SAMPLING AND TESTING TECHNICAL GUIDANCE FOR MARIJUANA PRODUCTS

Revised July 01, 2021

Supersedes February 11, 2021

Version 4.0

This information is intended for use by licensed safety compliance facilities and licensed marihuana safety compliance facilities, collectively defined as laboratories, regulated by the Marijuana Regulatory Agency (MRA).

This version of the technical guide combines and replaces all prior iterations published under the purview of MMFLA, MRTMA, MTA and the Administrative Rules.

This information does not constitute legal advice and is subject to change. Licensees are encouraged to seek legal counsel to ensure their operations comply with the Medical Marihuana Facilities Licensing Act and associated Administrative Rules.

Contents

This information does not constitute legal advice and is subject to change. Licensees are encouraged to seek legal counsel to ensure their operations comply with the Medical Marihuana Facilities Licensing Act and associated Administrative Rules.

This information does not constitute legal advice and is subject to change. Licensees are encouraged to seek legal counsel to ensure their operations comply with the Medical Marihuana Facilities Licensing Act and associated Administrative Rules.

This information does not constitute legal advice and is subject to change. Licensees are encouraged to seek legal counsel to ensure their operations comply with the Medical Marihuana Facilities Licensing Act and associated Administrative Rules.

INTRODUCTION

The Marijuana Regulatory Agency (MRA) is committed to evidence-based decision-making when implementing technical guidance for licensed laboratories. As research into marijuana use, safety, and testing advances, this guide may be revised and updated to reflect these changes where appropriate.

Upon receipt of your safety compliance facility/marihuana safety compliance facility license you must comply with all applicable statutes, administrative rules, and guidance/bulletins issued by the MRA.

The sampling and analysis described in this guide shall be conducted by a laboratory licensed by the MRA and accredited to the International Organization for Standardization (ISO), ISO/IEC 17025:2017 by an International Laboratory Accreditation Cooperation (ILAC) recognized accreditation body or by an entity approved by the MRA by one year after the date the license is issued in accordance with Rule 5(1)(a) in the Marihuana Sampling and Testing Rule Set (R 420.305(1)(a))**.**

Accreditation to ISO/IEC 17025 standards demonstrates successful implementation of a quality management system which includes but is not limited to: organizational structure, quality procedures, internal audits, and corrective actions. In addition to the quality management system, technical matters such as equipment calibration, traceability of controls, relevance of the method, and the validation data will be reviewed by the auditor.

Verification of the performance of all methods employed by the laboratory is required. Marijuana safety and potency should be analyzed using testing methodology validated by an independent third party and approved by the MRA.

Analytical testing of marijuana for safety and potency is increasingly recognized as a critical and necessary component of the industry for several reasons:[12]

Laboratory testing minimizes the risk of exposure to pesticides, microbes, heavy metals, molds, and residual solvents by providing consumers information about the products they are purchasing and helps to prevent consumption by sensitive populations.

- Quantification of cannabinoid profiles and potency is available to the consumer to inform decision making and aids in determining appropriate dosing for individual use.
- Laboratory testing provides transparency and promotes a sense of reassurance to consumers as well as ensuring product quality for the tested marijuana.

QUALITY ASSURANCE

According to Rule 7(3)(f) in the Marihuana Licensees Rule Set R 420.107(3)(f):

All laboratories must retain and employ at least one laboratory manager with a relevant advanced degree in a medical or laboratory science. This person must fill the role of a laboratory manager who is responsible for duties including the following:

- Ensure tests are conducted in accordance with Rule 5 in the Marihuana Sampling and Testing Rule Set R 420.305.
- Ensure test results are accurate and precise.
- Oversee day-to-day operations.
- Validate reporting requirements in the statewide monitoring system (Metrc).
- Verify ongoing conformity with ISO 17025 standards.
- Any other duties required and published by the MRA Rule 7(3)(f) in the Marihuana Licensees Rule Set R 420.107(3)(f).

All results entered in the statewide monitoring system (Metrc) must be legally valid and defensible. The laboratory should ensure that all test results are legally defensible by keeping thorough and accurate records as well as detailed chain of custody (COC) documents.

The quality assurance (QA) plan and/or standard operating procedures (SOPs) should describe the policies and procedures used by the facility for record integrity, retention, and storage.

The laboratory must have a procedure for monitoring the validity of results. The resulting data must be recorded in such a way that trends are detectable and, where possible, appropriated statistical techniques shall be applied to analyze and review the results. This monitoring should occur on an ongoing basis and should be reviewed by the laboratory manager/quality assurance manager and shall include, but not be limited to:

- Use of reference materials or quality control (QC) materials.
- Functional check(s) of measuring and testing equipment.
- Use of certified checks or working standards with control charts, where applicable.
- Intermediate checks on measuring equipment.
- Review of reported results.
- Intra-laboratory comparisons (proficiency testing).

Laboratories analyzing marijuana samples must adhere to all required QC procedures specified in the reference method(s) to ensure that routinely generated analytical data is scientifically valid and defensible and is of known and acceptable precision and accuracy.

To accomplish these goals, each laboratory must prepare a written description of its QA activities, included as part of a Quality Assurance Manual and as part of all relevant SOPs Rule 5(1)(c) in the Marihuana Sampling and Testing Rule Set R 420.305(1)(c). It is the responsibility of the laboratory manager/quality assurance manager to keep these documents up to date. A controlled version of the Quality Assurance Manual and all SOPs should be made readily accessible to all laboratory employees. Additionally, all laboratory personnel should be familiar with the contents of the Quality Assurance Manual as well as all SOPs for which they are responsible.

QUALITY ASSURANCE MANUAL

At a minimum, the following items should be addressed in the Quality Assurance Manual:

Laboratory organization and responsibility

- A chart or table showing the laboratory organization and lines of responsibility, including laboratory and QA managers.
- List of key individuals who are responsible for ensuring the production of valid measurements and the routine assessment of measurement systems for precision and accuracy (e.g., who is responsible for internal audits and review of the implementation of the plan and its requirements).
- Clearly defined job descriptions of all personnel.
- Descriptive training program aimed at keeping personnel updated on regulations and methodologies.
- Records documenting Demonstration of Capability (DOC) for all laboratory personnel.

Standard Operating Procedures (SOPs)

- All SOPs must be formatted to include the date(s) of revision(s) in accordance with Rule 5(1)(b) in the Marihuana Sampling and Testing Rule Set R 420.305(1)(b).
- All SOPs should be routinely updated to reflect all phases of current laboratory activities.
- Current copies of all SOPs must be made available and be easily accessible to all staff.

- SOPs are reviewed not less than annually and should be revised as changes are made.
- SOPs must include signature pages which may be electronic.
- Document history should be recorded, and changes noted and tracked.

Note: All SOPs related to the analysis of samples must be approved by the MRA. Any changes to a previously approved SOP must be sent to the MRA for review and approval prior to use. The MRA may request copies of any SOP if it is deemed necessary.

Field sampling procedures

- Describe all processes used to collect samples, including sanitation protocol.
- Ensure that all forms are legible and written in indelible ink and/or electronic data are retained, properly stored, and safely archived.
- Ensure that sampling protocols are clearly documented in an SOP and available to field samplers.
- Store both non-processed and processed samples at the proper temperature, isolated from laboratory contaminants.
- Maintain integrity throughout the life of all samples (e.g., track samples from receipt through analysis to disposal by utilizing the identification number from Metrc).
- Create and retain adequate Chain of Custody (COC) for samples.

Instrument calibration procedures *(may reference SOP)*

- Specify type of calibration used for each method and frequency of use.
- Describe calibration standards' source, age, storage, and labeling.
- Perform data comparability checks.
- Only one calibration curve may be utilized at a time.
- Calibration points may not be intentionally dropped, and calibration curves may not be adjusted to provide advantageous results.

Analytical procedures *(may reference SOP)*

- Cite complete method.
- Accurately describe and maintain quality control procedures required by the method(s). If the method does not have quality control procedures or if the procedures are less stringent than the ones listed in the quality control section, the laboratory is required to use the procedures in the quality control section of this technical guide.
- All SOPs must include sample preparation for all approved matrices.
- The laboratory must have a procedure in place that addresses the handling and reporting of any potentially hazardous contaminants that may be encountered during routine testing.

- A laboratory must notify the MRA if a test batch is found to contain levels of an unknown contaminant. Notification to the MRA should be sent via email to MRA-scf@michigan.gov and should include the Metrc sample tag number.

Data reduction, validation, reporting, and verification *(may reference SOP)*

- Describe data reduction process: method of conversion of raw data to reported unit of measure.
- Describe data validation process.
- Describe reporting procedures, include processes and format.
- Describe data verification process.
- Describe procedure for data corrections.

Quality control (QC) checks and frequency of use **(may reference SOP)**

Parameters for chemistry should include or reference:

- Instrument performance check standards.
- Frequency and acceptability of method detection limit (MDL) calculations.
- Frequency and acceptability of demonstration of low-level capability, calibration, internal and surrogate standards, laboratory reagent blank, field reagent blank, field, and laboratory matrix replicates.
- QC and proficiency testing samples.
- Laboratory fortified blank and laboratory fortified sample matrix replicates.
- Initial demonstration of method capability.
- Use of control charts.
- Qualitative identification/confirmation of contaminants.

Parameters for microbiology should include or reference:

- Positive and negative culture controls.
- Proficiency testing and quality control samples.
- Environmental monitoring controls.
- Shipment and batch QC.
- Sterility checks for buffers and broth.

Preventive maintenance procedures and schedules

- Describe location of instrument manuals, and all routine equipment maintenance schedules and documentation.
- List any maintenance and/or service contracts in place.

Corrective action contingencies

- Describe response to obtaining unacceptable results from analysis of proficiency testing samples and from internal QC checks.
- Name person(s) responsible for corrective actions.

- Describe how corrective actions are documented.
- All customer complaints should be logged on a complaint log and investigated.
- Investigations should be standardized and follow an internal SOP.
- Review of sample data including preparation should be the first step in the review process.
- Retesting samples should be done **ONLY IF** the analytical batch run was found to be out of control, all samples from the last acceptable run and all failed runs should be repeated.
- The repeated samples should come from new sample preparations.
- The MRA should be notified if any data was reported which does not conform to the approved quality assurance procedures.

Record keeping procedures

- Describe procedures and documentation of record keeping.
- List length of storage, media type (electronic or hard copy).
- Describe security policy of electronic databases.
- Document control should detail who has access to updating/changing procedures/protocols and laboratory documents.
- Any revisions should be noted, both major or minor, and listed in the document.

QUALITY CONTROL REQUIREMENTS

When methods do not include quality control parameters, the MRA has adopted the following requirements:[35]

DAILY REQUIREMENTS

Analytical Batch

- Must be clearly defined as every 20 samples.

Laboratory Reagent Blank

- Checks for background contamination should be the first sample of the analytical run; a blank should also be run before and after a calibration check (CC), initial calibration verification (ICV) /continuing calibration verification (CCV) and at the end of the run.

ICV/CCV

- Initial Calibration Verification (ICV) – the ICV is performed by analyzing a test solution of known analyte concentration(s) after calibration, but before sample testing on the initial day of the calibration. The ICV should be a standard that is not from the same vendor/Lot that is used for the calibration curve.
- Continuing Calibration Verification (CCV) – the CCV is performed by analyzing a test solution of known analyte concentration(s) prior to sample testing on each

testing day and continued periodically during the analytical batch run, no less frequently than once after each set of 20 samples. The CCV should be a standard that is not from the same vendor/lot that is used for the calibration curve **IF** calibration is maintained for more than one week.

Laboratory Fortified Matrix (LFM) / Laboratory Fortified Matrix Duplicate (LFMD)

- Analyze a sample with a known amount of standard added (spike).
- For the LFMD spike the same sample a second time (duplicate).
- Calculate Relative Percent Difference (RPD) between spiked sample and spiked duplicate, target value should be close to the first value and have a small RPD (less than 20%).
- Spike volume should be less than 1% of the volume. Example: spike with 1 mL of 1000 mg/L into 100 mL sample will equal a 10 mg/L increase in concentration.

Duplicate

- Analyze the same sample twice, this must be two separate preparations. The sample should be chosen at random and run together on the same analytical run.
- Calculate the relative percent difference (RPD) between first sample and replicate, target value should be close to the first value and have a small RPD (less than 20%).
- Variability may be introduced during sample preparation. To account for this, if more than one staff member is prepping samples, a sample duplicate for each set of prepared samples must be run.
- All validated approved methods have been demonstrated to be precise, therefore laboratories are **NOT** permitted to run samples in duplicate and average the results.

ANNUAL REQUIREMENTS

Demonstration of Capability (DOC)

- Each analyst must have a DOC which includes documentation that they can accurately run each test.
- Documentation that an analyst has read and understands all appropriate SOPs and methods.
- Backup analysts should do this once a year or any time there is a reason to question competence.
- Competency assessments should be completed not less than annually including having staff run a previously reported sample from sample preparation through result reporting to assure all staff are following the written SOPs.

Method Detection Limit (MDL)

- Run at least seven samples at low levels following procedure outlined below, i.e., daily requirements.

Corrective Action

- Corrective actions must be included in the SOPs for each method and should include what to do if QC tests fail or are out of range. For example, if standards fail, then recalibrate and run test again.

QC Acceptance

- Include in the SOP for each method the acceptance ranges for standards, duplicates, spikes, etc., and verify that they match the method requirements.

QC ACCEPTANCE CRITERIA*

*unless otherwise specified in reference method.

- LRB < MDL
- ICV/CCV ± 10%
- LFM/LFMD ± 20%
- RPD < 20%
- Reporting limit = MDL Calculations
- % Recovery for LFB = $\frac{\text{LFB Result x 100\%}}{\text{Expected Concentration}}$
- RPD – relative percent differences for duplicates and LFM/LFMD

  RPD = (|Num1-Num2| / ((Num1+Num2) / 2)) x 100
  Where:
  Num1= Original Number
  Num2= Second Number

- % Recovery for LFM – when using less than or equal to 1% spike volume compared to sample volume

  % Recovery = $\frac{\text{LFM Result – Sample Result X 100\%}}{}$

DEFINITIONS

A variety of definitions relating to detection limits and quantitation limits are published in reference literature and by government agencies, however, universally accepted procedures for calculating these limits do not exist. The definitions below attempt to clarify the meaning of these terms as recognized by the MRA.[13]

Analytical batch size: An analytical batch is defined as 20 samples excluding QC.

Calibration check (CC): Should be analyzed prior to sample analysis and every 10 – 20 samples thereafter (or after a 12-hour period, should less than 20 samples be analyzed). The CCV controls are generally created from the same source as the calibration material. The laboratory must outline acceptance criteria as relevant to the method; ideally, the CCV should fall within at least ± 15% of the spike value.

Calibration requirements: Calibration must occur not less than monthly. At the beginning of each day samples are to be analyzed, a calibration curve composed of four or more points including all target analytes should be generated according to the approved SOP. Where the determinative time is extensive and the instrument is stable, the calibration curve should be initially developed; thereafter, each day that samples are to be analyzed, this curve should be verified by analysis of a calibration check (CC) following the requirements listed below. The check must be +/- 10% of the known value.

Continuing calibration verification (CCV): This verification should be done at both the beginning and end of the analyses, including at least one standard for each of the target analytes at the expected concentration range. It is recommended that a calibration standard of one component of a multicomponent analyte also be analyzed each day or work shift. All checks must be within 10% of the known value or the instrument is to be recalibrated as specified in the calibration requirements.

Demonstration of capability (DOC): Each analyst should be assigned a file in which records are maintained that demonstrate the capability of the individual to perform analyses for which they are responsible on frequent or infrequent basis. At a minimum, the analyst should calibrate and analyze four standards to demonstrate their ability to run each test. Additionally, the file should contain documentation (signed form) that the analyst has read and understands all assigned SOPs and methods. Backup analysts should do this once a year. The primary analyst should recalculate DOCs when a change in the method, analyst, or instrument is made which could affect precision, accuracy, or sensitivity. Minor changes in methodology should prompt a check to verify that the precision, accuracy, and sensitivity have been maintained.

Initial demonstration of capability (IDOC): Before beginning the analysis of samples, an IDOC must be performed. The IDOC includes a demonstration of the ability to achieve a low background, the precision and accuracy required by the method, and determination of the limit of detection (LOD) (see below). An IDOC should be performed for each instrument. It is also recommended that an IDOC be performed by each analyst. In addition, it is recommended that the IDOC also addresses the variability

introduced if more than one sample preparation analyst is used. Precision, accuracy, and LOD should be comparable for each technician.

Laboratory fortified sample matrix: Laboratory fortified sample matrix requirements stated in the methods must be met. If there are no laboratory fortified sample matrix requirements in the method, the following guidelines are to be used: The laboratory should add a known quantity of analyte(s) to a percentage (to be described in the approved SOP) of the routine samples to determine sample matrix interference; the fortified concentration should not be less than the concentration of the sample selected for fortification unless specified by the method; if the sample concentration is unknown or less than detectable, the analyst should choose an appropriate concentration (e.g., a percentage of the published action limit or mid-point in the calibration range); over time, samples from all routine sources should be fortified; the procedure should be described in the SOP; if any of these checks are not within the criteria specified in the method or control limits specified in this document, and the laboratory performance is in control, the result for that sample should be flagged to inform the data user that the results are suspect due to matrix effects.

Laboratory reagent blank (LRB): An LRB should be carried through the full analytical procedure with every sample batch. In general, results from LRBs should not exceed the laboratory's minimum reporting limit (MRL), the lowest concentration of standard used for quantitation.

Limit of detection (LOD) or detection limit: The lowest concentration level that can be determined to be statistically different from a blank (99% confidence). The LOD is typically determined to be in the region where the signal to noise ratio is greater than five. Limits of detection are matrix, method, and analyte specific. The LOD is approximately equal to the MDL for those tests which the MDL can be calculated.

Limit of quantitation (LOQ): The minimum concentration or mass of an analyte in a target matrix that can be reported as a quantitative result. For all analyses aside from Target Analytes, the LOQ must be at a minimum 1/2 of the published action limit when the LOQ is not specified in the SMPR. The analyst should determine LOQs when any change is made which could affect the LOQs, or more frequently if required by the method. In addition, the analyst must demonstrate low-level capability on an ongoing basis through an LOQ determination or repeated low-level analyses.

Linear calibration range (LCR): The region of a calibration curve within which a plot of the concentration versus the response of a particular analyte remains linear, and the correlation coefficient of the line is approximately 1 (0.995 for most analytes). The plot may be normal-normal, log-normal, or log-log when allowed by the analytical method.

Low level quantitation: The laboratory's minimum reporting limits (MRL) should be reported to the client along with the data. The reporting limit must be below the MRA’s published action limits. Laboratories should run an LFB at their MRL every analysis day

and should not report contaminants at levels less than the level at which they routinely analyze their lowest standard.

Method detection limit (MDL): The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a target matrix containing the analyte. The MDL procedure is designed to be a straightforward technique for estimation of the detection limit for a broad variety of physical and chemical methods. The procedure requires a complete, specific, and well-defined analytical method. It is essential that all sample processing steps used by the laboratory be included in the determination of the MDL. To calculate MDLs, please follow this procedure.

STANDARD OPERATING PROCEDURE (SOP) REQUIREMENTS

All testing, QA, and QC procedures must be documented in an SOP and must include enough detail for someone who is not familiar with the test to perform it. Additionally, all SOPs should include:

- Step by step instructions detailing how to perform the analyses.
- Step by step instructions describing how data is generated and how values are reported.

QC acceptance criteria and definition of an “analytical test batch” (every 20 samples) as well as the minimum frequency of QC checks. The laboratory may only report quantitative results that are above the limit of quantification (LOQ) and below the upper limit of quantification (ULOQ) and this must be specified in the laboratory SOP manual. Results below the LOQ or above the ULOQ may be reported qualitatively as described by the laboratory.

Results below the LOD must not be reported as “zero” as this is misleading. These results could be reported as “none detected”, as “less than the limit of detection”, or as the measured value with the associated uncertainty.

VALIDATION REQUIREMENTS

In accordance with Rule 5(2) in the Marihuana Sampling and Testing Rule Set R 420.305(2).

The laboratory must present a validation report styled after peer-reviewed scientific publications, that includes enough information that an experienced analyst could repeat the validation study. The validation report must accompany the raw data and include, at minimum, the following:

- Introduction and summary.
- Materials and preparation methods.
- Method parameters.

- Chromatograms/spectra, calculations, and results.
- Method acceptance and limit performance data.
- Acceptable results of a graded external proficiency test that includes all analytes require by the MRA.
- Conclusions, discussion, and references.

Literature references must be peer-reviewed if not published by a government agency. Application notes are also acceptable.

Available methods from the AOAC Research Institute's Performance Tested Methods (PTM) and AOAC International's Official Methods of Analysis (OMA) programs with oversight from the Cannabis Analytical Science Program (CASP) advisory council are preferred methods but any third party validated method may be acceptable. For questions on specific methods, please reach out to the MRA laboratory scientists via email at MRA-scf@michigan.gov.

Methods used outside the manufacturer recommended specifications must be validated to ensure the method is fit for purpose. For example: the method in use is based on a method originally used for detection of THC in seized cannabis. The method includes only plant material using an LC-MS. The laboratory must validate the method to demonstrate appropriateness for purpose and usability on the laboratory instrumentation and for all matrices.

The laboratory must validate on any matrix which they wish to perform testing. This includes the following matrices:

- Flower
- Concentrates
- Marijuana infused products (edible)
    - Chocolate, hard candy, brownie, etc.
    - Infused beverages
- Marijuana infused products (non-edible)
    - Lotion, balm, etc.

The inclusion of multiple matrices for each product category is strongly encouraged; however, if only one type is included in the validation the product must represent as complicated a matrix as possible to encompass the intricacy of matrices routinely encountered during testing. All matrix samples must be logged and correctly identified in the Metrc system and identified in the validation report by the assigned Metrc tag.

Any changes to an approved methodology must be verified or revalidated as appropriate. All changes in methodology must be approved by the MRA. If the laboratory makes significant changes to the approved method, the method must be revalidated, and those results must be provided to the MRA for subsequent approval.

A method validation or revalidation is required for the following:

- Submission of a new or original method.

- Expansion of the scope of an existing validated method to include additional matrices.
- Modification of the range of the method beyond validated levels.
- Modifications which significantly alter the method's performance specifications such as fundamental/foundational technology, or complete modification of sample preparation.

If the licensee has questions about whether modifications require verification or validation, they should reach out to MRA-scf@michigan.gov and/or their assigned LSS for guidance.

Analytical Chemistry Methods

A laboratory validation is required to show that the method is fit for the purpose of analysis of the intended matrix and that any modifications to the original method do not negatively impact performance. All test methods must be based on compendia or published methods. AOAC Appendix K must be followed and, at a minimum, validations must verify accuracy, precision, analytical sensitivity, analytical selectivity, limit of detection, limit of quantitation, reportable range, and the identification of interfering substances.

All validations must be submitted to the MRA for approval with an acceptable and graded external proficiency test by a third party where all required analytes are shown to have passed. Validation protocols should include marijuana matrices (e.g., flower, infused products, and concentrates). If the initial validation study was not performed on marijuana matrices, an interference study should be performed and should include each matrix type analyzed by the laboratory Rule 5(2) in the Marihuana Sampling and Testing Rule Set R 420.305(2).

Microbiological Methods

In the absence of matrix matched methods validated to AOAC guidelines, a laboratory validation is required to show that the method is fit for the purpose of analysis of the intended matrix and that any modifications to the original method do not negatively impact performance. All test methods must be based on compendia or published methods. AOAC Appendix J must be followed and, at a minimum, validations must address accuracy precision, repeatability, reproducibility, robustness, inclusivity/exclusivity, limit of detection, limit of quantitation, reportable range, and the identification of interfering substances.

All validations must be submitted to the MRA for approval with an acceptable and graded external proficiency test by a third party, where all required analytes are shown to have passed. Validation protocols should perform inoculation of marijuana matrices with live organisms where feasible to ensure that both extraction and detection for the assay are tested. To further test the accuracy of the assay, probability of detection (POD) analyses, inclusivity, exclusivity, lot-to-lot stability, and robustness studies must be included in the validation studies. Methods adopted from a matrix specific standard method, inclusivity/exclusivity do not require a comprehensive reassessment, provided

that the referenced media, primers, probes, antibodies, critical chemistries, etc., were not modified.

Proficiency Testing

Rule 5(14) in the Marihuana Sampling and Testing Rule Set R420.305(14) requires the MRA to establish a proficiency testing program and designate laboratory participation. A laboratory shall analyze proficiency test (PT) samples using the same procedures with the same number of replicate analyses, standards, testing analysts and equipment as used for marijuana product testing. If the PT deviates from normal sample preparation, this must be documented in the SOP. Analysis of PT's must occur on a rotating schedule and should include all analysts who perform the testing. Proficiency tests should be thoroughly documented and completed by a single analyst.

The following guidelines for proficiency testing must be followed by all laboratories on an annual basis:

- Complete one set of acceptable, externally graded PT by a third party for all approved testing categories including all analytes.
- The PT samples must be procured from an accredited third-party vendor. Any ISO 17043 accredited PT vendor may be used.
- Results for all analytes must be quantified and all analytes must be included to be considered acceptable.
- The MRA must be listed as the accrediting body on the report and reports must come directly to MRA-scf@michigan.gov..
- The MRA will require unscheduled random testing of matrix matched samples (inter-laboratory comparisons) to evaluate the overall performance of the laboratories not less than annually.
- The MRA will require random audits of previously analyzed samples as needed or in response to complaints and/or investigations.

REQUIRED TESTS

All compliance testing must conform to ISO/IEC 17025 standards for quality control and quality assurance, including the validation of matrices not listed here.

All tests must meet the standard method performance requirements listed below. For matrices not listed, the method performance requirements should be as close to the published standard method performance requirements (SMPRs) as possible, using standard analytical methods.

Potency

Rule 5(16) in the Marihuana Sampling and Testing Rule Set R 420.305(16) prohibits a laboratory from desiccating samples prior to performing potency analysis.

In the preparation of samples intended for potency analysis, the laboratory may not adulterate or attempt to manipulate the total potency of the sample by adding trichomes

that were removed during the grinding and homogenization process. Any evidence of this will amount to falsification of data.

For the analysis of potency, a standard method for the quantitative analysis of cannabinoids has not yet been published, however the following references may be helpful:

- De Backer, B., Debrus, B., Lebrun, P., Theunis, L., Dubois, N., Decock, L., & Charlier, C. (2009). Innovative development and validation of an HPLC/DAD method for the qualitative and quantitative determination of major cannabinoids in cannabis plant material. *Journal of Chromatography B*, *877*(32), 4115-4124.
- Patel, B., Wene, D., & Fan, Z. T. (2017). Qualitative and quantitative measurement of cannabinoids in cannabis using modified HPLC/DAD method. *Journal of pharmaceutical and biomedical analysis*, *146*, 15-23.
- Concentrates: AOAC SMPR 2017.001
- Dried Plant Materials: AOAC SMPR 2017.002
- Edible Chocolates: AOAC SMPR 2017.019

Residual Solvent Testing

All testing methods must meet the SMPRs for the adopted reference method.

- United States Pharmacopeia (USP), 2008. “<467> Residual Solvents.”
- For Identification and Quantitation of Selected Residual Solvents in Cannabis-Derived Materials: AOAC SMPR 2019.002

Chemical Residue Testing

All testing methods must meet the SMPRs listed below.

- AOAC Official Method 2007.01 Pesticide Residues in Foods by Acetonitrile Extraction and Partitioning with Magnesium Sulfate- Gas Chromatography/Mass Spectrometry and Liquid Chromatography/Tandem Mass Spectrometry.
- Pesticides in Cannabis Flower: AOAC SMPR 2018.011

Heavy Metals

All testing methods must meet the standard method performance requirements for the adopted reference methods. Applicable references may include, but are not limited to:

- United States Pharmacopeia (USP), 233
- Using EPA 3052 (microwave digestion) for the sample prep.
- Determination of Heavy Metals in a Variety of Cannabis and Cannabis-Derived Products: AOAC SMPR 2020.001

Water Activity

- ASTM D8196-18

Microbial Assays (Qualitative)

Methods applicable to pathogenic Salmonella spp., Shiga toxic producing Escherichia coli (STEC), and Aspergillus spp.

- Detection of Aspergillus in Cannabis and Cannabis Products: AOAC SMPR 2019.001
- Detection of Salmonella species in Cannabis and Cannabis Products: AOAC SMPR 2020.002
- Detection of Shiga Toxin-Producing Escherichia coli in Cannabis and Cannabis Products: AOAC SMPR

All microbiological methods employed must include appropriate applicable controls.

Microbial Assays (Quantitative)

Methods applicable to total coliforms and total yeast and mold:

- Association of Official Analytical Collaboration (AOAC) International 2019. "Yeast and Mold Counts in Foods, 997.02."
- Association of Official Analytical Collaboration (AOAC) International 2019. "Total Coliform 991.14"
- USP 61, 62,1223

All quantitative PCR assays must be accompanied by either a traditional culture plating method or a method which has successfully completed the Emergency Response Validation of the AOAC Research Institute's Performance Tested Methods (PTM) and AOAC International's Official Methods of Analysis (OMA) programs with oversight from the Cannabis Analytical Science Program (CASP) advisory council. All methods must be performed according to manufacturer specifications. If the laboratory deviates from manufacturer directions of an AOAC validated method, that will be considered a new method and will require additional validation. Any questions or requests for clarification should be directed to MRA-scf@michigan.gov.Laboratories have until August 9, 2021 to implement the use of method(s) validated to AOAC Appendix J in compliance with the administrative rules.

Foreign Matter/Filth Analysis

- AOAC Official Method 970.74 Foreign Matter in Drugs (Leafy, Crude).

For further information regarding the use of a microscope, please refer to the ORA Laboratory Manual, FDA Office of Regulatory Affairs. In Section 4, Microanalytical & Filth Analysis, please see 4.2.2. Microscopic Examination and Microscope Accessories. Within that section, please refer to Section B (Discussion, Part 1 C re: stereomicroscopes) as well as Section B (Discussion, Part 2 Fundamental Microscopic Techniques and Procedures, part a).

Vitamin E Acetate

Rule 1(dd) in the Marihuana Sampling and Testing Rule Set (R 420.301(dd)) defines a target analyte as a non-marihuana active ingredient designated for analysis. Vitamin E Acetate has been identified as a target analyte by the MRA.

> Brabcová, I., Kovářová, L., Šatínský, D., Havlíková, L., & Solich, P. (2013). A fast HPLC method for determination of vitamin E acetate in dietary supplements using monolithic column. *Food analytical methods*, *6*(2), 380-385

FIELD SAMPLING

According to Rule 4(2)(b) in the Marihuana Sampling and Testing Rule Set (R 420.304(2)(b)) except otherwise required by the MRA, the laboratory shall collect a sample size that is sufficient to complete all required analyses and not less than 0.5% of the weight of the harvest batch.

- The maximum harvest batch is 50 pounds.

At least 50% of the sample must be homogenized for testing. This means that all increments should be combined into one composite sample. The composite sample is then divided in half; one half is the required untouched field duplicate; the other is the sample used for testing; all aliquots are taken from the split composite sample for testing; all sample aliquots removed for testing must be representative of the product taken.

The MRA may publish sample sizes for other marijuana products being tested. The laboratory must develop a statistically valid sampling method to collect a representative sample from each batch of marijuana product. The laboratory must have access to the entire batch for the purposes of sampling.

Standardized sampling procedures are an integral component to all laboratory testing. The objective of a well-defined sampling procedure is to ensure proper collection, clear labeling, careful sample transportation, and proper storage of samples to ensure sample integrity. The best way to track samples as they make their way from the originating facility, and throughout the analysis process, is to create and maintain a well-organized and detailed chain of custody (COC).

According to Rule 5(1)(b) in the Marihuana Sampling and Testing Rule Set R 420.305(1)(b) a laboratory shall maintain internal SOPs. Accurate and consistent results should be the primary goal of all laboratories. To support this goal, it is critical that all samples are obtained in a way that ensures the integrity of the analytical process. Sampling events should be performed consistently by all field staff using the accepted methodology. All field staff should be thoroughly trained in sampling procedures and confident in their ability to accurately perform all aspects of the sampling process.

For additional information regarding sample collection procedures, please refer to:

- Osterbauer, N., Krepps, S., Sackett, J., Holladay, C., Wendt, E., Wells, D., & Kristof, J. *Protocol for Collecting Samples of Usable Marijuana*. ORELAP-SOP-001 Rev. 3.0. 2016 December.
- Sexton, M., & Ziskind, J. (2013). Sampling cannabis for analytical purposes. *BOTEC Analysis Corp*, *26*.
- Thiex, N. J., & Ramsey, C. A. (2016). Taking and Testing GOODSamples: A Systematic Approach for Representative Sampling from Field to Test Portion. *Journal of Regulatory Science*, *4*(2), 1-8.

FIELD SAMPLING STAFF

Sampler Qualifications

Model qualifications for samplers are:

- Capable of performing all required duties.
- Free from undue burden that would cause a conflict of interest or bias in sampling.
- Capable of passing initial and ongoing demonstrations of capability.

Prior to testing samples, a satisfactory initial demonstration of capability (IDOC) or competency assessment must be documented and approved by the laboratory manager for all samplers. The IDOC should include principles, procedures, and policies for sampling. The IDOC should be repeated:

1. Every time there is a change in personnel or SOP.
2. When the sampler has not performed a sampling within a 12-month period.

This procedure should employ one of the following approaches to demonstrating capability:

1. Comparison of replicate samples within a defined relative standard deviation (%RSD).
2. Comparison of a sample collected to that of one collected by personnel with an existing IDOC within a defined relative percent difference (RPD).

Thereafter, ongoing/continuing demonstration of capability (CDOC) as per the quality control requirements referenced in the SOP should be done at least annually. The laboratory should have a documented procedure for performing the CDOC, should retain documentation verifying CDOC for each sampler, and must make this documentation available upon request.

SAMPLING IN THE FIELD

Field Duplicates

All laboratories should maintain a field duplicate. Field duplicates must be sampled in such a way as to replicate the primary sampling event and all requirements should be

clearly outlined in the field sampling SOP. If the laboratory opts to take an amount greater than 0.5% for the purposes of collecting a field duplicate, Rule 4(2)(a)(i) in the Marihuana Sampling and Testing Rule Set R 420.304(2)(a)(i) permits them to do so.

Field Audits

The laboratory must adopt an ongoing system for performing audits of field activities which the laboratory manager will oversee. Field audits should be conducted periodically and in accordance with a predetermined schedule and procedure. The goal of the field audit is to verify that the sampling events comply with the requirements of the regulations and demonstrate compliance with the designated sampling SOP.

If the findings of a field audit cast doubt on the effectiveness or validity of the field sampling events, corrective action should be taken, and preventative action must be enacted. If the audit shows that improper sampling may have led to incorrect test results, the laboratory should notify customers and identify any test results may have been affected.

Auditing Checks

Using audit checklists:

- Review sampling and performance records from the preceding year for deficiencies in the application of sampling protocol.
- Observe the sampler conducting sampling procedures.
- Have the auditor and sampler collect samples from the same harvest lot for evaluation and comparison of results.
- Record any deficiencies and initiate corrective action.

Field Quality Control

Field sampling equipment should be certified clean/sterile prior to use by the laboratory. In general, sampling equipment should be sterile for microbiology samples and clean for chemistry samples. The laboratory should perform cleanliness checks on each batch of sampling equipment prior to use the field. Results from cleaning procedure tests must be below the reporting limit of the target analyte(s) for the associated analyses. If cleanliness checks fail, the sampling equipment must be re-cleaned/sterilized, and retested.

Representative sampling should meet a 95% confidence level and limit sampling error. Increasing the number of sample increments to compensate for normal batch heterogeneity is the simplest means to achieve a representative sample.

Sample Size

Rule 12(7) in the Marihuana Operations Rule Set R 420.212(7) requires a laboratory to establish an adequate chain of custody (COC) as well as instructions for sample and storage requirements. Additionally, laboratories are required to develop a statistically valid sampling method to collect a representative sample from each batch. The laboratory shall collect a sample size that is sufficient to complete all required analyses and is not less than 0.5% of the weight of the harvest batch. At least 50% of the sample

taken must be homogenized for testing as outlined in Rule 4(2)(b) in the Marihuana Sampling and Testing Rule Set R 420.304 (2)(b). The MRA requires all laboratories to develop and submit an SOP that meets all aspects of the administrative rules and shall ensure that the procedures outlined are statistically valid.

The laboratory must develop a statistically valid sampling method to collect a representative sample from each batch of marijuana product. The laboratory must have access to the entire batch for the purposes of sampling Rule 4(2)(b) in the Marihuana Sampling and Testing Rule Set R 420.304 (2)(b).

Sampling a Batch of Marijuana

1. Physically locate the batch to be sampled as well as the source package and tag information from Metrc. The total weight of each batch should be compared to the weight recorded in the Metrc system to confirm that the laboratory has access to the entirety of the batch. The laboratory must verify the weight or number of units prior to sampling. If the weight or number of units does not match the Metrc system, the laboratory is not to sample the product until the data entry is corrected.
2. Review the container label information for batch number, producer, and other pertinent information. The laboratory should note a brief description of the product, e.g. 500 plastic vape cartridges labeled “cookie”. If any part of the batch is not homogenous, the sampler makes note on the COC and should refuse to sample the batch. The discrepancy should be immediately reported to the facility as well as the MRA. Each harvest batch should be separated and must be assigned a source package tag in the Metrc system. Do not sample if the product is not in the Metrc system or if the batch weight or details do not match.
3. Determine the number of containers in the batch and the batch size. Verify the batch size for each container. Do not sample if the batch size is unavailable, or the batch weight does not match the information in the Metrc.
4. Determine the total number of containers from which sample increments must be collected using a random number generator. Samples should be taken from each container.
5. Select the appropriate sampling tool to ensure that it reaches all portions of the container.
    a. Please note: All samples must be collected in compliance with Rule 2(2) in the Marihuana Employees Rule Set 420.602(2)(h) current good manufacturing practice in manufacturing, packing, or holding human food, 21 CFR part 110, as specified in these rules.
6. To prevent contamination, sampling tools should be cleaned prior to use and may be cleaned in the field between batches using an appropriate solvent and decontaminant to prevent cross-contamination of batches during sampling. Where aseptic technique is required, please refer to the FDA aseptic sample guidelines (Investigations Operations Manual Subchapter 4.3.6) for information. Sampling tools which appear to be contaminated or appear to be otherwise compromised should not be used.
7. Visually inspect each test sample increment to assess uniformity.

8. If non-uniformity is identified, record observation on the COC. Marijuana flowers are often variably sized. When drawing sample increments, approximately equal amounts of product are to be taken with each probing and from each container. Care must be taken by the sampler to not damage or contaminate the portion of the product which is not being collected.
9. Combine all sample increments to form the composite sample; it is never acceptable to select increments for individual tests. All test portions will be removed from the composite sample when the sample is at the laboratory for testing.
10. Ensure enough sample increments are taken to meet sample size requirements for all analytical methods being performed. The laboratory should have standard minimums for all testing categories which are consistent.
11. Seal and label the composite sample with the following minimum requirements:
    - Sample package tag assigned in the Metrc system
    - Sampling date and name of sampler
    - Producer's license.
12. Complete the COC form while onsite at the facility.
13. The sample, COC, and manifest from Metrc must be transported to the SCF using packaging appropriate for secure and timely transport.

Sampling Procedure for Pre-Rolls and Vape Products

Pre-rolls shall be in their final form prior to regulatory compliance testing. Final form is defined in the Marihuana Operations Rule Set R420.201(m) as the form a marijuana product is in when it is available for sale by a marijuana sales location.

For marijuana products intended for inhalation (vapes), the marijuana concentrate must be in the e-cigarette or vaping device.

These individual unit products should be homogenized together prior to testing in accordance with required sampling minimums (Table 2).

Sampling Procedure for Concentrates

The procedure is designed to ensure that each sampling event shall produce samples that are representative of the production batch specified. Production batches are limited to what can be produced on the same day.

1. The laboratory's sampling shall ensure that samples are collected randomly from the entire production batch. The COC shall document the total number of storage containers for a production batch and clearly identify containers selected for sampling.
2. At a minimum, each representative batch of adult-use or medical marijuana concentrate must be comprised of the minimum number of individual samples (Table 1). These samples will be taken separately and combined into a single sample (i.e., each individually collected sample shall be combined with the others in a single container):
3. The samples shall be collected in their final form.

4. The sampler shall wear sterile nitrile, latex, or equivalent gloves during sample collection. The gloves shall be changed between each production batch to minimize potential cross contamination.
5. The sample collection vials shall be labeled at the time of sampling.
6. All vials shall be immediately stored between 2º - 21º C.

Shatter/Wax/Slab Concentrates

Shatter, wax, or other concentrate slab may have varying degrees of thickness resulting in heterogeneous concentrations of cannabinoids, potential residual solvent(s), or pesticides. Thinner portions of the concentrate slab have greater exposed surface area, thus allowing for a higher rate of diffusion of residual solvents. Samples should be obtained from each region of thickness to provide a representative sampling of the overall product. To ensure representative sampling, the following is recommended:

1. Visually identify regions of varying thicknesses of the product.
2. Using forceps or a spatula collect the correct number of subsamples needed from each region of the overall production batch to meet the minimum number of samples described above.
3. The sample shall be collected and weighed to ensure the correct sample amount has been collected.
4. The sample vials shall be weighed and tared to ensure that the correct amount of sample is collected. Record the weight of each aliquot.

Distillate and Viscous Liquids

Viscous liquid concentrates of a single batch should be stored in a single container. The final size of the container will not be dictated by the MRA; however, it is important to note that a laboratory should consider viscous liquids in a single container to be homogeneous and any viscous liquids contained in multiple containers should be considered as the same number of separate batches. This means that if the batch in Metrc contains 1000g labeled with one Metrc tag but separated in to three containers, the processor is not compliant. Sampling a product labeled in this way is not compliant. Prior to sampling the facility will need to fix their Metrc entry to be three separate batches before the laboratory can sample the product. The laboratory should make note of this on the chain of custody.

If the viscous liquids are separated into containers as they are intended for sale, the laboratory should sample using the same sampling protocol they would employ for the statistically random selection of other marijuana products.

Viscous Liquids in Small Container (1 mL or less)

1. If the oil is of a viscosity that can be homogenized by hand through simple inversion, the oil shall be inverted a minimum of three times to ensure that the oil is homogenous.

    a. Each inversion must be complete, i.e., the oil must flow to the cap of the vial and back to the base three times.

2. Alternatively, if the oil is too viscous to invert, the laboratory should confirm with the facility representative that the sample is homogenous.
3. If the oil is stored and sampled in a container (syringe, dart, vial etc.), an empty container shall be weighed, and the weight recorded to confirm that the weight of all samples collected are accurate.
4. Record the weight and/or volume of each aliquot on the sampling document/COC.

Viscous Liquids in Medium to Large Volume Containers

1. Using a 0.5 mL or 1.0 mL pipette, syringe or other comparable utensil, remove the sample amount for each sample to be collected.
2. The aliquots shall be taken at different depths of the oil to ensure that the oil is sampled representatively.
3. The top third of the container, middle third of the container, and the bottom third of the container shall be sampled.
4. Each collection vial shall be weighed and tared prior to aliquoting the sample.
5. Record the weight and/or volume of each aliquot.

Table 1. Batch Sizes for Concentrates*.

Production Batch Size	Number of Increments	Size of increments
1-2 pounds	12	0.25 grams
2-3 pounds	15	0.25 grams
3-4 pounds	18	0.25 grams
4-10 pounds	23	0.25 grams
10+pounds	29	0.25 grams

Marijuana-Infused Products (Edibles)

A sample of marijuana edible product must be in final form for a laboratory to accept this material for compliance testing. Laboratories are not permitted to sample product in bulk without packaging for compliance testing. Units should be easily distinguishable. Production batches are limited to what can be produced on the same day. At a minimum, each test batch of adult-use or medical marijuana edibles must be comprised of at least the following number of separately taken samples:

Table 2. Batch Sizes for Marijuana-Infused Products*.

Edible Production Batch Size	Minimum Number of Units for Testing
Up to 100 units	2
Up to 500 units	4
Up to 1000 units	6
Up to 5000 units	8
Up to 10,000 units	10
Greater than 10,000 units	12

*****CDPH Sampling Protocols

1. The samples shall be collected randomly from a batch of product in final form and will follow the statistically valid sampling method employed by the laboratory.

2. The sampler shall wear sterile/sanitized nitrile, latex, or rubber gloves during sample collection.
3. The gloves shall be changed between each production batch to minimize potential cross contamination.
4. The sample product containers shall be labeled at the time of sampling.
5. All vials shall be immediately stored at a temperature appropriate to completely maintain the integrity of the sample and not to exceed 21^{o} C prior to shipping.
6. In order to collect random samples, the laboratory may choose to employ the following method:

- This can be accomplished by dividing the production process into thirds and selecting representative and random samples from each 1/3 of the production batch.
- Take the total number of samples produced, divide by 1/3, and select randomly from each third section of the batch.
- Each sample within each 1/3 of the batch must be selected randomly. For example, a production batch of 1000 sample units, six samples are required; therefore, two samples shall be taken from different locations within the beginning 1/3, two from different locations within the middle 1/3, and two from different locations within the end 1/3.

Chain of Custody Documentation

Rule 12(7) in the Operations Rule Set 420.212(7) requires SCFs to have an adequate chain of custody. The following information is what the MRA has deemed adequate and must be included at a minimum:

- Marijuana facility where the samples were collected (name, address, and license number).
- Date and time.
- Indication whether the samples are for retesting due to an initial test failure.
- If samples are for retesting, ensure that the product is not prohibited from retesting; samples on administrative hold cannot be sampled without MRA approval and removal of the hold.
- Product type (e.g., buds, concentrate, infused product).
- Whether products are in final form, i.e., individually wrapped as intended for sale, with or without labeling.
    - If the product is labeled with a concentration, make note of the intended concentration.
- Total mass of the source package and unique Metrc package tag.
- Total container number, # of sample increments, # of containers sampled.
- # of sample containers collected.
- Photographic documentation of the entire batch prior to sampling.
- Photographic documentation of the sample taken.
- Unique Metrc package tag for the sample package including the total mass sampled.
- Laboratory license number.

- Sampler's signature.
- Signature from the originating marijuana facility representative(s) present during the sample collection process. The signatures are attesting to the accuracy of the sampling information.
- Creation of a transfer manifest in the Metrc system.
- Sampling procedure ID and revision date.

Please ensure that all information is legible. Do not scribble or write over errors. Any errors should have one line through them with the initials of the person correcting the information, the date and time.

ADDITIONAL TESTING GUIDELINES FOR FIELD SAMPLERS

Testing Marijuana Product After Failed Initial Safety Testing

Rule 6(1) in the Sampling and Testing Rule Set 420.306(1) A laboratory may test marijuana product that has failed initial safety testing, except as indicated under subrule (3) of this rule.
(2) A failed marijuana product must pass 2 separate tests with new samples consecutively to be eligible to proceed to sale or transfer.
(3) The MRA may publish a remediation protocol including, but not limited to, the sale or transfer of marijuana product after a failed safety test as provided in these rules.
(4) The marijuana business that provided the sample is responsible for all costs incurred by a retest.

Research and Development (R&D) Testing

Rule 7(1) in the Sampling and Testing Rule set 420.307(1). As used in this rule, "research and development testing" means optional testing performed **before** final compliance testing.
(2) Except for R 420.304(2)(b), when performing research and development testing, the laboratory must comply with these rules.
(3) Punitive action shall not be taken against a marijuana business for conducting research and development testing.
(4) The MRA may publish guidance for research and development testing that must be followed by all marijuana businesses.
(5) All research and development testing material must be entered into the Metrc.

The licensee will select R&D testing at the time of the sampling. After the testing is completed, the appropriate laboratory staff will select the appropriate tests from the R&D tests listed in the Metrc system. The sample status will remain "testing in progress" until compliance testing is performed, at which point the status will update accordingly.

REQUIRED SAFETY TESTS AND ACTION LIMITS

The MRA has established action limits for all required analytes based on the most current literature. The laboratory shall report the results of the testing by indicating "pass" or "fail" in the Metrc system and on the certificate of analysis (COA). The results

in the Metrc system and the COA should be identical aside from the reported results of testing not required by the MRA (i.e., terpenes). For the purposes of chemical residue testing and target analyte testing, the MRA shall publish a list of quantification levels. All results will be reported in parts per million (ppm) and to three decimal places unless otherwise specified.

When reporting results for any analytes that were detected below the analytical method LOQ, include the numerical LOQ and indicate "<LOQ" in the notes. The laboratory's reporting limit must be at least their reported LOQ.

All products should be tested "as is" with minimal manipulation to the sample which could cause the results to no longer be representative of the product which will go to the consumer. Laboratories who are found to be manipulating samples (e.g., diluting samples, adding trichomes, incubating at low temperatures or for shorter than their approved SOPs), will be considered to be falsifying data and will be referred to compliance.

POTENCY

The analytes required for potency analysis include tetrahydrocannabinol (THC), tetrahydrocannabinol acid (THC-A), cannabidiol (CBD), and cannabidiol acid (CBD-A). Laboratories can analyze additional cannabinoids CBN, CBG, CBC, THC-V, CBD-V, CBG-A with approval from the MRA, and should be included in the scope of accreditation.

All flower material used for potency testing must be representative of the product used by the end consumer and homogenized in such a way that it is representative of the way a consumer would be using the product. This means that kief must not be reintroduced to the flower sample during the homogenization process. Sample processing should be performed in such a way as to minimize sequestration or loss of kief during the homogenization process. This can be accomplished by using non-porous materials such as stainless steel.

The laboratory shall analyze at minimum 0.5 grams of the representative sample of marijuana product to determine the cannabinoid profile. The laboratory shall establish a limit of quantitation (LOQ) of 1.0 mg/g or lower for all cannabinoids analyzed and reported.

Concentrates and Flower

Total THC and CBD values should be calculated and reported as follows:

Total THC%= (THCa * 0.877) + d9-THC

Total CBD%= (CBDa * 0.877) + CBD

Marijuana-Infused Products

For marijuana-infused products, the delta-9-THC concentration can be reported in mg/serving. If the item contains more than one serving, the mg/container should also be included.

> Rule 4 in the Marihuana-Infused Products and Edible Marihuana Product Rule Set R 420.404 (4). A marijuana sales location shall not sell or transfer marijuana-infused products that exceed the maximum THC concentrations established by the MRA by more than 10%. For the purposes of maximum THC for marijuana-infused products, the MRA shall publish a list of maximum THC concentrations and serving size limits.

If the reported delta-9 THC exceeds the maximum allowed, the product is considered failing.

Table 3. Maximum THC Concentrations for Marihuana-Infused Products.

The Maximum Delta-9-THC Concentrations for Medical Marijuana-Infused Products		
Product Type	**Per Dose**	**Per Container**
Gummies, baked goods, etc.	50 mg	200 mg
Capsules, tinctures, etc.	100 mg	2000 mg
Suppositories and tampons	100 mg	2000 mg
Transdermal Patches	100 mg	2000 mg
Topical products including lubricants, spa products, lotions, balms or rubs	N/A	N/A
Products not listed	10 mg	100 mg
The Maximum Delta-9-THC Concentrations for Adult-Use Marijuana-Infused Products		
Product Type	**Per Serving**	**Per Container**
Gummies, baked goods, etc.	10 mg	100 mg
Capsules, tinctures, etc.	10 mg	200 mg
Topical products including lubricants, spa products, lotions, balms or rubs	N/A	N/A
Products not listed	10 mg	100 mg

TERPENE TESTING

Rule 5(18) in the Marihuana Sampling and Testing Rule Set R 420.305(18). A laboratory may perform terpene analysis on a marijuana product by a method approved by the MRA. There are no established safety standards for this analysis. The laboratory shall analyze a sample of marijuana or marijuana-infused product to determine the terpenoid profile of the sample for the purposes of accurate labeling.

CHEMICAL RESIDUE

The laboratory shall analyze, at minimum, 0.5 grams of the representative sample for analysis of chemical residues.

Rule 5(11) in the Marihuana Sampling and Testing Rule Set R 420.305(11) For the purposes of chemical residue testing and target analyte testing, the MRA shall publish a list of quantification levels. Any result that exceeds the action limit is a failed sample. The LOQ's required for chemical residue testing are provided in the table below and are set at ½ the action limit. The list is evaluated and an ongoing basis and updated based on the best available scientific and industry data, or if the federal government adds marijuana to 40 CFR part 180, subpart C, or the federal insecticide, fungicide, and rodenticide act, 7 USC 136 to 136y.

Table 4. List of Banned Chemical Ingredients: Action Limit and LOQ[11].

Analytes	CAS Number	Action Limit (ppm)	LOQ (ppm)
Abamectin	71751-41-2	0.500	0.250
Acephate	30560-19-1	0.400	0.200
Acequinocyl	57960-19-7	2.00	1.00
Acetamiprid	135410-20-7	0.200	0.100
Aldicarb	116-06-3	0.400	0.200
Azoxystrobin	131860-33-8	0.200	0.100
Bifenazate	149877-41-8	0.200	0.100
Bifenthrin	82657-04-3	0.200	0.100
Boscalid	188425-85-6	0.400	0.200
Carbaryl	63-25-2	0.200	0.100
Carbofuran	1563-66-2	0.200	0.100
Chlorantraniliprole	500008-45-7	0.200	0.100
Chlorfenapyr	122453-73-0	1.00	0.500
Chlorpyrifos	2921-88-2	0.200	0.100
Clofentezine	74115-24-5	0.200	0.100
Cyfluthrin	68359-37-5	1.00	0.500
Cypermethrin	52315-07-8	1.00	0.500
Daminozide	1596-84-5	1.00	0.500
DDVP (Dichlorvos)	62-73-7	1.00	0.500
Diazinon	333-41-5	0.200	0.100
Dimethoate	60-51-5	0.200	0.100
Ethoprophos	13194-48-4	0.200	0.100
Etofenprox	80844-07-1	0.400	0.200
Etoxazole	153233-91-1	0.200	0.100
Fenoxycarb	72490-01-8	0.200	0.100
Fenpyroximate	134098-61-6	0.400	0.200
Fipronil	120068-37-3	0.400	0.200
Flonicamid	158062-67-0	1.00	0.500
Fludioxonil	131341-86-1	0.400	0.200
Hexythiazox	78587-05-0	1.00	0.500
Imazalil	35554-44-0	0.200	0.100
Imidacloprid	138261-41-3	0.400	0.200

Kresoxim-methyl	143390-89-0	0.400	0.200
Malathion	121-75-5	0.200	0.100
Metalaxyl	57837-19-1	0.200	0.100
Methiocarb	2032-65-7	0.200	0.100
Methomyl	16752-77-5	0.400	0.200
Methyl parathion	298-00-0	0.200	0.100
MGK-264	113-48-4	0.200	0.100
Myclobutanil	88671-89-0	0.200	0.100
Naled	300-76-5	0.500	0.250
Oxamyl	23135-22-0	1.00	0.500
Paclobutrazol	76738-62-0	0.400	0.200
Permethrins*	52645-53-1	0.200	0.100
Prallethrin	23031-36-9	0.200	0.100
Phosmet	732-11-6	0.200	0.100
Propiconazole	60207-90-1	0.400	0.200
Propoxur	114-26-1	0.200	0.100
Pyridaben	96489-71-3	0.200	0.100
Pyrethrins+	8003-34-7	1.00	0.500
Spinosad	168316-95-8	0.200	0.100
Spiromesifen	283594-90-1	0.200	0.100
Spirotetramat	203313-25-1	0.200	0.100
Spiroxamine	118134-30-8	0.400	0.200
Tebuconazole	80443-41-0	0.400	0.200
Thiacloprid	111988-49-9	0.200	0.100
Thiamethoxam	153719-23-4	0.200	0.100
Trifloxystrobin	141517-21-7	0.200	0.100

* Permethrins should be measured as cumulative residue of cis- and trans-permethrin isomers (CAS numbers 54774-45-7 and 51877-74-8).

+ Pyrethrins should be measured as the cumulative residues of pyrethrin 1, cinerin 1 and jasmolin 1 (CAS numbers121-21-1, 25402-06-6, and 4466-14-2 respectively)

RESIDUAL SOLVENTS

The laboratory shall analyze, at minimum, 0.25 grams of the representative sample to assess the presence of residual solvents in accordance with their associated action limits (Table 3). Action limits are based on the “International Conference for Harmonisation (ICH) Guideline Q3C (R5) on Impurities: Guidelines for residual solvents” and information provided by states with current marijuana programs. Please note that the LOQ for residual solvents must be ½ the action limit. Any detection that exceeds the published action limit is considered a failure.

Table 5. Action Limits for Residual Solvents.

Solvent	CAS Number	Action Limit for Inhaled Products (ppm)	Action Limit for Non-inhaled Products (ppm)
1,2-Dichloroethane	107-06-2	2.00	5.00
Acetone	67-64-1	750	5000
Acetonitrile	75-05-8	60.0	410
Benzene	71-43-2	1.00	2.00
Butanes all isomers*	106-97-8	800	5000
Chloroform	67-66-3	2.00	60.0
Ethanol	64-17-5	1000	5000
Ethyl acetate	141-78-6	400	5000
Ethyl ether	60-29-7	500	5000
Ethylene oxide	75-21-8	5.00	50.0
Heptane	142-82-5	500	5000
Hexanes all isomers^	110-54-3	50.0	290
Isopropyl alcohol	67-63-0	500	5000
Methanol	67-56-1	250	3000
Methylene chloride	75-09-2	125	600
Pentanes all isomers+	109-66-0	750	5000
Propane	74-98-6	2100	5000
Trichloroethylene	79-01-6	25.0	80.0
Toluene	108-88-3	150	890
Total xylenes (ortho-, meta-, para-)	1330-20-7	150	2170

* Butane isomers include 2-methylpropane or isobutane CAS Number 75-28-5.
+ Pentane isomers include isopentane (methylbutane) CAS Number: 78-78-4 & neopentane (dimethylpropane) CAS Number: 463-82-1 Y
^ Hexane isomers 2,2-Dimethylbutane CAS Number: 75-83-2, 2,3-Dimethylbutane CAS Number: 79-29-8, 2-Methylpentane CAS Number: 107-83-5, 3-Methylpentane CAS Number: 96-14-0

HEAVY METALS

The laboratory shall analyze, at minimum, 0.5 grams of the representative sample of marijuana products to assess the presence of heavy metals in accordance with their associated action limits based on a 5 gram/day consumption of marijuana (Table 6). These values were derived from USP 232-Elemental Impurities-Limits with additional information derived from the most recent consumption data available in the United States.[18][21] Please note that the laboratory's LOQ for heavy metals must be at a minimum ½ the published action limit. Any detection that exceeds the published action limit is considered a failure.

Table 6. Heavy Metal Action Limits.

Heavy metal	Action Limit (ppm)		
	Inhaled Marijuana Flower and Inhalable Compound Concentrate Products	**Inhaled Marijuana Concentrates**	**Other Marijuana Products**
Lead	1.00	0.500	0.500
Inorganic Arsenic	0.400	0.200	1.50
Mercury	0.200	0.100	3.00
Cadmium	0.400	0.200	0.500
Total Chromium	1.20	0.600	2.00
Nickel*	1.00	0.500	N/A
Copper*	N/A	3.00+	N/A

+ Copper is required for vaping products only.

FOREIGN MATTER ANALYSIS

Pests and other foreign matter including fungi, metal, or plastic fragments, and both organic and non-organic debris are found in food as well as tobacco products and may also be detected in marijuana. The FDA considers debris of this kind in food to pose a negligible health hazard but recognizes that quality and user experience is compromised. Because of this, the FDA has methods for monitoring this type of contamination (FDA 2013b), which can be consulted to compare standards for different food commodities.

The laboratory shall perform foreign material testing on the total representative sample prior to sample homogenization. When the laboratory performs foreign material testing, the laboratory shall do all of the following:

1. Develop a procedure and associated training documents for the identification of powdery mildew.
2. Examine both the exterior and interior of the dried flower sample.
3. Examine the exterior and interior of the marijuana-infused product sample.

If the sample fails foreign material testing, the test will be reported as a failure without consideration to the results of other tests.

Analysis for Organic Matter

The action limit for crude marijuana is not more than 5.0% of stems and not more than 2.0% of other foreign matter. All analysts and technicians should be trained, specifically, in the identification of powdery mildew on plant material. The presence of powdery

mildew must be accounted for in the calculation toward total foreign matter. The observed matter should be documented photographically, and a note of the results should be included in Metrc.

It is recommended that the laboratory clearly delineate calculation guidelines and ranges for total surface area contamination. Foreign matter analysis should be performed prior to all other testing, aside from microbials. The material remaining after foreign matter analysis is acceptable for all chemical testing but should not be used for microbial testing. The amount of marijuana or marijuana product used for testing should be no less than 30% of the total gram weight or total sample lot obtained for compliance testing.

In the case of marijuana flower, the allotted 30% should come from separate, intact buds.

1. The buds should be separated into no less than ten increments, the results from which can be averaged together as total foreign matter contamination.
2. Dissection of nodes should be done whenever physically possible.
3. If dissection of distinct nodes is deemed unnecessary, due to the small and compact nature of the buds (“popcorn” buds), the buds then should be examined in their entirety and additionally cut in half to observe the inside portion.
4. In the case of marijuana trim, kief, concentrate, or infused product, the calculation to determine 30% of the sampling batch should be included in the SOP.
5. Filth analysis should be performed at a low-power magnification.
6. Quantitation of filth should be done as a total surface area calculation. The laboratory-derived calculation should be included in the SOP.
7. If a sample fails for foreign matter, the laboratory should include a note in Metrc listing all contaminants identified.

Analysis for Inorganic Matter

For these purposes, inorganic matter includes, but is not limited to, any material that would not normally be found on a living organism (plant) and includes materials such as glass, metal shavings, or synthetic fibers. In this case, the presence of any inorganic matter on any marijuana plant, concentrate, or infused product would result in an automatic failure for foreign matter. The observed matter should be documented photographically, and a note of the results should be included in Metrc.

WATER ACTIVITY (a_w)

Water activity (a_w) is the partial vapor pressure of water divided by the standard state partial vapor pressure of water. With pure, distilled water having a water activity of exactly one. For testing purposes, water activity is a measure of the available water that can be utilized for microbiological growth. Values range from 0 to 1 with microbial growth unlikely below a_w 0.6. Most marijuana is dried and cured to a final water activity

level of a_w 0.3-0.6. Most pathogens cannot grow below a_w 0.9.[38] Based on the available research, the following guidelines have been developed:

- A marijuana sample shall be deemed to have passed water activity testing if the water activity does not exceed 0.65 a_w.
- An **edible** marijuana-infused product shall be deemed to have passed water activity testing if the water activity does not exceed 0.85 a_w.
- Any detection that exceeds the published action limit is considered a failure.
- Non-edible marijuana-infused products are **not** subject to water activity testing.
- Marijuana-infused beverages are **not** subject to water activity testing with approval from the MRA.

MICROBIALS

Any detection that exceeds the published action limit is considered a failure based on the criteria for acceptability (Table 7).

Table 7. Microbial Screening Action Limits (CFU/g).

	Action Limit (CFU/g)		
	Bud, shake/trim/kief/ Inhalable Compound Concentrate Products [a]	**Marijuana-Infused Products**	**Marijuana Extract non-solvent & non-CO2**
Medical Total Yeast & Mold Count	10,000	10,000	1,000
Adult-Use Total Yeast & Mold Count	100,000	10,000	1,000
Total Coliform	1000	100	100
Shiga toxin-producing *E. coli* (STEC)	Not detected in 1 gram	Not detected in 1 gram	Not detected in 1 gram
Pathogenic Salmonella spp.	Not detected in 1 gram	Not detected in 1 gram	Not detected in 1 gram
Aspergillus flavus, fumigatus, niger & terreus	Not detected in 1 gram	Not detected in 1 gram	Not detected in 1 gram
[a]Infused pre-rolls and combination products will follow the action limits for bud/shake/trim/kief.			

TARGET ANALYTES

Rule 1(1)(dd) of the Marihuana Sampling and Testing Rule Set (R 420.301(1)(dd) defines "Target Analyte" in the following way:

"Target analyte" means a non-marijuana inactive ingredient designated for analysis.

Vitamin E acetate has been identified as a target analyte by the MRA. All vape cartridges must be tested for vitamin E acetate. Any detection that exceeds the published LOQ (Table 6) is considered a failure.

Table 8. Target Analytes for Marijuana products Intended for Inhalation.

Target Analyte	(CAS) Number	LOQ (ppm)
Vitamin E acetate	58-95-7	100

HOMOGENEITY

Homogeneity testing or the process of homogeneous sampling, is when all items in a sample are chosen at random to be representative of the product batch so they have similar or identical traits. To perform homogeneity testing each dose or serving shall be treated as a separate individual sample and a total of 10 doses or servings shall be sampled at random. The weight and concentration of delta-9 THC must be recorded and the variability of weight and concentration of delta-9 THC among servings in a single package my not exceed +/- 15%.

This can be determined by first calculating the standard deviation (SD) among samples and subsequently calculating the relative standard deviation (RSD) for both weight and concentration of delta-9 THC.

The SD is calculated using the following formula:

$$SD = \sqrt{\frac{(sample1 - mean)^2 + (sample2 - mean)^2, \dots, (sample10 - mean)^2}{total\ number\ of\ samples - 1}}$$

The RSD is calculated using the following formula:

$$RSD = \frac{SD}{mean} x\ 100$$

The MRA has determined that the laboratories should complete potency testing based on the information provided by the processors at the time of the sampling event. If a product is sampled as an individual serving/dosage, the facility will report total THC by serving/dose. If the product is sampled in final form, total THC content for the package will be reported.

It is not incumbent on the laboratory to determine if the product will meet the package labeling requirements. The laboratory testing results provided on the package will report the calculated THC as the product was submitted for testing and is not required to replicate the processor designated package label for THC content. The processor designated package label will be considered the target THC.

pH

pH is a quantitative measure of the acidity or basicity of aqueous or other liquid solution and is a required test for marijuana-infused beverages. Any laboratory seeking approval to test marijuana-infused beverages must follow AOAC Method 945.10 and should conduct analyses and validations in accordance with all manufacturer specifications.

Table 9. Marijuana Testing Requirements.

	Bud, shake/trim from Harvest Batch	Marijuana Extract non-solvent & non-CO_2[a]	Marijuana Concentrate Co2 & Solvent-based	Marijuana Vape Product	Inhalable Compound Concentrate Products [c]	Marijuana-Infused Product
Vitamin E Acetate				√		
Homogeneity						√
Potency Analysis	√	√	√	√	√	√
Foreign Matter Inspection	√	√			√	√
Microbial Screen	√	√			√	√
Water Activity	√				√	√[b]
Heavy Metal Screen	√	√	√	√	√	√
Residual Solvents			√	√	√	√
Chemical Residue Analysis	√	√	√	√	√	√

[a] Extraction using ice water, rosin press or dry ice, this also includes kief.
[b] Not required for non-edible marijuana product or beverages with MRA approval.
[c] Moonrock, Caviar joint, infused pre-roll, tarantula etc.

APPENDIX A-DEFINITIONS

Accuracy – A combination of the bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value. (Standard Methods, 18th edition). For the purposes of laboratory certification, accuracy means the closeness of a measured value to its generally accepted value or its value based upon an accepted reference standard.

Action limit – The MRA defines an action limit as the maximum permissible level of contaminant in marijuana product allowable by the MRA. These standards are toxicologically derived to protect human health. A marijuana product with a value that exceeds the published action limit is considered a failed sample. A marijuana sample that is at or below the action limit is considered a passing sample.

Analytical sensitivity – The assay's ability to detect very low concentrations of a given substance. Analytical sensitivity is often referred to as the limit of detection (LOD). LOD is the actual concentration of an analyte in a sample that can be consistently detected ≥ 95% of the time.

Analytical selectivity – The degree to which the method can quantify the analyte of interest in the presence of other analytes, matrices, or other potentially interfering materials. This is usually achieved by isolation of the analyte through selective solvent extraction, chromatographic or other phase separations, or by application of analyte-specific techniques such as biochemical reactions (enzymes, antibodies) or instrumentation mass spectrometry (MS).

Batch – All marijuana product of the same variety that has been processed together and exposed to substantially similar conditions throughout processing.

Bias – Provides a measure of systematic, or determinative error in an analytical method. Bias is determined by assessing the percent recovery of spiked samples. Historically, the term accuracy has been used interchangeably with bias, although many sources make a distinction between the two. (Standard Methods, 18th edition).

Calibration – Modern instrumental methods depend upon the comparison of a signal from the unknown concentration of an analyte to that from a known concentration of the same or similar analyte. The simplest calibration procedure requires preparation of a series of standard solutions from the reference material, by dilution of a stock solution, covering a reasonable range of signal response from the instrument. Four or more points, approximately equally spaced over the concentration range of interest, performed in duplicate but measured at random (to avoid confusing nonlinearity with drift) is a suitable calibration pattern. Fit the calibration line and plot the residuals as a function of concentration. An acceptable fit produces a random pattern of residuals with a zero mean.

Chain of custody – The chronological documentation showing the collection, custody, control, transfer, analysis, and disposition of a sample.

CFU/g – Colony forming units per gram.

Final form – The form a marijuana product is in when it is available for sale by a marijuana sales location. For marijuana product intended for inhalation, the marijuana concentrate in the e-cigarette or vaping device.

Harvest batch – A designated quantity of harvested marijuana, all of which is identical in strain and has been grown and harvested together and exposed to substantially similar conditions throughout cultivation.

Inhalable compound concentrate products – These products are defined as any products that are created from multiple categories of inhalable products (i.e. marijuana concentrates and/or marijuana flower) that have been combined into a single final form intended for inhalation. This category also includes any products that are created from the combination of multiple marijuana concentrates from different sources. For example, if a processor opted to combine THCA powder with live resin, or any other combination of marijuana flower, shake/trim, kief, or concentrates.

Instrument detection limit (IDL) – The concentration equivalent to a signal, due to the analyte of interest, which is the smallest signal that can be distinguished from background noise by a particular instrument. The IDL should always be below the method detection limit, and is not used for compliance data reporting, but may be used for statistical data analysis and comparing the attributes of different instruments.

Interfering substances – One that at the given concentration causes a systematic error in the analytical result.

Linear calibration range (LCR) or range of linearity – The region of a calibration curve within which a plot of the concentration of an analyte versus, the response of that particular analyte remains linear and the correlation coefficient of the line is approximately 1 (0.995 for most analytes). The plot may be normal-normal, log-normal, or log-log when allowed by the analytical method. At the upper and lower bounds of this region (upper and lower limits of quantitation), the response of the analyte's signal versus concentration deviates from the line.

Limit of detection (LOD) or detection limit – The lowest concentration level that can be determined to be statistically different from a blank (99% confidence). The LOD is typically determined to be in the region where the signal to noise ratio is greater than five. Limits of detection are matrix, method, and analyte specific. The LOD is approximately equal to the MDL for those tests which the MDL can be calculated.

Limit of quantitation or lower limit of quantitation (LOQ) – Limit of quantitation is defined in rule as the minimum concentration or mass of an analyte in a given matrix that can be reported as a quantitative result.

The LOQ is mathematically defined as equal to ten times the standard deviation of the results for a series of replicates used to determine a justifiable limit of detection. Limits of quantitation are matrix, method, and analyte specific.

Marijuana-infused product – Any product containing marijuana that is intended for human consumption in a manner other than smoke inhalation.

Marijuana product – Marijuana or a marijuana-infused product, or both, as those terms are defined in the act unless otherwise provided for in these rules.

Marijuana concentrate – A product derived from marijuana that is kief, hashish, bubble hash, oil, wax, or other product, or that includes cannabinoids extracted from the plant by any means.

Marijuana product intended for inhalation – Any marijuana concentrate that is intended to be inhaled using an e-cigarette or vaping device.

Method detection limit (MDL) – The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a target matrix containing the analyte. The MDL procedure is designed to be a straightforward technique for estimation of the detection limit for a broad variety of physical and chemical methods. The procedure requires a complete, specific, and well-defined analytical method. It is essential that all sample processing steps used by the laboratory be included in the determination of the method detection limit. To calculate MDLs please follow this procedure.

Milligrams (mg) – A unit of mass equal to one thousandth (10^{-3}) of a gram.

Precision – A measure of the random error associated with a series of repeated measurements of the same parameter within a sample. Precision describes the closeness with which multiple analyses of a given sample agree with each other and is sometimes referred to as reproducibility. Precision is determined by the absolute standard deviation, relative standard deviation, variance, coefficient of variation, relative percent difference, or the absolute range of a series of measurements.

Production batch – A manufacturing event of batch of material containing any amount of medical or adult-use marijuana concentrate of the same category and produced using the same extraction methods, standard operating procedures and an identical group of harvest batch(es) of medical or adult-use marijuana; or (b) any amount of medical or adult-use marijuana product of the same exact type, produced using the same ingredients, standard operating procedures and the same production batch(es) of medical or adult-use marijuana concentrate. Production batches are limited to what can be produced the same day.

Raw pre-rolls – These products are defined simply as marijuana pre-rolls and contain only marijuana flower/shake/trim as well as the rolling paper/tip/filter used to give structure and function to the pre-roll. Typically, some sort of adhesive is used to seal the product. If the ‘adhesive’ used is marijuana concentrate, the product is no longer considered a raw pre-roll, but instead, an inhalable compound concentrate product, and the licensee should use the guidance for testing compound concentrate products included above.

Reportable range – The upper limit of the reportable range will be set at the concentration of the highest standard tested which exhibited acceptable results for

linearity, accuracy, and precision. The lower limit of the reportable range will be set at the lowest standard tested which exhibits acceptable results.

Reporting limit – Arbitrary number below which data is not reported. The reporting limit may or may not be statistically determined or may be an estimate that is based upon the experience and judgement of the analyst. Analytical results below the reporting limit are expressed as "less than" the reporting limit. Reporting limits are not acceptable substitutes for detection limits.

Representative sample – A sample obtained according to a sampling procedure designed to ensure that the different parts of a batch or the different properties of a batch are proportionally represented.

Sample matrix, or matrix – Defines the general physical-chemical composition of a sample other than the analyte of interest. General classes of matrices commonly referred to in the marijuana industry include flower, concentrate, marijuana-infused product, and all associated subtypes.

Sample standard deviation, or standard deviation (s) – A measure of the degree of agreement, or precision, among replicate analyses of a sample.

Sample – An amount of marijuana collected by laboratory personnel from a licensee and provided to a laboratory for testing.

Solvent – A substance that can dissolve another substance, or in which another substance is dissolved, forming a solution. Examples of solvents include water, acetone, turpentine, and ethanol.

Statewide monitoring system – Marijuana enforcement tracking reporting & compliance (Metrc).

Statistical outlier, or outlier – An observation or data point that appears to deviate markedly from other members of the population in which it occurs. The presence of outliers must be verified using an approved statistical method, at the 1% significance level.

Target analyte – Non-marijuana inactive ingredient designated for analysis.

Test batch – A group of 20 samples that are derived from a single production batch. The combined subset of samples is collectively submitted to a licensed testing facility for testing purposes.

Validation – The process of demonstrating or confirming the performance characteristics of a method of analysis. The validation of a method of analysis results in the specification of various aspects of reliability and applicability. Changes to the validation will require revalidation.

Water activity – The partial vapor pressure of water in a substance divided by the standard state partial vapor pressure of water.

REFERENCES

Aldous, K., Applen, J., Fan, Z., Fox, M., Kassner, S., Latshaw, M., & Verbrugge, D. (2016). Guidance for State Medical Cannabis Testing Programs. *Association of Public Health Laboratories*. [1]

AOAC. Official Methods of Analysis 991.14. 1994. Coliform and Escherichia coli counts in foods. AOAC. Intl. [2]

AOAC. Official Methods of Analysis 997.02. 2002. Yeast and mold counts in foods. AOAC. Intl. [3]

ASTM D8196-18, Standard practice for determination of water activity (aw) in cannabis flower, ASTM International, West Conshohocken, PA, 2018. [4]

Audino, S., Acevedo, B., Angerhofer, M., Astill, T., Atkins, P., Aubin, A., & Brown, A. N. Standard Method Performance Requirements (SMPRs®) 2018.011: Identification and quantitation of selected pesticide residues in dried cannabis materials. [5]

Audino, S., Angerhofer, M., Atkins, P., Brauninger, R. M., Brown, P. N., Burdette, C. Q., & Gibson, P. (2017). AOAC SMPR® 2017.002. *Journal of AOAC International*, *100*(4), 1204-1207. **[6]**

Brabcová, I., Kovářová, L., Šatínský, D., Havlíková, L., & Solich, P. (2013). A fast HPLC method for determination of vitamin E acetate in dietary supplements using monolithic column. *Food analytical methods*, *6*(2), 380-385. [7]

Das, P., Kumar, S. R., & Maity, A. Risk based approach to evaluate the safety, risk and control of Elemental Impurities in Pharmaceutical Drug Products [8]

De Backer, B., Debrus, B., Lebrun, P., Theunis, L., Dubois, N., Decock, L., & Charlier, C. (2009). Innovative development and validation of an HPLC/DAD method for the qualitative and quantitative determination of major cannabinoids in cannabis plant material. *Journal of Chromatography B*, *877*(32), 4115-4124. [9]

EPA, U. (1995). Method 3052: microwave assisted acid digestion of siliceous and organically based matrices. *Test Methods for Evaluating Solid Waste*. [10]

Farrer, D. G. (2016). *Technical Report: Oregon Health Authority's Process to Determine which Types of Contaminants to test for in Cannabis Products, and Levels for Action*. Oregon Health Authority, Public Health Division. [11]

Freeman, K., McHenry, M., Cats-Baril, W., & Grace, T. (2016). Cannabis Testing for Public Safety-Best Practices for Vermont Analytical Laboratories. *PhytoScience Institute*. [12]

Guidance, A. D. L. (1996). Laboratory Guide for Determining Method Detection Limits. *Wisconsin Department of Natural Resources Laboratory Certification Program April*.[13]

Guideline, I. H. T. (2005). Impurities: Guideline for residual solvents Q3C (R5). *Current Step*, *4*, 1-25. [14]

Guideline, I. H. (2018). Guideline for elemental impurities Q3D (R1). [15]

International Conference on Harmonization. (2003). Q1A (R2), Stability testing of new drug substances and products. In *International Conference on Harmonization*. Geneva: International Conference on Harmonization. [16]

Kagen, S. L., Kurup, V. P., Sohnle, P. G., & Fink, J. N. (1983). Marijuana smoking and fungal sensitization. *Journal of allergy and clinical immunology*, *71*(4), 389-393. [17]

Kilmer, B., Caulkins, J. P., Midgette, G., Dahlkemper, L., MacCoun, R. J., & Liccardo, P. R. (2013). *Before the grand opening: Measuring Washington State's marijuana market in the last year before legalized commercial sales*. Rand Corporation. [18]

Kowalcyk, B., McLellan, M. R., Goldman, L., Goldman, D., Holmes, H. T., & Weaver, C. (2016). Office of Regulatory Affairs Strategies for Building an Integrated National Laboratory Network for Food and Feed. [19]

Lehotay, S. (2007). AOAC Official Method 2007.01 Pesticide residues in foods by acetonitrile extraction and partitioning with magnesium sulfate. *Journal of AOAC International*, *90*(2), 485-520. **[20]**

Light, M. K., Orens, A., Lewandowski, B., & Pickton, T. (2015). *Market size and demand for marijuana in Colorado*. Marijuana Policy Group. [21]

Ma, C., Oketch-Rabah, H., Kim, N. C., Monagas, M., Bzhelyansky, A., Sarma, N., & Giancaspro, G. (2018). Quality specifications for articles of botanical origin from the United States Pharmacopeia. *Phytomedicine*, *45*, 105-119. [22]

McPartland, J. M., & McKernan, K. J. (2017). Contaminants of concern in cannabis: Microbes, heavy metals and pesticides. In *Cannabis sativa L.-Botany and Biotechnology* (pp. 457-474). Springer, Cham. [23]

Osterbauer, N., Krepps, S., Sackett, J., Holladay, C., Wendt, E., Wells, D., & Kristof, J. *Protocol for Collecting Samples of Usable Marijuana*. ORELAP-SOP-001 Rev. 3.0. 2016 December. [24]

Patel, B., Wene, D., & Fan, Z. T. (2017). Qualitative and quantitative measurement of cannabinoids in cannabis using modified HPLC/DAD method. *Journal of pharmaceutical and biomedical analysis*, *146*, 15-23.[25]

Pharm, E., & Lipomed, A. G. (2017). AOAC SMPR® 2017.001. [26]

Raber, J. C., Elzinga, S., & Kaplan, C. (2015). Understanding dabs: contamination concerns of cannabis concentrates and cannabinoid transfer during the act of dabbing. *The Journal of toxicological sciences*, *40*(6), 797-803. [27]

Sexton, M., & Ziskind, J. (2013). Sampling cannabis for analytical purposes. *BOTEC Analysis Corp*, *26*. [28]

Thiex, N. J., & Ramsey, C. A. (2016). Taking and Testing GOODSamples: A Systematic Approach for Representative Sampling from Field to Test Portion. *Journal of Regulatory Science*, *4*(2), 1-8. [29]

Thomas, R. (2018). *Measuring Elemental Impurities in Pharmaceuticals: A Practical Guide*. CRC Press. [30]

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy metal toxicity and the environment. In *Molecular, clinical and environmental toxicology* (pp. 133-164). Springer, Basel. [31]

Upton, R., & ElSohly, M. (Eds.). (2014). *Cannabis Inflorescence: Cannabis spp.; Standards of Identity, Analysis, and Quality Control*. American Herbal Pharmacopoeia. [32]

Unger, P., Brauninger, R., Hudalla, C., Holmes, M., & Sherman, B. (2014). Standards for Cannabis Testing Laboratories. *Eugene, OR: Cannabis Safety Institute. Retrieved*, *4*(01), 2016. [33]

United States Pharmacopoeia. (2009). USP< 61> Microbiological examination of nonsterile products: Microbial enumeration tests. In *USP Pharmacists' Pharmacopeia; United States Pharmacopeial Convention:* Rockville, MD: United States Pharmacopeial Convention. (p. S3). [34]

United States. Environmental Protection Agency. Office of Ground Water, & Drinking Water. Technical Support Center. (1997). *Manual for the Certification of Laboratories Analyzing Drinking Water: Criteria and Procedures, Quality Assurance*. US

Environmental Protection Agency, Office of Water, Office of Ground Water and Drinking Water, Technical Support Center. [35]

United States Pharmacopoeia. (2009). USP< 62> Microbiological examination of non-sterile products: tests for specified microorganisms. Rockville, MD: United States Pharmacopeial Convention. [36]

United States Pharmacopoeia. (2012). USP< 467> Residual solvents. Rockville, MD: United States Pharmacopeial Convention. [37]

Voelker, R., & Holmes, M. (2015). Pesticide use on cannabis. *Cannabis Safety Institute*, 1-19. [38]

Ziobro, G. C. (1996). Filth and extraneous materials in foods and drugs. *Journal of AOAC International*, *79*(1), 252-253. [39]

ACKNOWLEDGMENTS

Colorado Department of Public Health and Environment
Lori Dodson, MS, MT(ASCP), Deputy Director/Director of Laboratory Compliance
Natalie M. Laprade Maryland Medical Cannabis Commission