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Control charts —

Part 1:
General guidelines

Cartes de contrôle —

Partie 1: Lignes directrices générales

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Contents

Page

iii

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.

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ISO 7870-1 was prepared by Technical Committee ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 4, *Applications of statistical methods in process management*.

This first edition of ISO 7870-1 cancels and replaces ISO 7870:1993.

ISO 7870 consists of the following parts, under the general title *Control charts*:

⎯ *Part 1: General guidelines*

The following parts are planned:

⎯ *Part 2: Shewhart control charts*

⎯ *Part 3: Process acceptance control charts*

⎯ *Part 4: Process adjustment control charts*

⎯ *Part 5: Specialized control charts*

⎯ *Part 6: Guide to the application of statistical control charts*

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, or is not, 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 limits reflecting this variability, with the objective of determining whether the process has remained stable or not and variability has been reduced or not;

d) identify, investigate and possibly reduce/eliminate the effect of special causes of variability, which may 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 and the like;

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;

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 on-line 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 must 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 this part of ISO 7870.

Control charts —

Part 1:
General guidelines

1 Scope

This part of ISO 7870 presents key elements and philosophy of the control chart approach, and identifies a wide variety of control charts (including those related to the Shewhart control chart and those stressing process acceptance or on-line process adjustment).

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

2 Normative references

The following referenced documents are indispensable for the application 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 3534-2:2006, *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 3534-2 and the following apply. In some cases, additional clarification on terms from ISO 3534-2 is provided.

3.1
control chart
chart 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 and to control and reduce variation

NOTE 1   The particular order is usually based on time or sample number order.

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

[ISO 3534-2:2006, 2.3.1]

3.2
Shewhart control chart
control chart with Shewhart control limits intended primarily to distinguish between the variation in the plotted measure due to random causes and that due to special causes

[ISO 3534-2:2006, 2.3.2]

3.3

acceptance control chart

control chart intended primarily to evaluate whether or not the plotted measure can be expected to satisfy specified tolerances

[ISO 3534-2:2006, 2.3.3]

3.4

process adjustment control chart

control chart 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

[ISO 3534-2:2006, 2.3.3]

3.5

cumulative sum control chart

CUSUM chart

control chart 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   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   The best discrimination of changes in level is achieved when reference value is equal to the overall average value.

NOTE 3   The chart can be used in control, diagnostic or predictive mode.

NOTE 4   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.

[ISO 3534-2:2006, 2.3.5]

3.6

variables control chart

Shewhart control chart in which the measure plotted represents data on a continuous scale

[ISO 3534-2:2006, 2.3.6]

3.7

attribute control chart

Shewhart control chart in which the measure plotted represents countable or categorized data

[ISO 3534-2:2006, 2.3.7]

3.8

c chart

count control chart

attribute control chart for the number of incidences where the opportunity for occurrence is fixed

NOTE   Incidences of a particular type, for example, number of absentees, 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 square metres of fabric" and "errors in each 100 invoices".

[ISO 3534-2:2006, 2.3.8]

3.9
u chart
count per unit control chart
attribute control chart for the number of incidences per unit where the opportunity is variable

NOTE   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.

[ISO 3534-2:2006, 2.3.9]

3.10
np chart
number of categorized units control chart
attribute control chart for number of units of a given classification where the sample size is constant

NOTE   In the quality field, the classification usually takes the form of "nonconforming units".

[ISO 3534-2:2006, 2.3.10]

3.11
p chart
proportion or percent categorized units control chart
attribute control chart 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   In the quality field, the classification usually takes the form of "nonconforming unit".

NOTE 2   The "p" chart is applied particularly when the sample size is variable.

NOTE 3   The plotted measure can be expressed as a proportion or as a percentage.

[ISO 3534-2:2006, 2.3.11]

3.12
Xbar control chart
average control chart
variables control chart for evaluating the process level in terms of subgroup averages

[ISO 3534-2:2006, 2.3.12]

3.13
median control chart
variables control chart for evaluating the process level in terms of subgroup medians

[ISO 3534-2:2006, 2.3.13]

3.14
moving average control chart
control chart for evaluating the process level in terms of the arithmetic average of each successive n observations

NOTE 1   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   The current observation replaces the oldest of the latest $n + 1$ observations.

NOTE 3   It has the disadvantage of an unweighted carry-over effect lasting n points.

[ISO 3534-2:2006, 2.3.14]

3.15
individuals control chart
X control chart
variables control chart for evaluating the process level in terms of the individual observations in the sample

NOTE 1   This chart is usually accompanied by a moving range chart, frequently, with $n = 2$.

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

NOTE 3   Individual values are expressed by the symbols x_1, x_2, x_3,… Sometimes, the symbol y is used instead of x.

NOTE 4   In the case of charts for individuals, the symbol R represents the value of the moving range, which is the absolute value of the difference between two successive values, thus:

$$|x_1 - x_2|, \ |x_2 - x_3|, \ \text{etc.}$$

NOTE   Adapted from ISO 3534-2:2006, 2.3.15.

3.16
EWMA control chart
exponentially weighted moving average control chart
control chart for evaluating the process level in terms of an exponentially smoothed moving average

[ISO 3534-2:2006, 2.3.16]

3.17
trend control chart
control chart for evaluating the process level with respect to the deviation of the subgroup averages from an expected change in the process level

NOTE 1   The trend may be determined empirically or by regression techniques.

NOTE 2   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.

[ISO 3534-2:2006, 2.3.17]

3.18
R chart
range control chart
variables control chart for evaluating variation in terms of subgroup ranges

NOTE 1   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   The average of the range values for all subgroups is denoted by the symbol $\bar{R}$.

NOTE 3   Adapted from ISO 3534-2:2006, 2.3.18.

3.19
s chart
standard deviation control chart
variables control chart for evaluating variation in terms of subgroup standard deviations

[ISO 3534-2:2006, 2.3.19]

3.20
moving range control chart
variables control chart for evaluating variation in terms of the range of each successive n observations

NOTE   The current observation replaces the oldest of the latest $n + 1$ observations.

[ISO 3534-2:2006, 2.3.20]

3.21
multivariate control chart
control chart in terms of the responses of two or more mutually correlated variates combined as a single sample statistic for each subgroup

[ISO 3534-2:2006, 2.3.21]

3.22
multiple characteristic control chart
attribute control chart for evaluating the process level based on more than one characteristic

[ISO 3534-2:2006, 2.3.22]

3.23
demerit control chart
quality score chart
multiple characteristic control chart for evaluating the process level where different weights are apportioned to events depending on their perceived significance

[ISO 3534-2:2006, 2.3.23]

3.24
process adjustment
action to reduce the deviation from the target in the output characteristic by feed-forward control and/or feedback control

NOTE   Ongoing monitoring determines whether the process and the system of process adjustment itself are, or are not, in a state of statistical control.

[ISO 3534-2:2006, 2.3.24]

3.25
feed-forward control
making appropriate compensatory changes in some other control variable by measurement of fluctuations in an input variable

[ISO 3534-2:2006, 2.3.25]

3.26
feedback control
making appropriate compensatory changes in the control variable by using the deviation from target or error signal of the output characteristic itself

[ISO 3534-2:2006, 2.3.26]

3.27
control variable
variable in the process that is varied as a function of the actuating signal so as to change the value of the process output

NOTE 1   Actuating signal may be triggered by measurable changes in process.

NOTE 2   Adapted from ISO 3534-2:2006, 2.3.27.

3.28
autocorrelation
internal correlation between members of series of observations ordered in time

[ISO 3534-2:2006, 2.3.28]

4 Symbols

n	subgroup size
p	proportion or fraction of units
R ⟨SPC and acceptance sampling⟩	range
$\bar{R}$ ⟨SPC and acceptance sampling⟩	average range
s	sample standard deviation
x	individual measured value
$\bar{x}$	subgroup average value

NOTE 1   It should be noted that the rules in the ISO/IEC Directives, Part 2, make it necessary to depart from common SPC usage in respect to the differentiation between abbreviated terms and symbols. In ISO International Standards, 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 upper control limit, UCL, is valid but its symbol in equations becomes U_{CL}. The reason for this is to avoid misinterpretation of compound letters as an indication of multiplication.

NOTE 2   In cases of long established practice where a symbol and/or abbreviated term means different things in different applications, it is necessary to use a subject field limiter, ⟨ ⟩, to distinguish between them. This avoids the alienation of practitioners by the creation of unfamiliar abbreviated terms and symbols in their particular field that are unlike all related texts, operational manuals and dedicated software programs. An example is the abbreviated term "R" and symbol "R" which have different meanings in the fields of metrology and of statistical process control (SPC) and acceptance sampling. The symbol "R" is differentiated thus:

R ⟨metrology⟩	reproducibility
R ⟨SPC and acceptance sampling⟩	range

5 Concepts

5.1 Control chart

The control chart is a graphical display of data from the process, which allows a visual assessment of the process variability. At defined intervals, subgroups of items of a specified size are obtained and the value of a characteristic or feature of the items is determined. The data thus obtained are typically summarized through the use of appropriate statistics and it is these statistics that are plotted on the control chart. A typical control chart will consist of a centre line that reflects the level around which the plotted statistic may be expected to vary. In addition, this control chart will have two lines, called control limits, placed one on each side of the centre line that define a band within which the statistic can be expected to lie randomly when the process is in control.

The two control limits are used as a criterion for judging the state of control of a process. The limits define a band, the width of which is determined in part by the inherent variability of the process. If the chosen statistic

plots within the band, the chart is indicating that the process is in a state of statistical control and hence the process is allowed to continue operating as it is currently configured. However, a value of the statistic plotting outside the control limits indicates that the process may be "out of control". The control chart is then providing a signal suggesting that a special cause of variability may be present and consequently there is a need for action on the process.

Actions that may be taken on the process consist of:

a)   undertaking an investigation to determine the source(s) of a special cause, with a view to elimination, correction, or reduction of the effect of this cause in the future;

b)   making a process adjustment;

c)   continuing the process on a risk assessment basis;

d)   stopping the process or talking containment action until correction has been made; or

e)   in cases where special cause indications are of a positive nature (e.g. process improvement), retaining the special cause, making it permanent whenever possible.

Sometimes, a second set of limits called "warning limits" is also placed on the control chart. The observation of a plotted point falling outside the warning limits but not outside the control limits indicates that, although no "action" is required on the process, increased attention should be paid to the process since a suspicion has been raised that a special cause may have affected the process. It may prove advantageous to then shorten the interval of time to the next sample and/or increase the size of the next sample in order to more quickly determine if the process has undergone a change. When warning limits are included on the control chart, the control limits are then sometimes called "action limits".

Optional, additional rules used for judging the state of control of a process take various forms such as data points within limits but exhibiting unusual patterns. These rules, often called "decision rules", are defined in ISO 8258.

When the objective is that of process acceptance, additional limit(s), called acceptance limit(s), may be needed as a decision criterion to judge the process acceptability. See 5.3.

5.2   Statistical control of a process

Control charts are often used to judge the stability of a process. A process is considered to be in a "state of statistical control" (the process is effectively said to be "in statistical control") if it is affected by random causes only, i.e. if no extraordinary, unexpected, special causes have entered the system. Such special causes can affect either the level at which the process is operating, the degree of variability around the process level or both simultaneously.

In essence, when a process is "in statistical control" it is possible to predict reliably the behaviour of that process, whereas when non-random (or special) causes enter the system, the process is subject to the results of these causes and the outcome cannot be predicted without information about their presence and effect. A process found not to be in a state of statistical control is said to be "out of control" and requires intervention to bring it into such a state. For certain economic or natural phenomena, there may be no known way to intervene and the control chart simply serves to identify a lack of control.

5.3   Acceptance of a process

In addition to monitoring the stability of the process, control charts can also be used to judge the acceptability of a process. When the process is in statistical control, it is then possible to determine, with controlled risks of decision errors, if the process output does or does not meet product or service requirements. This is most effective when the variability of the process is small compared to the tolerance defined by the specifications. In such situations, the process level may temporarily shift to an out-of-control state, yet all product and service requirements are still being met. The control chart is then used to maintain the acceptable status of the

process, notwithstanding the dynamic nature of the process level. Specific control charts, as described in ISO 7966, are needed in this case.

5.4   Management of a process with a natural drift

When some irremovable disturbance causes the process level to drift, for example the concentration of a specific chemical in a batch, there may exist a compensatory variable that can be manipulated to adjust the level of the process. In this situation, specifically designed charts can be used to indicate when and by how much the process should be adjusted to compensate for the disturbance effects. This type of control often results in a significant reduction in the variability of the process. In particular, it guarantees that the process will not be adjusted more often than necessary (over-adjustment), which would instead increase the inherent variability.

5.5   Risks of decision errors

In judging the state of control of a process using a set of decision rules together with a limited sample of data points, two types of decision errors may be made.

The first type of error (type I error) is made when a plotted point results in the decision that the process is not in statistical control and action is required on the process; but the true situation is that the process is operating within a system of random causes. Hence, the process will have been erroneously declared to be "out of control". The risk of making this type of error is called the "alpha (α) risk".

The second type of error (type II error) results when a special cause affecting the process has occurred but the data from the process has not yet led to the decision being made that the process is "out of control". Until the control chart indicates otherwise, the process will erroneously be declared to be "in statistical control". The risk of making this type of error is called the "beta (β) risk".

To control the risk of these errors, control limits, sets of decision rules, and sample size can be appropriately chosen.

5.6   Design of data collection

5.6.1   General

The most important element of data collection is the selection of the characteristics to be studied and the identification of the place or stages of control. The way in which data are collected is of fundamental importance to the efficient operation of the control chart to discriminate effectively random against special causes. Based upon an understanding of the nature of the process and the data to be collected, careful consideration must be given to how the samples or subgroups are to be defined, their appropriate sizes, and the frequency at which they are obtained.

5.6.2   Measurement process evaluation

Before implementing any type of process control activity, it is of crucial importance to ensure the validity of the measurement process. The variability induced by the measurement process must be estimated in order to check that process can adequately detect product variation and that signals on the control chart will be free of measurement error (see ISO 10012).

5.6.3   Sample selection

Samples are subgroups of collected items obtained from the process in a defined manner. Data from characteristics of these items are determined from which statistics, such as a number of non-conformities or an average or a range, may be computed and plotted on the control chart.

Rational samples or subgroups should be selected in a manner that makes each subgroup as homogeneous as the process will permit. Within a rational subgroup, variation is presumed to be due only to random causes.

These causes are sources of variation inherent in a process over time. Rational subgroups are selected to enable the detection of any special causes of variation between subgroups. Short-term variability is measured using the variability within a series of reasonably homogeneous subgroups and determines the position of the control limits on the control chart, while long-term variability is usually evaluated in terms of changes between subgroups. Time order is often a good basis for forming subgroups because it allows for detection of special causes that may occur over time. However, other bases, such as the need to study operator-to-operator variability, machine-to-machine variability, or supplier-to-supplier variability may suggest that subgroups be defined across operator, machine, or supplier instead of over time.

The rational subgroup should be subject to all usual sources of random cause variation if it is to have meaningful value. For example, a series of repeat readings on a piece of material set in a testing instrument might fail to include the contribution of locating the material in the instrument or of obtaining the sample. If these aspects were inherent in a usual testing environment, the repeat readings would give an unrealistic, low estimate of inherent measurement variability. Thus, almost any actual measurement from the process would appear to be "out of control".

5.6.4 Sample size

Sample size should be selected so as to balance the ability to detect small shifts in the process and the risk of not detecting special causes. A larger sample size, although more costly, will provide a more precise assessment of the process, therefore allowing for a more efficient monitoring. However, if the sample is too large, special causes have more opportunities to occur within the collection period of the sample, causing increased within-sample variation; hence, control limits might be unduly widened and many special causes may occur without detection.

When dealing with attributes data, the sample size needed to detect changes in the process proportion will ordinarily be very much larger than the sample size using variables data, since attributes data carry much less information than variables data.

In some situations, it is impractical, or it does not make sense, to form subgroups, but rather to collect information on individual units, so that, essentially, samples are of size one. This is the case when testing is destructive or sampling is costly, or when repeated measurements on the process (continuous or batch processes) differ only because of instrument or analysis error.

5.6.5 Sampling frequency

Sampling frequency is dependent upon the magnitude of the shift in the process that is considered to be crucial to detect in a timely fashion, as well as upon the cost of the process operating in an out-of-statistical-control state. The smaller the shift to be detected, the greater the number of samples, of a given size, that will need to be collected before a signal is detected on the chart. Shortening the period between which samples are taken will decrease the period before any process fault is detected, and in which the process may have operated in an out-of-control state and produced faulty product. However, in defining the period, cost considerations of sampling and testing, may also be considered. Care should be taken to ensure that the period does not synchronize with parameters that may affect the process (e.g. always sampling at the start of the working period when temperatures are low, or every 50th product at the start of a raw material batch, or at a shift change).

5.7 Control charts for variables and attributes data

Control charts may be used for either "variables" or "attributes" data. Variables data represent observations obtained by measuring and recording the magnitude of the characteristic under study on a continuous scale of measurement. Attributes data represent (categorized or countable) observations obtained by noting the presence (or absence), or the frequency of occurrence of some characteristic or attribute in each of the items. A count is made of the number of units possessing the attribute or the frequency of occurrence of the characteristic on the item. Results are then expressed in terms of frequencies or proportions.

Fundamentally, control charts used for variables data (also called variables control charts) differ from control charts used for attributes data (also called attributes control charts) because of the different underlying distribution of the characteristic under study.

For most variables control charts, the normal distribution is generally assumed with observations being statistically independent. As a result of this assumption, two control charts are used for the dual purposes of controlling both the mean level or centre and the variability of the process. The first involves a measure of location (centre) such as the sample average, median, or a single measured characteristic itself if the sample contains only one item. The second uses a measure of dispersion (variability) of observations within the sample, such as the sample standard deviation or the sample range, or the absolute difference between two consecutive observations if the sample contains only one item at a point in time. Both types of charts are required in order for the variables control chart approach to be effective.

The distance between control limits on the chart for location (average) is a function of the variation that is monitored on the chart for dispersion. It is therefore important in constructing the control chart for process level (average) to verify that the process is in statistical control with respect to its dispersion.

For most attributes control charts, either the binomial or the Poisson distribution is generally assumed. Each of these distributions has a single parameter that must be monitored for stability of the process. Therefore, only a single chart is necessary for monitoring a process with attributes data. Because the standard deviation of the proportion or count may be estimated once the sample size is known and the proportion or count in the sample is determined, the control limits on the attributes chart can be determined.

6 Types of control charts

The system of control charts specified in this part of ISO 7870 is composed of those corresponding to the following process characteristics: "process stability", and "process acceptance".

When the purpose is to achieve or maintain process stability, the Shewhart control chart (see ISO 8258) and the related control charts [CUSUM charts (see ISO/TR 7871), exponentially weighted moving average (EWMA) charts, moving average (MA) charts] may be used.

When the purpose is to achieve process acceptance, acceptance control charts are used (see ISO 7966). However, ISO 7966 specifies that a preliminary Shewhart control chart study should be conducted to verify the validity of using an acceptance control chart. It is also mandatory to maintain control of the process variability.

Some of the specific charts within these general types are described in Clauses 7 and 8.

In addition, there are statistical methods, described in Clause 9, which apply when it is not possible to bring or maintain the process in statistical control. These methods will predict process adjustments, the purpose being to keep the process as close as possible to target.

7 Charts for process stability

7.1 General

Two general forms of the Shewhart control chart exist.

The first is a control chart with no pre-specified control limits. This chart uses control limits based on the sample or subgroup data plotted on the chart. This form of control chart is used to determine whether the observed values of a series of samples vary by an amount greater than would be expected by chance alone. In essence, this type of chart is used to detect any lack of control particularly in the research and development stages, or in early pilot trials or initial production and service studies. This control chart is useful for assessing the variation of a new process, product or service, including the variation of the measurement method. At this stage, caution must be exercised in the interpretation of the signals on the chart since the control limits are functions of the plotted data.

The second is a control chart with specified control limits, based on adopted standard values applicable to the statistical measures plotted on the chart. The standard values may be based on:

a) prior representative data (such as that obtained from experience using control charts with no pre-specified control limits);

b) an economic value derived from consideration of needs of service and cost of production; or

c) a desired target value defined in a specification.

This form of control chart is used to monitor ongoing processes by assessing whether the observed measures for a sample value differ from the adopted standard values by an amount greater than should be expected by chance alone.

Preferably, the standard values should be determined as described in a) above because the transition from the first phase using a control chart with no pre-specified limits to the second phase where control charts are used with specified control limits requires continuity of the process control.

Note that the second form of control chart not only evaluates the constancy of the cause system, but also evaluates whether that cause system is properly located in terms of the adopted economic or target values.

7.2 Partial listing of Shewhart and related control charts

7.2.1 General

This listing is divided into three categories. The first two, based on independent observations, use data obtained either from each subgroup or accumulated from more than one subgroup. The third includes data for which the assumption of independence does not hold.

7.2.2 Charts using data from only one rational subgroup for each plotted value

7.2.2.1 Variables data

Charts which can be used for variables data from only one rational subgroup for each plotted value include the following:

a) Xbar and R control charts (average for measure of central tendency and range for measure of dispersion) or Xbar and s control charts (standard deviation replacing range). Median control charts can be substituted for the average control charts;

b) X and moving range control charts (see 7.2.3);

c) multivariate chart.

Multivariate control charts are used to detect shifts in the mean or in the relationship (covariance) between several related characteristics. Typically only one summary statistic derived from the combination of the characteristics to be controlled is plotted on the chart.

7.2.2.2 Attributes data

Charts which can be used for attributes data from only one rational subgroup for each plotted value include the following:

a) p chart (proportion or percent categorized units control chart);

b) np chart (number of categorized units control chart);

c) c chart (count control chart);

d) u chart (count per unit control chart).