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An American National Standard

Standard Practice for Use of Control Charts in Statistical Process Control[1]

This standard is issued under the fixed designation E2587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial changes were made throughout in July 2021.

1. Scope

1.1 This practice provides guidance for the use of control charts in statistical process control programs, which improve process quality through reducing variation by identifying and eliminating the effect of special causes of variation.

1.2 Control charts are used to continually monitor product or process characteristics to determine whether or not a process is in a state of statistical control. When this state is attained, the process characteristic will, at least approximately, vary within certain limits at a given probability.

1.3 This practice applies to variables data (characteristics measured on a continuous numerical scale) and to attributes data (characteristics measured as percentages, fractions, or counts of occurrences in a defined interval of time or space).

1.4 The system of units for this practice is not specified. Dimensional quantities in the practice are presented only as illustrations of calculation methods. The examples are not binding on products or test methods treated.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E456 Terminology Relating to Quality and Statistics

E1994 Practice for Use of Process Oriented AOQL and LTPD Sampling Plans

E2234 Practice for Sampling a Stream of Product by Attributes Indexed by AQL

E2281 Practice for Process Capability and Performance Measurement

E2762 Practice for Sampling a Stream of Product by Variables Indexed by AQL

3. Terminology

3.1 *Definitions*—Unless otherwise noted in this standard, all terms relating to quality and statistics are defined in Terminology E456.

3.1.1 *assignable cause, n*—factor that contributes to variation in a process or product output that is feasible to detect and identify (see *special cause*).

3.1.1.1 *Discussion*—Many factors will contribute to variation, but it may not be feasible (economically or otherwise) to identify some of them.

3.1.2 *accepted reference value, ARV, n*—value that serves as an agreed-upon reference for comparison and is derived as: (*1*) a theoretical or established value based on scientific principles, (*2*) an assigned or certified value based on experimental work of some national or international organization, or (*3*) a consensus or certified value based on collaborative experimental work under the auspices of a scientific or engineering group. **E177**

3.1.3 *attributes data, n*—observed values or test results that indicate the presence or absence of specific characteristics or counts of occurrences of events in time or space.

[1] This practice is under the jurisdiction of ASTM Committee E11 on Quality and Statistics and is the direct responsibility of Subcommittee E11.30 on Statistical Quality Control.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.4 *average run length (ARL), n*—the average number of times that a process will have been sampled and evaluated before a shift in process level is signaled.

3.1.4.1 *Discussion*—A long ARL is desirable for a process located at its specified level (so as to minimize calling for unneeded investigation or corrective action) and a short ARL is desirable for a process shifted to some undesirable level (so that corrective action will be called for promptly). ARL curves are used to describe the relative quickness in detecting level shifts of various control chart systems (see 5.1.4). The average number of units that will have been produced before a shift in level is signaled may also be of interest from an economic standpoint.

3.1.5 *c chart, n*—control chart that monitors the count of occurrences of an event in a defined increment of time or space.

3.1.6 *center line, n*—line on a control chart depicting the average level of the statistic being monitored.

3.1.7 *chance cause, n*—source of inherent random variation in a process which is predictable within statistical limits (see *common cause*).

3.1.7.1 *Discussion*—Chance causes may be unidentifiable, or may have known origins that are not easily controllable or cost effective to eliminate.

3.1.8 *common cause, n*—(see *chance cause*).

3.1.9 *control chart, n*—chart on which are plotted a statistical measure of a subgroup versus time of sampling along with limits based on the statistical distribution of that measure so as to indicate how much common, or chance, cause variation is inherent in the process or product.

3.1.10 *control chart factor, n*—a tabulated constant, depending on sample size, used to convert specified statistics or parameters into a central line value or control limit appropriate to the control chart.

3.1.11 *control limits, n*—limits on a control chart that are used as criteria for signaling the need for action or judging whether a set of data does or does not indicate a state of statistical control based on a prescribed degree of risk.

3.1.11.1 *Discussion*—For example, typical three-sigma limits carry a risk of 0.135 % of being out of control (on one side of the center line) when the process is actually in control and the statistic has a normal distribution.

3.1.12 *EWMA chart, n*—control chart that monitors the exponentially weighted moving averages of consecutive subgroups.

3.1.13 *EWMV chart, n*—control chart that monitors the exponentially weighted moving variance.

3.1.14 *exponentially weighted moving average (EWMA), n*—weighted average of time ordered data where the weights of past observations decrease geometrically with age.

3.1.14.1 *Discussion*—Data used for the EWMA may consist of individual observations, averages, fractions, numbers defective, or counts.

3.1.15 *exponentially weighted moving variance (EWMV), n*—weighted average of squared deviations of observations from their current estimate of the process average for time ordered observations, where the weights of past squared deviations decrease geometrically with age.

3.1.15.1 *Discussion*—The estimate of the process average used for the current deviation comes from a coupled EWMA chart monitoring the same process characteristic. This estimate is the EWMA from the previous time period, which is the forecast of the process average for the current time period.

3.1.16 *I chart, n*—control chart that monitors the individual subgroup observations.

3.1.17 *lower control limit (LCL), n*—minimum value of the control chart statistic that indicates statistical control.

3.1.18 *MR chart, n*—control chart that monitors the moving range of consecutive individual subgroup observations.

3.1.19 *p chart, n*—control chart that monitors the fraction of occurrences of an event.

3.1.20 *R chart, n*—control chart that monitors the range of observations within a subgroup.

3.1.21 *rational subgroup, n*—subgroup chosen to minimize the variability within subgroups and maximize the variability between subgroups (see *subgroup*).

3.1.21.1 *Discussion*—Variation within the subgroup is assumed to be due only to common, or chance, cause variation, that is, the variation is believed to be homogeneous. If using a range or standard deviation chart, this chart should be in statistical control. This implies that any assignable, or special, cause variation will show up as differences between the subgroups on a corresponding $\bar{X}$ chart.

3.1.22 *s chart, n*—control chart that monitors the standard deviations of subgroup observations.

3.1.23 *special cause, n*—(see *assignable cause*).

3.1.24 *standardized chart, n*—control chart that monitors a standardized statistic.

3.1.24.1 *Discussion*—A standardized statistic is equal to the statistic minus its mean and divided by its standard error.

3.1.25 *state of statistical control, n*—process condition when only common causes are operating on the process.

3.1.25.1 *Discussion*—In the strict sense, a process being in a state of statistical control implies that successive values of the characteristic have the statistical character of a sequence of observations drawn independently from a common distribution.

3.1.26 *statistical process control (SPC), n*—set of techniques for improving the quality of process output by reducing variability through the use of one or more control charts and a corrective action strategy used to bring the process back into a state of statistical control.

3.1.27 *subgroup, n*—set of observations on outputs sampled from a process at a particular time.

3.1.28 *u chart, n*—control chart that monitors the count of occurrences of an event in variable intervals of time or space, or another continuum.

3.1.29 *upper control limit (UCL), n*—maximum value of the control chart statistic that indicates statistical control.