NIST Special Publication 2200
NIST SP 2200-08e2026

Suitability of *Cannabis* Scales

Considerations for Determining the Suitability of Scales Used for the Sale of Cannabis Products

Jan Konijnenburg
Loren Minnich
David Sefcik
Alan Heckert

This publication is available free of charge from:
https://doi.org/10.6028/NIST.SP.2200-08e2026

NATIONAL INSTITUTE OF
STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

NIST Special Publication 2200
NIST SP 2200-08e2026

Suitability of *Cannabis* Scales

Considerations for Determining the Suitability of Scales Used for the Sale of Cannabis Products

Jan Konijnenburg
Loren Minnich
David Sefcik
Office of Weights and Measures (OWM)
Physical Measurement Laboratory (PML)

Alan Heckert
Statistical Engineering Division
Information Technology Laboratory (ITL)

This publication is available free of charge from:
https://doi.org/10.6028/NIST.SP.2200-08e2026

June 2026

U.S. Department of Commerce
Howard Lutnick, Secretary

National Institute of Standards and Technology
Arvind Raman, NIST Director and Under Secretary of Commerce for Standards and Technology

Disclaimer
In contrast to hemp, marijuana remains a Schedule I substance under the Controlled Substances Act. NIST does not have a policy role related to the legalization of the production, sale, distribution, or use of *Cannabis* (including hemp and marijuana). NIST participates in the National Council of Weights and Measures (NCWM) as part of NIST's statutory mission to promote uniformity in state laws, regulations, and testing procedures.

Publication History
Approved by the NIST Editorial Review Board on 2026-06-16

How to Cite this NIST Technical Series Publication
Konijnenburg J, Minnich L, Heckert A, and Sefcik DA.(2026) Suitability of *Cannabis* Scales:Considerations for Determining the Suitability of Scales Used for the Sale of *Cannabis* Products. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) NIST SP 2200-08e2026. https://doi.org/10.6028/NIST.SP.2200-08e2026

Author ORCID iDs
Jan Konijnenburg: 0000-0003-2592-873X
Loren Minnich: 0009-0006-8082-2726
Alan Heckert: 0000-0002-8430-6757
David Sefcik: 0000-0001-7407-1950

Contact Information
owm@nist.gov
NIST Office of Weights and Measures
100 Bureau Drive, MS 2600
Gaithersburg, MD 20899

Abstract

In the last several years, the sale and use of *Cannabis* products have been legalized in multiple States in the U.S. With this legalization comes the legal control over the sale of *Cannabis* products, including weights and measures regulation.

State and local weights and measures jurisdictions in the U.S. are debating which requirements should be imposed on scales used for the sale of *Cannabis* products and their use. These include aspects such as accuracy, scale division, and auxiliary indications, which are subject to discussion within the National Council on Weights and Measures (NCWM).

The NIST Office of Weights and Measures has taken the initiative to provide objective, technical information on the most relevant aspects of weighing instruments regarding their suitability for selling *Cannabis* products, which can help clarify the discussion. The aim of this publication is to provide technical guidance for the decision-making process of determining suitability requirements for weighing instruments used for the sale of *Cannabis* products. The aim is not to provide a recommendation regarding any proposed technical requirement for a scale or its usage.

Acknowledgments

The NIST Office of Weights and Measures thanks the weights and measures divisions of Colorado, Delaware, Illinois, Maryland, Minnesota, Massachusetts, Nevada, New Jersey, New York, and Vermont for collecting and sharing data on scales that are used in their jurisdictions for the weighing of *Cannabis* products.

Keywords

Air buoyancy; Auxiliary indication; *Cannabis* scale; Low-density products; Minimum capacity; Moisture loss; Recommended minimum load; Scale division; Suitability; Verification scale interval.

Table of Contents

List of Tables

List of Figures

Executive Summary

With the legalization of the sale of *Cannabis* products in multiple states across the U.S., the question arose among weights and measures jurisdictions about what requirements should be imposed on scales that are used for the sale of *Cannabis* products. A task group was formed within the NCWM to create an answer to this question. However, after several years of debate, state regulators have not yet reached a consensus on a set of requirements.

This publication discusses the most relevant scale characteristics and provides technical insights to determine such requirements. These scale characteristics include the accuracy classification, the value of the verification scale interval, the monetary value per scale division, auxiliary indication, and the minimum capacity and recommended minimum load. To substantiate this, real-world data on the scales currently used to weigh *Cannabis* was collected from weights and measures jurisdictions in 9 States and analyzed to verify the suitability of an auxiliary indication.

Aspects of weighing instruments that inform tolerance and specifications.

This publication does not promote any position or recommendation with respect to any proposal for requirements on instruments used in the sale of *Cannabis* products.

The following conclusions are based on the analysis in this publication.

- Based on Table 7a, *Typical Class or Type of Device for Weighing Applications* in NIST Handbook 44, Section 2.20 *Scales*, and the fact that *Cannabis* products are high-value commodities like precious metals and gems, it is reasonable to conclude that scales used for the sale of *Cannabis* products should also be of accuracy Class II. However, the effect of air buoyancy and varying moisture levels may not justify the requirement for a Class II scale. Jurisdictions should consider this duality when determining the proper accuracy class for scales used in the sale of Cannabis products.
- The recommended minimum load (or minimum capacity) implicitly sets an upper limit on the verification scale interval. A separate requirement for a maximum value of the verification scale interval, applied only to scales used for the sale of *Cannabis* products, appears arbitrary (since there is no such requirement for other high-value commodities in NIST Handbook 44). It also undermines the purpose of the recommended minimum load requirement.
- NIST Handbook 44, Section 2.20, *Scales*, currently has no requirement for a minimum monetary increment per scale division. If desired, such a requirement could be implemented as a User Requirement for all commodities (or all high-value commodities) to avoid being arbitrary towards *Cannabis* products.
- At the low end of the weighing range, the uncertainty of the measurement result is mainly determined by the indication's resolution, while the measurement's accuracy does not play a role. Especially in the range below 50 verification scale intervals, the measurement inaccuracy is negligible. Therefore, it is justifiable to base the minimum capacity and recommended minimum load on the scale division, d, rather than on the verification scale interval, e.
- In that sense, the use of an auxiliary indication is a useful feature that extends the weighing range at the low end. However, because the auxiliary indication (scale division, d) must be differentiated, it may confuse consumers who are more familiar with devices where e = d and there is no differentiation of d.
- In response to the doubt that still exists among some members of the weights and measures community about the accuracy of scales equipped with an auxiliary indication, the NIST Office of Weights and Measures conducted a survey among states that regulate scales used for the sale of *Cannabis* products. The analysis of the collected data shows that for relatively small loads (1 g),

there is no significant difference in the performance between scales with an auxiliary indication (e = 0.1 g, d = 0.01 g) and scales without an auxiliary indication (e = d = 0.01 g). This supports the conclusion above that it is technically justified to express the minimum capacity (and the recommended minimum load) in units of the scale division, d.

These conclusions are intended to clarify the discussion and help regulators and other stakeholders develop a set of requirements for scales used in the sale of *Cannabis* products, based on scientific analysis.

1. Introduction

The aim of this publication is to provide objective information on how the discussed characteristics affect the weighing result, to assist state weights and measures officials in making an objective decision on the requirements for weighing instruments used for the sale of *Cannabis* products. This publication does not promote any position or recommendation with respect to any proposal for requirements on instruments used in the sale of *Cannabis* products.

With the legalization of *Cannabis* in many States, the suitability of the scales used in the sale of *Cannabis* products becomes increasingly important. *Cannabis* products are unique in that they have distinct properties from traditional commodities that are subject to weights and measures regulations, such as grocery products, precious metals, and gems.

In 2018, the National Conference on Weights and Measures (since renamed as the National Council on Weights and Measures (NCWM)) established the *Cannabis* Task Group to establish a harmonized approach for the suitability of scales, method of sale, packaging and labeling, safety aspects, and moisture loss related to the sale of *Cannabis* products.

Although the task group, which was established to address these many issues and considerations, has made significant progress by producing highly valuable reports, regulatory proposals, model laws, and regulations, there is still discussion and disagreement on how to harmonize technical requirements for scales used in the sale of *Cannabis* products. Two of the main discussion points among the stakeholders are the required value of the verification scale interval, e, and the use of an auxiliary indication.

This publication discusses the most important scale characteristics that play a role in the suitability of a weighing instrument used for the sale of *Cannabis* products.

Chapter 2 of this publication contains an objective, in-depth technical analysis of the most relevant characteristics of weighing instruments in relation to the weighing and sale of *Cannabis* products. These characteristics are the accuracy class (2.1), value of the verification scale interval (2.2), monetary value per scale division (2.3), auxiliary indications (2.4), and the minimum capacity and recommended minimum load (2.5).

Chapter 3 contains an analysis of real-world data collected by several State weights and measures jurisdictions regarding the use of an auxiliary indication.

Chapter 4 provides a summary of all discussed characteristics and the key takeaways of this publication.

2. Analysis of Relevant Scale Characteristics

NIST Handbook 44 [1] Section 2.20 Scales, UR.1. Selection Requirements lists several scale characteristics to consider when determining a scale's suitability for a given application. The most relevant aspects of scales used for the sale of *Cannabis* products are the accuracy class, the number of scale divisions, the minimum capacity (Min), and the verification scale interval. This section will discuss these characteristics in depth in relation to weighing *Cannabis* products. Other aspects of scales, not discussed in this publication, that may require consideration for the cannabis marketplace are operational considerations, such as the pan size, pan shape, and design for minimizing dust intrusion around the pan, and a draft shield. For more information, refer to NIST Handbook 44, Section 2.20, Scales, User Requirements regarding the selection, installation, use, and maintenance of scales.

A suitability aspect that is not explicitly mentioned in NIST Handbook 44 [1] is the monetary value per scale division or verification scale interval. Because *Cannabis* products are generally expensive, this aspect should be considered. Such a suitability criterion should be based on commercial considerations rather than the scale's meteorological capabilities.

In addition, this publication examines the benefits and drawbacks of an auxiliary indication in small-quantity weighing applications.

2.1. Accuracy Class and Number of Divisions

The performance of a scale is subject to a variety of influencing factors. Many of these factors, such as temperature, tilt, and warm-up effects, have linear effects on the measuring error. In other words, the error tends to be larger as the load on the scale increases. The relative accuracy of a weighing instrument can be expressed as a percentage of the load.

Note that the tolerances are expressed in verification scale intervals instead of percentages. The historical reason for this is unclear, but it is plausible that this approach was implemented because it made verification of instruments in the field easier. The consequence is that a scale's accuracy depends on the number of verification scale intervals. Figure 1 shows the maximum relative error of a Class II scale for a different number of verification scale intervals, such that the error still falls within the Class II tolerance.

Note: In many metrological standards (including OIML Recommendations), the tolerance is often referred to as Maximum Permissible Error (MPE).

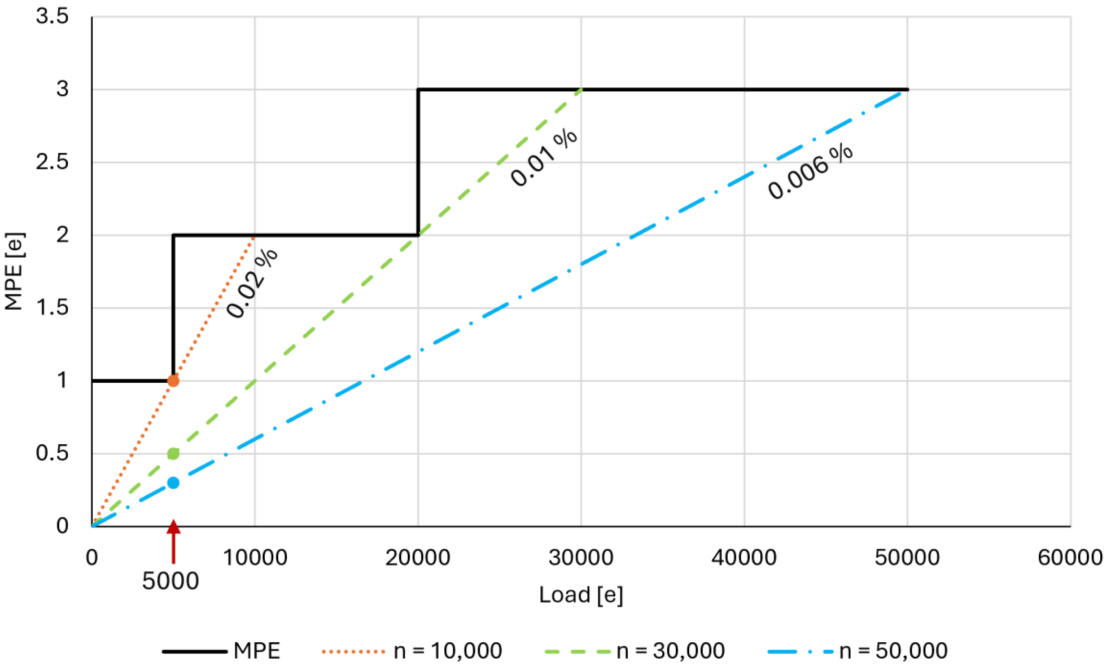

Figure 1: The maximum relative error of a Class II scale with 10,000, 30,000, and 50,000 verification scale intervals.

The plot in Figure 1 shows that, as the number of divisions increases, the relative error must decrease for the absolute error to remain within tolerance. For example, when the scale in Figure 1 has only 10,000 divisions, the absolute error at 5000 divisions (the first changeover point of the tolerance levels) can be as much as 1 e. When the scale has 30,000 divisions, the absolute error at 5000 divisions will be no more than 0.5 e. And when the scale has 50,000 divisions, the absolute error at 5000 divisions will be no more than 0.33 e.

Please note that the plot in Figure 1 does not depend on the size of the verification scale interval. Figure 2 shows the tolerances for four Class II scales with each 30,000 verification scale intervals. The four scales have different values for the verification scale intervals (e is 1 mg, 2 mg, 5 mg, and 10 mg). The tolerance at the maximum load (30,000 divisions) is 3 e in each case. As the plot shows, the relative error limit at the maximum load is identical in all four cases: 3 e/30,000 e = 0.01 %.

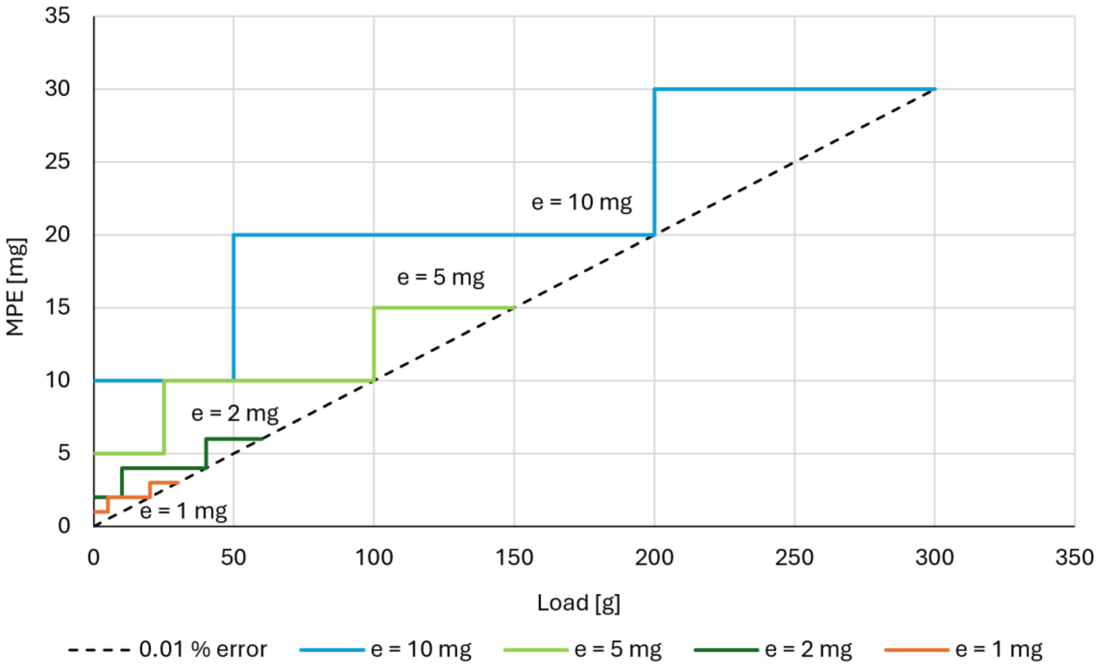

Figure 2: The tolerances of Class II scales with different verification scale intervals.

Figure 1 and Figure 2 show that the accuracy depends on the number of verification scale intervals, and not the size of the scale interval. The accuracy classes are, therefore, related to the number of verification scale intervals, with Class I offering the highest accuracy.

Note: See NIST Handbook 44, Section 2.20, Scales, Table 3, Parameters for Accuracy Classes for a complete overview of all accuracy classes.

Figure 3 below shows the typical relative error limit at the different change points of the tolerance (note that the relative error has a logarithmic scale).

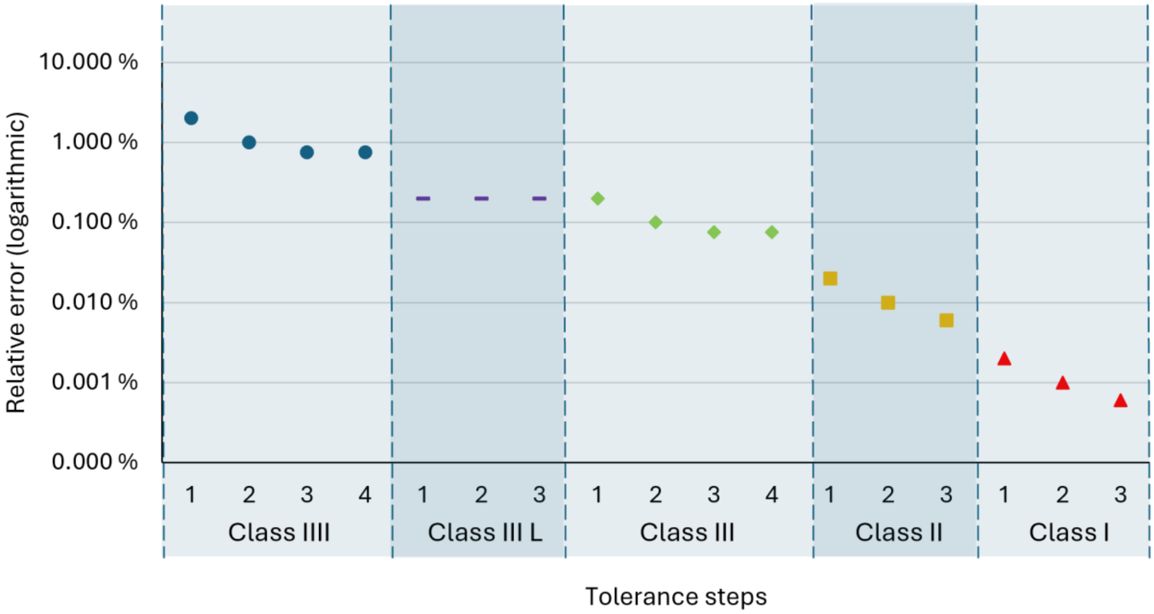

Figure 3: The relative inaccuracy of different accuracy classes at the tolerance steps for each class.

Note: Class III L may have up to 20 tolerance steps. Only three are plotted, as the relative error limit remains constant for this accuracy class.

Figure 3 shows that the estimated error limit of a Class I scale concentrates around 0.001 %, Class II around 0.01 %, Class III around 0.1 %, and Class IIII around 1 %. The tolerance steps of Class III L (1 e for every 500 divisions) have been designed such that the relative error limit is a constant 0.2 %.

See Table 1 below as adapted from Handbook 44. NIST Handbook 44 [1], Section 2.20 *Scales*, Table 7a, which assigns a typical accuracy class for a variety of applications.

Table 1. Typical Class or Type of Device for Weighing Applications according to Table 7a in NIST Handbook 44, Section 2.20.

Class	Approximate relative error	Weighing Application or Scale Type
I	0.001 %	Precision laboratory weighing
II	0.01 %	Laboratory weighing, precious metals and gem weighing, grain test scales
III	0.1 %	All commercial weighing not otherwise specified, grain test scales, retail precious metals and semi-precious gem weighing, grain-hopper scales, animal scales, postal scales, vehicle on-board weighing systems with a capacity less than or equal to 30,000 lb, and scales used to determine laundry charges
III L	0.2 %	Vehicle scales (including weigh-in-motion vehicle scales), vehicle on-board weighing systems with a capacity greater than 30,000 lb, axle-load scales, livestock scales, railway track scales, crane scales, and hopper (other than grain hopper) scales
IIII	1 %	Wheel-load weighers and portable axle-load weighers used for highway weight enforcement

Note: In practice, a scale with a higher accuracy class than that specified in Table 1 as "typical" may be used.

The above table indicates that Class III and Class II are typical for retail precious metals and semi-precious gem weighing. Commonly, the marketplace sees the applications for Class II scales due to the relatively high market value of these commodities. Since *Cannabis* products are also considered high-value commodities, there is a consensus among stakeholders that Class II is the most appropriate accuracy class for the retail sale of *Cannabis* products based on the classification in Table 1. However, the effect of air buoyancy and moisture variations suggests otherwise, as will be discussed in the next two paragraphs.

2.1.1. Air Buoyancy Effect

Unlike precious metals and gems, *Cannabis* has distinctively different physical properties that cannot be ignored. One of them is its density.

Every weighing result done under atmospheric conditions is subject to air buoyancy. Very similar to ships floating on water, there is an upward force on the object equal to the weight of the air displaced by the object. This upward force offsets the weighing results in the negative direction (i.e., resulting in a weight that is less than the object's actual mass).

The air buoyancy effect is more severe when the object's density approaches that of air. Stainless steel has a density of approximately 8000 mg/cm^3[2], while air has a density of approximately 1 mg/cm^3 [2]. For ordinary weighing operations, the upward force due to the displaced air is negligible compared to the weight of a steel object. However, the air buoyancy effect plays a significant role for less dense materials, like spices, herbs, and *Cannabis* buds.

Table 2 shows a list of spices and their densities obtained from the AVCalc online database, Aqua-Calc [3]. For example, the density of ground thyme is 290 mg/cm^3. With an upwards force of 1 mg/cm^3, 1 cm^3 of ground thyme leaves does not weigh 290 mg on a scale, but 289 mg: 1 mg less. This is a difference of 0.34 % compared to its actual mass.

Table 2. Reported density of several spices.

Commodity	Commodity ID	Density[a] [mg/cm^3]	Influence of 0.106 mg/cm^3 change in air density	Influence relative to Class II scale accuracy
ground cinnamon	100 % organic ground cinnamon, upc: 016291442139	650	0.016 %	1.6 x
	ground cinnamon, upc: 026662550882	410	0.026 %	2.6 x
ground black pepper	fine ground black pepper, upc: 016291441453	570	0.019 %	1.9 x
ground oregano	spices, oregano, dried (tsp, ground)	370	0.029 %	2.9 x
ground thyme	spices, thyme, dried (ground)	290	0.037 %	3.7 x
ground cumin	ground cumin, upc: 016291441200	810	0.013 %	1.3 x
	cumin ground, upc: 011150949804	410	0.026 %	2.6 x
onion powder	spice it!, onion powder, upc: 718343732112	810	0.013 %	1.3 x
	onion powder, upc: 096786600527	410	0.026 %	2.6 x
ground coriander	ground coriander, upc: 016291441866	410	0.026 %	2.6 x
	ground organic coriander, upc: 078742068589	490	0.022 %	2.2 x

Commodity	Commodity ID	Density[a] [mg/cm^3]	Influence of 0.106 mg/cm^3 change in air density	Influence relative to Class II scale accuracy
ground nutmeg	ground nutmeg, upc: 027229003070	410	0.026 %	2.6 x
	ground nutmeg, upc: 016291441323	570	0.019 %	1.9 x
garlic powder	garlic powder, upc: 855269003541	410	0.026 %	2.6 x
	100% pure garlic powder, upc: 608623000546	970	0.011 %	1.1 x

[a]The density values have been rounded to two significant figures

The tolerance of ordinary Class III scales for commerce lies in the order of 0.1 % (assuming 3 e tolerance at a range of 3000 verification scale intervals). That means that the air buoyancy effect on ground thyme is approximately 3.4 times the tolerance of a Class III scale.

It is impossible to avoid or compensate for the air buoyancy effect when weighing ordinary goods in the marketplace. Every weighment (and stakeholder) in the entire supply chain (from producer to retailer) is affected by air buoyancy. The question is whether all stakeholders are affected equally to guarantee equity in the market. To answer this question, the change in air buoyancy between the weighments should be considered instead of the absolute value of the air buoyancy effect.

In a cool, dry retail environment during a period of high pressure (20 °C/68 °F, 30 % relative humidity, and 1050 hPa), the density of air is 1.245 mg/cm^3 [4]. But in a slightly warmer and more humid retail environment during a period of low pressure (22 °C/72 °F, 50 % relative humidity, and 970 hPa), the density of air is 1.139 mg/cm^3 [4]. This is a difference of 0.106 mg/cm^3. The largest contributing factor to this variation is the air pressure, which, unlike indoor temperature and humidity, is an uncontrollable factor.

The error due to air buoyancy is determined by:

$$E = \rho_a V_c = \rho_a \frac{M_c}{\rho_c} = M_c \frac{\rho_a}{\rho_c}$$

Where ρ_a is the air density, V_c is the volume of the commodity, M_c is the mass of the commodity, and ρ_c.is the density of the commodity.

The value of this error is in a unit of mass. To analyze the influence of air buoyancy on a weighing result, it is more practical to use a relative error.

$$E_r = \frac{E}{M_c} \times 100\ \% = \frac{\rho_a}{\rho_c} \times 100\ \%$$

Where E_r is the relative error expressed as a percentage of M_c.

E_r is the relative error of a single weighing. To determine the influence of variation in the air density, the difference between the relative errors of two weighments must be considered.

$$\Delta E_r = \left(\frac{\rho_{a1}}{\rho_c} - \frac{\rho_{a2}}{\rho_c}\right) \times 100\ \% = \frac{\Delta\rho_a}{\rho_c} \times 100\ \%$$

Where $\Delta\rho_a$ is the difference between two air densities, ρ_{a1} and ρ_{a2}.

On the measurement of ground thyme, the change in environmental conditions would be 0.106 mg·cm^{-3} / 290 mg·cm^{-3} x 100 % = 0.037 %. Column 4 in Table 2 shows the relative variation in the weight indication due to a change in air density of 0.106 mg/cm^3 for all listed commodities.

The values shown in column 4 of Table 2 vary from 0.011 % to 0.037 %. These values are less than the accuracy of a Class III scale (0.1 %, see Figure 3). For these commodities, a Class III scale is considered suitable.

In general, many jurisdictions (nationally and internationally) require a Class II scale for the sale of *Cannabis* products. The accuracy of a Class II scale lies in the order of 0.01 % (see Figure 3). Compared to the accuracy of a Class II scale, the impact of the same variations is now 10 times larger than for the Class III scale. Column 5 in Table 2 shows the variation relative to the accuracy of a Class II scale. The smallest variation in the table (0.011 % for 100 % pure garlic powder, upc: 608623000546) is 1.1 times larger than the estimated accuracy of the scale. The largest variation (ground thyme) is 3.7 times the estimated accuracy.

Unfortunately, our office did not have access to a *Cannabis* sample to determine its density. The products included in Table 2 were chosen to demonstrate the effect air buoyancy has on low-density materials expected to be similar to *Cannabis*. It is reasonable to assume that the density of *Cannabis* lies within the same range as the spices listed in Table 2. That means that due to a change in air density of 0.106 mg/cm^3, the indication on the scale varies somewhere between 1.1 and 3.7 times the estimated accuracy of the scale. Figure 4 shows this variation alongside the Class II tolerance.

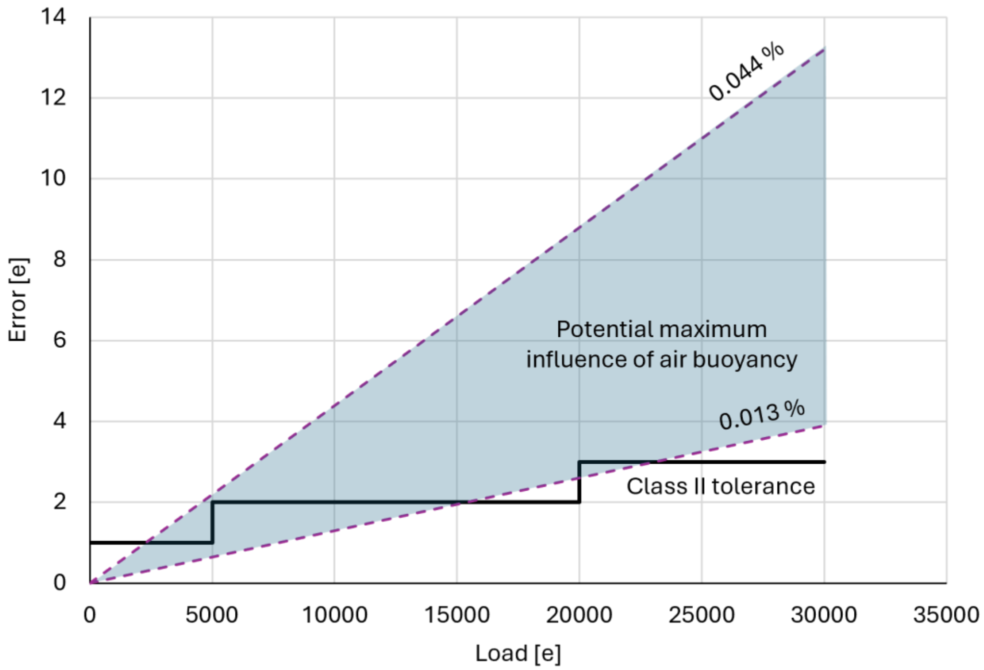

Figure 4: The potential maximum influence of air buoyancy compared to the Class II tolerance on the weighment of dried *Cannabis* buds.

The demonstration above of the possible influence of air buoyancy on weighing dried *Cannabis* buds uses several assumptions, such as the low and high air pressure values, and the density range of dried *Cannabis* buds. An in-depth analysis of the influence of air buoyancy goes beyond the scope of this report. The conclusion is that a significant effect of air buoyancy on the weighing of dried *Cannabis* buds cannot be ruled out and therefore the justification for requiring a Class II scale for weighing commodities such as dried *Cannabis* buds is debatable.

2.1.2. Moisture Loss/Gain

Another factor that plays an even bigger role than air buoyancy is the moisture content of dried *Cannabis*. A study by the State of Michigan Department of Agriculture and Rural Development [5] shows that the weight of dried *Cannabis* can change by several percent over several weeks, depending on the temperature, humidity, and storage method.

With the relative humidity varying between 15 % and 80 %, the average change in weight over a 12-week period can fluctuate in the order of ± 3 %. This is 300 times the accuracy of a Class II scale. Even without an in-depth study of the raw measurement data, the study clearly shows that the temperature and humidity have a significant influence on the weight of dried *Cannabis*.

There are multiple factors that affect the magnitude of this influence in a real-world situation, such as the maximum time between harvesting and sale of *Cannabis*, the storage and or packaging of the *Cannabis*, and the environmental conditions throughout the supply chain.

Nevertheless, a significant influence on the weight of *Cannabis* due to varying moisture levels cannot be ruled out. Therefore, the justification for requiring a Class II scale for weighing commodities such as dried *Cannabis* buds is debatable.

2.1.3. Conclusion

Most jurisdictions that allow the sale of *Cannabis* products (nationally and internationally) require a seller to use a Class II scale for weighing *Cannabis* products. This seems a logical choice, as Cannabis products are a high-value commodity and would therefore be treated the same as other high-value commodities, such as precious metals and gems. However, the advantage of higher accuracy of a Class II scale may be nullified by the effect of air buoyancy and moisture variations on the weighing result.

If the influence of air buoyancy and/or *Cannabis* moisture variations is deemed to have a significant effect on the weighing results, then the requirement for a Class III scale in the sale of dried Cannabis should be considered.

2.2. Value of the Verification Scale Interval

Within the NCWM, there is discussion on whether there should be a maximum value specified for the verification scale interval of scales used for the sale of *Cannabis* products. However, the current set of requirements in NIST Handbook 44 already sets such a limit.

The accuracy of a scale is determined by the accuracy class. It can be expressed as a percentage of the load, based on its fairly linear behavior. And although the relative accuracy of a scale is independent of the verification scale interval, e, the accuracy class does set a limit to the value of e for a scale.

For example, a Class II scale with a relative accuracy of 0.01 % would reach a 3 e tolerance limit at a load of 30,000 intervals, regardless of the value of e. The maximum number of verification scale intervals, designated by n_{max}, would therefore be 30,000. With a scale capacity (designated by *Max*) of 3 kg, the minimum value of the verification scale interval is therefore 3 kg/30,000 = 0.1 g.

For example, for a certain application, the maximum load (L_{max}) to be weighed is 3 kg. When weighing this load on a Class III scale with 3000 intervals (which is a typical number for this class), the verification scale interval would be 1 g. But when using a Class II scale with 30,000 intervals, the verification scale interval would be 0.1 g.

The number of intervals on a scale cannot exceed the maximum number for which it is certified (n_{max}). Therefore, the maximum number of intervals of a scale model, which relates to its classification, sets a lower limit for the verification scale interval:

$$e \geq \frac{L_{max}}{n_{max}} \tag{1}$$

The upper limit of the verification scale interval is determined by the minimum capacity (*Min*) of the scale (see 2.5 *Minimum Capacity*) and the smallest load that is to be weighed on the scale (L_{min}). The minimum capacity prevents the limited resolution of the weight indication from creating excessive uncertainty in the weighing result used in a transaction.

$$e \leq \frac{L_{min}}{Min} \tag{2}$$

Note: The minimum capacity and recommended minimum load are related and have (in most cases) the same value. The minimum capacity is defined as a characteristic of the scale, while the recommended minimum load is defined as a user requirement on the commodity to be weighed.

In practice, any scale where e is within these limits is deemed suitable with respect to the accuracy of the measurement. For a certain commodity, the range of e could vary depending on the capacity of the scale.

For example:

Assume two situations where a load of 1 kg of a certain commodity is being weighed on a Class III scale with 5000 verification scale intervals.

Situation 1 is at a wholesale company where the scale has a large capacity, and the 1 kg load is at the far low end of the weighing range. For Class III the minimum capacity is 20 e. Then the upper limit of the verification scale interval is:

$$e \leq \frac{L_{min}}{Min} = \frac{1\,kg}{20} = 50\ g$$

With e = 50 g and n = 5000, the capacity of this scale would be 250 kg.

In situation 2 a retail store has a scale with a small capacity, and the 1 kg load is at the upper end of the weighing range. Then the lower limit of the verification scale interval is:

$$e \geq \frac{Max}{n} = \frac{1\,kg}{5000} = 0.2\ g$$

These two extremes show that a 1 kg load of the same commodity can be weighed on a Class III scale with 5000 divisions, having a capacity ranging from 1 kg to 250 kg, and a verification scale interval ranging from 0.2 g to 50 g. In both extreme cases, the accuracy of the weighing result is deemed acceptable according to the specifications stated in NIST Handbook 44[1], Section 2.20 *Scales*, without any exceptions for high-value commodities like precious metals and gems.

In conclusion, the introduction of a requirement for a predefined verification scale interval for *Cannabis* products is arbitrary, and it indirectly conflicts with the NIST Handbook 44 published specification of the minimum capacity, the recommended minimum load, and their purpose.

2.3. Monetary Value per Scale Division

As explained in 2.2, *Value of the Verification Scale Interval*, the minimum capacity (and the recommended minimum load) places a maximum on the verification scale interval. This limitation is based on the uncertainty due to rounding of the measurement to the scale division. Another aspect that may place a maximum on the scale division is the price increment per division.

When weighing high-value commodities, the value of the scale division can have a significant impact on the total monetary cost. For example, for a commodity sold for \$15/g, a d = 0.1 g represents \$1.50, 10 % of the price. Although NIST Handbook 44 [1] does not pose any restrictions with respect to the maximum price increment per scale division; such a restriction may be considered when determining the suitability of a weighing instrument used for the sale of *Cannabis* products.

The following equation can be used to determine the desired scale division based on the minimum monetary value per division:

$$d \times up \leq mmvpd$$

$$d \leq \frac{mmvpd}{up} \tag{3}$$

Where *d* is the scale division, *up* is the unit price of the commodity, and *mmvpd* is the minimum monetary value per division.

For example, when the price of a commodity is \$5 per gram, and the minimum monetary value per division that is desired is \$0.02, then the maximum scale division of the weighing instrument is:

$$d \leq \frac{\$0.02}{\$5/g}$$

$$d \leq \ 0.004\ g$$

After rounding to an appropriate value for the scale division (scales are permitted divisions of 1, 2, or 5 x 10^k [1]):

$$d \leq \ 0.002\ g$$

Note: Please note that in paragraph 2.2 the minimum capacity (Min) limits the verification scale interval, e, because Min is related to the minimum recommended load, which is, according to NIST Handbook 44, section 2.20 *Scales*, Table 8 expressed in e. However, Eq. (3) relates to the minimum increment of the indicated weighing result, thus the scale division, d.

Achieving a desired minimum value for the monetary value per division limits the scale division regardless of the scale's accuracy. Since the accuracy of the scale does not play a role, the use of an auxiliary indication is a viable option to increase the resolution of the weight indication and achieve the desired minimum value for the monetary value per division.

Note: To determine the suitability of an auxiliary indication, other aspects besides the minimum value for the monetary value per division need to be considered. See also paragraph 2.4.

It is up to the local jurisdiction to determine an appropriate minimum value for the monetary value per division for a certain commodity, since NIST Handbook 44 [1] does not prescribe any minimum value. Currently, the discussion of a minimum monetary value per division is focusing on the sale of *Cannabis* products. However, when setting such limitations, it is recommended to consider other high-value commodities, such as gold, silver, saffron, and premium tea brands, to ensure equity in the sale of different types of commodities.

An additional factor that may influence the decision on the minimum monetary value per division is the November 12, 2025, production cessation of the one-cent coin in the U.S. As a result, many cash transactions are now rounded to \$0.05. Therefore, a minimum monetary value per division of no less than \$0.05 may be most appropriate.

In conclusion, if a limitation of the scale division is deemed necessary due to a large increment in the transaction price per scale division, then a general specification should be considered over an arbitrary limitation for a single commodity.

2.4. Auxiliary Indication

On scales without an auxiliary indication (e.g., the Class III scales that can be found in grocery stores), the scale division, d, equals the verification scale interval, e. The verification scale interval determines the scale's tolerance and is therefore an indication of its accuracy.

Unlike Class III scales, Class I and Class II scales may be equipped with an auxiliary indication. In most cases, this is in the form of an extra digit in the indication. Such an additional digit does not increase the scale's accuracy. To avoid any confusion about the accuracy, the additional digit must be differentiated from the other digits in the indication.

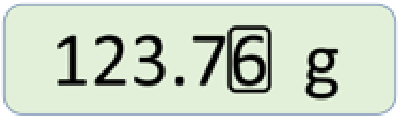

Figure 5: Example of an auxiliary indication in the form of a differentiated scale division.

The use of an auxiliary indication may not be very beneficial in the upper part of the weighing range since the inaccuracy of the scale plays a larger role in that part of the weighing range. But at the low end, the resolution plays a bigger role than the accuracy of the scale (see paragraph 2.5.2). By adding an additional digit, the uncertainty due to the resolution of the indication is reduced. For example, on a scale with a verification scale interval of 0.1 g, the uncertainty due to the display resolution is 0.05 g. With an additional digit (0.01 g), the uncertainty is reduced to 0.005 g.

Whether an auxiliary indication should be allowed in commercial transactions is a different discussion. The use of a scale with an auxiliary indication for commercial transactions to the general public may cause confusion among consumers about the exact meaning of the differentiated scale division and the accuracy of the scale. Therefore, Class III and Class IIII scales are not allowed to be equipped with an auxiliary indication.

Class I and Class II scales are mostly used in a laboratory environment and operated by trained users. For the sale of precious goods, such as gold, silver, and *Cannabis* products, a Class II scale is generally preferred (or even mandated) due to its higher accuracy. That means that these scales are now used for sales to the general public. Many countries, as well as the International Organization of Legal Metrology (OIML) Recommendation for scales, require that the auxiliary indication be disabled (i.e., no additional differentiated scale division) when a Class II scale is used for direct sales to the public. NIST Handbook 44 [1], Section 2.20 *Scales* does not contain such a limitation.

As will be explained in paragraph 2.5.2, the uncertainty of the weighing result due to the display resolution is reduced when the scale is equipped with an auxiliary indication. This is mainly effective at the low end of the weighing range where the measuring error of the weighing itself is less than the uncertainty due to the indication's resolution.

In conclusion, whether an auxiliary indication should be allowed on scales used for the sale of *Cannabis* products is a decision between the considerations for a smaller uncertainty due to a higher resolution, or avoiding confusion among consumers about the meaning of the differentiated scale division.

Such a decision will be based primarily on arguments justifying the prohibition of an auxiliary indication. Such arguments fall outside the scope of this publication and may vary by jurisdiction.

2.5. Minimum Capacity and Recommended Minimum Load

In *Cannabis* retail stores, *Cannabis* is sold in small quantities (e.g., 5 g). It is to be expected that many of the scales used for the sale of *Cannabis* products are used at the low end of their weighing range. When weighing relatively small loads, the minimum capacity and recommended minimum load should be taken into consideration.

The minimum capacity and the recommended minimum load have the same objective but have slightly different meanings. The minimum capacity is a specification of the weighing instrument, while the recommended minimum load is a user requirement. Both suggest that the instrument should not be used below certain values to reduce the risk of relatively large errors.

In NIST Handbook 44, Section 2.20. *Scales*, the minimum capacity of a scale (often denoted as Min) is referred to in UR.1. *Selection Requirements*, but that is the only reference to this term in section 2.20, and no value for the minimum capacity is specified. The recommendation not to use the scale for relatively small loads can be found in NIST Handbook 44, Section 2.20 *Scales*, UR.3.1. *Recommended Minimum Load*, which references Table 8 in that same Section to determine the value of the minimum load, based on the accuracy class and value of the verification scale interval. The reason for the specification of a minimum capacity is the uncertainty due to rounding of the indicated weighing result.

Note: Table 8 in NIST Handbook 44 currently specifies that the recommended minimum load be determined by d when e = d, and e when d < e. In the NCWM, there is ongoing discussion whether the recommended minimum load should be expressed in terms of e or d (as is the case in OIML Recommendations). Because the Scales Code effectively requires the recommended minimum load to be based on e, that is the value referred to in this publication.

2.5.1. Uncertainty Due to Rounding

NIST Handbook 44 [1] defines minimum capacity as: “The smallest load that may be accurately weighed. The weighing results may be subject to excessive error if used below this value.” This definition is deceiving, as the term ‘error’ is in metrology normally used as the deviation of the measurement. The ”relatively large errors” associated with “the use of a device to weigh light loads”, as described in UR.3.1., are due to the rounding of the scale division, d. Thus, the uncertainty of an indication is ± 0.5 d. The actual measured weight value lies somewhere between the indicated value − 0.5 d and the indicated value + 0.5 d. Note that this uncertainty represents the difference between the indicated value and the actual measured value (sometimes referred to as the internal weight value). This has nothing to do with the accuracy of the scale, which is the difference between the actual measured value and the actual load on the scale. Indication uncertainty and the scale accuracy are two separate aspects and should not be confused.

Suppose a scale with a 1 g scale division indicates a weight value of 1016 g (a relatively large load). Then the relative uncertainty due to rounding is ± 0.5 g/1016 g = ± 0.049 %. However, if the load on the scale is relatively light, for example, 6 g, then the relative uncertainty of the indication is ± 0.5 g/6 g = ± 8.3 %. For expensive products like *Cannabis*, ± 8.3 % could be a substantial Dollar amount.

The recommended minimum load for Class II scales is shown in Table 3 below. The scale is deemed suitable for loads that exceed or are equal to these values.

Table 3. Recommended minimum load and relative rounding uncertainty for class II scales.

Verification scale interval e	Recommended Minimum Load	Relative rounding uncertainty (if d = e)
e < 0.1 g	20 e	2.5 % (± 0.5 e/20 e)
e ≥ 0.1 g	50 e	1 % (± 0.5 e/50 e)

The uncertainty due to rounding of the indication has nothing to do with how accurately the scale measures the load applied. In other words, the accuracy of the scale does not change if the indication is extended with an extra digit. An extra digit does, however, reduce the uncertainty of the indication due to rounding.

2.5.2. Scale Accuracy Below the Recommended Minimum Load

The specification of a minimum capacity or recommended minimum load is a result of limiting the uncertainty of the weighing result due to the rounding of the indication. The accuracy of the measurement does not play a role.

The uncertainty of a weighing result is a combination of the error in the actual weighment (accuracy of the scale) and the resolution of the indication.

$$u_t = \sqrt{u_w^2 + u_r^2} \tag{4}$$

Where u_t is the total uncertainty of the weighing result, u_w is the uncertainty due to the inaccuracy of the weighment, and u_r is the uncertainty due to the resolution of the indication.

The uncertainty due to the resolution of the indication is half a scale division, 0.5 d. The uncertainty due to the inaccuracy of the weighment is not as straightforward.

Because the scale is approved for commercial use it complies with the specifications and tolerances in NIST Handbook 44 [1]. The error at the lower end of the weighing range will therefore be somewhere between − 1 e and + 1 e. When not taking any other factors into account, it is justified to set the uncertainty of the weighment to 1 e. In many discussions within the legal metrology community, the argument is made that the error of the scale at the low end of the weighing range could be as much as 1 e. This argument is based on the maximum permissible error.

However, when considering the actual performance of a scale, it can be concluded that an error of 1 e is not realistic. Figure 6 shows a more realistic error and tolerance of a Class II scale with 30,000 verification scale intervals. Assuming that the scale is approved for commercial use and that the error is linear, the error of a weighment will fall somewhere in the shaded area of the plot.

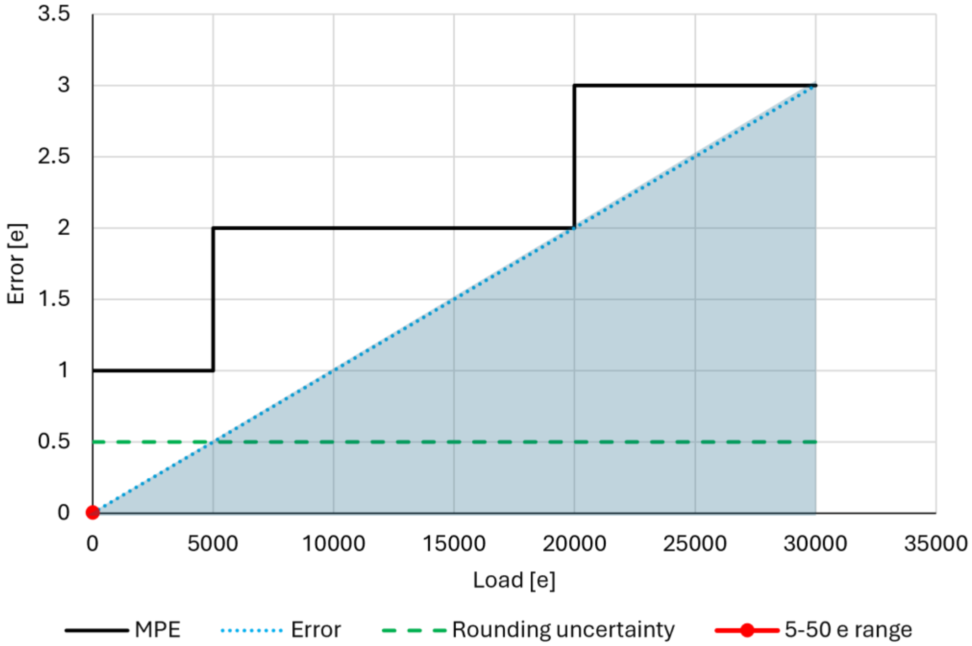

Figure 6: The maximum error, tolerance, and rounding uncertainty of a Class II scale.

Currently, the recommended load for a Class II scale with a verification scale interval, e, of 0.1 g is equal to 50 e. The main question is whether it is justified to express the recommended minimum load in scale divisions, d. Therefore, the focus of the discussion is the range below 50 e. This particular range is marked in Figure 6 with the red 'line'. However, since 50 e is so close to the zero point of the scale compared to the rest of the weighing range, the red line is plotted as a red dot practically on top of zero.

The error at 50 e for the plot in Figure 6 can be estimated at:

$$E_{50e} = \frac{3\ e}{30{,}000\ e} \times 50\ e$$

$$E_{50e} = 0.005\ e \tag{5}$$

That means that the uncertainty (expected error) of the weighment, u_w, in Eq. (4), can be reduced from 1 e to 0.005 e and is negligible compared to the uncertainty due to the display resolution, u_r, of 0.5 e. The total uncertainty of the weighing result is therefore determined by the display resolution.

2.5.3. Conclusion

The specification of a minimum capacity or recommended minimum load is a result of limiting the uncertainty of the weighing result due to the rounding of the indication. The accuracy of the measurement does not play a role.

This provides grounds for expressing the minimum capacity or the recommended minimum load in scale divisions, d, instead of verification scale intervals, e.

3. Auxiliary Indication Experiment

Within the weights and measures community, there is a discussion about the suitability of an auxiliary indication on scales used for the sale of *Cannabis* products. Paragraph 2.5.2 explains that when a scale is equipped with an auxiliary indication, it is agreeable to express the minimum capacity in scale divisions, d, instead of the verification scale interval, e. That would lower the minimum capacity accordingly.

For example, for a Class II scale where d = e = 0.1 g, the minimum load is 50 e, which equals 5 g. When the scale division, d, is one-tenth of the verification scale interval e (i.e., d = 0.01 g), paragraph 3.3.2 provides a minimum load of 50 d, which equals 0.5 g.

However, a minimum capacity expressed in d would also allow selecting a scale with the same minimum capacity but with a larger scale capacity or fewer verification scale intervals.

For example, assume the scale mentioned in the previous example has 30,000 verification scale intervals (thus a capacity of 3000 g with e = 0.1 g). Without an auxiliary indication (d = e), the minimum capacity equals 5 g. When using a scale with an auxiliary indication where d is one-tenth of e, while keeping d at 0.1 g and thus the same 5 g minimum capacity, the verification scale interval has now increased to e = 1 g. With the same number of divisions (30,000), the scale's capacity is now increased to 30,000 g (30 kg), which is often regarded as too large for weighing 'smaller' loads. Or, the scale could have fewer divisions (e.g., 5000), which is often regarded as a lower 'quality'.

To determine whether a scale is suitable for a certain load, subjective conclusions and emotions should be avoided. A relatively large capacity or a lower quality does not necessarily mean that the scale is not suitable. Based on the requirements in NIST Handbook 44 [1], a scale is deemed suitable if the load exceeds the scale's minimum capacity and if the scale's error falls within tolerance.

To provide some objective technical guidance based on real-world data, the NIST Office of Weights and Measures conducted an experiment in 2025, aiming to bring some clarity to the discussion. Weights and measures jurisdictions in multiple states were asked to collect data on scales that are used for the sale of *Cannabis* products.

3.1. Design of Experiment

A request was sent to 23 State weights and measures jurisdictions where the sale of *Cannabis* products has been legalized to collect the following information on scales used at retail that were inspected:

- The last 4 digits of the scale's serial number (as ID of the data set)
- The value of the verification scale interval, e
- The value of the scale division, d
- The scale's capacity
- The scale's indication at 1 g, 50 g, 100 g, and at the scale's capacity

Although the focus of the experiment was the scale indications at 1 g, indications at additional loads (including at the scale capacity) were requested to get information about the scale's linearity and adjustment.

As mentioned in the introduction, the main question among stakeholders is whether a scale (Scale type 2 in Table 4) with d = 0.01 g (and e = 0.1 g) is just as suitable as a scale (Scale type 1 in Table 4) where e = 0.01 g. In both cases, the scales are of accuracy class II, and the scale division, d, is 0.01 g

The recommended minimum loads for these scales are:

Table 4. Verification scale interval and recommended minimum load of two types of Class II scales.

Scale type	**Verification scale interval**	**Scale division**	**Recommended minimum load**
1	e = 0.01 g	d = e = 0.01 g	0.2 g (20 e)
2	e = 0.1 g	d = 0.01 g (auxiliary indication)	5 g (50 e)

If the suitability of the scales is determined by the recommended minimum load (not taking into account the price per scale division), then the following situations are of interest:

Table 5. Suitability of Scale 1 and Scale 2 for three consecutive load situations.

Situation	**Load, L**	**Scale 1 (RML[a] = 0.2 g)**	**Scale 2 (RML[a] = 5 g)**
A	L < 0.2 g	Not suitable	Not suitable
B	0.2 g ≤ L < 5 g	Suitable	Not suitable
C	L ≥ 5 g	Suitable	Suitable

[a] Recommended Minimum Load

In situation A, the load is too small to be weighed on both Scale type 1 and Scale type 2. Neither scale is recommended for use to weigh loads under 0.2 g.

In situation C, the load exceeds the recommended minimum load of both Scale type 1 and Scale type 2. If the values for the recommended minimum load on a Class II scale are deemed acceptable as prescribed in NIST Handbook 44 [1], Section 2.20, *Scales*, Table 8, *Recommended Minimum Load*, then this becomes irrelevant.

Note: Whether the defined values for the recommended minimum load are justified is not part of the discussion in this publication. Nor is the question whether the use of an auxiliary indication can or should be used in direct sales to the public (or any commercial transaction).

The only situation in which the difference in characteristics between Scale type 1 and Scale type 2 affects suitability is for a load between 0.2 g and 5 g (Situation B). This situation is the focus of this publication. Also, many of the transactions involving *Cannabis* products being sold in retail lie in the same order of magnitude. A 1 g test load was chosen to compare the instruments described by Scale type 1 and Scale type 2 in this experiment.

3.2. Results

Through the experiment, inspection results of 189 scales used at retail for the sale of *Cannabis* products were collected from 9 states. Data collected from 172 scales have been used for the analysis. The data from the remaining 17 scales were unsuitable due to concerns about the data collection process.

Appendix A contains the raw data received from the participating states, excluding the partial serial numbers. This data is divided into two groups. The first group, Group Alpha (Table 8), is data received from scales where e = 0.01 g. For this data set, the maintenance tolerance for a 1 g load is 0.01 g. The second group, Group Beta (Table 9), is data received from scales where e = 0.1 g and d = 0.01 g. For this group of data, the maintenance tolerance for a 1 g load is 0.1 g, which is ten times larger than the tolerance for Group Alpha.

The evaluation is performed by comparing the scale errors between the two groups. Since the question is whether a scale with e = 0.1 g and d = 0.01 g is just as suitable as a scale with e = 0.01 g without an auxiliary indication, the errors of both groups are expressed as multiples of 0.01 g (which is the tolerance at 1 g on a scale with e = 0.01 g).

Group Alpha contains data from 44 scales. Please note that the data in Table 8 includes both scales with and without an auxiliary indication. The reason for this is that the auxiliary indication can often be disabled without affecting the accuracy of the measurement. Whether the scales in Group Alpha have an auxiliary indication or not, their verification scale interval is 0.01 g. The remaining 128 scales (Group Beta) have a verification scale interval, e, of 0.1 g and a scale division, d, of 0.01 g.

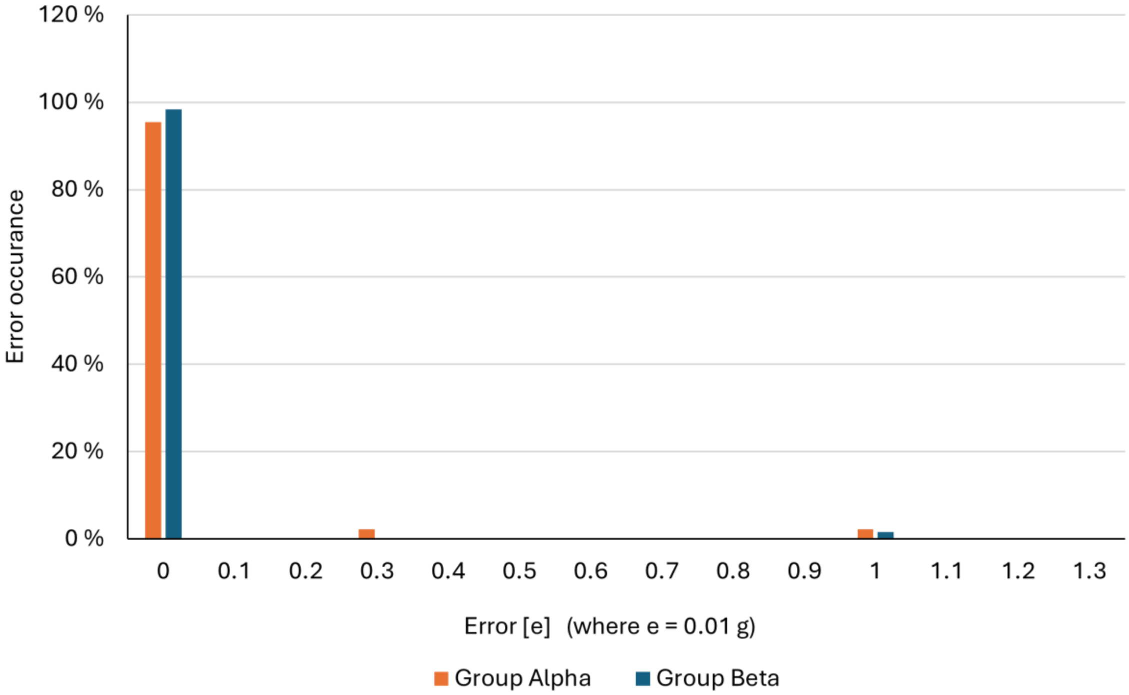

Figure 7: Percentage of errors in Group Alpha and Group Beta per magnitude of the error expressed in fractions of 0.01 g (0.1 = 0.001 g/1 = 0.01 g).

The vast majority of the indications at 1 g show a zero deviation from the 1 g test load. In both groups, only two scales show a deviation other than 0. Therefore, the magnitude of the deviations (errors) does not provide enough statistical information to answer the question of this experiment

Also, Group Alpha contains both scales with a 0.01 g resolution and scales with a 0.001 g resolution. Because of the difference in resolution of these two subgroups, it is impossible to say anything about the magnitude of the errors in this group.

It is therefore more useful to examine the number of errors observed than to consider the magnitude of the errors observed.

One of the errors observed in Group Alpha (number 24 in Table 8) has a magnitude of 0.003 g. If the scale was configured to have no auxiliary indication (d = e = 0.01 g), the indication would have been rounded down to 0.00 g. Therefore, the observed error of 0.003 g in Group Alpha will be treated as a non-error, resulting in a single error for the entire Group Alpha.

Table 6. Overview of the measurands of the experiment.

Group	**Alpha**	**Beta**
Verification scale interval and scale division	e = 0.01 g	e = 0.1 g, d = 0.01 g
Scales examined	44	128
Number of error values outside the tolerance	0	0
Number of non-zero error values	1[a]	2
Error rate	2.27 %	1.56 %

[a] Scale 24 in Group Alpha (see Table 8 in Appendix A) would indicate 1.00 g at the load of 1 g if it were configured with a scale division of 0.01 g. This indication is, therefore, considered to have no error

3.3. Analysis

Since there are two mutually exclusive outcomes, either an error occurred or an error did not occur, the error rate can be treated as a binomial proportion. Specifically, we define p1 as the probability of an error for Group Alpha and p2 as the probability of an error for Group Beta. The question of interest is whether p1 = p2, which can be alternatively defined as p1 – p2 = 0. For this data, p1 – p2 = 2.27 % – 1.56 % = 0.71 %.

Table 7 gives confidence intervals for the difference of proportions (p1 – p2) based on the Agresti-Caffo method [6]. Since the confidence intervals contain zero (the result we would expect if the scales performed equally well), we can conclude that the difference in proportions for the two groups is not statistically significant. In other words, the observed difference is not large enough to prove a difference between the scales in Group Alpha and the scales in Group Beta:

Table 7. Upper and lower limit of the difference in percentage error rate at different confidence levels based on the Agresti-Caffo method for establishing the difference of proportion confidence limits.

Confidence level	**Lower limit**	**Upper limit**
90 %	− 3.36 %	7.44 %
95 %	− 4.39 %	8.47 %
99 %	− 6.42 %	10.50 %

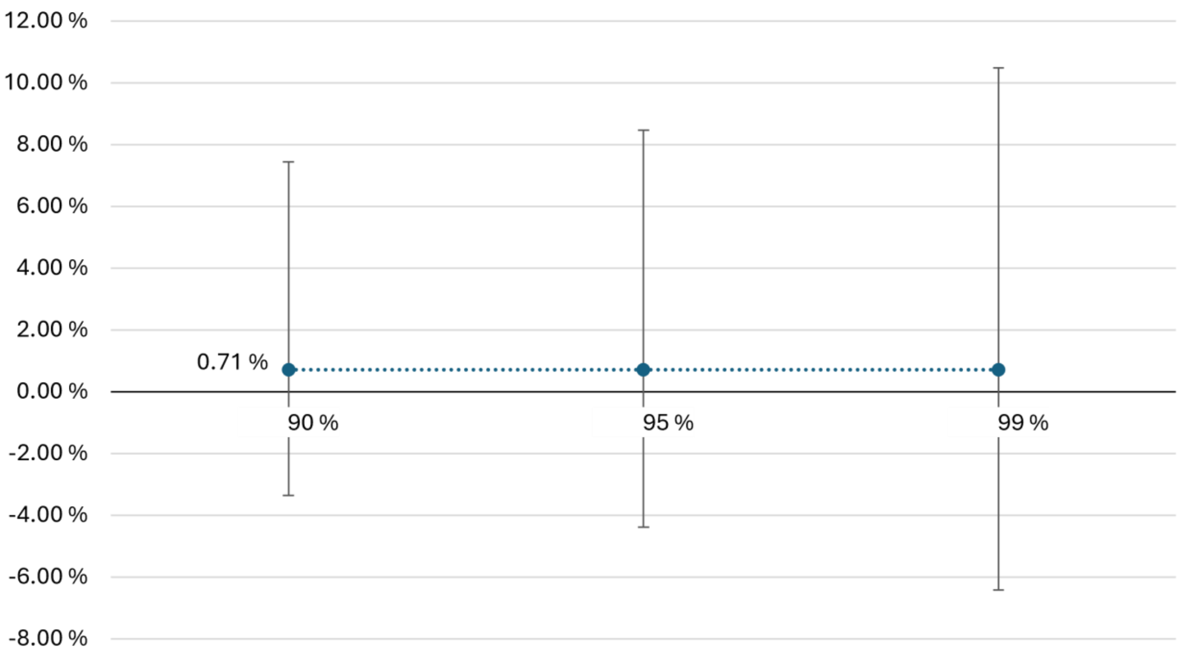

Figure 8: Graphical representation of the confidence intervals in Table 7.

To make a statement about the suitability of the scales in Group Beta compared to Group Alpha, the following conclusions can be deduced from the results in Table 8 and Table 9:

1. None of the scales in either group indicated an error at a 1 g load that is outside the tolerance.
2. Because the case where the percentage error rates of both groups are identical (difference is 0 %) and falls within the confidence intervals from Figure 8, the results can be interpreted as there is no statistically significant difference in the performances between the two groups

3.4. Conclusion of the Experiment

The analysis indicates that at a 1 g load, there is no statistically significant difference in performance between scales with a verification scale interval of 0.1 g and an auxiliary indication of 0.01 g, and scales with a verification scale interval of 0.01 g without an auxiliary indication.

It supports the conclusion in paragraph 2.5.2 that it is technically justified to express the minimum capacity (and the recommended minimum load) in units of the scale division, d.

4. Summary

Below is a summary of the key takeaways:

1. Chapter 2 discusses the five most relevant characteristics of scales used for the sale of *Cannabis* products. Paragraph 2.1 discusses the accuracy class as a measure of a weighing instrument's relative accuracy. Most jurisdictions require an accuracy Class II for instruments used for the sale of *Cannabis*. Considerations for necessity for Class II scale use include air buoyancy effects and effect of the varying moisture levels in *Cannabis*.
2. Paragraph 2.2 discusses the lower and upper limits for the verification scale interval determined by the minimum and maximum load to be weighed on the scale, its maximum number of divisions, and the

recommended minimum load for the scale's accuracy class. Whenever the verification scale interval falls within these limits, it is deemed suitable according to the current principles in NIST Handbook 44. There is no technical reason to deviate from these principles.

3. Paragraph 2.3 discusses the monetary increment size per scale division. This characteristic is not a technical aspect and is not subject to any requirements in NIST Handbook 44. It is not a characteristic of the scale and highly depends on the value of the commodity being weighed.
4. The use of an auxiliary indication (a differentiated extra digit) may be beneficial to obtain a higher resolution of the weight indication, as discussed in paragraph 2.4. It minimizes uncertainty in the weighing result due to rounding and reduces the monetary increment per scale division. Additionally, the extra digit of an auxiliary indication is required to be differentiated from the other digits. This may confuse the consumer about why the last digit is displayed differently from the other digits. The decision of whether to allow or forbid the use of auxiliary indications is a non-technical one.
5. Paragraph 2.5 discusses the minimum capacity and the minimum recommended load. The minimum capacity is a scale characteristic, while the recommended minimum load is a user requirement. These parameters set an upper limit on the verification scale interval and are intended to limit uncertainty in the weighing result caused by rounding of the weight indication. The accuracy of the measurement itself is irrelevant in this context. Auxiliary indications provide an additional digit in the indication of the weighing result, reducing the uncertainty due to rounding of the indication.
6. Chapter 3 discusses a 2025 experiment conducted by the NIST Office of Weights and Measures, which collected measurement data from 172 scales across 9 US states used for the sale of *Cannabis*. The scales have been divided into 2 groups: one group of scales without an auxiliary indication, where $e = d = 0.01$ g, and a second group of scales with an auxiliary indication, where $e = 0.1$ g and $d = 0.01$ g. The experiment aimed to investigate whether there is a difference in performance between the two groups. A statistical analysis of the collected data showed that there is no significant difference in performance between these two groups.

References

[1] Chavez Baucom I, Benham E, Konijnenburg J, Lee G, Lippa K, McGuire J, Minnich L, Williams J (2026) Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices. https://doi.org/10.6028/NIST.HB.44-2026

[2] OIML (2004) OIML D 28 - Conventional value of the result of weighing in air. Available at https://www.oiml.org/en/publications/documents/publication_view?p_type=2&p_status=1

[3] AVCalc LLC Aqua-Calc. Available at https://www.aqua-calc.com/page/density-table

[4] Picard A, Davis RS, Gläser M, Fujii K (2008) Revised formula for the density of moist air (CIPM-2007). *Metrologia* 45(2):149. https://doi.org/10.1088/0026-1394/45/2/004

[5] Sabat M, Michigan Department of Agriculture and Rural Development Cannabis Moisture Study. Available at https://cdn.ncwm.com/userfiles/files/Meetings/Annual/Pub%2016%20Archive/2024/LR%20Supporting%20Files/NET-22_1-MI%20Cannabis%20Moisture%20Study-2024-05-08.pdf

[6] Agresti A, Caffo B (2000) Simple and Effective Confidence Intervals for Proportions and Differences of Proportions Result from Adding Two Successes and Two Failures. *The American Statistician* 54(4):280–288. https://doi.org/10.1080/00031305.2000.10474560

Appendix A. Survey Data

Table 8. Group Alpha: e = 0.01 g.

No.	Capacity [g]	e [g]	d [g]	Indication L = 1 g	Indication L = 50 g	Indication L = 100 g	Indication L = capacity
1	2000	0.01	0.01	1.00	50.00	99.99	1999.95
2	2000	0.01	0.01	1.00	49.99	99.99	2000.54
3	420	0.01	0.01	1.00	50.00	100.00	420.01
4	220	0.01	0.01	1.00	50.00	100.00	219.99
5	320	0.01	0.01	0.99	49.99	99.99	319.99
6	120	0.01	0.01	1.00	50.01	100.02	120.02
7	320	0.01	0.01	1.00	49.99	99.98	319.98
8	520	0.01	0.01	1.00	50.00	100.00	519.99
9	120	0.01	0.01	1.00	49.99	99.98	99.98
10	120	0.01	0.01	1.00	50.00	99.99	119.98
11	120	0.01	0.01	1.00	49.99	99.98	119.98
12	320	0.01	0.001	1.000	50.000	100.000	320.000
13	3200	0.01	0.001	1.000	50.000	100.000	3200.000
14	122	0.01	0.001	1.000	-	-	122.000
15	320	0.01	0.001	1.000	-	99.990	319.990
16	320	0.01	0.001	1.000	-	100.000	319.990
17	320	0.01	0.001	1.000	49.990	99.990	319.950
18	320	0.01	0.001	1.000	49.990	99.990	319.980
19	320	0.01	0.001	1.000	50.000	99.998	319.998
20	320	0.01	0.001	1.000	49.999	100.000	320.002
21	320	0.01	0.001	1.000	49.999	100.000	319.992
22	320	0.01	0.001	1.000	50.002	100.004	320.016
23	320	0.01	0.001	1.000	50.000	100.001	320.003
24	320	0.01	0.001	1.003	50.001	100.013	320.017
25	320	0.01	0.001	1.000	50.000	99.998	319.998
26	320	0.01	0.001	1.000	50.000	100.001	320.002
27	320	0.01	0.001	1.000	50.000	99.999	319.993
28	320	0.01	0.001	1.000	50.000	100.000	320.008
29	320	0.01	0.001	1.000	49.980	99.970	319.980
30	620	0.01	0.001	1.000	50.000	100.000	620.000
31	320	0.01	0.001	1.000	50.000	100.000	319.990
32	320	0.01	0.001	1.000	49.980	99.970	319.980
33	320	0.01	0.001	1.000	49.990	99.990	319.970
34	320	0.01	0.001	1.000	50.000	100.000	320.000
35	320	0.01	0.001	1.000	49.990	99.980	-
36	320	0.01	0.001	1.000	49.990	99.980	-
37	320	0.01	0.001	1.000	49.990	99.980	-
38	320	0.01	0.001	1.000	49.980	99.960	-
39	320	0.01	0.001	1.000	49.990	99.980	-
40	320	0.01	0.001	1.000	49.980	99.960	-
41	320	0.01	0.001	1.000	50.000	100.000	-
42	320	0.01	0.001	1.000	49.990	99.990	-
43	320	0.01	0.001	1.000	50.000	100.000	-
44	320	0.01	0.001	1.000	50.010	100.020	-

Note: Since there are only a small number (11) of scales with e = d = 0.01 g, scales with e = 0.01 g and d = 0.001 g are also included. The rationale is that in theory, these scales can be configured such that d = e = 0.01 g without affecting their accuracy.

Table 9. Group Beta: d = 0.01 g, e = 0.1 g.

No.	Capacity [g]	e [g]	d [g]	Indication L = 1 g	Indication L = 50 g	Indication L = 100 g	Indication L = capacity
1	1200	0.1	0.01	1.00	50.00	99.90	1199.80
2	1500	0.1	0.01	1.00	50.00	99.99	1499.80
3	1500	0.1	0.01	1.00	50.00	100.00	1499.90
4	1500	0.1	0.01	1.00	50.00	100.00	1499.80
5	1500	0.1	0.01	1.00	50.00	100.00	1499.90
6	1500	0.1	0.01	1.00	50.00	100.00	1500.00
7	1500	0.1	0.01	1.00	50.00	100.00	1499.80
8	1500	0.1	0.01	1.00	50.00	100.00	1500.00
9	1200	0.1	0.01	1.00	49.99	-	1199.80
10	1220	0.1	0.01	1.00	50.00	-	1219.98
11	2200	0.1	0.01	1.00	49.99	99.90	2199.69
12	1500	0.1	0.01	1.00	49.99	99.98	1499.83
13	1500	0.1	0.01	1.00	50.00	100.00	1499.90
14	6200	0.1	0.01	1.00	50.00	100.00	6199.70
15	2200	0.1	0.01	1.00	50.00	100.00	2199.89
16	2200	0.1	0.01	1.00	50.00	100.00	2199.69
17	6200	0.1	0.01	1.00	50.00	100.00	6199.70
18	6200	0.1	0.01	1.00	50.00	100.00	6199.70
19	2200	0.1	0.01	1.00	50.00	100.00	2200.00
20	6200	0.1	0.01	1.00	50.00	100.00	5072.00
21	2200	0.1	0.01	1.00	50.00	100.00	2199.69
22	2200	0.1	0.01	1.00	50.00	100.00	2199.89
23	2200	0.1	0.01	1.00	50.00	100.00	2200.00
24	6200	0.1	0.01	1.00	50.00	100.00	6204.00
25	2200	0.1	0.01	1.00	50.00	100.00	2200.10
26	1500	0.1	0.01	1.00	49.99	99.99	1500.01
27	1500	0.1	0.01	1.00	50.00	100.00	1499.94
28	1500	0.1	0.01	1.00	49.99	99.98	1499.97
29	5200	0.1	0.01	1.00	50.01	100.01	5200.01
30	5000	0.1	0.01	1.00	50.00	100.00	5000.00
31	1500	0.1	0.01	1.01	50.02	100.02	1500.02
32	1500	0.1	0.01	1.00	50.00	100.00	1499.88
33	1500	0.1	0.01	1.00	50.00	100.01	1500.04
34	1500	0.1	0.01	1.00	50.00	100.02	1500.30
35	1500	0.1	0.01	1.00	50.00	100.02	1500.23
36	1500	0.1	0.01	1.00	50.00	100.00	1500.00
37	1500	0.1	0.01	1.00	50.00	100.00	1499.90
38	1500	0.1	0.01	1.00	50.00	100.00	1499.80
39	1500	0.1	0.01	1.00	50.00	99.99	1499.80
40	1500	0.1	0.01	1.00	50.00	100.00	1499.90
41	1500	0.1	0.01	1.00	50.00	100.00	1499.90
42	1500	0.1	0.01	1.00	50.00	99.90	1499.80
43	1500	0.1	0.01	1.00	50.00	100.00	1499.90
44	1500	0.1	0.01	1.00	50.00	100.00	1499.90
45	1500	0.1	0.01	1.00	50.00	100.00	1499.70
46	1500	0.1	0.01	1.00	50.00	100.00	1499.80
47	1500	0.1	0.01	1.00	49.90	99.90	1499.40
48	1500	0.1	0.01	1.00	49.90	99.90	1499.70
49	1200	0.1	0.01	1.00	50.00	99.90	1199.90
50	620	0.1	0.01	1.00	50.00	99.90	619.90
51	620	0.1	0.01	1.00	50.00	100.00	620.00
52	620	0.1	0.01	1.00	49.90	99.90	619.90
53	1500	0.1	0.01	1.00	50.00	100.00	-
54	1500	0.1	0.01	1.00	50.00	100.00	-
55	1220	0.1	0.01	1.00	50.02	100.05	-

No.	Capacity [g]	e [g]	d [g]	Indication L = 1 g	Indication L = 50 g	Indication L = 100 g	Indication L = capacity
56	1220	0.1	0.01	1.00	50.01	100.00	-
57	1220	0.1	0.01	1.00	50.00	100.00	-
58	1220	0.1	0.01	1.00	50.00	100.00	-
59	1220	0.1	0.01	1.00	50.01	100.01	-
60	1220	0.1	0.01	1.00	50.00	100.00	-
61	1220	0.1	0.01	1.00	50.01	100.01	-
62	1500	0.1	0.01	1.00	50.01	100.01	-
63	1500	0.1	0.01	1.00	49.99	99.98	-
64	1500	0.1	0.01	1.00	50.00	100.00	-
65	1500	0.1	0.01	1.00	49.99	99.96	-
66	1500	0.1	0.01	1.00	49.97	99.94	-
67	1500	0.1	0.01	1.00	49.99	99.98	-
68	1200	0.1	0.01	1.01	50.00	100.00	-
69	1500	0.1	0.01	1.00	49.99	99.99	-
70	1500	0.1	0.01	1.00	50.00	100.00	-
71	1500	0.1	0.01	1.00	49.99	99.99	-
72	1500	0.1	0.01	1.00	50.00	100.00	-
73	1500	0.1	0.01	1.00	50.00	100.00	-
74	1220	0.1	0.01	1.00	50.00	100.00	-
75	1500	0.1	0.01	1.00	50.00	100.00	-
76	1220	0.1	0.01	1.00	50.00	100.00	-
77	1220	0.1	0.01	1.00	50.10	100.20	-
78	1220	0.1	0.01	1.00	50.00	100.00	-
79	1220	0.1	0.01	1.00	50.02	100.05	-
80	-	0.1	0.01	1.00	50.01	100.01	-
81	1220	0.1	0.01	1.00	49.98	99.96	-
82	1220	0.1	0.01	1.00	50.01	100.02	-
83	1220	0.1	0.01	1.00	50.00	100.00	-
84	1220	0.1	0.01	1.00	50.01	100.02	-
85	1220	0.1	0.01	1.00	50.00	100.00	-
86	1220	0.1	0.01	1.00	50.01	100.01	-
87	1220	0.1	0.01	1.00	50.00	100.00	-
88	1220	0.1	0.01	1.00	50.00	100.01	-
89	1220	0.1	0.01	1.00	50.01	100.01	-
90	1500	0.1	0.01	1.00	50.00	100.00	-
91	1220	0.1	0.01	1.00	50.03	100.05	-
92	1220	0.1	0.01	1.00	50.00	100.01	-
93	1500	0.1	0.01	1.00	50.00	99.98	-
94	1500	0.1	0.01	1.00	49.99	99.99	-
95	1220	0.1	0.01	1.00	50.00	100.00	-
96	-	0.1	0.01	1.00	49.99	100.00	-
97	1500	0.1	0.01	1.00	50.00	100.00	-
98	1220	0.1	0.01	1.00	50.00	100.00	-
99	810	0.1	0.01	1.00	50.00	100.00	-
100	1500	0.1	0.01	1.00	50.00	100.00	-
101	1500	0.1	0.01	1.00	50.01	100.02	-
102	1500	0.1	0.01	1.00	50.00	100.00	-
103	1500	0.1	0.01	1.00	50.00	100.00	-
104	1500	0.1	0.01	1.00	50.00	100.01	-
105	1500	0.1	0.01	1.00	50.00	100.01	-
106	1500	0.1	0.01	1.00	50.01	100.01	-
107	1500	0.1	0.01	1.00	50.01	100.02	-
108	1500	0.1	0.01	1.00	50.00	100.00	-
109	1500	0.1	0.01	1.00	50.00	100.00	-
110	5000	0.1	0.01	1.00	50.00	99.98	-
111	810	0.1	0.01	1.00	50.00	100.00	-
112	1500	0.1	0.01	1.00	50.00	100.00	-

No.	Capacity [g]	e [g]	d [g]	Indication L = 1 g	Indication L = 50 g	Indication L = 100 g	Indication L = capacity
113	1500	0.1	0.01	1.00	50.00	100.00	1500.00
114	1500	0.1	0.01	1.00	50.00	99.99	1500.00
115	1500	0.1	0.01	1.00	50.00	100.00	1500.01
116	1500	0.1	0.01	1.00	50.00	100.01	1500.02
117	1500	0.1	0.01	1.00	50.00	100.00	1500.01
118	1500	0.1	0.01	1.00	50.00	100.00	1499.99
119	1500	0.1	0.01	1.00	50.00	100.00	1500.00
120	1500	0.1	0.01	1.00	50.00	99.99	1500.00
121	1500	0.1	0.01	1.00	50.00	100.00	1499.99
122	1500	0.1	0.01	1.00	50.00	100.01	1500.02
123	1100	0.1	0.01	1.00	50.01	100.02	1000.22
124	1100	0.1	0.01	1.00	50.00	100.00	1100.02
125	1100	0.1	0.01	1.00	50.00	100.00	1100.01
126	1100	0.1	0.01	1.00	50.03	100.10	1101.16
127	1000	0.1	0.01	1.00	50.03	100.06	1000.64
128	1000	0.1	0.01	1.00	50.02	100.03	1000.24