

HB



Reference Test

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Reference Test



- ▶ Checks ... shall be carried out by the competent departments ... by sampling on the packer's premises or, ... of the importer or of his agent established in the Community.
- ▶ Must be carried out to check prepackages comply
 - Quantity, labelling,
- ▶ Quantity check ('reference tests') specified Annex II
- ▶ No frequency for the checks stipulated
- ▶ Also check systems, equipment and records

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Reference Test Process



- ▶ Ensure measurements can be made to the required level of accuracy,
- ▶ Decide on whether a non-destructive test can be carried out,
- ▶ Identify a batch,
- ▶ Determine the sample size needed for the tests,
- ▶ Withdraw the sample, randomly,
- ▶ Measure the contents of each prepackage,
- ▶ Determine the number of defective,
- ▶ Determine average of prepackages, may be a sub-set,
- ▶ Check against the criterion,
- ▶ Take appropriate action.

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Measurement Accuracy



- ▶ The actual contents of prepackages may be measured directly by means of weighing instruments or volumetric instruments or, in the case of liquids, indirectly, by weighing the prepacked product and measuring its density.
- ▶ Irrespective of the method used, the error made in measuring the actual contents of a prepackage shall not exceed one-fifth of the tolerable negative error for the nominal quantity in the prepackage.
- ▶ The procedure for measuring the actual contents of a prepackage may be the subject of domestic regulations in each Member State.
- ▶ 'error' is interpreted as the expanded uncertainty of measurement ($k=2$)

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Uncertainty Budgets



- ▶ Identify all possible sources of error,
- ▶ For those that cannot be corrected, determine or estimate the magnitude of the error,
- ▶ Establish the type of distribution to determine the 'divisor',
- ▶ Determine the ratio impact (sensitivity) on the attribute being measured,
- ▶ Calculate a standard uncertainty for each source of error,
- ▶ Combine these to provide a combined standard uncertainty,
- ▶ Multiply by an appropriate factor (k value) to obtain the confidence level required, producing an expanded uncertainty.
- ▶ See WELMEC 6.9

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HB Sources of Error

- ▶ Using an MCB and templet
 - MCB permitted error
 - Templet error
 - Reading error
- ▶ Magnitude of error
 - MCB, from Directive
 - Templet markings, 0.5 mm
 - Reading templet, 0.5 mm

HB Distribution & Divisor

- ▶ MCB, using the maximum permitted error
 - A rectangular distribution,
 - Divisor is $\sqrt{3}$,
- ▶ Templet (marking) error, estimate maximum limit
 - Estimate volume of liquid equal to 0.5 mm height variation in liquid fill
 - Again a rectangular distribution,
 - Divisor is $\sqrt{3}$,
- ▶ Reading error, of 0.5 FTE will be the same as for templet marking error

HB Sensitivity

- ▶ Calculate the impact ratio of the change on the volume or weight of the product.
- ▶ Example: templet error
 - Diameter at fill height, 4 cm, 1 mm change gives
 - Working in cm as $\text{cm}^3 = 1 \text{ ml}$
 - $\frac{1}{4}\pi d^2 h = \frac{1}{4}\pi 3^2 0.1 \approx 1.3$

HB Uncertainty Budget

Element	Value	Divisor	Multiplier	Std Unc
		(distribution)	(sensitivity)	(ml)
▶ MCBs	6 ml	$\sqrt{3}$	1	3.5
Templet error	0.5 mm	$\sqrt{3}$	1.3	0.4
Reading error	0.5 mm	$\sqrt{3}$	1.3	0.4
Combined uncertainty (MCB dominant)				3.54
Expanded uncertainty (k=2)				7.09

HB Exercise

- ▶ The weight of 500 g prepackages of biscuits is determined using a NAWI with a scale division of 1 g (assume maximum error 1 g), and assuming a constant tare of 10.8 g, where the tare variability, s_t , is 1.2 g. What is the measurement error and does this meet the needs of the Directive for carrying out a reference test?

HB Simple Weight Uncertainty Budget

Element	Value	Divisor	Multiplier	Std Unc
		(distribution)	(sensitivity)	(ml)
▶ NAWI – tare	1 g	$\sqrt{3}$	1	0.6
NAWI – gross	1 g	$\sqrt{3}$	1	0.6
Tare variability, s_t	1.2 g	1	1	1.2
Combined uncertainty				1.47
Expanded uncertainty (k=2)				2.94

HB Suitability

- ▶ Measurement error is 2.94 g
- ▶ The TNE for a 500 g pack of biscuits is 3% or 15 g and so one-fifth of TNE = 3 g. So this method of test measures the contents of each pack with sufficient accuracy to meet the requirements of the Directive.
- NOTES
 - *NAWI - tare*, 1 g division, this is the maximum permissible error (mpe) for the NAWI up to 500 g. (If the NAWI was calibrated then the actual uncertainty can be used).
 - *NAWI - gross*, as above
 - The divisor is $\sqrt{3}$, which is the recognised method of converting a limit into a standard uncertainty.
 - *Tare variability* - 1.2 is a standard deviation and so needs no divisor to obtain a standard uncertainty.

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HB Example: Volume

- ▶ The quantity of a gaseous drink in a 330 ml glass bottle is determined, after allowing its temperature to stabilise along with some water, by:
 - ▶ marking the level of liquid in the bottle,
 - ▶ weighing the full bottle,
 - ▶ emptying the bottle and weighing it dry,
 - ▶ filling the bottle to the mark with water of known density,
 - ▶ weighing the bottle filled with water,
 - ▶ taking the temperature of the water,
 - ▶ from standard water density tables the volume of the drink can be determined.
- ▶ What are the sources of error and how can they be quantified?

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HB Type of Reference Test

- ▶ The Directive states that there are two sampling plans:
 - ▶ — one for non-destructive testing, i.e., testing which does not involve opening the package,
 - ▶ — the other for destructive testing, i.e., testing which involves opening or destroying the package.
- ▶ For economic and practical reasons, the latter test shall be limited to the absolutely essential minimum; it is less effective than the non-destructive test.
- ▶ Destructive testing shall therefore be used only when non-destructive testing is impracticable. As a general rule it shall not be applied to batches of fewer than 100 units.

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HB Batch Identification

- ▶ The batch shall comprise all the prepackages of the same nominal quantity, the same type and the same production run, packed in the same place, which are to be inspected.
- ▶ Food and cosmetic products are required to have batch codes.
- ▶ Batch size for reference test
 - 1 hour production when taken from the end of the packing line (or the actual time it takes to pack if this is less than 1 hour)
 - Maximum 10,000 in warehouse from the same batch.

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HB Sample Size

- ▶ Specified in Annex II
- ▶ Sample size for actual contents (defective) test may differ from average test
- ▶ The average test sample size shall be a subset of the actual contents sample.
- ▶ All samples shall be random
- ▶ Take extra for breakages
- ▶ Random numbers, times, layered numbers

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HB Sample Sizes



Batch Size	Non-destructive Test		Destructive Test	
	Defective test	Average test	Defective test	Average test
1 - 99	100 %	100 %	-	-
100 - 500	30 + 30 = 60	30	20	20
501 - 3,200	50 + 50 = 100	50	20	20
3,201 & over	80 + 80 = 160	50	20	20

No destructive tests are permitted for batches less than 100 prepackages

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HB Example:



- ▶ The biscuit packer is producing 4,000 packs of plain biscuits each one hour on the packing line, and
- ▶ He has some choc biscuits in the warehouse.
- ▶ You are able to carry out a non-destructive test using a constant tare weight,
- ▶ What sized sample do you draw from the batches?

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HB Answer:



- ▶ From the line, production rate is more than 3,200 per hour so sample size must be 160 for the defective test, (plus a few more for breakages). From these the sample of size 50 for the average test must be drawn at random.
- ▶ Any batch size can be selected up to 10,000 prepackages. If informed that the packing rate is 2,500 per hour, can select a batch of this size. If so must take 100 items for the defective test, plus a few for breakages & use a random 50 for average test.

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HB Sampling



- ▶ Health and safety
- ▶ Hygiene
- ▶ Personal protective equipment (PPE)
 - can include, white coats, reflective jackets, gloves, beard snoods, toe protectors.
- ▶ End of line(s), past packers checking point
- ▶ Warehouse
 - 2 empty pallets, for full & broken
 - Containers for carrying sample to measuring point.

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HB Defective Test - Actual Contents



- ▶ A prepackage is considered defective if its actual content is less than the 'minimum acceptable contents'. The 'minimum acceptable contents' is calculated by subtracting the tolerable negative error (TNE) for the contents concerned from the nominal quantity of the prepackage, i.e. below T1.
- ▶ Example:
 - ▶ The biscuits are marked 500 g and so the TNE is 3% = 15 g.
 - ▶ Therefore the 'minimum acceptable contents' is $500 - 15 \text{ g} = 485 \text{ g}$.
 - ▶ Any prepackage with contents less than 485 g is considered 'defective'

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HB Acceptable Defectives

- ▶ The number of acceptable 'defective' prepackages is considered to be 2.5%.
- ▶ The number permitted in a reference test sample is a higher proportion than this to give the packer the benefit of the doubt – as a sample may have been selected which contains a higher proportion of defectives than the batch from which it was taken.

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HB Criteria for defectives

Batch Size	Non-destructive Test		Destructive Test	
	Sample size	Acceptable number of defectives	Sample size	Acceptable number of defectives
1 - 99	100 %	2.5 %	-	-
100 – 500	30 + 30 = 60	1 (reject if >2) then 4	20	1
501 – 3,200	50 + 50 = 100	2 (reject if >4) then 6	20	1
3,201 & over	80 + 80 = 160	3 (reject > 6) then 8	20	1

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HB Example:

- ▶ A batches of 2,500 choc biscuits has been sampled and the contents of the first 50 prepackages have been measured.
- ▶ There are 5 defective prepackages,
- ▶ What decision can be made?

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HB Answer:

- ▶ As 5 is greater than 4 then the number of defectives is too great and the batch fails the reference test and the other 50 items do not need to be tested for defectives – although they may form part of the random sample used for the average test and some may still need to be measured.

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HB Average Test

The average of the batch is acceptable if it is greater than:

$$Q_n - s \cdot t(1 - \alpha) / \sqrt{n},$$

In this formula:

- Q_n = the nominal quantity of the prepackage,
- n = the number of prepackages in the sample for this check,
- s = the estimated standard deviation of the actual contents of the batch,
- $t(1 - \alpha) = 0.995$ confidence level of a Student distribution with $\nu = n - 1$ degree of freedom.

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HB Criteria

The acceptance criteria for the various sample sizes are:

Test type	Batch size	Sample size	Criteria	
			Acceptance	Rejection
Destructive	Whatever the number (≥ 100)	20	$x \geq Q_n - 0.640s$	$x < Q_n - 0.640s$
Non destructive	100 to 500 inclusive	30	$x \geq Q_n - 0.503s$	$x < Q_n - 0.503s$
Non destructive	> 500	50	$x \geq Q_n - 0.379s$	$x < Q_n - 0.379s$

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HB Exercise:



- ▶ The reference test on a batch of 2,500 prepackages of 500 g choc biscuits is carried out. The quantity in each of 50 prepackages is determined and the average quantity is calculated as being 496.8 g with the estimate of the standard deviation of the batch (standard deviation of the sample using $n-1$ divisor) being 9.2 g.
- ▶ Is this acceptable?

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HB Answer:



- ▶ The batch is acceptable if the average,

$$x \geq Qn - 0.379s,$$
 that is

$$x \geq 500 - 0.379 \times 9.2 \text{ g}$$

$$x \geq 500 - 3.4868 \text{ g}$$

$$x \geq 496.5 \text{ g}$$
- ▶ As the average determined of 496.8 g is greater than 496.5 g then the batch is acceptable

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HB Appropriate Action



- ▶ If both tests pass then the batch is acceptable.
- ▶ If either, or both, tests failed refer to domestic law & guidance.
- ▶ Any items below T2 should not be marketed
- ▶ Packer or importer may rectify a failed batch using one or more of the following:–
 - removing excessive defective items,
 - removing the lower quantity prepackages to increase the average, e.g. using an automatic checkweigher,
 - producing another batch with an enhanced average and mixing it with the failed batch so that the new batch has an acceptable average.

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HB Retail Monitoring



- ▶ Directive Annex I 6 permits competent departments to do other checks
- ▶ If < 100 prepackages, no reference test by sampling
- ▶ Other tests may indicate need for reference test at packer's or importer's premises.
- ▶ Retail checks can
 - Check label compliance
 - Identify new packers & importers.

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HB Questions



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