Revision of R 87: Quantity of product in prepackages

Révision de la R 87 : Quantité de produit dans les préemballages

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Foreword

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This publication - reference OIML R 87, Edition 2015 (E) - was developed by Technical Committee TC 6 Prepackaged products. It was approved for final publication by the International Committee of Legal Metrology in 2015 and will be submitted to the International Conference on Legal Metrology in 2016 for formal sanction. It supersedes the previous edition of R 87 (2004).

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Quantity of product in prepackages

1 Scope

This Recommendation specifies:

- Legal metrology requirements for prepackaged products (also called prepackaged commodities or prepackaged goods) labeled in predetermined constant nominal quantities of mass, volume, linear measure, area, or count; and
- Sampling plans and procedures for use by legal metrology officials in verifying the quantity of product in prepackages.

*Note:* The sampling plans are not recommended for use in the quantity control processes of packer.

The following informative Annexes are also included:

- an examination procedure outline where sampling is used;
- procedures for determining average tare mass;
- procedures for determining the drained quantity of products in liquid medium;
- procedures for determining the actual quantity of frozen products;
- requirements for prohibition of misleading prepackages;
- basis for statistical sampling model used;
- a schematic representation to explain the application of $T_1$ and $T_2$ errors;
- an alternative sampling plan using a stepwise approach; and
- references for documents mentioned.

2 Terminology

2.1 Definitions

2.1.1 actual quantity

amount of product that a prepackage contains as determined by measurement

*Note:* The actual quantity in a prepackage “i” is designated by the symbol $Q_i$.

2.1.2 Error

2.1.2.1 average error

sum of individual prepackage errors considering their arithmetic signs divided by the number of prepackages of the sample size $n$

*Note:* The average error is designated by the symbol $E_{ave}$. 
2.1.2.2 individual prepackage error
difference between the actual quantity of product in a prepackage and the nominal quantity of that prepackage

*Note:* The individual prepackage error for a prepackage “i” is designated by the symbol $E_i$, and can be calculated by $E_i = Q_i - Q_{nom}$.

2.1.2.3 $T1$ error

a deficiency that is greater than the applicable tolerable deficiency ($T$) (see 2.15) but not greater than twice the applicable tolerable deficiency ($2T$) for the given nominal quantity

\[ T1 \text{ error: } (Q_{nom} - 2T) \leq Q_i < (Q_{nom} - T) \]

*Note:* See Annex G for an example of the application of errors.

2.1.2.4 $T2$ error

a deficiency that is greater than twice the applicable tolerable deficiency ($2T$) for the given nominal quantity

\[ T2 \text{ error: } Q_i < (Q_{nom} - 2T) \]

*Note:* See Annex G for an example of the application of errors.

2.1.3 inadequate prepackage

prepackage containing an actual quantity (see 2.1) that is less than the nominal quantity (see 2.7)

*Note:* An inadequate prepackage is sometimes also referred to as a non-conforming prepackage.

2.1.4 inspection lot

an identified group of prepackages which will be inspected against the requirements of this document

*Note:* An inspection lot is sometimes referred to as a batch.

2.1.5 medium

a fluid that is put in the prepackage together with the product, either separated from, in or surrounding the product, and that is intended to be left over after use of the product, except for items naturally in the product

*Note 1:* For the purpose of this recommendation a fluid include:

a) either liquid, semi-liquid or frozen liquids, or

b) a gas or a mixture of gasses, whether under positive, negative or atmospheric pressure, or

c) a combination of both (a) and (b).

*Note 2:* The term “use” would include consumption.

*Note 3:* A medium is sometimes also referred to as “liquid packing medium”.

*Note 4:* A medium can be separated from the product and other solid items that were put in the prepackage by measuring procedures in Annex C and Annex D.
Note 5: A medium also includes:
   a) the liquid mediums as specified in Clause 4.3.3 of the CODEX STAN 1-1985 “Labelling of prepackaged foods” which covers foods on which the drained mass must be marked\(^1\), and
   b) the ice-glaze as specified in CODEX standards on ice-glazed foods.

2.1.6 misleading prepackage
prepackage that is made, formed, presented, marked or filled in any way that may mislead a consumer about the quantity of contents that it contains

2.1.7 nominal quantity
quantity of product in a prepackage declared on the label

Note 1: The symbol “\(Q_{\text{nom}}\)” is used to designate the nominal quantity.

Note 2: In some national legislation the nominal quantity of the product is referred to as “net quantity”, “net contents”, “net mass” or “net volume”.

Note 3: The nominal quantity should be declared in accordance with OIML R 79 [1].

2.1.8 packing material
everything of the prepackage that is intended to be left over after use of the product, except for items naturally in the product

Note 1: The term “use” would include consumption.

Note 2: Packing material is generally used to contain, protect, handle (e.g. lollipop stick), deliver, preserve (e.g. ice or glazing), transport, inform about and serve as an aid (e.g. food serving tray) while using the product it contains.

Note 3: Packing material also includes: the container, ice (not naturally in the product e.g. glazing), solid items that were put in the prepackage together with the product such as wrappers, lollipop sticks, wax around cheese, and a medium that was put in the prepackage together with the product and that is intended to be left over after use of the product.

Note 4: Packing material is sometimes referred to as individual package, tare, packaging, or packaging material.

\(^1\) CODEX STAN 1-1985 Clause 4.3.3: “In addition to the declaration of net contents, a food packed in a liquid medium shall carry a declaration in the metric system of the drained weight of the food. For the purposes of this requirement, liquid medium means water, aqueous solutions of sugar and salt, fruit and vegetable juices in canned fruits and vegetables only, or vinegar, either singly or in combination.”
2.1.9 prepackage

single item for presentation as such to a consumer, consisting of a product and its packing material, made up before being offered for sale and in which the quantity of the product has a predetermined value, whether the packing material encloses the product completely or only partially, but in any case in such a way that the actual quantity of product cannot be altered without the packing material either being opened or undergoing a perceptible modification.

Note 1: For the purpose of this document prepackages include packages marked with a constant nominal quantity. The term “predetermined value” refers to the value determined prior to the prepackage being offered for sale.

Note 2: The quantity of some products may change after packing due to desiccation or chemical reactions.

2.1.10 product

all of the prepackage that is not packing material

Note 1: Product includes liquids or gasses that were put in the prepackage together with the product and that are not intended to be left over after use of the product (e.g. air in chocolate mousse).

Note 2: Product includes liquids or gasses that were put in the prepackage with the product and that are intended to be left over after use of the product (e.g. liquid in mozzarella cheese, air in hair gel).

Note 3: Product includes liquids or gasses that were not put in the prepackage with the product and that are not intended to be left over after use of the product (e.g. curdling of yoghurt or honey).

2.1.11 random sampling

sampling procedure where prepackages to be included in a sample are chosen randomly from the inspection lot (i.e. each prepackage in the inspection lot has an equal probability of being selected to be included in the sample)

Note: This is also referred to as “sampling without replacement”.

2.1.12 sample

set of prepackages taken at random from an inspection lot to be inspected to determine conformance with specified criteria for purposes of making decisions concerning acceptance or rejection of the entire inspection lot

2.1.13 sample correction factor (SCF)

The factor calculated using:

a) the Student’s t inverse cumulative distribution function \((tp, n-1)\) with \(p\) as the probability equivalent to 0.005 and \((n-1)\) as the degrees of freedom, and

b) a finite population correction factor \(\sqrt{(N-n)/(N-1)}\) with \(n\) as the sample size and \(N\) as the inspection lot size
\[ SCF = - t_{0.005,n-1} \sqrt{\frac{n(N-1)}{(N-n)}} \]

**Note 1:** SCF always has a positive sign because \( t_p, n-1 \) has a negative sign for \( p=0.005 \).

**Note 2:** See F.3 for the statistical background to SCF.

### 2.1.14 Sample size

Number of prepackages taken from an inspection lot and included in a sample

*Note:* The symbol “\( n \)” is used to designate the sample size.

### 2.1.15 Tolerable deficiency

Permitted deficiency in the quantity of product in a prepackage

*Note 1:* The symbol “\( T \)” is used to designate tolerable deficiency.

*Note 2:* Tolerable deficiency is sometimes referred to as the tolerable negative error, limits of error or tolerances.

*Note 3:* By convention \( T \) is a positive number but, in use it represents a negative value of quantity, or negative error.

### 2.2 Acronyms and symbols

- **AGM** Actual Gross Mass which is equivalent to the actual mass of the prepackage (Annex A).
- **ATM** Average Tare Mass which is equivalent to the actual mass of the packing material (Annex A).
- **C** Arbitrary constant (Annex F).
- **CGM** Calculated Gross Mass (Annex A).
- **\( d_i \)** Difference between the individual prepackage error and the average error \( (d_i = E_i - E_{ave} \) in Annex A).
- **\( E_{ave} \)** Average of errors for all prepackages in an inspection lot which is equivalent to the mean value of actual net quantities minus the nominal net quantity \( (E_{ave} = Q_{ave} - Q_{nom}) \).
- **\( E_i \)** Error of net quantity in an individual prepackage which is equivalent to the actual net quantity minus the nominal net quantity \( (E_i = Q_i - Q_{nom}) \).
- **\( e_{ave} \)** Average of errors for all prepackages in a sample which is equivalent to the mean value of actual net quantities minus the nominal net quantity \( (e_{ave} = q_{ave} - Q_{nom}) \).
- **\( H_{T1} \) and \( H_{T2} \)** Proportion of prepackages with T1 and T2 errors, respectively, in the inspection lot (Annex H). \( H_{Ti} = N_{Ti} / N \) (\( i = 1 \) or 2).
\( k_1 \) Arbitrary constant which means the maximum number of T1 error packages that is listed in Column 4 of Table 2a or Table 2b (Annex F).

\( N \) Lot size which is equivalent to the total number of prepackages contained in an inspection lot.

\( n \) Sample size which is equivalent to the total number of prepackages in a sample.

\( N_{T1} \) and \( N_{T2} \) Number of prepackages with T1 and T2 errors, respectively, in the inspection lot (Annex H).

\( n_{T1} \) and \( n_{T2} \) Number of prepackages with T1 and T2 errors, respectively, in the sample (Annex H).

\( M_{T1} \) and \( M_{T2} \) Number of prepackages with T1 and T2 errors, respectively, in the inspection lot (Annex F).

\( P(x) \) Probability function in which a criterion \( x \) is satisfied (Annex F).

\( P_{ac} \) Probability for accepting an inspection lot (Annex H).

\( Q_{ave} \) Mean value of actual net quantities (\( Q_i \)) in all prepackages in an inspection lot.

\( q_{ave} \) Mean value of actual net quantities (\( Q_i \)) in all prepackages in a sample.

\( Q_i \) and \( q_i \) Actual net quantity in an individual prepackage.

\( Q_{nom} \) Nominal net quantity declared on the label of a prepackage.

\( s \) Sample standard deviation for actual net quantities (\( Q_i \)) in all (or a group) of prepackages contained in a sample.

\( SCF \) Sample Correction Factor defined in 2.13 which is always a positive value.

\( T \) Tolerable deficiency defined by Table 1 in 3.4.

\( t_{p,f} \) Student’s \( t \) inverse cumulative distribution function with two parameters of probability (\( p \)) and number of freedom (\( f \)).

\( Z \) Standard normal random variable or z-score which is used to calculate the probability of a score occurring within a normal distribution and facilitates the comparisons of scores from different normal distributions [z-score = (\( x \) – mean)/standard deviation)] (Annex F).

\( \mu \) Population mean value of an inspection lot (Annex F).

\( \sigma \) Population standard deviation for actual net quantities (\( Q_i \)) in all prepackages contained in an inspection lot.

\( \rho \) Density of product (Annex A).
3 Metrological requirements for prepackages

3.1 General
Prepackages shall meet the requirements in 3.2 and 3.3 at any level of distribution including at the point-of-pack, import, distribution and wholesale transactions, and sale (e.g. where a prepackage is offered or exposed for sale).

3.2 Average requirement
The average actual quantity of product in prepackages shall be at least equal to the nominal quantity.

Note: Clauses 4.2 and 4.3 give criteria to be met if the average actual quantity of product in prepackages in an inspection lot is estimated by sampling.

3.3 Individual prepackage requirements
3.3.1 The actual quantity of product in a prepackage shall accurately reflect the nominal quantity but tolerable deficiencies \(T\) shall be allowed (see clause 3.4 and Table 1).

3.3.2 A homogenous group of prepackages shall contain no more than 2.5 % of packages having \(T_1\) errors.

Note: Clauses 4.2 and 4.3 give criteria to be met if this requirement is evaluated by sampling prepackages from an inspection lot.

3.3.3 No prepackage shall have a \(T_2\) error.

3.4 Tolerable deficiencies
For all prepackages, the tolerable deficiencies \(T\) are specified in Table 1.

Note: Clause 3.3 gives requirements for the application of tolerable deficiencies to individual prepackages in the sample.
Table 1 - Tolerable deficiencies in actual content for prepackages

<table>
<thead>
<tr>
<th>Nominal quantity of product ((Q_{\text{nom}})) in g or mL</th>
<th>Tolerable Deficiency ((T)) (^a)</th>
<th>Percent of (Q_{\text{nom}})</th>
<th>g or mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 50</td>
<td>9</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>50 to 100</td>
<td>-</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>100 to 200</td>
<td>4.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>200 to 300</td>
<td>-</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>300 to 500</td>
<td>3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>500 to 1 000</td>
<td>-</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>1 000 to 10 000</td>
<td>1.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>10 000 to 15 000</td>
<td>-</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Above 15 000</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) \(T\) values are to be rounded up to the next 0.1 of a g or mL for \(Q_{\text{nom}}\) less than or equal to 1 000 g or 1 000 mL and to the next whole g or mL for \(Q_{\text{nom}}\) higher than 1 000 g or 1 000 mL.

<table>
<thead>
<tr>
<th>Nominal quantity of product ((Q_{\text{nom}})) in length</th>
<th>Percent of (Q_{\text{nom}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Q_{\text{nom}} \leq 5) m</td>
<td>No tolerable deficiency allowed</td>
</tr>
<tr>
<td>(Q_{\text{nom}} &gt; 5) m</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nominal quantity of product ((Q_{\text{nom}})) in area</th>
<th>Percent of (Q_{\text{nom}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (Q_{\text{nom}})</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nominal quantity of product ((Q_{\text{nom}})) in count</th>
<th>Percent of (Q_{\text{nom}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Q_{\text{nom}} \leq 50) items</td>
<td>No tolerable deficiency allowed</td>
</tr>
<tr>
<td>(Q_{\text{nom}} &gt; 50) items</td>
<td>(1^b)</td>
</tr>
</tbody>
</table>

\(^b\) Calculate the value of \(T\) by multiplying the nominal quantity by 1 percent and rounding the result up to next whole number. The value may be larger than 1 percent due to the rounding but this is accepted because the products are whole items and cannot be divided.
4 Reference test for metrological requirements

4.1 General inspection requirements

4.1.1 Legal metrology officials shall conduct tests to determine if prepackages comply with the requirements of this Recommendation. The tests may be performed by sampling prepackages at any level of distribution including at the point-of-pack, import, distribution and wholesale transactions, and sale.

Note: Practical timing and place of metrological control may be chosen by the national responsible body.

4.1.2 An inspection lot taken from the production line shall consist of all prepackages not rejected by a checking system. Care shall be taken to prevent other than normal operating adjustments or other corrective actions in the production and prepackage filling process. Sample prepackages must be collected after the point of final checking by the packer.

4.1.3 The expanded uncertainties (at the $k=2$ level of confidence) associated with measuring instruments and test methods used for determining quantities shall not exceed $0.2 \ T$. Examples of the source of uncertainty include the maximum permissible error and repeatability in weighing and measuring instruments, variations in packing material and fluctuations in density determinations caused by the differing amounts of solids in the liquid or temperature changes.

4.1.4 An inspection shall consist of checking the following three values irrespective of whether or not a sample is used to inspect compliance of the inspection lot:
   a) The average error of the lot (see 3.2).
   b) The number of inadequate prepackages in the inspection lot that have a $T1$ error (see 3.3.2).
   c) The number of inadequate prepackages in the inspection lot that have a $T2$ error (see 3.3.3).

Note: National legislation may permit allowances in addition to tolerable deficiencies for the loss of quantity of product after packaging caused by ordinary and customary exposure to environmental conditions that occur in storage and distribution in the evaluation of both the average and individual prepackage requirements. These additional allowances would typically not apply to products packed in hermetically sealed (airtight) packing material.

4.1.5 An inspection lot is:
   a) accepted if it satisfies the requirements fixed for the three parameters above; or
   b) rejected if it does not satisfy one or more of the requirements.

4.2 Control by sampling of inspection lots

4.2.1 Metrological requirements when an inspection lot is sampled.

The tests for acceptance or rejection of inspection lots shall be conducted on the basis of random sampling (see 2.11 and 4.3). Inspection lots shall consist of prepackages that have been produced under conditions that are presumed to have been uniform (homogeneous). A random sample of sample size $n$ shall be selected from the inspection lot. The parameters in 3.2 and 3.3 shall be applied to the sample as follows:

a) Average requirement - The average of the actual quantities of product in the prepackages of an inspection lot shall be at least equal to the nominal quantity. The probability of incorrectly rejecting an inspection lot which satisfies this requirement shall be no more than 0.5 %. The probability of correctly rejecting an inspection lot with an average actual quantity less than $Q_{nom} - 0.74\sigma$ shall be at least 90 %.
**Note:** \( \sigma \) is the standard deviation of the full population of the inspection lot (see Annex F).

**b)** Individual prepackage requirement - The actual quantity of product in a prepackage shall accurately reflect the nominal quantity, however, deviations shall be allowed (see 3.3). In the case that an inspection lot contains 2.5 % of prepackages with \( T1 \) errors the probability of acceptance through sample testing shall be at least 95 %. In the case that an inspection lot contains 9% of prepackages with \( T1 \) and \( T2 \) errors the probability of correctly rejecting through sample testing be at least 90%.

**Note:** The numerical criteria (2.5% and 9%) may not be strictly applied when a number of inadequate prepackages is rounded (see Clause 4.5 Note).

### 4.3 Statistical principles of control by sampling

#### 4.3.1 Test of average requirement

Reject the lot if 
\[
\frac{e_{\text{ave}} + SCF}{s} \leq 0
\]

where \( s \) is the sample standard deviation of the individual errors, and \( SCF \) is found in column 3 of Table 2b or calculated using the formula in 4.5.1.

- a) This test guarantees that the probability of incorrectly rejecting an inspection lot which satisfies the requirement set out in 4.2.1 a) is no more than 0.5%.
- b) This test also guarantees that lots with average actual quantity less than \( Q_{\text{nom}} - 0.74 \sigma \) will be correctly rejected with probability of at least 90%.

**Note 1:** An alternative formula would be \( Q_{\text{ave}} \leq Q_{\text{nom}} - SCF \times s \)

**Note 2:** See A.3.8 and F.3 for the statistical background to this average requirement.
4.3.2 Test of individual prepackage requirement for $T_1$ errors

Reject the lot if the number of prepackages having a $T_1$ error is larger than the number in column 4 of Table 2a and 2b.

a) This test guarantees the probability of incorrectly rejecting an inspection lot that satisfies the criteria set out in 4.2.1 b) is no more than 5%.
b) This test also guarantees that a lot which has 9% of the packages having a $T_1$ and $T_2$ errors will be correctly rejected with a probability of at least 90%.

4.3.3 Test of individual prepackage requirement for $T_2$ errors

Reject the lot if the number of prepackages having a $T_2$ error is larger than zero.

There shall be no inadequate prepackages in the sample that have a $T_2$ error.

4.4 Lot size for inspection purposes

4.4.1 When sample prepackages are collected from the production line, the size of the inspection lot shall be equal to the maximum hourly output of the production line without any restriction as to the inspection lot size.

4.4.2 When sample prepackages are collected at the premises of the packer but not from the production line (where the hourly production is known), the size of the inspection lot shall be equal to the maximum hourly output of the production or 100 000 whichever is the lesser.

4.4.3 When the sample prepackages are not collected at the premises of the packer (where the hourly production or original lot size is not known) then the inspection lot size shall be defined by the inspector but shall not exceed 100 000. The inspection lot shall be regarded as being homogeneous.

Note 1: Generally the inspector should take the number of prepackages available as the inspection lot size.
4.5 Sampling characteristics

4.5.1 Sampling using the lot size determined at the time of inspection

When inspection is carried out by means of sampling from an inspection lot the sample size in column 3 of Table 2a shall be used when checking compliance to the individual prepackage requirement and as the sample size for inspecting the average requirement. The SCF for the identified lot size is calculated using the formula:

$$SCF = -t_{0.005, n-1} / \sqrt{\frac{n(N-1)}{(N-n)}}$$

Or

$$SCF = -T.INV (0.005, n-1) / (SQRT (n \times (N-1) / (N-n)))$$

<table>
<thead>
<tr>
<th>Inspection lot size, N</th>
<th>Sample size, n</th>
<th>Number of prepackages allowed with T1 error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td>Under 32 100% inspection</td>
</tr>
<tr>
<td>33</td>
<td>47</td>
<td>32</td>
</tr>
<tr>
<td>48</td>
<td>59</td>
<td>34</td>
</tr>
<tr>
<td>60</td>
<td>99</td>
<td>50</td>
</tr>
<tr>
<td>100</td>
<td>179</td>
<td>64</td>
</tr>
<tr>
<td>180</td>
<td>599</td>
<td>83</td>
</tr>
<tr>
<td>600</td>
<td>100 000 or more</td>
<td>98</td>
</tr>
</tbody>
</table>

4.5.2 Sampling plans for lot sizes with discreet numbers

When inspection is carried out by means of sampling from an inspection lot with discreet numbers the sample size in column 2 of Table 2b shall be used when checking compliance to the individual prepackage requirement and as the sample size for inspecting the average requirement.
Table 2b - Sampling plans for lot sizes with discreet numbers

<table>
<thead>
<tr>
<th>Inspection lot size $N$</th>
<th>Sample size $n$</th>
<th>SCF $t_{0.005, n-1} \sqrt{\frac{n(N-1)}{(N-n)}}$</th>
<th>Number of prepackages allowed with $T1$ error</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>60</td>
<td>0.22</td>
<td>3</td>
</tr>
<tr>
<td>200</td>
<td>64</td>
<td>0.27</td>
<td>3</td>
</tr>
<tr>
<td>300</td>
<td>79</td>
<td>0.26</td>
<td>4</td>
</tr>
<tr>
<td>400</td>
<td>81</td>
<td>0.26</td>
<td>4</td>
</tr>
<tr>
<td>500</td>
<td>81</td>
<td>0.27</td>
<td>4</td>
</tr>
<tr>
<td>600</td>
<td>82</td>
<td>0.27</td>
<td>4</td>
</tr>
<tr>
<td>700</td>
<td>82</td>
<td>0.27</td>
<td>4</td>
</tr>
<tr>
<td>800</td>
<td>82</td>
<td>0.28</td>
<td>4</td>
</tr>
<tr>
<td>900</td>
<td>96</td>
<td>0.25</td>
<td>5</td>
</tr>
<tr>
<td>1000</td>
<td>96</td>
<td>0.26</td>
<td>5</td>
</tr>
<tr>
<td>1500 and larger</td>
<td>98</td>
<td>0.26</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: The above tables uses a rounding method where numbers larger than or equal to $[J-0.5]$ and less than $[J+0.5]$ are rounded to J as an integer.
Annex A
Outline of examination procedure where sampling is used
(Informative)

A.1 General

This outline may be used to develop test procedures for checking the quantity of product in prepackages by means of drawing samples from an inspection lot to ensure compliance with Clause 3 “Metrological requirements for prepackages”.

Note: Where the full production lot is tested (sampling not carried out) the requirements of Clause 3 are applied without the need for any correction as is the case with sampling.

A.2 Acronyms and symbols

<table>
<thead>
<tr>
<th>Term</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Gross Mass</td>
<td>AGM</td>
</tr>
<tr>
<td>Actual Quantity of Product</td>
<td>Q_i</td>
</tr>
<tr>
<td>Average Error</td>
<td>E_{ave}</td>
</tr>
<tr>
<td>Average Tare Mass</td>
<td>ATM</td>
</tr>
<tr>
<td>Calculated Gross Mass</td>
<td>CGM</td>
</tr>
<tr>
<td>Density of product</td>
<td>\rho</td>
</tr>
<tr>
<td>Individual Prepackage Error</td>
<td>E_i</td>
</tr>
<tr>
<td>Nominal Quantity</td>
<td>Q_{nom}</td>
</tr>
<tr>
<td>Sample Correction Factor</td>
<td>SCF</td>
</tr>
<tr>
<td>Sample Size</td>
<td>n</td>
</tr>
<tr>
<td>Sample Standard Deviation</td>
<td>s</td>
</tr>
<tr>
<td>Difference between the individual prepackage error and the average error</td>
<td>d_i</td>
</tr>
<tr>
<td>Tolerable Deficiency</td>
<td>T</td>
</tr>
</tbody>
</table>

A.3 Procedure

A.3.1 Define the inspection lot according to 4.2.1 and 4.4.

A.3.2 Determine a sample size appropriate for the inspection lot using Table 2a or 2b.

A.3.3 Determine the tolerable deficiency (T) appropriate for the nominal quantity of the prepackages according to Table 1.

A.3.4 Determine the number of prepackages allowed to have T1 errors from column 4 of Table 2a and 2b.
A.3.5 Measure (see Notes 1 and 2 below) and record the \textit{AGM} for each prepackage to be opened for tare determination. Determine the \textit{ATM} using the procedures in Annex B.

\textit{Note 1}: This step is followed only when gravimetric non-destructive testing is used.

\textit{Note 2}: Packages with protective gas or vacuum packages shall be opened before weighing to determine the \textit{AGM}.

A.3.6 Measure and record the \textit{AGM} of the remaining prepackages in the sample and determine the \( E_i \) for all prepackages in the sample using either A.3.6.1 or A.3.6.2 below.

A.3.6.1 If gravimetric non-destructive testing is used:

a) Calculate the \textit{CGM} that may be used for computing \( E_i \) as follows (see Note 1):

\[
\text{CGM} = \text{Average Tare Mass} + \text{Nominal Quantity of prepackage} \quad \text{(see Note 2)}.
\]

b) Determine \( E_i \) by subtracting the \textit{CGM} from the \textit{AGM} of each prepackage.

\[
E_i = \text{AGM} - \text{CGM}
\]

\textit{Note 1}: This method is only a recommendation; any accurate method of computing individual prepackage errors is acceptable. The method used shall be recorded in the test report.

\textit{Note 2}: When gravimetric testing is used to determine the actual quantity of fluids in prepackages labeled in units of volume, the nominal quantity of liquid product in the prepackage is the nominal volume multiplied by the density of a measured volume of the liquid at a reference temperature. The internationally recommended temperature is 20 °C for the volume declaration of liquids that are not frozen.

\textit{Note 3}: When gravimetric testing is used to determine the actual quantity of fluids in prepackages labeled in units of volume and the test is related to masspieces of a density of 8.0 g/mL, a quantity of product expressed in units of volume should be calculated using the formula below:

\[
V = \frac{Q_i \times 0.99985}{\rho - 0.0012}
\]

A.3.6.2 When destructive testing is used (\textit{CGM} is not required), determine the actual quantity of the product \( Q_i \) and then calculate the individual prepackage error as:

\[
E_i = Q_i - Q_{\text{nom}}
\]

A.3.7 Determine if the test results meet the individual prepackage requirement according to the requirements of A.3.7.1 to A.3.7.4 inclusive.

A.3.7.1 Identify all prepackages in the sample with \( E_i < 0 \).

A.3.7.2 For these prepackages, are there any with \( E_i < -2T ? \) If so, the lot shall be rejected.
A.3.7.3 For these prepackages, count the number with $E_i < -T$. If this number is larger than the value in column 4 of Table 2a and 2b, the lot shall be rejected.

A.3.7.4 All other prepackages meet the individual prepackage requirement.

A.3.8 Determine if the test results meet the average prepackage requirement according to the requirements of A.3.8.1 to A.3.8.3 inclusive.

A.3.8.1 Calculate $E_{ave}$ by summing the individual prepackage errors $E_i$ obtained in A.3.6.1 or A.3.6.2, as applicable, and dividing the sum by the sample size $n$. If $E_{ave}$ is 0 or a positive number, the average rule is satisfied and there is no need to proceed to A.3.8.2.

A.3.8.2 Determine the standard deviation of the individual prepackage errors of the sample using the formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(E_i - E_{ave})^2}{n-1}}$$

Note: This can be achieved by the following method - For each individual prepackage in the sample calculate $d_i^2 = (E_i - E_{ave})^2$. Sum up the $d_i^2$ and divide the sum by $(n-1)$ to obtain $s^2$. Determine the sample standard deviation $s$ by calculating the square root of $s^2$.

A.3.8.3 From the formula $\frac{E_{ave}}{s} + SCF \leq 0$ calculate the quantity $\frac{E_{ave}}{s} + SCF$ where $SCF$ is taken from column 3 of Table 2b or calculated using the formula in Clause 4.5.1. If this is zero or negative reject the lot, otherwise accept.

A.4 Additional Resources for Test Methods

For examples of test methods for a wide variety of products in different prepackages, see the following articles or OIML publications:

1. Russing, J.: Special methods for testing of certain types of prepackages such as sparkling beverages, aerosols, ice cream (OIML Bulletin - Number 96, September 1984).

2. OIML G 14 edition 2011: Density measurement
Annex B

Tare Procedures

(Informative)

B.1 General

These procedures permit the use of either used or unused packing material to determine the actual quantity of product in the prepackage as follows:

\[ Q_i = AGM - ATM \]

B.2 Terminology

B.2.1 Unused dry tare

Mass of unused packing material of one prepackage.

B.2.2 Used dry tare

Packing material that has been used as part of a prepackage and that has been separated from the product and completely cleaned to approximate the state of the packing material when new.

B.2.3 Acronyms and symbols

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Tare Mass (average actual mass of packing material)</td>
<td>( ATM )</td>
</tr>
<tr>
<td>Actual Gross Mass (actual mass of the prepackage)</td>
<td>( AGM )</td>
</tr>
<tr>
<td>Actual Quantity of Product</td>
<td>( Q_i )</td>
</tr>
<tr>
<td>Sample standard deviation</td>
<td>( s )</td>
</tr>
</tbody>
</table>

B.3 Procedure

B.3.1 Randomly select a tare sample of 25 packing materials from either the sample of prepackages taken from an inspection lot (used dry tare) or selected from new packing materials at the point-of-pack (unused dry tare).

*Note:* In the case of used dry tare determine the gross mass of the prepackage before opening the packing material (see A.3.5).

B.3.2 Where used dry tare will be used, clean the packing material in the sample by using normal household procedures used by consumers of the product. The packing material should not be dried in an oven.
B.3.3 Determine the mass of 10 of the selected packing materials in the sample.

B.3.4 Determine the ATM of the 10 tare samples weighed in B.3.3 and proceed as per B.3.4.1 to B.3.4.3.

B.3.4.1 If the ATM is equal to or less than 10 % of the nominal quantity of the product then use the ATM to determine the actual quantity of product in the prepackages according to the applicable requirements in A.3. If the ATM exceeds 10 % of the nominal quantity of product determine the sample standard deviation (s) of the initial sample and proceed to B.3.4.2 or B.3.4.3, as applicable.

B.3.4.2 If the ATM is greater than 10 % of the nominal quantity and s is equal to or less than 0.25 x T, use the additional 15 samples of packing materials selected in B.3.1 and weigh as in B.3.3. Determine the combined average of the 25 samples of packing materials. Use this ATM of 25 packing materials to determine the actual quantity of product in the prepackages according to the applicable requirements in A.3.

B.3.4.3 If the ATM is greater than 10 % of the nominal quantity and s is greater than 0.25 x T of the product the ATM cannot be used and it is necessary to determine and to consider every individual tare mass (destructive testing). Open the prepackages and determine the actual quantity of product in each prepackage according to the applicable requirements in A.3.
Annex C
Drained quantity of products packed in liquid medium

(Informative)

C.1 General

C.1.1 This procedure may be used to determine the drained quantity of product in a liquid medium and may be applied to prepackages with nominal quantities up to 50 kg.

C.1.2 The drained quantity requirements apply to food products packed in the following liquid mediums, either singly or in combination, which are regarded as packing material and shall not be included as part of the nominal quantity of the product:

a) water,

b) aqueous solutions of salt (brine),

c) aqueous solutions of sugars or other sweetening substances,

d) fruit or vegetable juices in canned fruit or vegetables only,

e) vinegar.

C.2 Test apparatus

C.2.1 For draining the product from a prepackage, use a flat sieve with a square mesh of 2.5 mm and a wire thickness of 1.0 mm and drip pans. The diameter of this sieve should be 20 cm for use with prepackages where the container has a capacity of 850 mL or less, and 30 cm for use with containers of capacity exceeding 850 mL. If the declared drained mass is 2.5 kg or more, the quantity may, after weighing the whole amount, be divided among several sieves.

Note: For standardized sieves see ISO 3310-1 Test Sieves - Technical Requirements and Testing - Part 1: Test sieves of metal wire cloth.

C.2.2 For determination of quantity, a weighing instrument shall meet the requirements of Clause 4.1.3.

C.3 Procedure for determining the actual quantity of the solid component of the product.

C.3.1 Apply the requirements of Clause 3 “Metrological requirements for prepackages in an inspection lot”.

C.3.2 Select a sample of prepackages in accordance with Clause 4.2. Sampling shall be performed when the products are ready to be marketed according to the packer, when distribution has taken place or at any time later than 30 days after sterilization, pasteurization or similar process.

C.3.3 Store the samples for a period of 12 hours before testing within the temperature range specified by the packer or between 20 °C to 24 °C.

C.3.4 Determine the mass of the empty sieve.
C.3.5 Open the prepackage and pour the product and liquid medium across the sieve. Distribute the product and liquid medium over the surface of the sieve but do not shake the material on the sieve. Tilt the sieve to an angle of 17° to 20° from the horizontal to facilitate draining.

C.3.6 Carefully invert by hand all solid product, or parts thereof, which have hollows or cavities (e.g. sliced fruit) if they fall on the sieve with hollows or cavities facing upwards.

C.3.7 Allow a 2 minute drain time.

C.3.8 Reweigh the sieve plus contents and calculate the drained mass of the product as follows:

\[ P = P_{e2} - P_{e1} \]

where: \( P \) = drained mass of the product  
\( P_{e1} \) = mass of the clean sieve  
\( P_{e2} \) = mass of the sieve plus product after draining

C.3.9 Before the subsequent weighing of the same sieve ensure that it is clean and free of product debris. The sieve does not have to be dry as long as it is weighed accurately before being used.
Annex D

Test procedures for determining the actual quantity of frozen products

(Informative)

D.1 General

D.1.1 The requirements of Clause 3 “Metrological requirements for prepackages” are applicable to the inspection lots of prepackages measured after removing excess ice (packing material) according to the procedures in D.3 to D.5.

Note: It is not the intention to thaw the product but only to remove excess ice and the product itself should remain frozen to prevent the loss of moisture naturally contained in the product.

D.1.2 When a product not mentioned in D.3 to D.5, is enclosed in a layer of ice or has any excess ice within it or on its surface, the procedures in D.3 to D.5 may be suitably adapted or methods used to remove the excess ice which will achieve an equivalent result and are acceptable in national legislation, may be used.

D.2 Test apparatus

D.2.1 20 cm and 30 cm diameter sieves with 2.5 mm square wire mesh size and wire thickness of 1.0 mm and drip pans.

Note: For standardized sieves see ISO 3310-1 Test Sieves - Technical Requirements and Testing - Part 1: Test sieves of metal wire cloth.

D.2.2 For determination of quantity, a weighing instrument shall meet the requirements of Clause 4.1.3.

D.2.3 Water bath of a size suitable to immerse the prepackage or a wire mesh basket containing the ice glazed product and capable of maintaining water temperature of 20 °C and 26 °C within an accuracy of ± 1 °C.

D.2.4 Cold water spray.

D.2.5 Wire mesh basket large enough to hold the content of a ice glazed product and with mesh size small enough to retain the product.

D.3 Frozen fruits and vegetables

D.3.1 Determine the mass of the sieve and the drip pan to be used. For prepackages with a nominal quantity up to and including 1.4 kg use a 20 cm diameter sieve, or use a 30 cm diameter sieve for prepackages with a nominal quantity greater than 1.4 kg.

D.3.2 Immerse the prepackage in a water bath maintained at 20 °C ± 1 °C. If the prepackage is not watertight, place it in a plastic bag and remove any excess air using a vacuum and then seal it securely. When all of the excess ice has melted, remove it from the water bath and wipe it dry. Open the prepackage with care and a minimum of agitation.

D.3.3 Transfer the product to the pre-weighed sieve. With the sieve tilted approximately 17 ° to 20 ° from the horizontal to facilitate drainage, distribute the product evenly over the sieve in one sweeping
motion. Drain for 2 minutes then transfer the sieve containing the product to the preweighed drip pan and determine the actual mass of the product on a suitable weighing instrument (See D.2.2).

D.3.4 Repeat D.3.1 to D.3.3 for each prepackage in the sample.

D.4  Glazed seafood and glazed poultry (product that is covered with a film of ice to preserve its quality) and blocks of frozen fish (see CODEX STAN 165 - 1989).

D.4.1 Determine the mass of the sieve and the drip pan to be used. For prepackages with a nominal quantity up to and including 900 g use a 20 cm diameter sieve, or use a 30 cm diameter sieve for prepackages with a nominal quantity greater than 900 g.

D.4.2 Remove the product from the packing material. Place it in a wire mesh basket large enough to hold the contents of the prepackage and with openings small enough to retain the product. Place the wire mesh basket containing the product under a gentle spray of cold water until the ice glaze is removed. Agitate the product with care to avoid damage.

D.4.3 Transfer the product to the pre-weighed sieve. Incline the sieve to approximately $17^\circ$ to $20^\circ$ from the horizontal to facilitate drainage without shifting the product. Drain for 2 minutes and then transfer the sieve with the product to the pre-weighed drip pan. Determine the actual mass of product on a suitable weighing instrument (See D.2.2).

D.4.4 Repeat D.4.1 to D.4.3 for each prepackage in the sample.

D.5  Frozen shrimp and crabmeat

D.5.1 Determine the mass of the sieve and the drip pan to be used. For prepackages with a nominal quantity up to and including 450 g use a 20 cm diameter sieve, or use a 30 cm diameter sieve for prepackages with a nominal quantity greater than 450 g.

D.5.2 Remove the product from the packing material and place in a wire mesh basket large enough to hold the contents of the prepackage and with openings small enough to retain the product. Immerse the basket containing the product in a water bath maintained at $26^\circ$C ± $1^\circ$C with a continuous water flow so that the top of the basket extends above water level. When all of the excess ice has melted, remove it from the water bath.

D.5.3 Transfer the product to the pre-weighed sieve. Incline the sieve to approximately $17^\circ$ to $20^\circ$ from the horizontal to facilitate drainage without shifting the product. Drain for 2 minutes and then transfer product to the pre-weighed drip pan. Determine the actual mass of product on a suitable weighing instrument.

D.5.4 Repeat D.5.1 to D.5.3 for each prepackage in the sample.
Annex E
Prohibition of misleading prepackages
(Informative)

E.1 General requirements

A prepackage may not have a shape, size or any feature that may mislead or deceive a consumer as to the actual quantity contained in such prepackage. This includes a false bottom, sidewalls, lid or other covering. A prepackage may not be constructed or filled in such a way that may mislead or deceive a consumer.

E.2 Complete filling

A prepackage may not be partially filled in such a way that may deceive a consumer unless the difference between the actual volume of the packing material and the volume of the product it contains (slack fill) is required in the production process. If a consumer cannot fully view the product in a prepackage it may be considered to be filled. A prepackage with excessive nonfunctional slack fill (slack fill that is not required by any production process) is considered to be a misleading one.

E.3 Functional slack fill

Reasonable slack fill may serve a necessary function for the following reasons which should not be regarded as misleading:

   a) protection of the product;
   b) the requirements of machines used for enclosing the contents of the prepackage;
   c) unavoidable product settling during shipping and handling; and
   d) the need for the prepackage to perform a specific function (e.g. where packaging plays a role in the preparation or consumption of a food), where such a function is inherent in the nature of the product and is clearly communicated to consumers.

E.4 Aerosol dispensers

The fill level of aerosol dispensers may be in accordance with national requirements or recognized industry standards specified in national requirements.
Annex F

Basis for statistical sampling model used

(Informative)

F. 1 Introduction.

This Appendix gives the probabilistic and statistical assumptions and reasons that underpin the acceptance sampling presented in this document. Section F.2 of this Annex derives the probability distribution of a prepackage sampled from an acceptable lot. The two lot requirements, the average and the individual, taken together determine both the mean and the standard deviation of a prepackage sampled from such a lot. Finally, section F.4 describes calculation of the values in Table 2a and 2b.

Note: Several reports, namely Sim [2], Willink [3], and Field [4], pointed out that the document OIML R87 (2004 version) contained imprecise and hard to interpret statements of the lot testing requirements, and also some errors in calculation. Specifically, both Sim and Willink pointed out that the document contained errors in Table 2 of section 4.2, in that the sample sizes and the acceptable number of prepackages with T1 errors did not guarantee the probability of rejection of an unacceptable lot being at least 0.9. Willink also noted that OIML R87 did not use the requirement that there are no T2 errors in the sample in the probability calculations. This Annex attempts to correct this situation by giving the probabilistic and statistical assumptions and reasoning that underpin the acceptance sampling presented in this document.

Section 2 of this Annex derives the probability distribution of a prepackage sampled from an acceptable lot. The two lot requirements, the average and the individual, taken together determine both the mean and the standard deviation of a prepackage sampled from such a lot (this fact was not noted in the 2004 edition of OIML R87). Finally, section 4 describes the correct calculation of the values in Table 2a and 2b.

F.2 Sampling from an Acceptable Lot.

An acceptable lot satisfies the requirement that:

a) the mean $\mu$ is greater than or equal to $Q_{\text{nom}}$, and that

b) the percentage of prepackages in the lot with $q_i < Q_{\text{nom}} - T$ is no greater than 2.5%.

Consider a lot with $\mu = Q_{\text{nom}}$ and the percentage of prepackages in the lot with $q_i < Q_{\text{nom}} - T$ being equal to 2.5%. If we assume that a randomly selected prepackage from such a lot has a value $q$ which follows a normal distribution, then these two properties uniquely determine the mean and variance of the normal distribution. The graph below illustrates this fact. It shows that such a normal curve is centered at $Q_{\text{nom}}$ and its standard deviation is obtained by solving the equation

$$\frac{(Q_{\text{nom}} - T) - Q_{\text{nom}}}{\sigma} = \frac{T}{\sigma} = -1.96.$$
Thus an acceptable lot is one whose sampled packages have values \( q_i \) which are sampled from a 
\[ N \left( \mu = Q_{\text{nom}}, \sigma^2 \leq \left( \frac{T}{1.96} \right)^2 \right) \] 
density.

**F.3 Test of Average Requirement.**

Derivation of the test of section 4.3.1

A statistical test satisfying the requirement given in section 4.2.1 a) can be stated as:

Reject the lot if \( E_{\text{ave}} \leq C \) for a constant \( C \) found to satisfy the requirement that the probability 
\[ P (E_{\text{ave}} \leq C) = 0.005 \] 
when the prepackages are sampled from a lot with \( \mu = Q_{\text{nom}} \) and standard deviation \( \sigma \).

For a sample of size \( n \), sampled from a lot of size \( N \) without replacement, the average error is distributed approximately as 
\[ E_{\text{ave}} \sim N \left( 0, \frac{\sigma^2 \left( \frac{N-n}{N-1} \right)}{n} \right) \] 
where the factor \( \frac{N-n}{N-1} \) is the finite population correction factor. Now \( E_{\text{ave}} \) can be converted to a Student’s \( t \) density with \( n-1 \) degrees of freedom as

\[ P (E_{\text{ave}} \leq C) = P \left( \frac{E_{\text{ave}}}{s \sqrt{\frac{N-n}{N-1}}} \leq \frac{C}{s \sqrt{n(N-1)}} \right) = P \left( t_{n-1} \leq \frac{C}{s \sqrt{n(N-1)}} \right). \]
The requirement that \( P (E_{\text{ave}} \leq C) = 0.005 \) then becomes the requirement that

\[
P \left( t_{n-1} \leq \frac{C}{s \sqrt{(N-n)/n(N-1)}} \right) = 0.005,
\]

and since \( P (t_{n-1} \leq t_{0.005,n-1}) = 0.005 \), we get

\[
t_{0.005,n-1} = \frac{C}{s \sqrt{(N-n)/n(N-1)}}.
\]

This leads to the result that \( C = st_{0.005,n-1} \sqrt{\frac{N-n}{n(N-1)}} \), giving the test

\[
\text{Reject the lot if } \frac{E_{\text{ave}}}{s} \leq t_{0.005,n-1} \sqrt{\frac{N-n}{n(N-1)}}.
\]

where, the quantity

\[-t_{0.005,n-1} \sqrt{\frac{N-n}{n(N-1)}}\]

is equivalent to SCF (Sample Correction Factor) defined in 2.13.

This test is constructed so that it guarantees the probability requirement of section 4.2.1.a).

The test also needs to satisfy a second requirement, that is, that it achieves probability of rejection of 0.9 for unacceptable lots with \( \mu \leq Q_{\text{nom}} - 0.74\sigma \) where \( \sigma \) is the standard deviation of the lot. For the lot and sample sizes given in Table 2a and 2b this is satisfied.

Suppose that for the lot being tested, \( \mu = Q_{\text{nom}} - 0.74\sigma \). Then \( E_{\text{ave}} \sim N \left( -0.74\sigma \frac{\sigma^2}{n} \frac{(N-n)}{n(N-1)} \right) \).

So the requirement in 4.2.1 a. states that \( P \left( E_{\text{ave}} \leq st_{0.005,n-1} \sqrt{\frac{N-n}{n(N-1)}} \right) = 0.9 \), and converting to a Student \( t \) density as above we get
\[ P \left( E_{ave} \leq st_{0.005,n-1} \sqrt{\frac{N-n}{n(N-1)}} \right) = P \left( t_{n-1} \leq \frac{st_{0.005,n-1} \sqrt{N-n}}{s \sqrt{nN}} + 0.74 \frac{\sqrt{n(N-1)}}{N-n} \right) \geq 0.9 \]

and since \( P(t_{n-1} \leq t_{0.9,n-1}) = 0.9 \), we conclude that the requirement is satisfied if

\[ \sqrt{\frac{n(N-1)}{N-n}} \geq \frac{t_{0.9,n-1} - t_{0.005,n-1}}{0.74}. \]

For each \( N \) and \( n \) in Table 2a and 2b we can show that this inequality holds and so the requirement is satisfied.

\textbf{F.4 Test of Individual requirement.}

Calculation of the values in Table 2a and 2b.

The test of the individual requirement is done using the statistics \( n_{T_1} \) and \( n_{T_2} \). These two statistics follow a multivariate hypergeometric distribution [4], that is, their density is defined as

\[ P(n_{T_1}, n_{T_2}) = \binom{M_{T_1}}{n_{T_1}} \binom{M_{T_2}}{n_{T_2}} \binom{N-M_{T_1}-M_{T_2}}{n-n_{T_1}-n_{T_2}} \frac{n}{N}, \]

where \( \binom{a}{b} = \frac{a!}{b!(a-b)!} \).

\( M_{T_2} \) is the number of prepackages in the lot with T2 errors. \( M_{T_1} \) is the number of prepackages in the lot for which \(-2T < E_i < T\). This probability distribution is a generalization of the hypergeometric density used in [1], it is required in order to account for the fact that in addition to the criteria based on \( n_{T_1} \), the lot may be rejected on the basis of \( n_{T_2} \). The need to take this into account was also noted by [2].

1. When a package is sampled from an acceptable lot, we showed above that the values \( q_i \) follow

\[ N \left( Q_{nom}, \frac{T}{1.96} \right)^2 \] distribution.

Now, given the size of the lot \( N \),

\[ M_{T_2} = N * P(q_i < Q_{nom} - 2T) = N * P(Z < -3.92) \approx N * 0 = 0. \] Then \( M_{T_1} = 0.025 * N \).

Now for a particular choice of \( n \) and these \( M_{T_1} \) and \( M_{T_2} \) we require that \( P(n_{T_1} \leq k_1, n_{T_2} = 0) = 0.95 \).
2. Suppose that a package is sampled from a lot with $M_{T_1} + M_{T_2}$ being 9% of the lot size $N$. It is required that such a lot be rejected with probability 0.9. This means that for such a lot it is required that $P(n_{T_1} \leq k_1, n_{T_2} = 0) = 0.1$. In order to be able to calculate this probability we need to have $M_{T_2}$ and we know that $M_{T_2} = N * P(q_i < Q_{nom} - 2T)$. To facilitate making this probability calculation we need to make an assumption about the mean $\mu$. The most conservative choice (the hardest to detect unacceptable lot is one with the correct mean but too many T1 errors) is to have $\mu = Q_{nom}$.

For this choice, using the same kind of arguments as in section 1,

$$q_i \sim N\left(Q_{nom}, \left(\frac{T}{1.34}\right)^2\right)$$

and so

$$P(q_i < Q_{nom} - 2T) = P(Z < -2.68) = 0.0037.$$ 

Thus $M_{T_2} = N * 0.0037$ and $M_{T_1} = 0.09 * N - 0.0037 * N = 0.0863 * N$.

3. For a given lot size $N$ we now find the sample size $n$ and the value $k_1$ such that for $M_{T_1} = 0.025 * N$ and $M_{T_2} = 0$, $P(n_{T_1} \leq k_1, n_{T_2} = 0) = 0.95$, and for $M_{T_1} = 0.0863 * N$ and $M_{T_2} = 0.0037 * N$, $P(n_{T_1} \leq k_1, n_{T_2} = 0) = 0.1$. These values are given in Table 2a and 2b.
Annex G
Schematic representation for the application of T1 and T2 errors
(Informative)

Figure 1 gives a schematic representation of the application of $T_1$ and $T_2$ errors as defined in 2.2.3 and 2.2.4 respectively.

<table>
<thead>
<tr>
<th>Negative individual package errors ($E_i$) (inadequate prepackage)</th>
<th>100 g</th>
<th>Nominal Quantity ($Q_{nom}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-T \leq E_i &lt; 0$</td>
<td>$-4.5 \leq E_i &lt; 0$</td>
<td>Negative individual package quantities $Q_i$ between less than $Q_{nom}$ and $(Q_{nom} - T)$ are acceptable variations.</td>
</tr>
<tr>
<td>$-2T \leq E_i &lt; -T$</td>
<td>$-9 \leq E_i &lt; -4.5g$</td>
<td>Negative individual package errors less than $-T$ but equal to or greater than $-2T$ are called $T1$ errors.</td>
</tr>
<tr>
<td>$E_i &lt; -2T$</td>
<td>$E_i &lt; -9 g$</td>
<td>Negative individual package errors less than $-2T$ are called $T2$ errors.</td>
</tr>
</tbody>
</table>
Annex H
Stepwise sampling plan
(Informative)

H.1 Introduction

In the revision of OIML R 87 it had been pointed out that there were inadequate statistical expressions in the existing document. In order to improve such problems OIML TC 6 agreed at the meeting in 2011 to set up an ad-hoc working group (WG) on statistical methods and expressions used in the R 87.

In addition, some member states requested the addition of a more practical sampling method for inspectors that would enable testing with a smaller sample size. However, a simple decrease in the sample size might cause an increase in the probability of a false judgment. This fact shows the need to actually increase the sample size to assure confidence in the testing. In order to respond to the requirements a stepwise (or multiple) sampling method was introduced.

The procedures proposed by this annex may be adopted in support of OIML R 87 based on a requirement from the authority in each member state or region.

H.2 Acronyms and symbols used in this annex

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_i$</td>
<td>Error of net quantity in an individual prepackage which is equivalent to the actual net quantity minus the nominal net quantity ($E_i = Q_i - Q_{nom}$).</td>
</tr>
<tr>
<td>$E_{ave}$</td>
<td>Average of errors for all prepackages in an inspection lot which is equivalent to the mean value of actual net quantities minus the nominal net quantity ($E_{ave} = \bar{Q}<em>{ave} - Q</em>{nom}$).</td>
</tr>
<tr>
<td>$e_{ave}$</td>
<td>Average of errors for all prepackages in a sample which is equivalent to the mean value of actual net quantities minus the nominal net quantity ($e_{ave} = \bar{q}<em>{ave} - Q</em>{nom}$).</td>
</tr>
<tr>
<td>$H_{T1}$ and $H_{T2}$</td>
<td>Proportion of prepackages with T1 and T2 errors, respectively, in the inspection lot ($H_{Ti} = N_{Ti}/N$, i=1 or 2).</td>
</tr>
<tr>
<td>$N$</td>
<td>Lot size which is equivalent to the total number of prepackages contained in an inspection lot.</td>
</tr>
<tr>
<td>$N$</td>
<td>Sample size which is equivalent to the total number of prepackages in a sample.</td>
</tr>
<tr>
<td>$N_{T1}$ and $N_{T2}$</td>
<td>Number of prepackages with T1 and T2 errors, respectively, in an inspection lot.</td>
</tr>
<tr>
<td>$n_{T1}$ and $n_{T2}$</td>
<td>Number of prepackages with T1 and T2 errors, respectively, in a sample.</td>
</tr>
<tr>
<td>$P_{ac}$</td>
<td>Probability for accepting an inspection lot.</td>
</tr>
<tr>
<td>$Q_i$</td>
<td>Actual net quantity in an individual prepackage.</td>
</tr>
<tr>
<td>$Q_{nom}$</td>
<td>Nominal net quantity declared on the label of a prepackage.</td>
</tr>
<tr>
<td>$Q_{ave}$</td>
<td>Mean value of actual net quantities ($\bar{Q}_i$) in all prepackages in an inspection lot.</td>
</tr>
<tr>
<td>$q_{ave}$</td>
<td>Mean value of actual net quantities ($\bar{q}_i$) in all prepackages in a sample.</td>
</tr>
</tbody>
</table>
\( S \) Sample standard deviation for actual net quantities \((Q_i)\) in all (or a group) of prepackages contained in a sample.

\( \sigma \) Population standard deviation for actual net quantities \((Q_i)\) in all prepackages contained in the inspection lot.

\( SCF \) Sample Correction Factor defined by Equation H.1 which always has a positive value.

\( t_{p, f} \) Student’s t inverse cumulative distribution function with two parameters of probability \((p)\) and number of freedom \((f)\).

**H.3 Inspection requirements specified in R 87**

The OIML R87 stipulates seven important and statistical criteria on which an inspection lot is accepted (or rejected) when a total inspection method or a sampling method is used. A summary of the criteria is shown in Table H.1.
Table H.1: Inspection requirements specified in R 87

<table>
<thead>
<tr>
<th>Method of inspection</th>
<th>No.</th>
<th>Kind of criteria</th>
<th>Numerical criteria or characteristics</th>
<th>Probability for accepting the lot</th>
<th>Relevant clauses in R87</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total inspection</strong></td>
<td>1</td>
<td>Average</td>
<td>$Q_{\text{ave}} \geq Q_{\text{nom}}$</td>
<td>No need for consideration*1</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Individual</td>
<td>$H_{T1} \leq 2.5 %$ and $H_{T2} = 0 %$</td>
<td></td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Sampling inspection</strong></td>
<td>3</td>
<td>Average</td>
<td>$Q_{\text{ave}} \geq Q_{\text{nom}}$</td>
<td>$P_{\text{ac}} &gt; 99.5 %$</td>
<td>4.2.1 a) and 4.3.1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>PR*5</td>
<td>$Q_{\text{ave}} &lt; Q_{\text{nom}} - 0.74\sigma$</td>
<td>$P_{\text{ac}} &lt; 10 %$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>PR*5</td>
<td>$H_{T1} \leq 2.5 %$*3</td>
<td>$P_{\text{ac}} &gt; 95 %$</td>
<td>4.2.1 b) and 4.3.2</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Individual</td>
<td>$H_{T1} \geq 9 %$*4</td>
<td>$P_{\text{ac}} &lt; 10 %$</td>
<td>4.2.1 b) and 4.3.2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>CR*5</td>
<td>$h_{T2} = 0 %$</td>
<td>No need for consideration</td>
<td>4.3.3</td>
</tr>
</tbody>
</table>

*1 In total inspection method, all prepackages of an inspection lot are measured. In this method, both criteria 1 and 2 shall be met in order that the inspection lot would be accepted. In this case, the acceptance of the lot will be decided clearly, and there is no need to consider a probability because $P_{\text{ac}}$ becomes 100 % if all criteria be met and it becomes 0 % otherwise.

*2 For sampling inspection method, an inspection method shall be selected or planned in order that all of the criteria 3-7 would be met. In this method, an inspection lot with the specified numerical characteristics shall be accepted under the specified criteria of probabilities ($P_{\text{ac}}$).

*3 These numerical criteria are set in order that an adequate inspection lot would be accepted with a probability more than the specified values ($P_{\text{ac}}$). In the sampling method however, these criteria are confirmed indirectly based on the inspection result of the sample.

*4 These characteristics are set for an inadequate inspection lot to be tested, and this lot shall be accepted with a probability less than the specified values ($P_{\text{ac}}$). In other words, this lot shall be rejected in order to ensure that consumer’s risk becomes less than the specified probability ($P_{\text{ac}}$).

*5 PR indicates criteria to reduce producer’s risk and CR indicates criteria to reduce consumer’s risk.
H.4 Test procedure for the stepwise sampling method

This clause explains the stepwise sampling method based on the average and individual requirements specified in Clauses 3 and 4 of R 87. This method requires that a test be conducted for the individual requirement (Clause H.4.1) initially and only if this requirement is satisfied, then requires another test for the average requirement (Clause H.4.2). Both tests shall be satisfied in order for an inspection lot to be accepted.

H.4.1 Test procedures for individual prepackage requirements.

Practical test procedures for the individual requirement (Criteria 5 to 7 of Table H.1) are given below. They are also illustrated using flow charts in the Figures H.1 to H.4.

H.4.1.1 Identify the inspection lot to be tested.

H.4.1.2 Find out the nominal net quantity ($Q_{nom}$), and decide the tolerable deficiency to be applied to prepackages in the lot using Table 1 in R 87.

H.4.1.3 Decide (or find out) the size of the inspection lot ($N$) based on the requirements in Clause 4.4 in R 87 (CD3). Find the maximum value of the sample size ($n$), which might be required throughout all the sampling steps, from Table H.2. A case with $N=100-139$ and $n=70$ (at step 4) is employed in the following explanations.

H.4.1.4 Take 70 prepackages randomly from the inspection lot and mark them with identification numbers (#1-#70). This group of 70 items is referred to as the 'original sample' in these procedures. This procedure is necessary in order to maintain randomness in sampling and not to repeat measurements on the same item.

H.4.1.5 **STEP 1**: Take a small group of 35 prepackages (#1-#35) from the original sample and measure the actual net quantity in each. After the measurements, do not mix the measured 35 prepackages with the rest. Then, count the number of prepackages with T1 and T2 errors. If there is no prepackage with T1 error among the 35 (note that $n_{T1} = 0$ at step 1 in Table H.2), the individual requirement is satisfied (go to H.4.2). If there are one, two or three prepackages with T1 errors, go to procedures H.4.1.6, H.4.1.7 or H.4.1.8, respectively.

H.4.1.6 **STEP 2**: If there is one prepackage with T1 error among the 35, take an additional small group of prepackages from the original sample up to #45 and measure the actual net quantities of the additional prepackages. If there is no additional prepackage with T1 error, the individual requirement is satisfied (go to H.4.2). If there are two or three prepackages in total with T1 errors, go to procedures H.4.1.7 or H.4.1.8, respectively.

H.4.1.7 **STEP 3**: If there are two prepackages with T1 errors, take an additional small group of prepackages from the original sample up to #60 and measure the actual net quantities of the additional prepackages. If there is no additional prepackage with T1 error, the individual requirement is satisfied (go to H.4.2). If there are three prepackages in total with T1 errors, go to procedure H.4.1.8.

H.4.1.8 **STEP 4**: If there are three prepackages with T1 errors, take all items left in the original sample (70 in total) and measure the actual net quantities of the additional prepackages. If there is no additional prepackage with T1 error, the individual requirement is satisfied (go to H.4.2).

H.4.1.9 In the procedures H.4.1.5 to H.4.1.8, the inspection lot shall be rejected immediately if there is one prepackage with T2 error, or four or more prepackages with T1 errors.
H.4.2  Test procedure for average requirement

Only if the test for individual requirement (H.4.1) has been passed, another test for average requirement shall be followed based on Criteria 3 and 4 of Table H.1. Firstly, obtain actual numbers of lot size \( N \) and sample size \( n \) when the individual test has been passed. Then, calculate the \( SCF \) (Sample Correction Factor) using Equation H.1, in which \( t_{0.005, n-1} \) represents the value of Student’s \( t \) inverse cumulative distribution function at a probability of 0.5 \%. Equations H.1 was designed in order that \( SCF \) would have a positive value by adding a negative sign before the function \( t_{0.005, n-1} \). It is because this function produces a negative value for a probability \( \rho \) less than 50 \% \( (t = -2.63 \) for \( \rho = 0.5 \% \) and \( n = 100) \). \( SCF \) can be obtained using functions of Microsoft Excel (Version 2010 or later) as given by Equation H.1’.

\[
SCF = \frac{-t_{0.005, n-1}}{\sqrt{\frac{n(N-1)}{(N-n)}}}
\]  

\[
SCF = -\text{T.INV} \left(0.005, n-1\right) / \left(\text{SQRT} \left( n \times \left(\frac{N-1}{N-n}\right)\right)\right) \]  

(H.1)

(H.1’)

Then, confirm if \( SCF \) meets the criterion given by Equation H.2. If this criterion is fulfilled, it is concluded that the inspection lot satisfies the average requirement. In Equation H.2, \( e_{\text{ave}} \) represents an average of the errors \( E_i \) with positive or negative sign that were measured for all (or small group of) prepackages taken from the original sample. \( s \) represents sample standard deviation of the errors \( E_i \) with a positive sign. In the case of step 1 for \( N = 100 \) in Table H.2, \( e_{\text{ave}} \) and \( s \) are equivalent to the values for the 35 prepackages (\#1-\#35).

\[
e_{\text{ave}} / s > -SCF
\]  

(H.2)

H.4.3  Final assessment

If the inspection lot passes the individual requirement (H.4.1) as well as the average requirement (H.4.2), it shall be concluded that the lot fulfills all requirements by this annex based on the OIML R 87, and the inspection lot should be accepted.
Table H.2: Values of sample sizes \((n)\) and acceptable prepackages with T1 errors \((n_{T1})\) in the stepwise sampling method proposed in this annex

<table>
<thead>
<tr>
<th>Lot size ((N))</th>
<th>Step No.</th>
<th>Sample size in each step ((n))</th>
<th>Acceptable number of prepackages in the sample with T1 errors ((n_{T1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>139</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>70</td>
</tr>
<tr>
<td>140</td>
<td>289</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>80</td>
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<tr>
<td></td>
<td></td>
<td>5</td>
<td>90</td>
</tr>
<tr>
<td>290</td>
<td>999</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>90</td>
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<tr>
<td></td>
<td></td>
<td>5</td>
<td>100</td>
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<td></td>
<td></td>
<td>6</td>
<td>115</td>
</tr>
<tr>
<td>1 000</td>
<td>100 000</td>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>130</td>
</tr>
</tbody>
</table>
Figure H.1  Stepwise sampling method to test the individual requirement for a lot size $N=100-139$

Step 1: Start the entire procedure

- Take 70 prepackages from the lot (N=100-139) and mark them with ID numbers (#1-
- Measure actual net quantities of the prepackages #1 to #35
- Are there any with T2 errors?
  - No
    - Are there any with T2 errors?
      - No
        - How many prepackages are there with T1 errors?
          - 0
            - Step 2 (Fig. H.2)
            - Individual test is passed
              (conduct average test in H4.2)
          - 1
            - Step 2 (Fig. H.2)
          - 2
            - Step 3 (Fig. H.3)
          - 3
            - Step 4 (Fig. H.4)
            - Individual test is passed
              (conduct average test in H4.2)
          - 4 or more
            - Reject the lot
  - Yes
    - How many prepackages are there with T1 errors?
      - 0
        - Step 2 (Fig. H.2)
      - 1
        - Step 2 (Fig. H.2)
      - 2
        - Step 3 (Fig. H.3)
      - 3
        - Step 4 (Fig. H.4)
        - Individual test is passed
          (conduct average test in H4.2)
      - 4 or more
        - Reject the lot
    - Reject the lot

START
Stepwise sampling method to test the individual requirement for a lot size $N=100-139$

Step 1: A case when one prepackage with T1 error was found in step 1

 Measure net quantities of the additional prepackages up to #45

- **No**
  - Are there any with T2 errors?

- **Yes**
  - Reject the lot

- **How many prepackages are there with T1 errors in total?**
  - 1
    - Individual test is passed (conduct average test in H4.2)
  - 2
    - Step 3 (Fig. H.3)
  - 3
    - Step 4 (Fig. H.4)
  - 4 or more
    - Reject the lot

**Figure H.2**  Stepwise sampling method to test the individual requirement for a lot size $N=100-139$

Step 2: A case when one prepackage with T1 error was found in step 1
Figure H.3  Stepwise sampling method to test the individual requirement for a lot size $N=100-139$

Step 3: A case when two prepackages with T1 error were found in step 1 or 2
Figure H.4  Stepwise sampling method to test the individual requirement for a lot size $N=100-139$

Step 4: A case when three prepackages with T1 error were found in step 1, 2 or 3
Annex I
References
(Informative)

[1] OIML R 79 Labelling requirements for prepackages


