20.25	13.625
Al	10-Jan-15	11	20.4375	9.75
Al	11-Jan-15	22	28.6875	11
Ed	08-Jan-15	33	18.75	12.25
Ed	09-Jan-15	44	20.25	13.625
Ed	10-Jan-15	11	20.4375	9.75
Ed	11-Jan-15	22	28.6875	11
Denise	08-Jan-15	33	18.75	12.25
Denise	09-Jan-15	44	20.25	13.625
Denise	10-Jan-15	11	20.4375	9.75
Denise	11-Jan-15	22	28.6875	11
Carl	08-Jan-15	33	18.75	12.3125
Carl	09-Jan-15	44	20.25	13.625
Carl	10-Jan-15	11	20.4375	9.75
Carl	11-Jan-15	22	28.6875	11
Betty	08-Jan-15	33	18.75	12.25
Betty	09-Jan-15	44	20.25	13.625
Betty	10-Jan-15	11	20.375	9.6875
Betty	11-Jan-15	22	28.6875	10.9375
Ed	14-Jan-15	22	28.6875	11
Ed	14-Jan-15	33	18.75	12.25
Ed	14-Jan-15	44	20.25	13.625
Ed	14-Jan-15	11	20.375	9.75
Denise	18-Jan-15	22	28.6875	10.9375
Denise	18-Jan-15	33	18.75	12.25
Denise	18-Jan-15	44	20.25	13.5625
Denise	18-Jan-15	11	20.4375	9.75
Carl	22-Jan-15	22	28.6875	11
Carl	22-Jan-15	33	18.75	12.1875
Carl	22-Jan-15	44	20.1875	13.625
Carl	22-Jan-15	11	20.4375	9.75
Betty	26-Jan-15	22	28.6875	11
Betty	26-Jan-15	33	18.75	12.25
Betty	26-Jan-15	44	20.1875	13.625
Betty	26-Jan-15	11	20.4375	9.75
Al	31-Jan-15	22	28.6875	11
Al	31-Jan-15	33	18.75	12.25
Al	31-Jan-15	44	20.25	13.625
Al	31-Jan-15	11	20.4375	9.75

Serial Number	Overall Stats		Barrel Stats	
	Means	Stdevs	Means	Stdevs
#11	20.43438	0.024627	9.734375	0.028932
#22	28.68125	0.027951	* 11.02813	0.201225
#33	18.7125	0.076948	12.25	0.020278
#44	20.23355	0.027766	13.61842	0.019237
#22*			10.98355	0.028276
	Pooled Stdev - OL	0.044944	Pooled Stdev - BL	0.024586

*The first value for SN 22 widely differs from the mean. It is removed here as an example of a possible action for dealing with outliers.

Pooled Stdev - OL: Enter this value on page 2, cell C8.

Pooled Stdev - BL: Enter this value on page 3, cell C8.

Data and calculations adapted from results by:
Johnson County Sheriff's Office,
Virginia Dept. of Forensic Science

Table A.2—Measurement Uncertainty Estimation Form for Overall Length of the Firearm

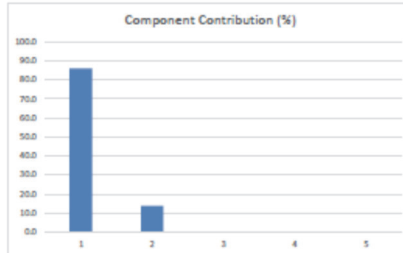
Measurement Uncertainty Estimation Form

Measurement: Overall Length of a Firearm
Range of measurement values: 19 inch to 29 inch
Procedure name and revision: Example Uncertainty Budget
Estimation prepared by: Task Group on Uncertainty of Measurement **Date Prepared:** 4/11/2021

Attention! See explanatory notes on row 7, on column A, and in cells B13 and C19.

Line Item	Uncertainty Component	Value	Units	Type	Statistical Distribution	Divisor	Degrees of Freedom	Standard Uncertainty	Component Contribution %
1	Measurement Process Reproducibility (from page 1)	0.0449	inch	A	normal	1.00	>60	0.0449	86.0
2	Length scale readability (1/16 inch)	0.0625	inch	B	rectangular	3.46	∞	0.0181	13.9
3	Measuring scale calibration uncertainty	0.0014	inch	A	normal	1.00	19	0.0014	0.1
4	Reference length standard calibration uncertainty (obtained from vendor)	0.0002	inch	B	normal	2.00	∞	0.0001	0.0
5	Thermal expansion of measuring tool for ± 5 °C (conservative choices)	0.0023	inch	B	rectangular	1.73	∞	0.0013	0.1
6	Other sources of uncertainty,...								
								Sum	100

Combined Standard Unc	u_c			0.04847673
Expanded Unc	U (k=2)			0.09695347
Expanded Unc	U (k=3)			0.1454302
Reported Uncertainty:	**0.097**	k=2		
Reported Uncertainty:	**0.145**	k=3		



NOTE: Regardless of the number of digits that are showing in a cell, Excel carries the maximum number of significant figures in the background and will use the entire number for further calculations

Table A.3—Measurement Uncertainty Estimation Form for Barrel Length of the Firearm

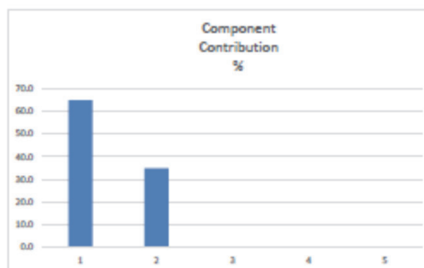
Measurement Uncertainty Estimation Form

Measurement: Barrel Length of a Firearm
Range of measurement values: 9.7 inch to 13.5 inch
Procedure name and revision: Example Uncertainty Budget
Estimation prepared by: Task Group on Uncertainty of Measurement **Date Prepared:** 4/11/2021

Attention! See explanatory notes on row 7, on column A, and in cells B13 and C19.

Line Item	Uncertainty Component	Value	Units	Type	Statistical Distribution	Divisor	Degrees of Freedom	Standard Uncertainty	Component Contribution %
1	Measurement Process Reproducibility (from page 1)	0.0246	inch	A	normal	1.00	>60	0.0246	64.8
2	Length scale readability (1/16 inch)	0.0625	inch	B	rectangular	3.46	∞	0.0180	34.9
3	Measuring scale calibration uncertainty	0.0014	inch	A	normal	1.00	19	0.0014	0.2
4	Reference length standard calibration uncertainty (obtained from vendor)	0.0002	inch	B	normal	2.00	∞	0.0001	0.0
5	Thermal expansion of measuring tool for ± 5 °C (conservative choices)	0.0021	inch	B	rectangular	1.73	∞	0.0012	0.2
6	Other uncertainty sources, etc.								
								Sum	100

Combined Standard Unc	u_c			0.030551723
Expanded Unc	U (k=2)			0.061103446
Expanded Unc	U (k=3)			0.091655169
Reported Uncertainty:	**0.061**	k=2		
Reported Uncertainty:	**0.092**	k=3		



NOTE: Regardless of the number of digits that are showing in a cell, Excel carries the maximum number of significant figures in the background and will use the entire number for further calculations

Annex B
(informative)

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