

CIMT Further Statistics p163 Example

X = number of non-conforming ball bearings in scoop

$$X \sim \text{Bin}(n, p)$$

$$\text{We estimate } p \text{ with } \hat{p} = \frac{16 + 6 + 11 + \dots + 10 + 13}{95 + 99 + 115 + \dots + 92 + 112} = \frac{109}{1040}$$

$$\text{We estimate } n \text{ as the mean of scoop sizes} = \frac{1040}{10} = 104$$

$$\text{so } X \sim \text{Bin}(104, p)$$

$$\text{Approximate } X \text{ with } Y \sim N(104p, 104pq)$$

This is valid if $104p > 5$ and $104q > 5$

$$\frac{Y}{104} = \text{proportion of non - conforming ball bearings}$$

$$\frac{Y}{104} \sim N\left(p, \frac{pq}{104}\right)$$

$$\text{So } \frac{Y}{104} \sim N\left(\frac{109}{1040}, \frac{109}{1040} \times \frac{931}{1040} \times \frac{1}{104}\right)$$

$$UCL = \frac{109}{1040} + 3 \times \sqrt{\frac{109}{1040} \times \frac{931}{1040} \times \frac{1}{104}} = 0.1949$$

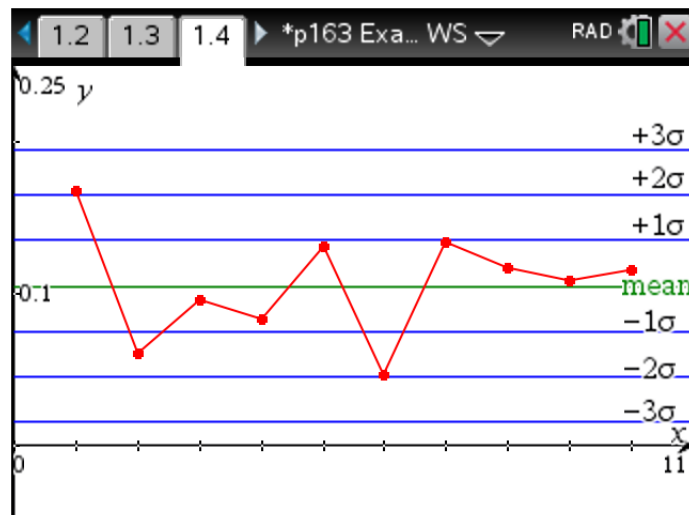
$$UWL = \frac{109}{1040} + 2 \times \sqrt{\frac{109}{1040} \times \frac{931}{1040} \times \frac{1}{104}} = 0.1649$$

$$LWL = \frac{109}{1040} - 2 \times \sqrt{\frac{109}{1040} \times \frac{931}{1040} \times \frac{1}{104}} = 0.0447$$

$$LCL = \frac{109}{1040} - 3 \times \sqrt{\frac{109}{1040} \times \frac{931}{1040} \times \frac{1}{104}} = 0.0147$$

We don't really need the lower limits, as we are measuring proportions of non-conforming and low proportions of this are not concerning to us.

A sample	B no_in_...	C non_c...	D nc_pr...	E
=			=non_cor	
1	1	95	16	16/95
2	2	99	6	2/33
3	3	115	11	11/115
4	4	120	10	1/12
5	5	84	11	11/84
6	6	107	5	5/107
7	7	97	13	13/97
8	8	119	14	2/17
9	9	92	10	5/46
10	10	112	13	13/112
11				
12				
nc_proportion: = 'non_conforming' / 'no_in_scoop'				



We bear in mind the following Western Electric Company Rules for Control Charts:

- Any single data point falls outside a 3σ limit
- Two out of three consecutive points fall beyond the same 2σ limit
- Four out of five consecutive points fall beyond the same 1σ limit
- Eight consecutive points fall on the same side of the centre line

Only the first reading lies beyond the $+2\sigma$ limit, which is not concerning to us.

/cont.

b) i) proportion of sample non-conforming = $21/115 = 0.1826$

This value is between $+2\sigma$ and $+3\sigma$ limits.

Take another scoop straight away and see if the problem persists.

ii) proportion of sample non-conforming = $8/94 = 0.0851$

This value is below the $+2\sigma$ limit, and does not give us cause for concern, as low values of non-conformity are not a problem

iii) proportion of sample non-conforming = $20/92 = 0.2174$

This value is above the $+3\sigma$ limit, and indicates that the process is out of control.

Production should be halted and the problem investigated.

iv) proportion of sample non-conforming = $3/12 = 0.25$

This value is above the $+3\sigma$ limit, and suggests that the process is out of control. But this result may be considered unreliable due to the small sample size of 12.

Suggest taking another, larger scoop for sampling.

v) proportion of sample non-conforming = $1/104 = 0.0096$

This value is below the -3σ limit, and does not give us cause for concern, as low values of non-conformity are not a problem.