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Control charts —

Part 3: Acceptance control charts

Cartes de contrôle —

Partie 3: Cartes de contrôle pour acceptation

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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 second edition cancels and replaces the first edition (ISO 7870-3:2012), of which it constitutes a minor revision with the following changes:

— typo corrections in 9.1, example 1;

— editorial updates.

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

An acceptance control chart combines consideration of control implications with elements of acceptance sampling. It is an appropriate tool for helping to make decisions with respect to process acceptance. The bases for the decisions may be defined in terms of

a) whether or not a designated percentage of units of a product or service derived from that process will satisfy specification requirements;

b) whether or not a process has shifted beyond some allowable zone of process level locations.

A difference from most acceptance sampling approaches is the emphasis on process acceptability rather than on product disposition decisions.

A difference from usual control chart approaches is that the concept of process acceptance is introduced in the process control. The process usually does not need to be in control about a single standard process level; as long as the within-subgroup variability remains in control and is much smaller than the tolerance spread, it can (for the purpose of acceptance) run at any level or levels within a zone of process levels which would be acceptable in terms of tolerance requirements. Thus, it is assumed that some assignable causes will create shifts in the process levels which are small enough in relation to requirements that it would be uneconomical to attempt to control them too tightly for the purpose of mere acceptance.

The use of an acceptance control chart does not, however, rule out the possibility of identifying and removing assignable causes for the purpose of continuing process improvement.

A check on the inherent stability of the process is required. Therefore, variables are monitored using Shewhart-type range or sample standard deviation control charts to confirm that the variability inherent within rational subgroups remains in a steady state. Supplementary examinations of the distribution of the encountered process levels form an additional source of control information. A preliminary Shewhart control chart study should be conducted to verify the validity of using an acceptance control chart.

Control charts —

Part 3:
Acceptance control charts

1 Scope

This document gives guidance on the uses of acceptance control charts and establishes general procedures for determining sample sizes, action limits and decision criteria. An acceptance control chart should be used only when:

a) the within subgroup variation is in-control and the variation is estimated efficiently;

b) a high level of process capability has been achieved.

An acceptance control chart is typically used when the process variable under study is normally distributed; however, it can be applied to a non-normal distribution. The examples provided in this document illustrate a variety of circumstances in which this technique has advantages; these examples provide details of the determination of the sample size, the action limits and the decision criteria.

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:

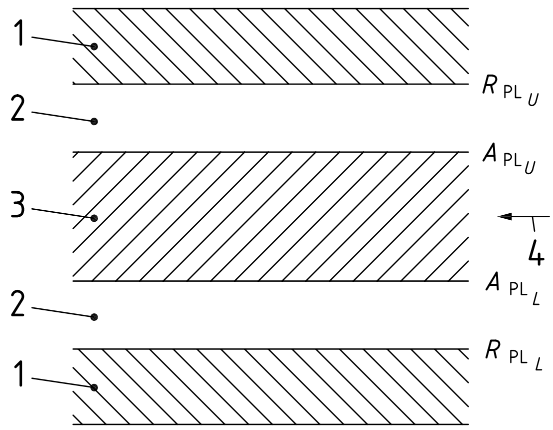
— ISO Online browsing platform: available at https://www.iso.org/obp

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

3.1
acceptable process
process which is represented by a Shewhart control chart with a central line within the acceptable process zone

Note 1 to entry: Ideally, the average value $\bar{X}$ of such a control chart would be at the target value.

Note 2 to entry: The acceptable process zone is shown in Figure 1. Information on the Stewhart control chart can be found in ISO 7870-2.



Key

1 rejectable processes
2 indifference zone
3 acceptable processes
4 target level
R_{PL_U} upper RPL line
A_{PL_U} upper APL line
A_{PL_L} lower APL line
R_{PL_L} lower RPL line

Figure 1 — Two-sided specification limits: Upper and lower APL and RPL lines in relation to processes of acceptable, rejectable, and indifference (borderline) quality

4 Symbols and abbreviated terms

NOTE The ISO/IEC Directives makes it necessary to depart from common SPC usage in respect to the differentiation between abbreviated terms and symbols. An abbreviated term and its symbol can differ in appearance in two ways: by font and by layout. To distinguish between abbreviated terms and symbols, abbreviated terms are given in Arial upright and symbols in Times New Roman or Greek italics, as applicable. Whereas abbreviated terms can contain multiple letters, symbols consist only of a single letter. For example, the conventional abbreviation of acceptable process limit, APL, is valid but its symbol in equations becomes A_{PL}. The reason for this is to avoid misinterpretation of compound letters as an indication of multiplication.

4.1 Symbols

A_{CL} acceptance control limits

A_{PL} acceptable process level

L lower specification limit

n subgroup sample size

p_0 acceptable proportion nonconforming items

p_1 rejectable proportion nonconforming items

P_a probability of acceptance

R_{PL} rejectable process level or non-acceptable process zone

T target value, i.e. the optimum value of the characteristic

U upper specification limit

$\bar{X}$ average value of the variable X plotted on a control chart

z variable that has a normal distribution with zero mean and unit standard deviation

$z_p{}'$ normal deviate that is exceeded by $100p'$ % of the deviate in a specified direction (similarly for z_α, z_β, etc.)

α risk of not accepting a process centred at the APL

β risk of not rejecting a process centred at the RPL

μ process mean

σ_w within-subgroup standard deviation corresponding to the inherent process variability

$\sigma_{\bar{X}}$ standard deviation of the subgroup average corresponding to the inherent process variability: $\sigma_{\bar{X}} = \sigma_w / \sqrt{n}$

4.2 Abbreviated terms

ACL acceptance control limits

APL acceptable process level

L lower specification limit (used as a subscript)

OC operating characteristic

RPL rejectable process level or non-acceptable process zone

U upper specification limit (used as a subscript)

5 Description of acceptance control chart practice

In the pursuit of an acceptable product or service, there often is room for some latitude in the ability to centre a process around its target level. The contribution to overall variation of such location factors is additional to the inherent random variability of individual elements around a given process level. In most cases, some shifts in process level must be expected and can be tolerated. These shifts usually result from an assignable cause that cannot be eliminated because of engineering or economic considerations. They often enter the system at infrequent or irregular intervals, but can rarely be treated as random components of variance.

There are several seemingly different approaches to treating these location factors contributing variation beyond that of inherent variability. At one extreme is the approach in which all variability that results in deviations from the target value must be minimized. Supporters of such an approach seek to improve the capability to maintain a process within tighter tolerance limits so that there is greater potential for process or product quality improvement.

At the other extreme is the approach that if a high level of process capability has been achieved, it is not only uneconomic and wasteful of resources, but it can also be counterproductive to try to improve the capability of the process. This often is the result of the introduction of pressures which encourage “tampering” with the process (over-control) by people qualified to work on control aspects but not product or process quality improvement programmes.

The acceptance control chart is a useful tool for covering this wide range of approaches in a logical and simple manner. It distinguishes between the inherent variability components randomly occurring throughout the process and the additional location factors which contribute at less frequent intervals.

When shifts appear, the process may then stabilize at a new level until the next such event occurs. Between such disturbances, the process runs in control with respect to inherent variability.

An illustration of this situation is a process using large uniform batches of raw material. The within-batch variability could be considered to be the inherent variability. When a new batch of material is introduced, its deviation from the target may differ from that of the previous batch. The between-batch variation component enters the system at discrete intervals.

An example of this within- and between-batch variation can very well occur in a situation where a blanking die is blanking a machine part. The purpose of the chart is to determine when the die has worn to a point where it must be repaired or reworked. The rate of wear is dependent upon the hardness of the successive batches of material and is therefore not readily predictable. It will be seen that the use of an acceptance control chart makes it possible to judge the appropriate time to service the blanking die.

The acceptance control chart is based on the Shewhart control chart (i.e. $\bar{X}$ – R chart or $\bar{X}$ – s chart) but is set up so that the process mean can shift outside of control limits of the Shewhart control chart if the specifications are sufficiently wide, or be confined to narrower limits if the inherent variability of the process is comparatively large or a large fraction of the total tolerance spread.

What is required is protection against a process that has shifted so far from the target value that it will yield some predetermined undesirable percentage of items falling outside the specification limits, or exhibits an excessive degree of process level shift.

When a chart of the average value of data sets from a process is plotted, in sequence of the production, one notices a continual variation in average values. In a central zone (acceptable process, Figure 1), there is a product that is indisputably acceptable. Data in the outer zones (Figure 1) represent a process that is producing product that is indisputably not acceptable.

Between the inner and the outer zones are zones where the product is acceptable but there is an indication that the process should be watched and, as the outer zone is approached, corrective action may be taken. These criteria are the basic concepts for the acceptance control chart. The description in this document is designed to provide practices for the establishment of appropriate action lines for one- and two-sided specification situations.

Since it is impossible to have a single dividing line that can sharply distinguish a good from an unsatisfactory quality level, one must define a process level that represents a process that should be accepted almost always ($1 - \alpha$). This is called the acceptable process level (APL), and it marks the outer boundary of the acceptable process zone located about the target value (see Figure 1).

Any process centred closer to the target value than the APL will have a risk smaller than α of not being accepted. So the closer the process is to the target, the smaller the likelihood that a satisfactory process will not be accepted.

It is also necessary to define the process level that represents processes that should almost never be accepted ($1 - \beta$). This undesirable process level is labelled the rejectable process level (RPL). Any process located further away from the target value than the RPL will have a risk of acceptance smaller than β.

The process levels lying between the APL and RPL would yield a product of borderline quality. That is, process levels falling between the APL and RPL would represent quality which is not so good that it would be a waste of time, or represent over-control, if the process were adjusted, and not so bad that the product could not be used if no shift in level were made. This region is often called the "indifference zone". The width of this zone is a function of the requirements for a particular process and the risks one is willing to take in connection with it. The narrower the zone, i.e. the closer the APL and RPL are to each other, the larger the sample size will have to be. This approach will permit a realistic appraisal of the effectiveness of any acceptance control system, and will provide a descriptive method for showing just what any given control system is intended to do.

As with any acceptance sampling system, the four elements required for the definition of an acceptance control chart are:

a) an acceptable process level (APL) associated with a one-sided α-risk;

b) a rejectable process level (RPL) associated with a one-sided β-risk;

c) an action criterion or acceptance control limit (ACL);

d) the sample size (n).

NOTE Generally, the defined risks are one-sided in this document. In the case of two-sided specifications, the risks are either a 5 % risk to go above an upper limit or a 5 % risk to go below a lower limit. This results in a 5 % (not 10 %) total risk.

Simplicity of operation is of critical importance to the use of a procedure such as an acceptance control chart. Only the acceptance control limits and the sampling instructions (such as sample size, frequency, or method of selection) need to be known to the operator who uses the chart, although training him to understand the derivation is not difficult and can be helpful. It is thus no more complicated to use than the Shewhart chart. The supervisor, quality expert, or trained operator will derive these limits without much effort from the above considerations and will obtain a more meaningful insight into the process acceptance procedure, and a better understanding of the control implications.

6 Acceptance control of a process

6.1 Plotting the chart

The sample average value of the quality characteristic is plotted on acceptance control charts in the following way. A point is plotted on the chart for each sample with an identification number (numerical order, time order, etc.) on the horizontal scale, and the corresponding sample average on the vertical scale.

6.2 Interpreting the chart

When the plotted point falls above the upper acceptance control limit ACL_U or below the lower acceptance control limit ACL_L, the process shall be considered non-acceptable.

If a plotted point is close to the control line, the numerical values shall be used to make the decision.

7 Specifications

Theoretically, the specification of the values of any two of the defining elements APL (with α−risk), RPL (with β−risk), acceptance control limit (ACL) or sample size (n) of an acceptance control chart system determines the remaining two values; however, in practice, it is essential that APL (with α-risk) be defined first. In addition, the within-rational subgroup value of σ_w must be known or have been estimated by the usual control chart techniques such as using $\hat{\sigma}_w = \overline{R}/d_2$ or $\overline{s}/c_4$. It is essential that the inherent random variability be in a state of statistical control in order for the risk computations to be meaningful. This can be monitored through the use of a Shewhart-type control chart for ranges or standard deviations (see ISO 7870-2).

Two selections of pairs of defining elements may be chosen.

a) Definition of the APL and RPL along with their respective α- and β-risks, and determination of the sample size (n) and the acceptance control limit (ACL).

   Often, α = 0,05 is chosen in acceptance control chart applications since there are few instances where a process continuously runs at the APL. This means that the risk of rejection on each side of the target value, T, should always be smaller than α.

   This option is generally used when

