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Control charts —

Part 1:
General guidelines

Cartes de contrôle —

Partie 1: Lignes directrices générales

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 4, *Applications of statistical methods in process management*.

This third edition of ISO 7870-1 cancels and replaces the second edition (ISO 7870-1:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Added Annex A, specifying the conventions for drafting control charts.

A list of all parts in the ISO 7870 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Every production, service, or administrative process contains a certain amount of variability due to the presence of a large number of causes. The observed results from a process are, as a result, not constant. Studying this variability to gain an understanding of its characteristics provides a basis for taking action on a process.

Control charts are a fundamental tool of statistical process control (SPC). They provide a simple graphical method that can be used to

a) indicate if the process is stable, i.e. operating within a stable system of random causes, also known as inherent variability and referred to as being in a “state of statistical control”,

b) estimate the magnitude of the inherent variability of the process,

c) compare information from samples representing the current state of a process against control limits reflecting this variability, with the objective of determining whether the process variability has remained stable or is reduced or increased,

d) identify, investigate, and possibly reduce/eliminate the effect of special causes of variability, which can drive the process to an unacceptable level of performance,

e) aid in the regulation of a process through the identification of patterns of variability such as trends, runs, cycles, etc.,

f) determine if the process is behaving in a predictable and stable manner so that it will be possible to assess if the process is able to meet specifications,

g) determine whether or not the process can be expected to satisfy product or service requirements and process capability for the characteristic(s) being measured,

h) provide a basis for process adjustment through prediction using statistical models, and

i) assist in the assessment of the performance of a measurement system.

A major virtue of the control chart is its ease of construction and use. It provides the production or service operator, engineer, administrator, and manager with an online indicator about the behaviour of the process. However, in order for the control chart to be a reliable and efficient indicator of the state of the process, careful attention has to be paid at the planning stage to such matters as selecting the appropriate type of chart for the process under study and determining a proper sampling scheme.

General concepts useful to a successful design of a control chart are presented in Annex A.

Control charts —

Part 1:
General guidelines

1 Scope

This document presents key elements and the philosophy of the control chart approach, and identifies a wide variety of control charts (including those related to the Shewhart control chart, those stressing process acceptance or online process adjustment, and specialized control charts).

It presents an overview of the basic principles and concepts of control charts and illustrates the relationship among various control chart approaches to aid in the selection of the most appropriate part of ISO 7870 for given circumstances. It does not specify statistical control methods using control charts. These methods are specified in the relevant parts of ISO 7870.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

ISO 3534-2, *Statistics — Vocabulary and symbols — Part 2: Applied statistics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3534-1, ISO 3534-2 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
control chart
chart with *control limits* (3.2) on which some statistical measure of a series of samples is plotted in a particular order to steer the process with respect to that measure

Note 1 to entry: The particular order is usually based on time or sample number order.

Note 2 to entry: The control chart operates most effectively when the measure is a process variable which is correlated with an ultimate product or service characteristic.

[SOURCE: ISO 3534-2:2006, 2.3.1, modified — added "with control limits" after "chart" in definition, deleted "and to control and reduce variation" after "to that measure".]

3.2
control limit
statistical value defining an intended level of stability for a produced characteristic

Note 1 to entry: One or two control limits are represented on the control chart.

Note 2 to entry: The term “stability” is not meant only for a process in control but it can also be stability against a target value.

3.3
Shewhart control chart
control chart (3.1) with *Shewhart control limits* (3.4) intended primarily to distinguish between the variation in the plotted measure due to random causes and that due to special causes

[SOURCE: ISO 3534-2:2006, 2.3.2]

3.4
Shewhart control limit
control limit (3.2) determined statistically from the variation of the process due to the random causes alone

3.5
acceptance control chart
control chart (3.1) intended primarily to evaluate whether or not the plotted measure can be expected to satisfy specified tolerances

[SOURCE: ISO 3534-2:2006, 2.3.3]

3.6
process adjustment control chart
control chart (3.1) which uses a prediction model of the process to estimate and plot the future course of the process if no change is made, and to quantify the change to be made to keep the process deviations within acceptable limits

[SOURCE: ISO 3534-2:2006, 2.3.4]

3.7
variables control chart
control chart (3.1) in which the measure plotted represents data on a continuous scale

[SOURCE: ISO 3534-2:2006, 2.3.6, modified — deleted "Shewhart" before "control chart".]

3.8
attributes control chart
control chart (3.1) in which the measure plotted represents countable or categorized data

[SOURCE: ISO 3534-2:2006, 2.3.7, modified — in the term, "attributes" used instead of "attribute"; in the definition, deleted "Shewhart" before "control chart".]

3.9
***c* chart**
count control chart
attributes control chart (3.8) for the number of incidences where the opportunity for occurrence is fixed

Note 1 to entry: Incidences of a particular type, for example, number of absentees and number of sales leads, form the count. In the quality field, incidences are often expressed as nonconformities and the fixed opportunity relates to samples of constant size or fixed amount of material. Examples are “flaws in each 100 m^2 of fabric” and “errors in each 100 invoices”.

[SOURCE: ISO 3534-2:2006, 2.3.8]

3.10
u **chart**
count per unit control chart
attributes control chart (3.8) for the number of incidences per unit where the opportunity is variable

Note 1 to entry: Incidences of a particular type, for example, number of absentees and number of sales leads, form the count. In the quality field, incidences are often expressed as nonconformities and the variable opportunity relates to subgroups of variable size or variable amounts of material.

[SOURCE: ISO 3534-2:2006, 2.3.9]

3.11
np **chart**
number of categorized units control chart
attributes control chart (3.8) for number of units of a given classification where the subgroup size is constant

Note 1 to entry: In the quality field, the classification usually takes the form of “nonconforming units”.

[SOURCE: ISO 3534-2:2006, 2.3.10, modified — definition uses "subgroup" instead of "sample".]

3.12
p **chart**
proportion categorized units control chart
percent categorized units control chart
attributes control chart (3.8) for number of units of a given classification per total number of units in the sample expressed either as a proportion or percent

Note 1 to entry: In the quality field, the classification usually takes the form of “nonconforming unit”.

Note 2 to entry: The *p* chart is applied particularly when the subgroup size is variable.

Note 3 to entry: The plotted measure can be expressed as a proportion or as a percentage.

[SOURCE: ISO 3534-2:2006, 2.3.11]

3.13
standardized *p* **chart**
attributes control chart (3.8) where proportions of given classification are expressed as standardized normal variates

3.14
X **bar control chart**
average control chart
variables control chart (3.7) for evaluating the process level in terms of subgroup averages

[SOURCE: ISO 3534-2:2006, 2.3.12]

3.15
median control chart
variables control chart (3.7) for evaluating the process level in terms of subgroup medians

[SOURCE: ISO 3534-2:2006, 2.3.13]

3.16
moving average control chart
control chart (3.1) for evaluating the process level in terms of the arithmetic average of each successive *n* observations

Note 1 to entry: This chart is particularly useful when only one observation per subgroup is available. Examples are process characteristics such as temperature, pressure and time.

Note 2 to entry: The current observation replaces the oldest of the latest $n + 1$ observations.

Note 3 to entry: It has the disadvantage of an unweighted carry-over effect lasting *n* points.

[SOURCE: ISO 3534-2:2006, 2.3.14]

3.17
individuals control chart
***X* control chart**
variables control chart (3.7) for evaluating the process level in terms of the individual observations in the sample

Note 1 to entry: This chart is usually accompanied by a moving range chart, frequently with $n = 2$.

Note 2 to entry: It sacrifices the advantages of averaging in terms of minimizing random variation and the normal distribution central limit theorem assumptions.

Note 3 to entry: Individual values are expressed by the symbols $x_1, x_2, x_3, \ldots$

Note 4 to entry: In the case of charts for individuals, the symbol R_{moving} represents the value of the moving range, which is the absolute value of the difference between two successive values, thus, $|x_1 - x_2|, |x_2 - x_3|$, etc.

[SOURCE: ISO 3534-2:2006, 2.3.15, modified — Note 3 to entry and Note 4 to entry added.]

3.18
cumulative sum control chart
CUSUM chart
control chart (3.1) where the cumulative sum of deviations of successive sample values from a reference value is plotted to detect shifts in the level of the measure plotted

Note 1 to entry: The ordinate of each plotted point represents the algebraic sum of the previous ordinate and the most recent deviation from the reference, target, or control value.

Note 2 to entry: The best discrimination of changes in level is achieved when reference value is equal to the overall average value.

Note 3 to entry: The chart can be used in control, diagnostic or predictive mode.

Note 4 to entry: When used in control mode, it can be interpreted graphically by a mask (e.g. *V*-mask) superimposed on the graph. A signal occurs if the path of the CUSUM intersects or touches the boundary of the mask. Alternatively, a tabular approach to CUSUM may be used instead.

[SOURCE: ISO 3534-2:2006, 2.3.5, modified —Last sentence to Note 4 to entry added.]

3.19
EWMA control chart
exponentially weighted moving average control chart
control chart (3.1) for evaluating the process level in terms of an exponentially smoothed moving average

[SOURCE: ISO 3534-2:2006, 2.3.16]

3.20
***Z* chart**
variables control chart (3.7) for evaluating the process in terms of subgroup standardized normal variates

3.21
group control chart for averages
variables control chart (3.7) for evaluating the process level in terms of subgroup (with several sources) highest and lowest averages with corresponding source identification

3.22
group control chart for ranges
variables control chart (3.7) for evaluating the process variation in terms of subgroup (with several sources) highest ranges with corresponding source identification

3.23
high-low control chart
variables control chart (3.7) for evaluating the process level in terms of subgroup largest and smallest values

3.24
trend control chart
control chart (3.1) for evaluating the process level with respect to the deviation of the subgroup averages from an expected change in the process level

Note 1 to entry: The trend can be determined empirically or by regression techniques.

Note 2 to entry: A trend is an upward or downward tendency, after exclusion of the random variation and cyclical effects, when observed values are plotted in the time order of the observations.

[SOURCE: ISO 3534-2:2006, 2.3.17]

3.25
***R* chart**
range control chart
variables control chart (3.7) for evaluating variation in terms of subgroup ranges

Note 1 to entry: The value of the subgroup range is given by the symbol R, the difference between the largest and smallest observations of a subgroup.

Note 2 to entry: The average value of the subgroup ranges is denoted by the symbol $\overline{R}$.

[SOURCE: ISO 3534-2:2006, 2.3.18, modified — Note 1 to entry and Note 2 to entry added.]

3.26
***s* chart**
standard deviation control chart

variables control chart (3.7) for evaluating variation in terms of subgroup standard deviations

Note 1 to entry: The value of the subgroup standards deviation is given by the symbol s.

Note 2 to entry: The average value of the subgroup standard deviations is denoted by the symbol $\overline{s}$.

[SOURCE: ISO 3534-2:2006, 2.3.19, modified — Note 1 to entry and Note 2 to entry added.]

3.27
moving range control chart
variables control chart (3.7) for evaluating variation in terms of the range of each successive n observations

Note 1 to entry: The current observation replaces the oldest of the latest $n + 1$ observations.

[SOURCE: ISO 3534-2:2006, 2.3.20]

3.28
control chart for coefficient of variation
variables control chart (3.7) for evaluating variation in terms of subgroup coefficient of variation

3.29
multivariate control chart
control chart (3.1) in terms of the responses of two or more mutually correlated variates combined as a single sample statistic for each subgroup

[SOURCE: ISO 3534-2:2006, 2.3.21]