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4.1 Balances and Weight Measurement

4.1.1 Introduction

Balances are used to measure the weight of materials, chemicals, or specimens in the laboratory. Standard weights are weight reference standards used to verify the function and calibration of balances.

4.1.2 Scope

This procedure describes the methods for use and quality assurance of balances and standard weights, and procedure for weight measurement in the Controlled Substances Unit.

4.1.3 Terminology

Weight-based penalty threshold is the specified weight of a controlled substance above which the penalty for a given charge changes, as defined by the law(s) applicable to the case.

Dynamic Weighing is the process whereby a weighing vessel is placed on the balance and tared. The item to be weighed is then immediately transferred to the tared weighing vessel without removing the vessel from the balance, and the net weight is recorded. Dynamic weighing is defined as a single weighing event for measurement uncertainty purposes.

Static Weighing is the process whereby a weighing vessel is placed on the balance and tared. The vessel is then removed from the balance, the item to be weighed is transferred to the weighing vessel that is then placed on the balance, and a reading is obtained. Static weighing is defined as two weighing events for measurement uncertainty purposes.

4.1.4 Application to Casework

For most items and specimens selected for analysis, measurement of net weight will be conducted prior to testing.

If measurement of net weight prior to testing is not performed, the details of the weight measurement shall be recorded and should be reported, such as “weight recorded after analysis” or “gross weight.”

Dosage units (e.g., blotter papers, tablets, capsules) will not routinely be weighed if they are enumerated. Exception: Schedule 2 narcotic dosage units shall be weighed if the weight could be 50 grams or more.

Liquids are most frequently measured in units of volume. Measurement of the net weight of liquids is generally not performed.

4.1.5 Quality Assurance

Each balance used for weight measurement in the Controlled Substances Unit shall be uniquely identified. The balance make and model, if unique to the laboratory, is sufficient reference in case records for this purpose.

The unique identification of a balance should be recorded on all quality assurance documentation pertaining to that balance. Make, model, and serial number or internal unique identifier is sufficient.

Some balances are equipped with a built-in automatic adjustment feature. Despite this feature, these balances are still subject to the same regular calibration checks and annual calibration by an accredited service provider. Users of these balances should not manually override the factory default settings of the internal adjustment feature.

4.1.6 Calibration of Balances and Standard Weights

4.1.6.1 New Balances & Moved Balances

New balances will be calibrated after installation and before use.

Calculation of uncertainty of measurement and determination of operating range will be performed after calibration for all new balances.

1) A minimum of ten balance checks will be performed, with at least one measurement taken daily over ten working days, to generate initial reproducibility data for the calculation of uncertainty of measurement for new balances.

This 10-day check procedure may also be applied if a balance is moved from one location in the laboratory to a new location in order to generate reproducibility data in the new location.

4.1.6.2 Calibration Schedule

All balances used for weight measurement will be calibrated yearly. The calibration traceability certificates will be kept.

Standard weights shall be calibrated once every five years. The calibration certificates issued will be kept.

All calibrations of balances and standard weights shall be performed by an external calibration provider that meets the requirements of ANAB AR 3125 6.5.1.1 a) or b). Refer to Appendix 4 for external calibration providers that meet these requirements.

If so equipped, internal calibrations or internal adjustments should not be manually initiated by users of the balance.

4.1.6.3 Care & Handling of Weights

When not in use, the standard weights will be stored in the padded container provided by the manufacturer. To measure a standard weight, remove the weight from the padded container before placing the weight on the balance.

If the weight is dropped or becomes damaged it will be taken out of service and recalibrated by an external calibration service. Documentation of this event will be kept with the calibration certificates for that standard weight.

Standard weights shall be shipped or transported in a padded case designed to withstand the abuses of shipping or transport. The padded container provided by the manufacturer is suitable for this purpose. When shipping standard weights, the case should be held shut with latches and/or rubber bands. The case should be further packaged in a cardboard box and shipping instructions given by the calibration service provider shall be followed.

4.1.6.4 Verification of Calibration through Routine Balance Checks

At a minimum, the calibration shall be verified on a bi-weekly basis for each balance used for weight measurement.

The calibration should also be verified if a balance loses power.

The available standard weight that is nearest to but not greater than the capacity of the balance shall be selected for bi-weekly calibration checks.

The same standard weight should be used for all calibration checks.

The measured weight of the standard weight shall be documented for each calibration check.

The Balance Check form and Control Chart are used to document bi-weekly calibration checks (See Appendix 4).

If the Balance Check form is not available, calibration checks will be recorded on Form FS-094 and the results transcribed to the Balance Check form to produce a Control Chart.

4.1.6.5 Verification of Calibration within a Case

The calibration shall be verified additionally when a weight measurement or combined total weight measurement is made that meets or exceeds a weight-based penalty threshold. This check is documented in the case record.

4.1.6.6 Balance Calibration Check Procedure

To measure a standard weight, remove the weight from the padded container before placing the weight on the balance. Cotton or cloth gloves should be worn or coated-tip forceps should be used when handling standard weights to minimize thermal conduction and skin contamination.

Measure the weight of the standard according to regular measurement procedures.

To account for any contribution of the operator to the uncertainty of measurement, all analysts shall conduct at least one balance calibration check annually for each balance that the analyst might use for weight measurement in casework.

The completed Balance QA Summary and Balance Check Form may be printed and retained in the balance logbook or stored electronically as a PDF.

4.1.6.7 Calibration Check Acceptance Criteria

For all calibration checks, the measured weight of the standard weight should fall within +/- 0.1% range of the weight's reference value. This range is given by the Upper and Lower Acceptance Limits on the control chart.

4.1.6.8 Interpretation of Balance Control Charts

Variation is expected in data. The variation should generally be within the control limit (3σ).

The balance will be taken out of service and the calibration re-evaluated if:

a) One measurement falls outside of the upper or lower acceptance limit (0.1% of reference value).
b) Two measurements in a row fall outside of the upper or lower control limit (3σ).

4.1.6.9 Out of Service

When a balance is placed "out of service"

a) The balance shall be clearly marked as being out of service.
b) The date and measurement result that caused the balance to be placed out of service will be documented in the Out of Service Record table in the Balance Checks form.
c) The Unit Supervisor shall be notified.
d) The Unit Supervisor shall examine the effect of the defect or departure from acceptance limits on previously analyzed cases. The Unit Supervisor shall contact the Technical Leader and the Corrective Action procedure in the Laboratory Operations Manual shall be followed.

Maintenance or calibration may be required prior to returning the balance to service.

4.1.6.10 Return to Service

A balance may be returned to service after maintenance or calibration if proper function has been demonstrated.

a) Proper function is assessed by performing a calibration check with at least two standard weights, one of which shall be approximately 5% of the capacity of the balance, and one of which shall be close to, but not greater than, the capacity of the balance. If all measurements are within the acceptance limits the proper function of the balance is verified.
b) The measurement results of the standard weights used shall be documented in the Comments field of the Out of Service table on the Balance Check form.

c) The date at which the balance is returned to service will be documented in the Out of Service table in the Balance Checks form or balance logbook.

The standard weight measured shall also be entered in the Balance Check form if calibration check acceptance criteria are met.

NOTE: Balance check results that are outside of the acceptance limit of +/-0.1% of the reference value should not be recorded in the main data table of the Balance Checks form.

4.1.7 Equipment

Analytical, top-loading, or high-capacity electronic balances are acceptable for routine casework.

4.1.7.1 Operating Range

The operating range is determined upon installation of a new balance, and on an annual basis after yearly balance calibration using the Operating Range form in Appendix 5-B.

The maximum load of a balance is the capacity of the balance as designated by the manufacturer.

The minimum load of a balance is calculated after collecting ten consecutive measurements of a standard weight that is approximately 5% of the balance capacity.

If the minimum balance load is equal to or larger than the weight of the item being measured, a more precise balance should be used or the substance should be reported as a residue, whichever is appropriate.

4.1.8 Measurement Procedure

Each balance used for weight measurement shall be identified in the case record by unique identifier.

To obtain a net or gross weight of the specimen:

a) Visually inspect the balance to ensure it is level and free of any debris.
b) If required, place tare vessel (weighing paper, weigh boat, etc.) in the center of the weighing pan. Close the doors of the balance shield, if present.
c) Tare the balance (if required press zero).
d) Read the stable value from the display. If the stable value displayed is not zero, repeat steps c) and d).
e) Place the material or item to be measured into the tare vessel or on the center of the weighing pan, as applicable.
f) Read the stable value from the display and record it in the case record or other measurement log as appropriate.
g) Remove the test item from the balance pan. Close the doors of the balance shield, if present.

4.1.9 Quality Assurance

The balance used for weight measurement shall be uniquely identified in the case record.

Dynamic weighing should be preferentially used. Occasions of static weighing shall be documented in the case record.

Weights shall be recorded in the case record as they are displayed on the balance.

Calculations involving weights will be performed with the weights as recorded.

4.1.9.1 Calibration Verification

When a weight measurement or combined total weight measurement exceeds a weight-based penalty threshold, the calibration and linearity of the balance(s) used shall be verified through the measurement of standard weights.

a) One standard weight selected and measured should exceed the weight of the specimen when practicable.
b) One standard weight selected and measured should be at or near the weight of the specimen or penalty threshold, whichever is less.
c) One standard weight selected and measured should be less than the weight of the specimen or penalty threshold, whichever is less.

The measurement results of the standard weights used to verify the function of a balance shall be within +/- 0.1% of the nominal value of the standard.

When possible, the check of the balance shall be made on the same day and as close to the time of the weight measurement as practical. In this context, "weight measurement" is the weight measured and reported, or the series of weights measured and reported as a combined total weight.

The verification of the balance will be documented by recording the nominal and measured weight of each standard weight in the case record.

4.1.10 Reporting

Weights of evidence should be reported to the precision of the balance.

Truncated weights may be reported for measurements of three or more decimal places. To truncate a weight for reporting, remove the least significant digit (farthest to the right) in the measurement result.

Gross weights shall be clearly reported as such, and the report shall include a clear description of the packaging materials included in the weight measurement.

4.1.11 Measurement Uncertainty

Refer to the section on Measurement Uncertainty in the Controlled Substances Procedures Manual for the calculation and reporting of measurement uncertainty.

Uncertainty of measurement shall be applied to the weight as measured and recorded. Uncertainty of measurement shall not be applied to truncated weights.

4.1.12 Case Records and Reviews

The unique identifier of the balance used shall be recorded in the case record.

Weights are recorded as displayed on the balance.

Calculations are performed with the weights as recorded. Manual calculations shall be verified.

The reported weight has the appropriate units.

4.1.13 Safety

Caution should be used to avoid electrical shock, particularly if the balance is exposed to liquids.

4.1.14 References

International vocabulary of metrology - Basic and general concepts and associated terms (VIM). JCGM 200:2012, 3rd edition.

GWP Good Weighing Practice TM “A Risk Based Approach to Select and Test Weighing Instruments” Mettler-Toledo, July 2009.

GWP Good Weighing Practice TM “SOP for Periodic Repeatability Tests (Routine Tests),” Mettler Toledo Laboratory & Weighing Technologies, October 2007.

United States Pharmacopeial Convention, Chapter 41 “Balances.”

United States Pharmacopeial Convention, Chapter 1251 “Weighing on an Analytical Balance.”

4.2 Procedure for Cleaning a Balance

4.2.1 Scope

This procedure describes the method for cleaning a laboratory benchtop balance. The cleanliness of a balance can impact efficiency, balance lifetime, and user safety.

4.2.2 Terminology

Cleaning is the physical removal of foreign material such as dust or dirt.

Decontamination is the removal of microorganisms or hazardous materials to leave an item safe for further handling.

Disinfection is the inactivation of disease-producing microorganisms.

4.2.3 Frequency of Cleaning

A balance should be cleaned of spills and debris after every use.

When handling potentially toxic substances, the balance shall be cleaned after use.

If a balance is obviously dirty, cleaning shall be performed before use.

4.2.4 General Information

Clean the balance in its working location; do not tilt, move or carry it around.

Wear appropriate personal protective equipment (lab coat, gloves, safety glasses).

NOTE 1: Avoid creating airborne respirable dusts while cleaning.

NOTE 2: Avoid all skin contact with debris, cleaning agents, and potentially contaminated surfaces.

Do not spray or pour liquids directly on the balance. Instead, spray or dampen a cleaning cloth or tissue and wipe the balance with the cloth.

Balances resist a wipe-cleaning, decontamination or disinfection with alcohols and some hydrocarbons. Exposure can occur for some minutes without damage to the balance.

4.2.5 Cleaning Procedure

Clean the area surrounding the balance with a tissue.

Remove weighing pan and drip tray. Use a damp cloth or tissue and clean with a mild cleaning agent or alcohol.

NOTE: If draft shields are to be removed, refer to the operator's manual. Clean draft shields with window cleaning solution or isopropanol.

Clean the balance.

a) For removal of powder or dust, use a disposable tissue or fine brush. Never blow air across balance to remove dust; this could transport the dust inside the balance.
b) For removal of sticky substances, use a damp lint-free cloth and mild solvent (isopropanol is recommended).
c) For removal of liquids, use an absorbent cloth.

Replace the weighing pan and drip tray. Verify balance is level and operational.

4.2.6 References

Mettler Toledo Reference Paper "8 Steps to a Clean Balance and 5 Solutions to Keep It Clean." Mettler Toledo, November 2016

Mettler Toledo, "SOP Cleaning a Balance." November 2016.

Sartorius, "Importance of Proper Cleaning and Maintenance for Balances in the Laboratory."

4.3 Volume Measurement

4.3.1 Introduction

Volume is a measure of how much space a material occupies. Volumetric glassware is used to measure the volumes of materials, chemicals, or specimens in the laboratory. Volumes are measured at room temperature and pressure unless otherwise specified.

4.3.2 Scope

This procedure describes the methods for use and quality assurance of volumetric glassware and the method for measurement of volume in the Controlled Substances Unit.

4.3.3 Terminology

Volume-based penalty threshold is the specified volume of a controlled substance above which the penalty for a given charge changes, as defined by the law(s) applicable to the case.

Volumetric Glassware in this procedure refers to volumetric flasks and graduated cylinders.

4.3.4 Application to Casework

Typically, volume measurement is performed for liquids and weight measurement is performed for solids. Measurement of the net weight of liquids is generally not performed.

For most liquid specimens selected for analysis, measurement of volume will be conducted prior to testing.

If measurement of volume prior to testing is not performed, the details of the volume measurement shall be recorded and should be reported, such as “volume measured after analysis.”

4.3.5 Quality Assurance

4.3.5.1 Calibration of Volumetric Glassware

Volumetric glassware used for volume measurement of exhibits shall be calibrated “To Contain”. “To Contain” glassware may be recognized by the inscription “TC” on the device.

New volumetric glassware shall be calibrated before use. Manufacturer-supplied calibration certificates are sufficient to document the calibration of the glassware. Calibration certificates shall be kept.

The calibration of uniquely identified volumetric glassware shall be checked once every 10 years if the glassware continues to be used to determine conformance with a volume- or purity-based penalty threshold. Glassware not used for critical measurements need not be checked as frequently.

All calibrations of volumetric glassware shall be performed by an external calibration provider that meets the requirements of ANAB AR 3125 6.5.1.1 a) or b). Refer to Appendix 4 for external calibration providers that meet these requirements.

4.3.5.2 Calibration of Pipettes

New volumetric pipettes shall be calibrated before use. Manufacturer-supplied calibration certificates are sufficient to document the calibration of the equipment. Calibration certificates shall be kept.

The calibration of uniquely identified volumetric pipettes shall be checked annually if the apparatus continues to be used to aspirate or deliver specified volumes of liquid. Most commonly this applies to purity or volume determinations. Pipettes not used for critical measurements or used for simply for convenience need not be checked as frequently.

All calibrations of volumetric pipettes shall be performed by an external calibration provider that meets the requirements of ANAB AR 3125 6.5.1.1 a) or b). Refer to Appendix 4 for external calibration providers that meet these requirements.

4.3.5.3 Equipment Records

One calibrated “To Contain” Class A 500 mL graduated cylinder shall be designated for use for volume measurement of exhibits that are subject to a volume-based penalty threshold.

This graduated cylinder shall be uniquely identified by a serial number or unique name that includes designation of the laboratory and volume. Examples: BP-500mL; MD-500-A.

The unique identifier of the equipment used shall be recorded in the case record for measurements made with calibrated volumetric glassware or pipettes.

Calibration certificates and records shall be kept for uniquely identified volumetric glassware and pipettes. The calibration certificate shall reference the serial number and bear the unique name of the graduated cylinder, if used.

NOTE: Volumetric glassware or pipettes need not be uniquely identified if they will not be used for measurements critical to a result or they are not used for any measurement that is to be compared to a volume- or purity-based legal penalty threshold.

4.3.5.4 Intermediate Checks of Calibration

Volumetric glassware and pipettes shall be visually inspected for irregularities, moisture, or damage before use.

No other intermediate checks of the calibration status are required.

4.3.6 Equipment

When not in use, volumetric glassware should be stored clean in a cabinet. Pipettes should be stored vertically and without a tip.

If volumetric equipment becomes damaged, it shall be taken out of service and a replacement ordered.

Graduated cylinders are used for volume measurement of routine casework. Volumetric flasks are used for volume measurement in the preparation of solutions. Pipettes are used for dispensing microvolumes.

The maximum volume of volumetric glassware is the capacity of the glassware as given by the manufacturer's largest graduation mark.

The minimum volume of volumetric glassware is the volume measured by the smallest manufacturer's graduation mark.

If the minimum volume of a piece of glassware is larger than the volume of the item being measured, a different measuring device should be used or the volume should be reported as less than the minimum gradation, whichever is appropriate. Example: Item 1, <1 mL.

If the maximum volume of a piece of glassware is less than the volume of the item being measured, a higher capacity measuring device should be used. If no higher capacity measuring device is available, the volume should be either:

a) Reported as greater than the maximum graduation of the glassware used. Example: Item 1, >500 mL.

   OR

b) Measured in several portions, each less than the capacity of the measuring device, and the total volume calculated by the sum of the measurements of all portions. Uncertainty of measurement for this method shall be calculated by the method for multiple specimens described in the Uncertainty of Measurement section of the Controlled Substances Procedures Manual.

4.3.7 Measurement of Volume Procedure with a Graduated Cylinder

1. Select a TC graduated cylinder. A calibrated and uniquely identified cylinder is required for cases that are subject to a volume based penalty threshold.
2. Visually inspect the graduated cylinder for irregularities, moisture, or damage.
3. Transfer the evidence to be measured into the graduated cylinder.
4. Measure the volume of the liquid in the graduated cylinder by aligning the eye normal to, and in the same horizontal plane as the meniscus.
5. Use a meniscus reader to visualize the bottom of the meniscus. A meniscus reader can be printed from Appendix 29-B.
6. Place the meniscus reader, black side down, behind the graduated cylinder.
7. Move the meniscus reader so that the edge of the black side is slightly below the meniscus.
8. The position of the bottom of the meniscus relative to the graduation of the cylinder is the measurement result. Note: If the meniscus is convex up, read the volume at the top of the meniscus.
9. Volume measurements shall be estimated to the nearest 1/10th graduation and will be recorded in the analytical notes to this precision.

For example: if the graduation marks are every 5 mL, the volume shall be estimated to the nearest 0.5 mL. Any greater or lesser extent of estimation or other approximation shall cause the volume to be documented and reported as "approximate."

Calculations involving volumes will be performed with the volume measurements as recorded.

Results of calculations involving an approximate volume will be reported as "approximate".

4.3.8 Reporting

4.3.8.1 Scale Correction

Apply scale correction to the volume measurement before reporting.

The correction to the measurement result is calculated in the Estimation of Measurement Uncertainty for Volume Form.

1. The value established for Scale Correction shall be added to the measurement value before truncation or use in any calculation.
2. The corrected measurement result should be truncated to zero decimal places for reporting.

Example: A scale correction is -0.037 mL. The measurement value is 99.5 mL. The corrected result is 99.5 mL + (-0.037 mL) = 99.463 mL. The truncated result is 99 mL.

4.3.8.2 Approximate Volumes

Approximate volumes shall be reported as "approximate" and no scale correction need be applied.

Examples of approximate volumes:

Measurement made with a measurement device that is not calibrated or does not have records of calibration.

Measurement is not estimated to one-tenth of the graduation interval.

4.3.9 Measurement Uncertainty

The estimation of Measurement Uncertainty is determined by intra-laboratory study and information provided about the calibration of the graduated cylinder.

Each analyst performing volume measurement in casework shall be within the tolerance established for volume measurement at the laboratory.

Refer to Uncertainty of Measurement section of the Controlled Substances Procedures Manual for requirements for calculation and reporting of measurement uncertainty.

4.3.10 Case Records and Reviews

The glassware used for volume measurement is uniquely identified in the case record if the measurement is critical to the result, such as if the case is subject to a volume-based penalty threshold.

Measured volumes are estimated at 1/10th of the graduation interval.

Measured volumes are reported after scale correction.

Calculations are performed with the volumes as recorded. Calculations made by hand shall be verified by the technical reviewer.

Approximate volumes are recorded and reported as “approximate.”

The reported volume has the appropriate units.

4.3.11 Safety

No additional requirements or considerations.

4.3.12 References

International vocabulary of metrology - Basic and general concepts and associated terms (VIM). JCGM 200:2012, 3rd edition.

NIST GMP 3 – Good Measurement Practice for Method of Reading a Meniscus using Water or Other Wetting Liquid.

ASTM E691-16 Standard Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

4.4 Uncertainty of Measurement

4.4.1 Introduction

No measurement is exactly known. If a measurement is repeated several times using the same measurement process, a different measured quantity value is obtained each time, assuming that the measuring system has sufficient resolution (sensitivity). Measurement uncertainty is a parameter associated with the variability of a measurement result.

4.4.2 Scope

This procedure applies to the estimation and reporting of measurement uncertainty in the Controlled Substances Unit. Also refer to the following sections:

0 Procedure for Estimating the Uncertainty of Measurement for Weight

4.5.11 Calculation of Combined Uncertainty for Total Weight of Multiple Specimens

4.6 Procedure for Estimating the Measurement Uncertainty for Volume

4.4.3 Terminology

Measurement refers to the process of experimentally obtaining one or more values that express the size, weight, or amount of something. Measurement does not apply to nominal properties.

Measurement uncertainty refers to the parameter associated with the result of a measurement that characterizes the dispersion of values that could reasonably be attributed to the measurand.

The concept of “doubt” is often introduced in dictionary definitions of the word uncertainty. This common definition is different from the scientific use of the word uncertainty. “Uncertainty of measurement” does not imply doubt about the validity of a measurement; on the contrary, knowledge of the uncertainty implies increased confidence in the validity of the measurement result.

For qualitative analyses, although individual methods have limitations, the uncertainty of qualitative methods is not typically amenable to being expressed in numerical terms. Relevant limitations of a qualitative analytical scheme shall be documented and reported according to the applicable casework guidelines.

Standard uncertainty refers to the uncertainty of a measurement result expressed as a standard deviation.

Combined standard uncertainty refers to standard measurement uncertainty that is obtained when the measurement result is obtained from the values of a number of other quantities.

Expanded measurement uncertainty refers to the product of a combined standard uncertainty and a coverage factor that is larger than the number one. Also called “overall uncertainty,” or simply “uncertainty”.

Coverage factor refers to a numerical factor used as a multiplier of the combined standard uncertainty to expand the uncertainty corresponding to a specific level of confidence.

Measurand refers to the quantity intended to be measured.

Weight (or Volume) Based Penalty Threshold refers to the specified weight (or volume) of a controlled substance above which the penalty for a given charge changes, as outlined by applicable State of Michigan law or by applicable federal law if the case is being tried at the federal level.

4.4.4 Uncertainty Components

4.4.4.1 Components of measurement uncertainty for weight determination include:

- Uncertainty or tolerance of the applied load
- Readability
- Repeatability and reproducibility of the weighing system
- Balance operation and number of weighing operations
- Sample loss during transfer
- The effects of
  - temperature changes
  - drafts or wind
  - off center loading
  - indicator drift
  - electrical noise
  - vibration

4.4.4.2 Components of measurement uncertainty for volume determination include:

- Uncertainty of the measuring device
- Readability
- Scale error
- Operator
- Test method
- Volatility of measurand
- Temperature effects

4.4.4.3 Components of measurement uncertainty for purity determination include:

- Sampling
- Analytical technique or procedure
- Reference material
- Concentration of analyte
- Uncertainty of measuring devices
- Environmental conditions

4.4.5 Application of Requirements

The procedure for estimation and reporting measurement uncertainty shall be applied when measurement values are reported for

the quantity (weight or volume) of materials measured in casework.

Exceptions: gross weight, approximation of volume, and numerical count do not require an evaluation of uncertainty of measurement.

the concentration (by weight or volume) or purity (fraction of the whole) of a controlled substance.

As such, the specific measuring device used for a reported result is required to have been included in or evaluated against the estimation of measurement uncertainty for that method. All balances and all specified volume measurement devices are subject to these requirements.

4.4.6 Frequency and Documentation of Calculation of Measurement Uncertainty

The uncertainty of measurement for each balance shall be determined on a yearly basis.

If a balance is moved to a different location, a new uncertainty of measurement shall be determined.

The uncertainty of measurement for volume shall be determined upon acquisition of a new volume measurement device to be used for volume measurement in casework, or as specified in quantitation procedures, and after any subsequent calibration of a volume measurement

device. This does not apply to devices used for volume approximation such as beakers, flasks, or graduated cylinders not used for measurement related to volume-based penalty threshold. Refer to the procedure on Volume Measurement in this manual.

The result(s) of the uncertainty of measurement shall be retained in the Controlled Substances Unit and shall be reported consistent with this procedure and provided upon request.

If the test method produces qualitative or semi-quantitative results, then analytical measurement uncertainty is not quantified.

Calibration data and laboratory-generated balance check quality control data are used to populate a Microsoft Excel spreadsheet that partitions sources of uncertainty, quantifies uncertainty for each component, and calculates the expanded uncertainty for measurement uncertainty for weight determinations.

4.4.7 Case Records and Reviews

The measured weight or volume and the measurement uncertainty are reported in the same units.

Manual calculations are recorded in the worksheet and verified by the reviewer.

The expanded uncertainty and coverage factor shall be recorded in the examination worksheet if

a) The measured weight is within 5 grams of a weight-based penalty threshold
b) The measured volume is within 10 mL of a volume-based penalty threshold
c) The measured weight or volume are within 5% of a penalty threshold

The measured value, expanded uncertainty, and coverage probability shall be reported if the measured weight or volume are within 5% of a penalty threshold.

The coverage probability shall be at least 95.45%.

If a coverage probability greater than approximately 95% is used, the reason for use and coverage factor applied shall be documented in the case record.

The appropriate scale correction shall be applied to the measurement result before rounding when applicable.

4.4.7.1 Reporting examples:

"The weight of item 1 was 50.02 g ±0.03 g. Measurement uncertainty of weight measurements is reported at a level of confidence of approximately 95%."

“The volume of item 1 was 2,622 mL ±6 mL given a coverage probability of approximately 95%.”

4.5 Estimating the Measurement Uncertainty for Weight

4.5.1 Specification of the Measurement Process

The measurand for this procedure is the weight of a substance. The balance used is specified each time this procedure is applied.

The balance used for the measurement shall be calibrated at least once annually by an external calibration provider that is accredited to ISO/IEC 17025 by an accrediting body that is a signatory to the IAAC Multilateral Recognition Arrangement or ILAC Mutual Recognition Arrangement, with the calibration to be performed listed in a scope of accreditation.

The mass reference standards used for the estimation of uncertainty shall be calibrated at least once every five years by an external calibration provider that is accredited to ISO/IEC 17025 by an accrediting body that is a signatory to the IAAC Multilateral Recognition Arrangement or ILAC Mutual Recognition Arrangement, with the calibration to be performed listed in a scope of accreditation.

The name of the balance (make, model, serial number) shall be recorded on the documents associated with the estimation of measurement uncertainty.

4.5.2 Uncertainty Components

The uncertainty components included in the measurement uncertainty for weight determination are readability, tolerance of the standard weight, calibration, location, operator, and reproducibility.

Uncertainty Component	Data Source	Evaluation
Balance Display Resolution at zero and at load	Display on balance	Type B
Balance Calibration	Balance Calibration Report	Type B
Balance Location	Covered in calibration data (not moved since calibration) and QC data	
Standard Weight tolerance	Standard Weight Calibration Report	Type B
Reproducibility (includes operator, temperature, location, humidity, and internal adjustment variations)	Quality Control data	Type A

Also considered in the estimation of the measurement uncertainty are sample loss in transfer and buoyancy.

a) Sample loss in transfer is not able to be accurately or readily estimated. The impact to the final measurement is conservative since sample loss always results in an underestimation of the

quantity of material being weighed. Uncertainty due to sample loss is therefore not included in this procedure.

b) Buoyancy is not able to be accurately or readily estimated because the density of seized drug exhibits is highly variable and generally unknown. For material that has a lower density than the calibration weights (density of steel is 8.0 g/cm^3), the measurement displayed by the balance is conservative and underestimates the true weight of the material. No buoyancy correction is made in the estimation of uncertainty of measurement by this procedure.

4.5.3 Quantify Uncertainty Components

Calibration reports and laboratory-generated quality control data are used to populate an uncertainty budget.

The Estimation of Measurement Uncertainties for Weight form is found in Appendix 25-A. An alternate form should be used for kilogram balances if repeated measurements on the balance appear to have a standard deviation of zero. The Balance and Measurement Uncertainty Workbook - kilogram balances form is found in Appendix 25-E.

4.5.4 Convert to Standard Uncertainties

The Estimation of Measurement Uncertainties form converts each component into a standard uncertainty. Calculations used are found in Appendix 4-B.

4.5.5 Calculate Combined Standard Uncertainty

The combined standard uncertainty is calculated by the Root Sum of Squares method in the Estimation of Measurement Uncertainties form.

4.5.6 Expanded Uncertainty and Coverage Factor (k)

The combined standard uncertainty shall be expanded by multiplying by a coverage factor (k).

4.5.6.1 Selection of k

The coverage factor shall be selected based on considerations relevant to the analytical context and is usually in the range of 2 to 3.

The coverage factor (k) shall provide a coverage probability of at least 95.45%, often referred to as approximately 95%.

For most purposes, it is appropriate to use k=2. However, this value may be insufficient where the combined uncertainty is based on observations with relatively few degrees of freedom. In this instance, the selection of k to provide the minimum coverage probability depends on the effective number of degrees of freedom.

4.5.6.2 Calculation of the Coverage Factor

To determine the appropriate coverage factor that will provide a coverage probability of at least 95.45% the following operations are automatically made in the Estimation of Measurement Uncertainty for Weight Form:

a) The combined standard uncertainty is expanded by a factor of 2.00, as would be done with infinite degrees of freedom.

b) The actual effective degrees of freedom for all uncertainty components is calculated using the Welch-Satterthwaite equation (Appendix 4-B).

c) The effective coverage factor (k_{eff}) required to provide exactly 95.45% coverage probability is determined by the two-tailed t-distribution given the effective degrees of freedom calculated in step ii. See Appendix 4-B.

d) The combined standard uncertainty is expanded by the effective coverage factor (k_{eff}) calculated in step c).

e) The expanded uncertainties calculated in step a) and step d) are compared.

f) If the two values from step a) and d) are the same when rounded up to the precision of the balance, it is appropriate to use a coverage factor of 2 to expand the combined uncertainty.

g) If the two values are not the same when rounded up to the precision of the balance, it is appropriate to expand the combined uncertainty by the coverage factor calculated given the two-tailed t-distribution for the calculated effective degrees of freedom.

All calculations are automatically applied in the Estimation of Measurement Uncertainty for Weight Form.

The coverage factor selected and expanded uncertainty calculated by these operations is displayed.

The coverage factor selected by this method provides at least the required minimum coverage probability of 95.45%.

The Estimation of Measurement Uncertainty for Weight form also calculates and reports a coverage factor and expanded uncertainty for a coverage probability of 99.7%.

A coverage probability greater than approximately 95% may be used and the reason for use and coverage factor shall be documented in the case record.

4.5.7 Evaluate the Expanded Uncertainty

The expanded uncertainty should be evaluated to determine if it seems appropriate given the uncertainty components and the tested device. Investigation of unusually small or excessively large uncertainties should include a review of calculations for arithmetical error.

The values for each component in the uncertainty budget shall be reviewed by a second analyst. The values should be reviewed for accuracy, proper transcription, and proper conversion of units when applicable. The reviewer's name or initials shall be recorded on the Estimation of Measurement Uncertainty Form.

Evaluation of the expanded uncertainty and review of the estimation of uncertainty shall occur before reporting the uncertainty of measurement.

4.5.8 Reporting of Measurement Uncertainty (Weight)

The expanded uncertainty and associated coverage probability shall be recorded in the examination worksheet for all cases in which

a) the measured weight is within +/- 5 grams of a weight-based penalty threshold

OR

b) in any case in which an uncertainty of measurement is reported.

The measurement uncertainty shall be reported for all measurements in which the measurement result is within 5% of a weight-based penalty threshold.

Examples of ± 5% ranges of common weight-based penalty thresholds.

Threshold	Reporting Range (+/- 5%)
50 g	47.5 g – 52.5 g
1,000 g	950 g – 1050 g
70.87 g	67.32 g – 74.42 g
1133.98 g	1077.28 g – 1190.68 g

When reporting an uncertainty of measurement, the report shall state the measured quantity value (weight of the substance) along with the associated expanded uncertainty and the coverage probability (also termed 'level of confidence').

4.5.9 Minimum Reported Coverage Probability

The level of confidence shall provide a minimum coverage probability of 95.45%.

4.5.10 Rounding and Significant Digits

The expanded uncertainty shall be rounded up to at most two significant digits.

The expanded uncertainty shall be expressed with both plus or minus values.

The measurement result and the expanded uncertainty shall be reported to the same level of significance.

4.5.10.1 Reporting Example

"The weight of item 1 was 50.02 g ±0.03 g. Measurement uncertainty of weight measurements is reported at a level of confidence of approximately 95%."

4.5.11 Calculation of Combined Uncertainty for Total Weight of Multiple Specimens

4.5.11.1 Multiple Specimens

When weights are added to calculate a total weight, the uncertainties associated with each individual measurement must be taken into account in the combined uncertainty. The Root Sum Squares method is used for this calculation, and may be used for occasions of static or dynamic weighing

4.5.11.2 Dynamic Weighing

Dynamic weighing is defined as the process whereby a weighing vessel is placed on the balance and tared. The item to be weighed is then immediately transferred to the tared weighing vessel without removing the vessel from the balance, and the net weight is recorded.

Calculating the uncertainty of measurement for multiple weighings using dynamic weighing:

For dynamic weighing, the formula to calculate the total combined uncertainty for multiple weighings is:

$U_{total} = \sqrt{(n^2 r + n(1-r))} \times u_c$

Where

n is the number of measurements

r is the correlation coefficient representing the relationship between the measurement of any pair of items.

Note: Without empirically determining the value of r, the value of r shall be assigned to be 1, as this is the most conservative approach.

u_c is the combined uncertainty of a single measurement

U_{total} is the total combined uncertainty of the multiple measurements

Example

Dynamic weighing of multiple items: The contents of five pieces of plastic are each weighed and the individual net weights are added together to determine a total net weight. The estimated combined uncertainty of measurement for the balance used is +/- 0.06 g.

What is the total net weight and uncertainty of measurement (C.L. of 95%)?

Calculate the Total Net Weight

Net weight 1: 1.25 g

Net weight 2: 1.95 g

Net weight 3: 2.20 g

Net weight 4: 1.35 g

Net weight 5: 1.50 g

Total Net Weight: 8.25 g

and **Calculate the Total Uncertainty**

$U_{total} = \sqrt{(n^2 r + n(1-r))} \times u_c$

$U_{total} = \sqrt{(5^2 (1) + 5(1-1))} \times 0.06$ g

$U_{total} = \pm 0.30$ g

Calculate the expanded uncertainty by multiplying the total combined uncertainty by k=2 for a confidence level of approximately 95%.

Expanded Uncertainty = ±0.30 g x 2

Expanded Uncertainty = ±0.60 g

Therefore, the total net weight is 8.25 grams ±0.60 g.

The report would provide the following statement of the uncertainty of measurement:

"The total weight of the material held within five pieces of plastic is 8.25 g ±0.60 g. Measurement uncertainty of weight measurements is reported at a level of confidence of approximately 95%."

4.5.11.3 Static Weighing

Static weighing is defined as the process whereby a weighing vessel is placed on the balance and tared. The vessel is then removed from the balance and the item to be weighed is transferred to the weighing vessel which is then placed on the balance and a reading is obtained.

Calculating the uncertainty of measurement for multiple weighings using static weighing:

For static weighing, the formula to calculate the total combined uncertainty for multiple weighings is:

$U_{total} = \sqrt{(n^2 r + n(1-r))} \times 2u_c$

Where

n is the number of measurements

r is the correlation coefficient representing the relationship between the measurement of any pair of items.

Note: Without empirically determining the value of r, the value of r shall be assigned to be 1, as this is the most conservative approach.

u_c is the combined uncertainty of a single measurement

U_{total} is the total combined uncertainty of the multiple measurements

4.5.11.4 Calculation of Combined Uncertainty for Total Weight Using Multiple Balances

Calculating the uncertainty of measurement for multiple weighings:

For dynamic weighing

$U_{total} = \sum^{\text{number of devices used}} \sqrt{(n_i^2 r + n_i (1-r))} \times u_{ci}$

Or,

Total Uncertainty =

$(\sqrt{(\text{number of readings on balance 1})^2 r + (\text{number of readings on balance 1})(1-r))} \times u_{ci}) + (\sqrt{(\text{number of readings on balance 2})^2 r + (\text{number of readings on balance 2})(1-r))} \times u_{ci}) + \ldots$

For static weighing

$U_{total} = \sum^{\text{number of devices used}} \sqrt{(n_i^2 r + n_i (1-r))} \times 2u_{ci}$

4.5.11.5 Example of calculation with multiple balances

Dynamic weighing of 5 items with two balances: The contents of five pieces of plastic are weighed and the individual net weights are added together. The estimated combined uncertainty of measurement for balance (1) is +/- 0.06 g and the combined uncertainty for balance (2) is +/- 0.03 g.

Calculate the Total Net Weight (all balances)

Net weight 1: 1.25 g (balance 1)

Net weight 2: 1.95 g (balance 1)

Net weight 3: 2.20 g (balance 1)

Net weight 4: 1.35 g (balance 2)

+ Net weight 5: 1.50 g (balance 2)

Total Net Weight: 8.25 g

And Calculate the Total Uncertainty

$U_{total} = \sum^{\#balances} \sqrt{(n_i^2\, r + n_i\,(1-r))} \times u_{ci}$

$U_{total} = (\sqrt{(3^2 \times 1 + 3(1-1))} \times 0.06\text{ g}) + (\sqrt{(2^2 \times 1 + 2(1-r))} \times 0.03\text{ g})$

$U_{total} = +/- 0.24$ g

Calculate the expanded uncertainty by multiplying the total combined uncertainty by k=2 (level of confidence of approximately 95%):

Expanded Uncertainty = ±0.24 g x 2

Expanded Uncertainty = ±0.48 g

Therefore, the total net weight is 8.25 g ±0.48 g at a level of confidence of approximately 95%.

4.6 Estimating the Measurement Uncertainty for Volume

4.6.1 Specification of the Measurement Process

The measurand for this procedure is the volume of a liquid. The measuring device used is a calibrated 500 mL graduated cylinder, and the unique identifier of the equipment is specified each time this procedure is applied.

At each laboratory, the measuring device used is one 500 mL graduated cylinder, calibrated by the manufacturer upon purchase and subsequently at least once every ten years. Calibration shall be performed by an external calibration provider that is accredited to ISO/IEC 17025 by an accrediting body that is a signatory to the IAAC Multilateral Recognition Arrangement or ILAC Mutual Recognition Arrangement, with the calibration to be performed listed in a scope of accreditation.

The measuring device information (such as manufacturer, capacity, serial number, unique identifier) shall be recorded on the documents associated with the estimation of measurement uncertainty.

The unique identifier of the calibrated 500mL graduated cylinder for volume measurement is recorded in the case record when applicable.

4.6.2 Uncertainty Components

The uncertainty components included in the measurement uncertainty for volume are scale readability, scale error, calibration, reading of the meniscus, experience of analyst, differences in volatility, and location and temperature variation.

Uncertainty Component	Data Source	Evaluation
Scale readability	Interval between graduation marks of scale	Type B
Cylinder calibration	Cylinder Calibration Report	Type B
Temperature variation	Covered in Intralaboratory Study	
Scale error	Cylinder Calibration Report	Correction added or subtracted from measurement result
Reproducibility (includes variation due to analyst, temperature, location, meniscus reading, and volatility)	Intralaboratory Study	Type A

Also considered in the estimation of the measurement uncertainty is sample loss in transfer.

a) Sample loss in transfer is not able to be accurately or readily estimated. The impact to the final measurement is conservative since sample loss always results in an underestimation of the quantity of material being measured. Uncertainty due to sample loss is therefore not included in this procedure.

4.6.3 Quantify Uncertainty Components

Calibration reports and data from the intra-laboratory study are used to populate an uncertainty budget.

Intralaboratory Study

a) An intra-laboratory comparison required all analysts to measure the volume of typical liquids using the procedure for volume measurement and the calibrated graduated cylinder used for casework.
b) The standard deviation and largest difference between analysts were determined.
c) Each new analyst will be required to provide objective evidence during competency testing that their performance meets the laboratory tolerance for volume measurement established through the initial intra-laboratory study.
d) The study is referenced in the Appendix to this section.
e) The Estimation of Measurement Uncertainty for Volume form is found in Appendix 4-D.

4.6.4 Convert to Standard Uncertainties

The Estimation of Measurement Uncertainty for Volume form converts each component into a standard uncertainty. Calculations used are found in Appendix 25-B.

4.6.5 Calculate Combined Standard Uncertainty

The combined standard uncertainty is calculated by the Root Sum of Squares method in the Estimation of Measurement Uncertainty for Volume form.

4.6.6 Expanded Uncertainty and Coverage Factor (k)

The combined standard uncertainty shall be expanded by multiplying by a coverage factor (k).

The coverage factor shall be selected based on considerations relevant to the analytical context and is usually in the range of 2 to 3.

The coverage factor (k) shall provide a coverage probability of at least 95.45%, often referred to as approximately 95%.

For most purposes, it is appropriate to use k=2. However, this value may be insufficient where the combined uncertainty is based on observations with relatively few degrees of freedom. In this instance, the selection of k to provide the minimum coverage probability depends on the effective number of degrees of freedom.

To determine the appropriate coverage factor that will provide a coverage probability of at least 95.45% the following operations are automatically made in the Estimation of Measurement Uncertainty for Volume Form:

a) The combined standard uncertainty is expanded by a factor of 2.00, as would be done with infinite degrees of freedom.

b) The actual effective degrees of freedom for all uncertainty components is calculated using the Welch-Satterthwaite equation (Appendix 25-B).

c) The effective coverage factor (k_{eff}) required to provide exactly 95.45% coverage probability is determined by the two-tailed t-distribution given the effective degrees of freedom calculated in step ii. See Appendix 25-B.

d) The combined standard uncertainty is expanded by the effective coverage factor (k_{eff}) calculated in step c).

e) The expanded uncertainties calculated in step a) and step d) are compared.

f) If the two values from step a) and d) are the same when rounded up to the precision of the balance, it is appropriate to use a coverage factor of 2 to expand the combined uncertainty.

g) If the two values are not the same when rounded up to the precision of the balance, it is appropriate to expand the combined uncertainty by the coverage factor calculated given the two-tailed t-distribution for the calculated effective degrees of freedom.

h) All calculations are automatically applied in the Estimation of Measurement Uncertainty for Volume Form.

i) The coverage factor selected and expanded uncertainty calculated by these operations is displayed.

j) The coverage factor selected by this method provides at least the required minimum coverage probability of 95.45%.

The Estimation of Measurement Uncertainty for Volume form also calculates and reports a coverage factor and expanded uncertainty for a coverage probability of 99.7%.

A coverage probability greater than approximately 95% may be used and the reason for use and coverage factor shall be documented in the case record.

4.6.7 Evaluate the Expanded Uncertainty

The expanded uncertainty should be evaluated to determine if it seems appropriate given the uncertainty components and the tested device. Investigation of unusually small or excessively large uncertainties should include a review of calculations for arithmetical error.

The values for each component in the uncertainty budget shall be reviewed by a second analyst. The values should be reviewed for accuracy, proper transcription, and proper conversion of units when applicable. The reviewer's name or initials shall be recorded on the Estimation of Measurement Uncertainty for Volume Form.

Evaluation of the expanded uncertainty and review of the estimation of uncertainty shall occur before reporting the uncertainty of measurement.

4.6.8 Reporting of Measurement Uncertainty (Volume)

Apply scale correction to the volume measurement.

a) Known scale correction shall be taken into account prior to reporting the measurement result.
b) The correction to the measurement result is calculated in the Estimation of Measurement Uncertainty for Volume Form. The calculation is (actual volume at scale maximum – stated maximum, as reported by the calibration certificate).
c) The value established for Scale Correction shall be added to the measurement value before rounding.

   Example: A scale correction is -0.037 mL. The measurement value is 99.5 mL. The corrected result is 99.5 mL + (-0.037 mL) = 99.463 mL. Rounding rules (see 25.6.10) are applied to this value.

The expanded uncertainty and associated coverage probability shall be recorded in the examination worksheet for all cases in which

a) the measured volume is within +/- 10 mL of a volume-based penalty threshold

   OR

b) in any case in which an uncertainty of measurement is reported.

The measurement uncertainty shall be reported for all measurements in which the volume measurement is within 5% of a volume-based penalty threshold.

Example: for a threshold of 2,662 mL, the reporting range for measurement uncertainty (+/- 5% of threshold) is 2,528 mL to 2,796 mL.

When reporting an uncertainty of measurement, the report shall state the measured quantity value (volume of the substance) along with the associated expanded uncertainty and the coverage probability (also termed 'level of confidence').

4.6.9 Minimum Reported Coverage Probability

The level of confidence shall provide a minimum coverage probability of 95.45%.

4.6.10 Rounding and Significant Digits

The measurement result shall be truncated to zero decimal places after the scale correction has been applied.

The expanded uncertainty shall be rounded up to at most two significant digits.

The expanded uncertainty shall be expressed with both plus or minus values.

The measurement result and the expanded uncertainty should be reported to the same level of significance, usually zero decimal places.

4.6.11 Reporting Example

"The volume of item 1 was 2,662 mL +/- 6 mL. Measurement uncertainty of volume is reported at a level of confidence of approximately 95%."

4.6.12 Calculation of Combined Uncertainty for Total Volume of Multiple Specimens

When volumes are added to calculate a total volume, the uncertainties associated with each individual measurement must be taken into account in the combined uncertainty. The Root Sum Squares method is used for this calculation and may be used for occasions when total volume is calculated from measurements taken with the same device or different devices.

For multiple measurements, the formula to calculate the total combined uncertainty is:

$U_{total} = \sqrt{(n^2 r + n(1-r))} \times u_c$

Where

n is the number of measurements

r is the correlation coefficient representing the relationship between the measurement of any pair of items.

Note: Without empirically determining the value of r, the value of r shall be assigned to be 1, as this is the most conservative approach.

u_c is the combined uncertainty of a single measurement

U_{total} is the total combined uncertainty of the multiple measurements

Example

The total volume of a liquid was measured by successive measurements of five portions of the liquid. The individual volumes of each portion were added together after scale correction was applied to determine a total volume. The estimated combined uncertainty of measurement for the graduated cylinder used is +/- 1.0 mL.

What is the total volume and uncertainty of measurement (C.L. of 95%)?

Calculate the Total Volume

Portion 1:	99.5 mL
Portion 2:	100.0 mL
Portion 3:	95.0 mL
Portion 4:	99.0 mL
Portion 5:	100.0 mL
Total Volume:	493.5 mL

and **Calculate the Total Uncertainty**

$U_{total} = \sqrt{(n^2 r + n(1-r))} \times u_c$

$U_{total} = \sqrt{(5^2 (1) + 5(1-1))} \times 1.0$ mL

$U_{total} = \pm 5.0$ mL

Calculate the expanded uncertainty by multiplying the total combined uncertainty by k=2 for a confidence level of approximately 95%.

Expanded Uncertainty = ±5.0 mL x 2

Expanded Uncertainty = ±10.0 mL

After rounding rules, the expanded uncertainty is ±10 mL

Therefore, the total volume is 493 mL ±10 mL, given a confidence level of approximately 95%.

4.6.12.1 Multiple measurements using multiple devices

One 500 mL graduated cylinder is used for all critical volume measurements at the laboratory. In the rare circumstance that more than one device is used in measuring a single volume or total volume, the formula below will be used to calculate the total combined uncertainty.

$U_{total} = \sum_{i=1 \text{number of devices used}} \sqrt{(n_i^2 r + n_i (1-r))} \times u_{ci}$

For further information on uncertainty of measurement with multiple devices contact the Technical Leader.

4.7 (VACANT)

4.8 References

USP Chapter 41 “Balances”. The United States Pharmacopeial Convention, 2014.

NIST Technical Note 1297

NIST GMP 3 – Good Measurement Practice for Method of Reading a Meniscus Using Water or other Wetting Liquid.

ASCLD/LAB Policy on Measurement Uncertainty AL-PD-3060

ASCLD/LAB Guidance on the Estimation of Measurement Uncertainty

Overview AL-PD-3061 v1.0 2013

Annex A Details on the NIST 8-Step Process AL-PD-3062 v1.0 2013

Annex B Drug Chemistry Discipline Three Examples – Weight, Volume, and Purity Determination AL-PD-3063 v1.0 2013

American Association for Laboratory Accreditation (A2LA) G104 – Guide for Estimation of Measurement Uncertainty In Testing. G104, December 4, 2014.

EURACHEM/CITAC Guide “Quantifying Uncertainty in Analytical Measurement” 2nd Ed. SLR Ellison et al., Eds.

Farrance, Ian and Robert Frenkel “Uncertainty of Measurement: A Review of the Rules for Calculating Uncertainty Components through Functional Relationships.” The Clinical Biochemist Reviews, Vol. 33, May 2012, pp 49-75.

International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM 3rd Edition) JCGM 200:2012

JCGM Section 5 “Determining Combined Standard Uncertainty” Online. www.iso.org (December 1, 2016).

NIST GLP 9. “Good Laboratory Practice for Rounding Expanded Uncertainties and Calibration Values.” 2014.

NISTIR 6919 "Recommended Guide for Determining and Reporting Uncertainties for Balances and Scales"

Chapter 1 through 3 relate to the use of balances in the Controlled Substances Discipline.

Additional Definitions and References from the NISTIR 6919 Guide

Appendix

Appendix 4 - External Calibration Service Providers for Weights and Balances

Service Provider	Accreditation	Scope	Dates
Toby's Instrument Shop, Inc. 1382 Industrial Dr. Suite 6 Saline, MI 48176 (734) 944-1510	Accredited by A2LA to ISO/IEC 17025:2017 Certificate # 1586.01	Field calibration of balances	Current accreditation: July 2, 2019 to July 31, 2021 Previous accreditations: August 1, 2017 to July 31, 2019. July 6, 2015 to July 31, 2017.
NBS Calibrations (Northern Balance and Scale, Inc.) 9556 W Bloomington Freeway Bloomington, MN 55431 (800) 722-5398	Accredited by A2LA to ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 Certificate # 1684.01	Field calibration of balances Class 1 standard weight calibration	Current accreditation: July 18, 2018 to August 31, 2020 Previous accreditations: November 22, 2016 to August 31, 2018 August 9, 2016 to November 30, 2016
Michigan Department of Agriculture and Rural Development E.C. Heffron Metrology Laboratory 940 Venture Lane Williamston, MI 48895 Mr. Nicholas Santini (517) 655-8202	Accredited by NVLAP to ISO/IEC 17025:2017 and ANSI/NCSL Z540-1-1994 Certificate # 200408-0	Class 1 standard weight calibration	Current accreditation: September 9, 2019 to September 30, 2020 Previous accreditations: August 15, 2018 to September 30, 2019 August 23, 2017 to September 30, 2018 August 23, 2016 to September 30, 2017

Appendix 4 – Volume Calibration Service Providers

SERVICE PROVIDER	ACCREDITATION	SCOPE	DATES
Michigan Department of Agriculture and Rural Development **E.C. Heffron Metrology Laboratory** 940 Venture Lane Williamston, MI 48895 Mr. Nicholas Santini (517) 655-8202	Accredited by NVLAP to ISO/IEC 17025:2005 and ANSI/NCSL Z540-1-1994 Certificate # 200408-0	Scope includes volume calibration.	Current accreditation: August 15, 2018 to September 30, 2019 Previous accreditations: August 23, 2016 to September 30, 2017 August 23, 2017 to September 30, 2018
Manufacturer Calibration Manufacturers accredited to ISO/IEC 17025 for calibration of volumetric glassware meet the requirements for external calibration providers.	Certificates from the manufacturer should be examined for notation of accreditation to ISO/IEC 17025:2005 or ISO/IEC 17025:2017. Example: Corning (Pyrex) serialized and certified volumetric glassware is calibrated in an ISO/IEC 17025:2005 accredited calibration laboratory. The laboratory is accredited by entidad Mexicana de acreditacion, a.c., a signatory to ILAC (certificate #V-58, 02/17/2016).		
VWR Contracted Lab A NVLAP laboratory accredited to ISO/IEC 17025 for calibration of pipettes meets the requirements for external calibration providers. Select a service with 10 measurements per channel per volume.	Certificates from the calibration service provider should be examined for notation of accreditation to ISO/IEC 17025 and the scope of accreditation must include calibration of the applicable equipment. Pipette calibration and routine maintenance may be performed by the same provider. The provider must be accredited for calibration and provide “as left” performance data in the calibration report.		

4-A Balance and Measurement Uncertainty Workbook

4-B Mathematical Expressions and Calculations

4-C Student T Distribution

4-D Measurement Uncertainty for Volume Form

4-E Balance and Measurement Uncertainty kilogram balances workbook