Statistical Process Control and Statistical Quality Control

Product and intermediate specifications should be described and presented using statistical process control performance metrics. The statistical process control and statistical quality control metrics include trending, run rules and run rule violation actions.

Statistical process control is the application of a defined statistical metric to a process variable. Usually on line measurements are continuous data from the instruments that are not subject to a discrete sampling and reporting frequency. Since there is a continuous stream of data, many times the same rules of discrete measurements are applied. Use a process control error summing method to determine the quality of the on line process measurements. Usually level, pressure, flow and temperature measurements are controlled on line by using a common PID loop. Many plants run their loops in manual and do not take advantage of the automation installed and thus losses are reported and much wasted troubleshooting could be avoided by simply properly applying and tuning the PID control loop. There are many tuning algorithms and loop performance criteria that can be applied. One of the most common is the integrated absolute error.

Statistical Quality Control is the combination of the discrete sample and the continuous data into the statistically correct methods to determine and characterize the system's performance. Since many chemical operations are based upon a constituent mass balance and those calculations are taken from both flow data continuously recorded by a flow meter in the pipe and composition data from a discrete sample that is sent to the lab, the rules of statistical quality control will apply to the criteria for the performance based on the discrete data component combined in the calculations. The most common and useful run chart is an x bar r chart.

Using an x bar r chart, the performance measure should be recorded at the sample frequency designated for each specification characteristic.

1. characteristic #1
    a. sampled by operator once every XX hours from Sample Port SP-XX
    b. measured using a validated Test Method TM

2. characteristic # 2 and so on…….

The mean and standard deviation for each measure shall be calculated and adjusted once every 30 samples.

The mean plus three times the standard deviation shall define the Upper Control Limit (UCL).
The mean minus three times the standard deviation shall define the Lower Control Limit (LCL).
The UCL and LCL define the capability of the system every 30 performance data points.
The Upper and Lower Specification Limits shall be defined by mutual agreement.

Three action bands are defined as follows:

1. The one sigma band = the mean minus one standard deviation to the mean plus one standard deviation
2. The two sigma band = the mean minus two standard deviations to the mean plus two standard deviations
3. The three sigma band = the mean minus three standard deviations to the mean plus three standard deviations

Western Electric Statistical Quality Control Run Rules

The following run rules shall apply and initiate action:

Rule A1: Four of five points fall outside the one sigma band on the same side of the mean
Rule A2: Seven of eight consecutive points fall on the same side of the mean

1. A violation of Rule A shall initiate live vocal and logged communication between the corresponding lead operators on shift for affected units.

Rule B: Two of three points fall outside of the two sigma band on the same side of the mean.

1. A violation of Rule B shall initiate live vocal and logged communication between the corresponding lead operators on shift for both affected units.
2. If Rule B is violated in conjunction with the system being in a Rule A violation, immediate remedial action shall be taken by the lead operator on shift to correct the violation.
3. Operations management shall be notified of a Rule B violation remedial action.

Rule C: Any single point falls outside of the three sigma zone.

1. A violation of Rule C shall initiate live vocal and logged communication between the corresponding lead operators on shift for both units affected.
2. A Rule C violation in conjunction with a Rule A and or Rule B violation, or a second consecutive Rule C violation shall initiate immediate remedial action by the lead operator on shift to correct the violation.
3. Operations Leadership and Executive Technical Leadership shall be notified of any Rule C violation.

Rule D1: While in any Rule C violation, any subsequent point falls outside the Upper or Lower Specification Limit

1. A violation of Rule D1 shall initiate immediate on call response to site and assembly of the Critical Action Response Team (CART) which shall be made up of personnel designated by plant engineers and plant managers.

2. A violation of rule D1 shall initiate an immediate resample and retest. If the second test verifies the first result, then the lead operators are to agree on immediate remediation action without waiting for the CART. At the agreed resample time after the immediate remediation action determined by the two lead operators the violation of rule D1 is again verified, then an immediate rule D2 violation shall be declared and rule D2 remediation action shall be initiated.

Rule D2: While in any Rule D1 violation any subsequent point falls outside the Upper or Lower Specification Limit

1. A Rule D2 violation shall trigger the CART to initiate a controlled shutdown of the system.
2. Executive Leadership shall be notified on any Rule D2 violation.

All rule violations are to be manually logged by the lead operator on shift.

All rule violations shall be posted on the shift change Obvious At A Glance (OAG) Board and shall be first priority of discussion at all shift change and operations status meetings.

Rule violations are cleared by three consecutive points subsequent to the violation being in compliance.
Once a rule violation is cleared, all OAG boards shall be reset.

A Rule D2 violation shutdown shall require a remediation and restart plan to be presented to Executive Leadership no longer than 24 hours after the Rule D2 violation system shut down. The system shall be re-started once the remediation and restart plan is accepted by the Executive Leadership. If Executive Leadership does not respond or take action specifically approving or dis-approving the restart plan within 12 hours of its receipt, the system may be restarted by the CART and operate under Rule D1 violation condition.