POLITECNICO
MILANO 1863

DEPARTMENT OF MECHANICAL
ENGINEERING

EXTRA EXERCISE CLASS 3

Control Charts for small shifts

mecc

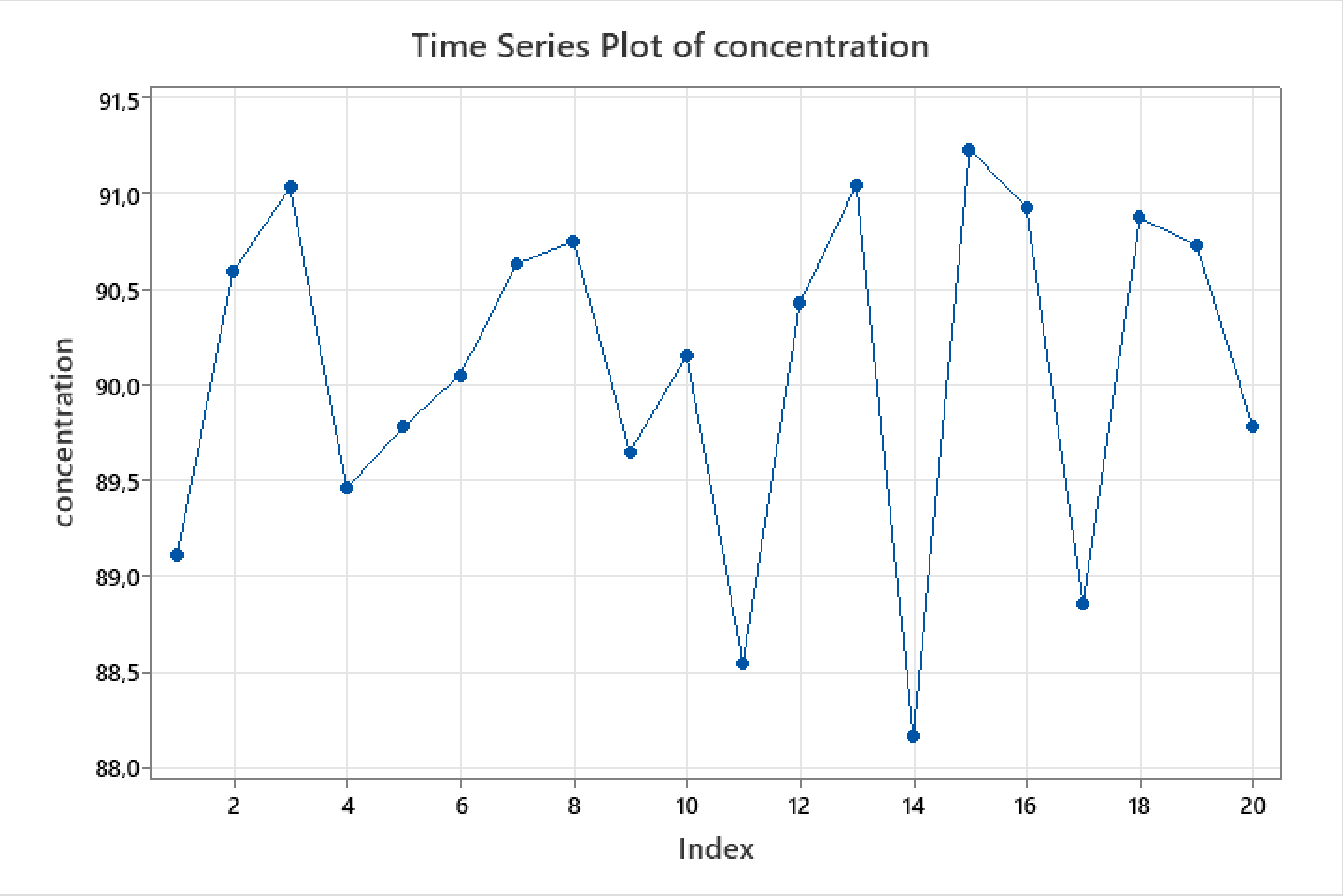
DIPARTIMENTO DI ECCELLENZA
MIUR 2018-2022

SMALL SHIFTS CONTROL CHARTS EXTRA EXERCISE

The concentration of a chemical compound is consecutively measured for 20 samples and stored in `*concentration.csv*`.

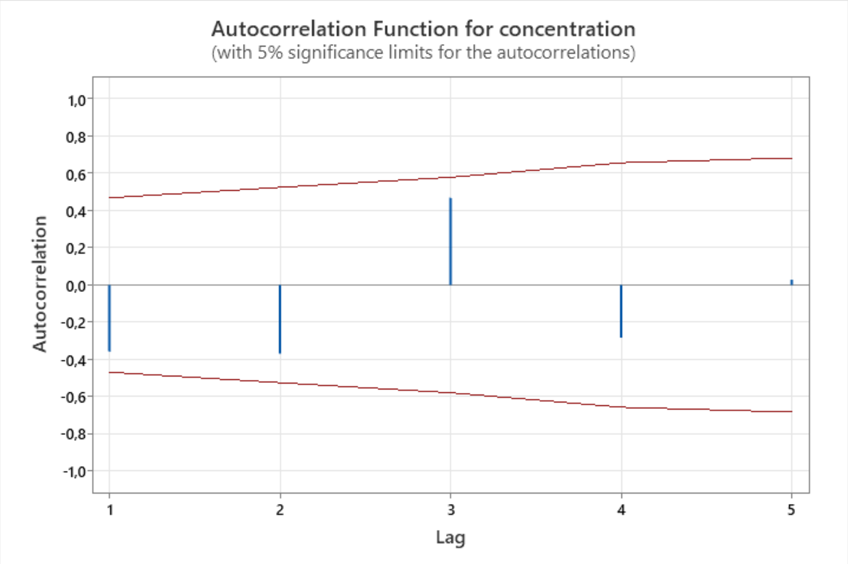
1. Design a CUSUM chart by using 0.8% as an estimate of the standard deviation and 90% as target value. Is the process IC?

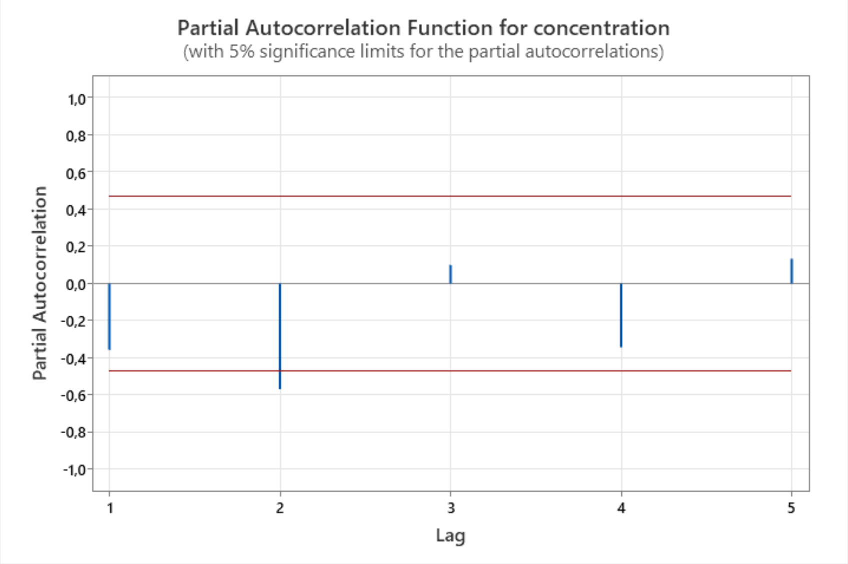
2. Five additional samples are collected (90.75, 91.00, 91.15, 90.95 and 91.86). Apply the designed control chart and determine if the process is IC or not. In the presence of OOCs, estimate the new process mean.



Point 1 Design a CUSUM chart by using 0.8% as an estimate of the standard deviation and 90% as target value. Is the process IC?

First, **randomness** assumptions check:





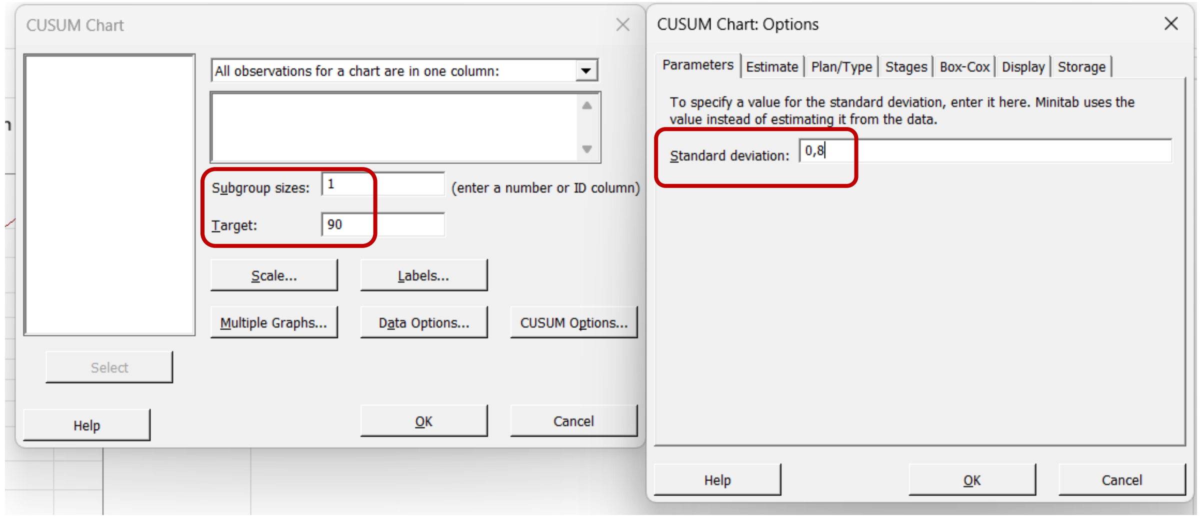
Test

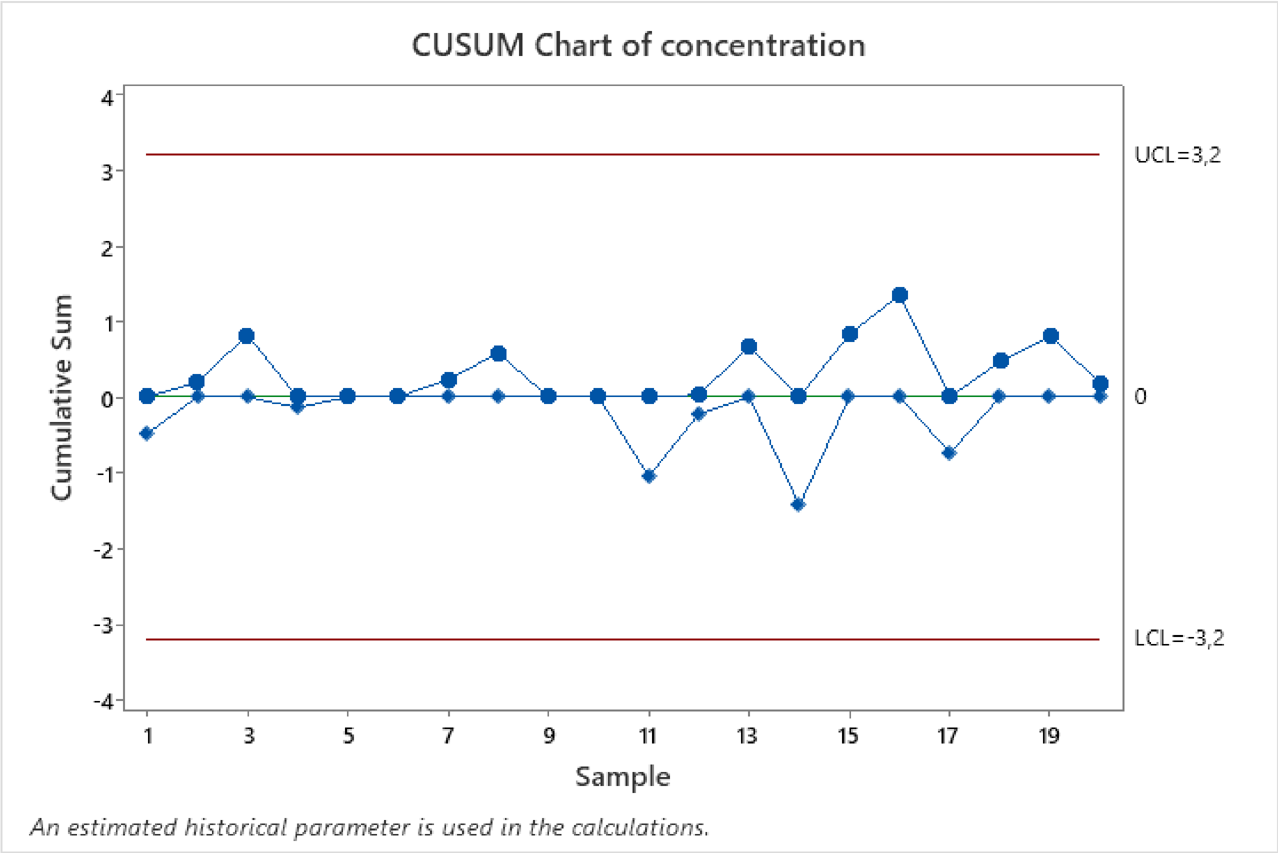
Null hypothesis	H_0: The order of the data is random
Alternative hypothesis	H_1: The order of the data is not random

Number of Runs		
Observed	Expected	P-Value
13	10,90	0,329

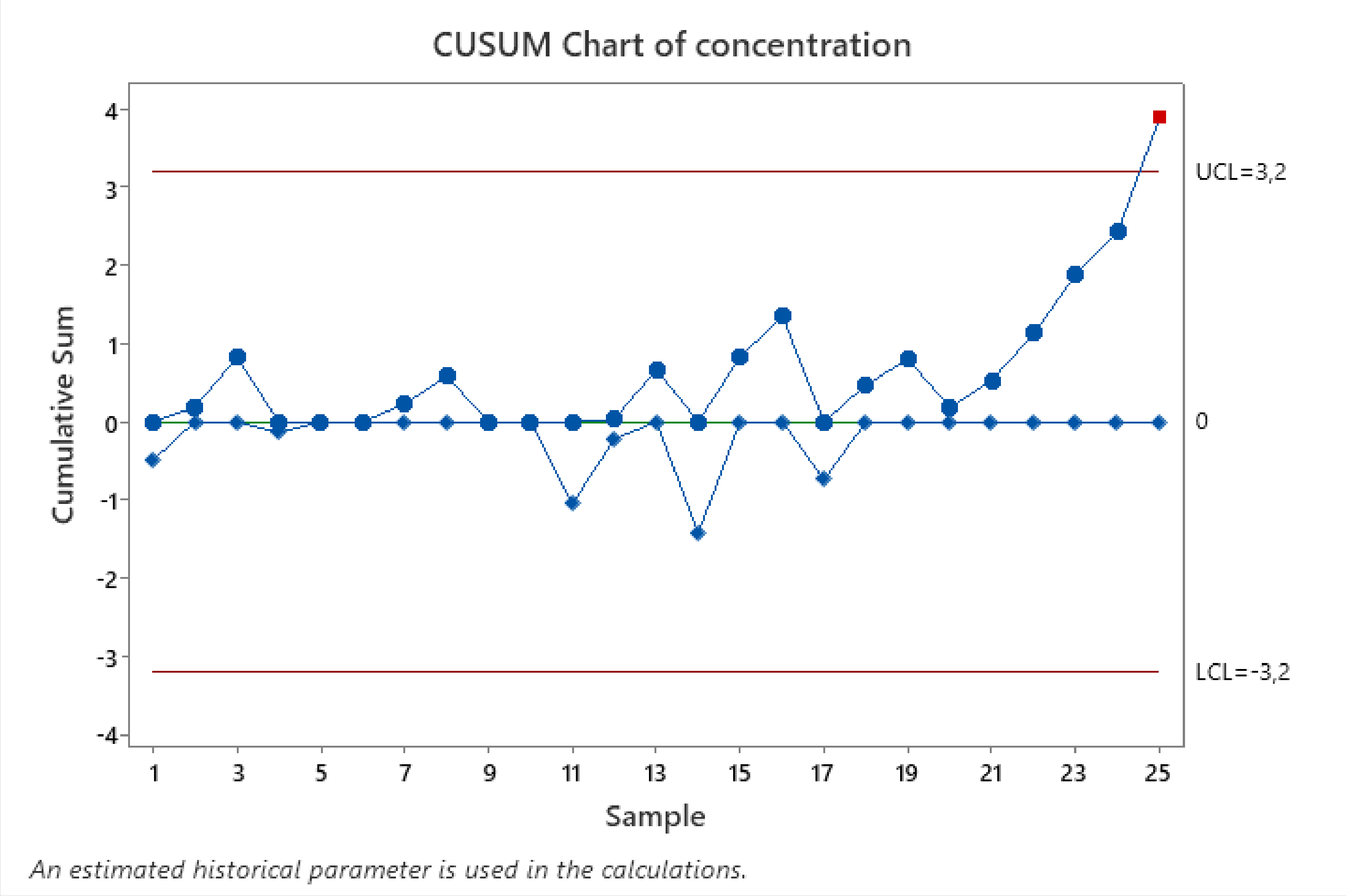
The p-value may not be accurate for samples with fewer than 11 observations above K or fewer than 11 below.

Point 1 Design a CUSUM chart by using 0.8% as an estimate of the standard deviation and 90% as target value. Is the process IC?





Point 2 Five additional samples are collected (90.75, 91.00, 91.15, 90.95 and 91.86). Apply the designed control chart and determine if the process is IC or not. In the presence of OOCs, estimate the new process mean.

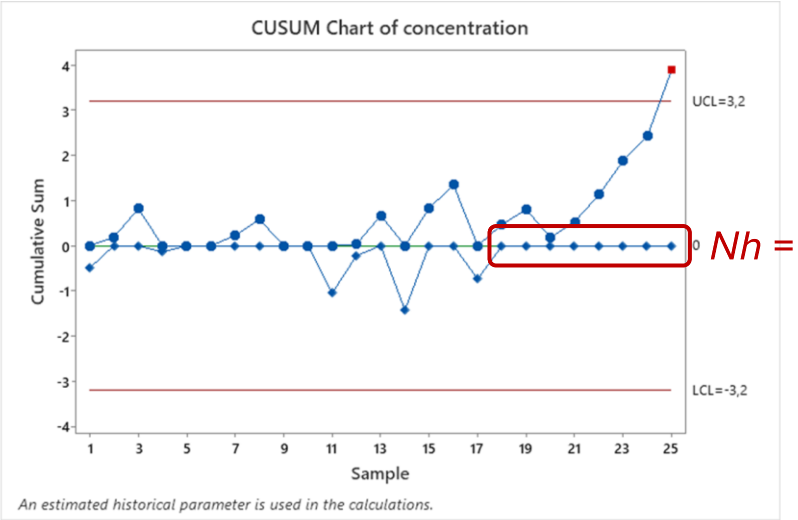


Point 2 Five additional samples are collected (90.75, 91.00, 91.15, 90.95 and 91.86). Apply the designed control chart and determine if the process is IC or not. In the presence of OOCs, estimate the new process mean.

The **new estimated process mean** is calculated by the following formula:

$$\hat{\mu} = \mu_0 + K + \frac{C_i^+}{N_h} = 90 + 0.8 \cdot \frac{1}{2} + \frac{3.89}{8} = 90.886$$

Where *Nh* is the number of consecutive non-zero values of the upper cumulator when the OOC is detected.



Nh = 8 points

ATTRIBUTE CONTROL CHARTS EXTRA EXERCISE

To establish the control chart, 30 samples of $n = 50$ cans each were selected at half-hour intervals over a three-shift period in which the machine was in continuous operation. The data are in the file “Cans.csv”.

Design a **p-chart** using this data to determine if the process was in control when these data were collected.

Design a p-chart using this data to determine if the process was in control when these data were collected.

Since the 30 samples contain nonconforming cans, we find:

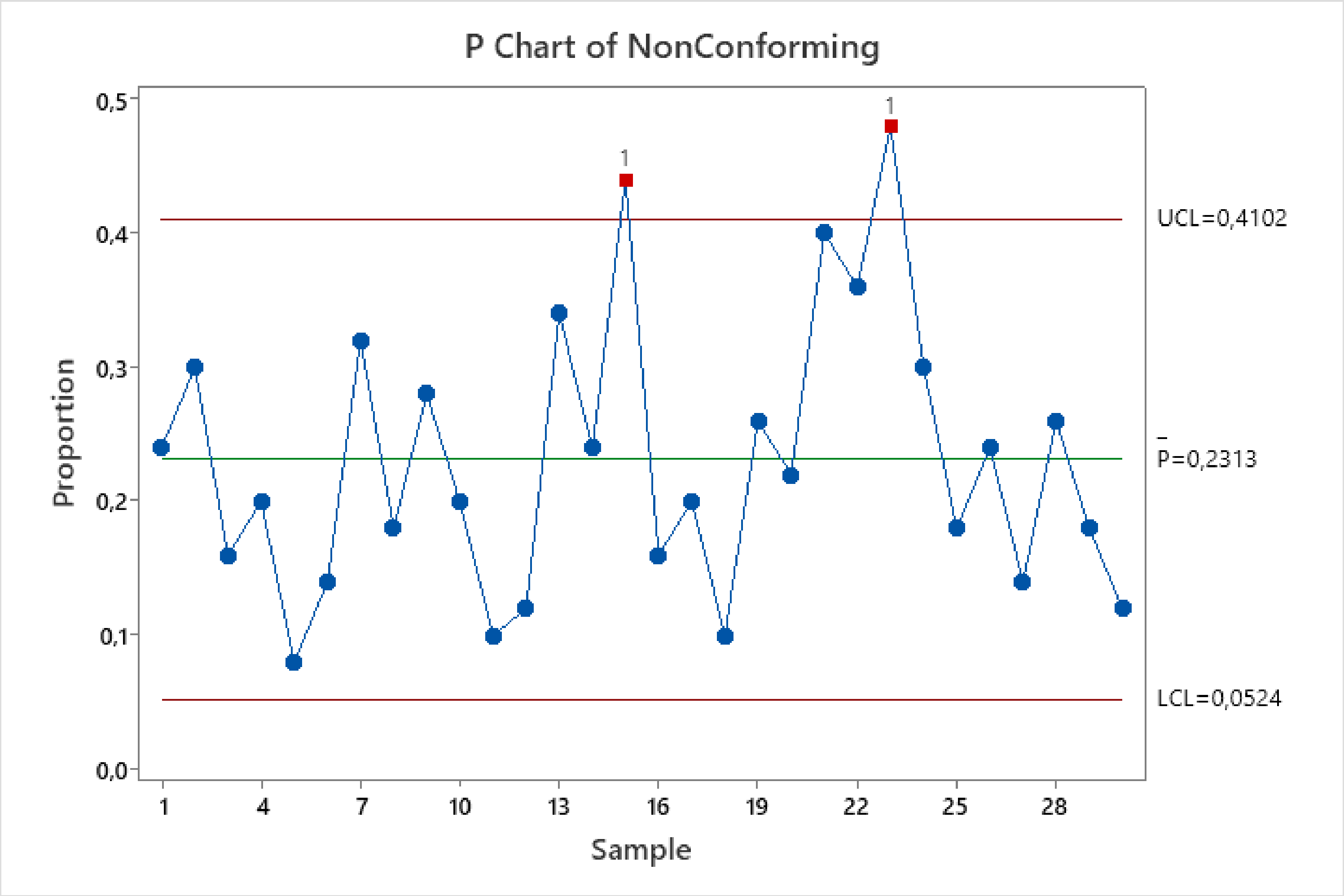
$$\overline{p} = \frac{\sum_{i=1}^{m} D_i}{mn} = \frac{347}{(30)(50)} = 0.2313$$

Using as an estimate of the true process fraction nonconforming, we can now calculate the upper and lower control limits as:

$$\begin{aligned}\overline{p} \pm 3\sqrt{\frac{\overline{p}(1-\overline{p})}{n}} &= 0.2313 \pm 3\sqrt{\frac{0.2313(0.7687)}{50}} \\ &= 0.2313 \pm 3(0.0596) \\ &= 0.2313 \pm 0.1789\end{aligned}$$

$$\begin{cases} \mathrm{UCL} = \overline{p} + 3\sqrt{\dfrac{\overline{p}(1-\overline{p})}{n}} = 0.2313 + 0.1789 = 0.4102 \\ \mathrm{LCL} = \overline{p} - 3\sqrt{\dfrac{\overline{p}(1-\overline{p})}{n}} = 0.2313 - 0.1789 = 0.0524 \end{cases}$$

Design a p-chart using this data to determine if the process was in control when these data were collected.



Test Failed at points: 15; 23.

These points must beinvestigated to see whether an assignable cause can be determined.

Design a p-chart using this data to determine if the process was in control when these data were collected.

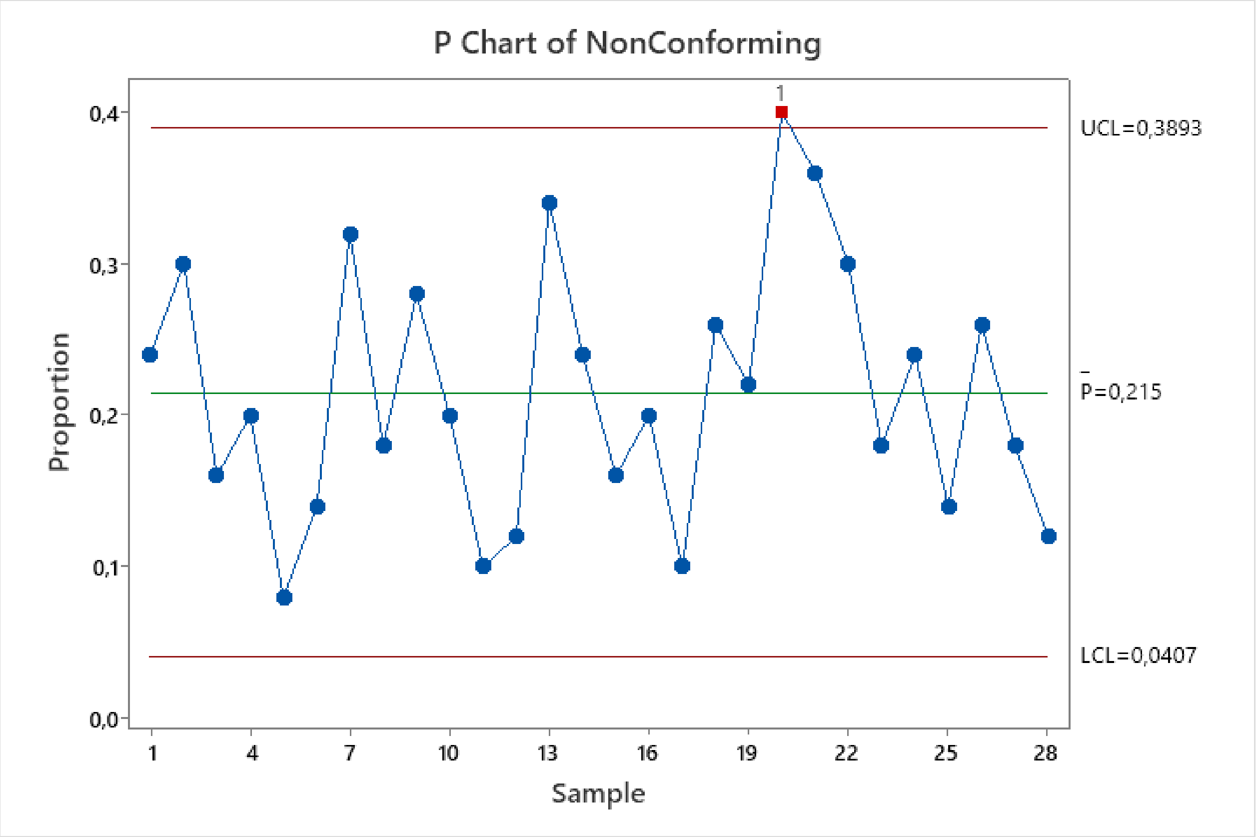
It is discovered that the data from sample 15 indicates that a new batch of cardboard stock was put into production during that half-hour period. The introduction of new batches of raw material sometimes causes irregular production performance, and it is reasonable to believe that this has occurred here.
Furthermore, during the half-hour period in which sample 23 was obtained, a relatively inexperienced operator had been temporarily assigned to the machine.

Consequently, ooc samples are eliminated, and the revised control limits are calculated:

$$\bar{p} = \frac{301}{(28)(50)} = 0.2150$$

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.2150 + 3\sqrt{\frac{0.2150(0.7850)}{50}} = 0.3893$$

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = 0.2150 - 3\sqrt{\frac{0.2150(0.7850)}{50}} = 0.0407$$



Note that sample 21 now exceeds the upper control limit. However, analysis of the data does not produce any reasonable or logical assignable cause for this, and we decide to retain the point.
Therefore, we conclude now that the new control limits can be used for future samples