



HB 

Control System

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HB 

Controls Systems

- ▶ *the check ... shall be so organized that the quantity of the contents is effectively ensured.*
- ▶ Ensure the 3 Packers' Rules are met
 - Batch pass reference test, whatever portion sampled
- ▶ As effective as reference test in detecting non-compliance
 - 50 items from 10,000
- ▶ Packer & Importer can decide


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Terms


- ▶ Average
 - Example: 1, 2, 2, 3, 4, 7, 9
 - **Mean** (4), median (3) and mode (2)
- ▶ Variability
 - Standard deviation of group, s_n (2.73)
 - **Estimate of batch**, $s_{(n-1)}$ (2.94)
 - Range (8)

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HB Control by sampling 


- ▶ Packer needs to:
 - Assess process variability
 - Consider tare (packaging) variability
 - Consider other variables, e.g. desiccation, temperature at time of fill (milk 5°C)
 - Decide sampling rate
 - Establish target quantity
 - Set limits for average & variability
 - Monitor process

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HB Process variability 


- ▶ At least 200 values
- ▶ From 3 production runs (from records)
- ▶ Determine average & standard deviation
- ▶ Checked for 'normality'
- ▶ Target to address variability for compliance of all 3 rules. Higher of
 - Q_n
 - $T1 + 2s$
 - $T2 + 3.72s$

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HB Example: 500 g Biscuits 


- ▶ TNE = 15 g, T1 = 485 g, T2 = 470 g
- ▶ Variability: plain - 7g, jam - 8g, choc - 9g
- ▶ For variability of 7 g
 - $Q_n = 500g$
 - $T1 + 2s = 485 + 2 \times 7 = 485 + 14 = 499g$
 - $T2 + 3.72s = 470 + 3.72 \times 7 = 496.04g$
- ▶ What are targets for variabilities of 8g & 9g?

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HB Results 


Biscuit	s	Qn	T1 + 2s	T2 + 3.72s
Plain	7	500	499	496.04
Jam	8	500	501	499.76
Choc	9	500	503	503.48

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HB Tare Variability 


- ▶ Combine with process variability $s_o(t) = \sqrt{s_o^2 + s_t^2}$, & calculate as above
- ▶ Or add allowance of $0.85 s_t$
- ▶ Example: Packers uses a constant tare of 10.8 g, with a variability of 1.2 g. What are target quantities using both method

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HB Results 


Biscuit	Variability s	Target using $s_o(t)$	Target adding $0.85 s_t$
Plain	7	500	501.02
Jam	8	501.18	502.02
Choc	9	503.78	504.50

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HB Sampling Allowance 


- ▶ No allowance needed if at least 50 items are sampled from a production period (PP)
 - $PP = 10,000/\text{packing rate}$, min 1 hr, max 8 hr
- ▶ If < 50 allowance needed so as to ensure that the control system is as effective as the reference test
- ▶ Table of allowances, z ,
 - Allowance = $z s$ (or $z s_o(t)$)

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HB Production Period 


- ▶ Packing rates: plain 4,000, jam 3,000, choc 2,000
What is the production period?
- ▶ The production period is
 - ▶ - for plain biscuits $10,000/4,000 = 2.5$ hours
 - ▶ - for jam biscuits $10,000/2,500 = 4$ hour and
 - ▶ - for chocolate biscuits $10,000/2,000 = 5$ hours.

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HB Samples per Production Period 


- ▶ As a sample is taken from the line every half an hour, then the number of samples taken to monitor the production of 10,000 prepackages is:
 - ▶ for plain biscuits $2.5 / 0.5 = 5$
 - ▶ for jam biscuits $4.0 / 0.5 = 8$
 - ▶ for chocolate biscuits $5.0 / 0.5 = 10$.

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HB Prepackages checked per Production Period 


- ▶ If samples of size 5 are taken ½ hourly, how many prepackages are taken?
- ▶ - for plain biscuits $5 \times 5 = 25$, this is less than 50 and so an allowance is applicable,
- ▶ - for jam biscuits $8 \times 5 = 40$, this is less than 50 and so an allowance is applicable,
- ▶ - for choc biscuits $10 \times 5 = 50$, no allowance is required

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HB Z factors – part 


No in sample, n	No of samples, k						
	2	3	4	5	6	7	8
2	0.84	0.70	0.61	0.54	0.47	0.41	0.35
3	0.65	0.53	0.46	0.37	0.31	0.26	0.21
4	0.54	0.44	0.35	0.27	0.21	0.17	0.13
5	0.46	0.37	0.27	0.20	0.15	0.11	0.07
6	0.40	0.31	0.21	0.15	0.10	0.07	0.03

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HB Example z factors 

- ▶ Plain biscuits, n=5 and k=5
z = 0.2, so allowance is $0.2 \times 7.10 = 1.42g$
So target becomes **501.40 g**
- ▶ Jam biscuits, n=5 and k=8
Z = 0.07, so allowance is $0.07 \times 8.09 = 0.57g$
so target becomes **501.75 g**
- ▶ Choc biscuits, n=5 and k=10
z=0, as 50 prepackages sampled
so target remains as **503.78 g**


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HB Action Limit for the Average 

- ▶ 1 in 1,000 probability used
- ▶ $3.09s_e$ below target
- ▶ Central limit theorem, $s_e = s_o(t) / \sqrt{n}$, where n is sample size


- ▶ Warning limit - 1 in 40 probability,
 - 2 consecutive warnings = action
- ▶ $1.96s_e$ below target
- ▶ Upper limits no nearer the target,
 - Duty on alcohol

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HB Example average limits 


- ▶ - for plain biscuits,
 $se = s_o(t) / \sqrt{n} = 7.10 \text{ g} / \sqrt{5} = 3.175 \text{ g}$,
 action limit $501.40 - 3.09 \times 3.175 = 491.6 \text{ g}$.
- ▶ - for jam biscuits,
 $se = s_o(t) / \sqrt{n} = 8.09 \text{ g} / \sqrt{5} = 3.681 \text{ g}$,
 action limit is $501.75 - 3.09 \times 3.618 = 490.6 \text{ g}$.
- ▶ - for choc biscuits,
 $se = s_o(t) / \sqrt{n} = 9.08 \text{ g} / \sqrt{5} = 4.061 \text{ g}$,
 action limit is $503.78 - 3.09 \times 4.061 = 491.2 \text{ g}$

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HB Exercise 


- ▶ If both action & warning limits are used, what would be:
 the new targets, and
 the warning limit
 for the biscuit lines?

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HB **Sample Variability Action Limits** 


- ▶ If $s < 0.5$ TNE, the packer need only control the average.
- ▶ If $s > 0.5$ TNE the variability needs monitoring as a change may require a different target.
- ▶ Standard factors are used to calculate limits
- ▶ 1 in 1,000 and 1 in 40 probability limits used

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HB **Variability Limit Factors** 


Sample size	2	3	4	5
Upper Action	3.29	2.62	2.33	2.15
Upper Warning	2.24	1.92	1.77	1.67
Lower Warning	-	0.16	0.27	0.35
Lower Action	-	0.03	0.09	0.15

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HB **Example calculation** 

- ▶ What are the action limits for the biscuit line sample standard deviations?
- ▶ Plain biscuits, $s=7.1$ g which is < 0.5 TNE, no need to monitor variability
- ▶ Jam biscuits, $s= 8.09$ g, so limit is (for samples of size 5) $2.15 \times 8.09 = 17.4$ g
- ▶ Choc biscuits, limit is $9.08 \times 2.15 = 19.5$ g


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HB Cusum Control 

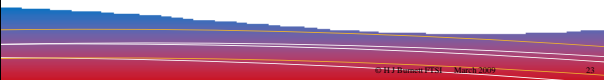
- ▶ Target is set
- ▶ Target value subtracted from average of sample
- ▶ These differences are accumulated
- ▶ Change over several 5 plots are checked
- ▶ Detects changes quicker as more data used
- ▶ WELMEWC 6.5 at E.8.3




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HB MCB & Templets 


- ▶ Similar to control by sampling but target needs to take into account:
 - MCB tolerance
 - Error in fill height measurement
 - Temperature of liquid at time of test
 - Variability of process
 - Accuracy of templet markings



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HB Example: 200 ml MCB 

- ▶ At fill height of 10 mm, internal diameter is 40mm. MCB tolerance is 6 ml, so $s_{(mcb)} \sim 3$ ml. Filling process, $s = 5$ ml.
- ▶ MCB has a cross sectional area at the fill height of $\pi(2^2) = 12.6 \text{ cm}^2$. Therefore 1 mm change in liquid height equates to 1.3 ml.
- ▶ MCB & templet error = $\sqrt{\{3^2 + 0.4^2 + 0.4^2\}} = 3.1$ ml
- ▶ Combine variability = $\sqrt{\{(3.1)^2 + (5)^2\}} = 5.9$ ml
- ▶ Target quantity calculated as before, see next slide



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HB MCB Target Example



- ▶ Therefore the target quantity needs to be the greater of
- ▶ $Q_n = 200.0 \text{ ml}$
- ▶ $T1 + 2 s = 191 + 2 \times 5.9 = 202.8 \text{ ml}$
- ▶ $T.2 + 3.72 s = 182 + 3.72 \times 5.9 = \mathbf{203.9 \text{ ml}}$
- ▶ Target quantity will be 203.9 ml, assuming more than 50 items are checked each production period; otherwise a sampling allowance (z) is needed.
- ▶ The limits for average & standard deviation are calculated as in the section above.

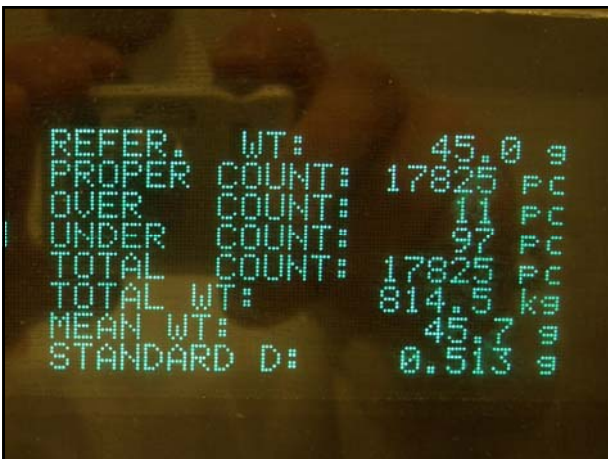
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HB Checkweighers



- ▶ Set points are the weights at which accept & reject decisions are made.
- ▶ Set points can be at Q_n' , $T1'$ & $T2'$
- ▶ Set points need to be used that take into account:
 - ▶ Zone of indecision (zoi),
 - 6 x standard deviation of a package
 - ▶ Tare variability
 - ▶ Other appropriate allowances, e.g. desiccation
 - ▶ Requirements will depend on domestic legislation


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HB Set Point Calculations 


- ▶ From WELMEC 6.5, under review
- ▶ If $zoi < 0.25$ TNE, no allowance needed
- ▶ If $zoi > 0.25$ TNE, allowance 0.5 TNE + 0.125 TNE
- ▶ If $s(t) < 0.1$ TNE, no allowance needed,
- ▶ If $s(t) > 0.1$ TNE, allowance is 0.85 $s(t)$

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HB Exercise: Set Point Calculation 


- ▶ Biscuit packaging has average weight of 10.8 g and a variability of s_t 1.2 g. He checks the zone of indecision of the checkweigher by passing a pack over the instrument 50 times and obtains from the checkweigher the calculated standard deviation of readings of 1 g.
- ▶ Therefore the zone of indecision is 6×1 g = 6 g.
- ▶ What should the set point be for the nominal quantity, T1 and T2?

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HB Set Point Result 


- ▶ Q_n ' set point will be:
 $= 500$ g + 10.8 (average tare) + 0 (no allowance for tare variability as it is less than 0.1 TNE) + 0.5×6 (zoi) - 0.125×15 (TNE)
 $= 500 + 10.8 + 3 - 1.875$ g
 $= 511.925$ g, which rounded = **511.9 g**
- ▶ TU1' set point will be:
 $=$ similarly $= 485 + 10.8 + 0 - 1.875$
 $=$ **496.9 g**
- ▶ TU2' set point will be:
 $= 470 + 10.8 + 0 - 1.875$ = **481.9 g**

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HB **Monitoring Checkweighers** 


- ▶ Recommendation
- ▶ To ensure set points do not drift, check all the set points (Qn, T1 and T2) with dummy packs weights with a 20 % chance of rejection, and an 80 % chance of rejection, at set point. Weights = set point $\pm 0.142 \times zoi$.
- ▶ (Note: If $0.142 \times$ zone of indecision is smaller than one-tenth of the TNE, use $0.1 \times$ TNE).
- ▶ One pass of each (1 overweight, 1 underweight) test pack. If each is correctly graded, test ends. Otherwise,
- ▶ Four more passes at each test weight. If at least one pass at each weight results in correct grading, test ends. Otherwise adjust checkweigher.


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HB **Dummy Pack Weight Calculation** 

- ▶ What should the biscuit packer's dummy packs for checking the set points weigh?
- ▶ (a) For Q_n ' set point, $511.925 \pm 0.142 \times 6$
 $= 511.925 \pm 0.852$
 $= 511.073 \text{ g (511.07 g) and } 512.777 \text{ g (512.78 g)}$
- ▶ (b) For $T1$ ' set point $496.925 \pm 0.142 \times 6$
 $= 496.925 \pm 0.852$
 $= 496.073 \text{ g (496.07 g) and } 497.777 \text{ g (497.78 g)}$
- ▶ (c) For $T2$ ' set point $481.925 \pm 0.142 \times 6$
 $= 481.925 \pm 0.852$
 $= 481.073 \text{ g (481.07 g) and } 482.777 \text{ g (482.78 g)}$

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HB **Checkweigher Dummy Packs** 

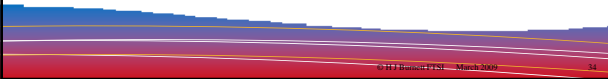


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HB Spreadsheets



- ▶ A spreadsheet to calculate the quantity controls for sampling can be found at:
▶ <http://www.somerset.gov.uk/media/BB6/79/QuantityControlsCalc.xls>
- ▶ A spreadsheet to calculate the checkweigher controls can be found at:
▶ <http://www.somerset.gov.uk/media/BB6/6F/CheckWeigherControlsCalc.xls> .



HB Questions

