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**Statistical methods in process  
management — Capability and  
performance —**

**Part 5:  
Process capability estimates  
and performance for attributive  
characteristics**

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*Méthodes statistiques dans la gestion des processus — Aptitude et  
performance* — 5:2019

<https://standards.iteh.org/catalog/standards/sist/9316115f-1168-4171-a6c0-1565a609c824/iso-22514-5-2019>  
*Partie 5: Estimations de l'aptitude du processus et performance pour  
les caractéristiques par attributs*



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ISO 22514-5:2019

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CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

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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](http://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](http://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](http://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 product and process management*.

A list of all parts in the ISO 22514 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](http://www.iso.org/members.html).

## Introduction

Organizations need to evaluate the capability and performance of their key processes including processes where the key characteristics only can be evaluated based on attributes. The methods described in this document are intended to assist any organization in this respect.

Process capability and performance evaluations are also necessary to enable organizations to assess the capability and performance of their suppliers. Those organizations will find the indices contained within this document useful in this endeavour.

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# Statistical methods in process management — Capability and performance —

## Part 5: Process capability estimates and performance for attributive characteristics

### 1 Scope

This document describes a method to calculate process capability and performance indices for attribute characteristics. This method can be used as a supplement to the commonly used capability calculations for variable characteristics.

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

### 3 Terms and definitions

ISO 22514-5:2019  
<https://standards.iteh.ai/catalog/standards/sist/9316115f-1168-4171-a6c0-1565a609c8a/iso-22514-5-2019>

For the purposes of this document, the terms and definitions given in 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/>

### 4 Symbols and abbreviated terms

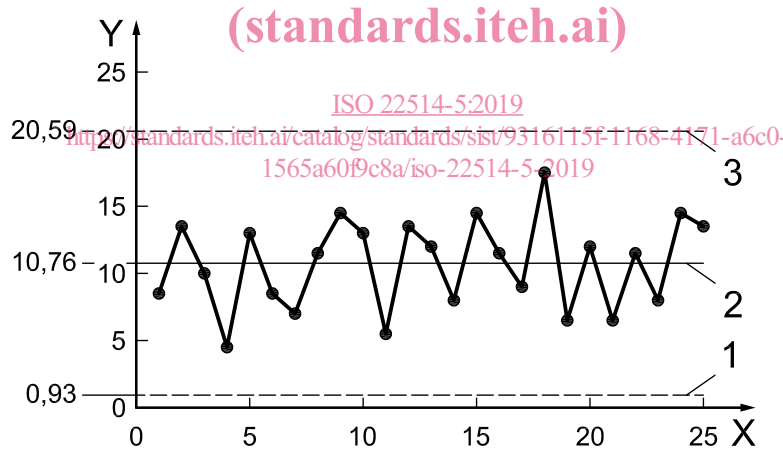
$\bar{c}$	average number of nonconformities
$C_p^*$ , $C_{pk}^*$ , $C_{pkL}^*$ , and $C_{pkU}^*$	process capability indices
FRC	first run capability
$n$	subgroup size
NHU	nonconformities per hundred units
NMU	number of nonconformities per million
$\bar{p}$	average proportions of nonconforming units
$p_U$	fraction of nonconforming units over upper specification limits

$p_L$	fraction of nonconforming units under lower specification limits
PCI	process capability index
$Q_p$	process quality level
$P_p^*$ , $P_{pk}^*$ , $P_{pk_L}^*$ , and $P_{pk_U}^*$	process performance indices
$\bar{u}$	average proportions of nonconformities
$z_\alpha$	quantile of the standardized normal distribution from $-\infty$ to $\alpha$

## 5 Pre-conditions for application

### 5.1 General

Attributes data represent (categorized or countable) observations obtained by noting the presence (or absence), or the frequency of occurrence of one or more characteristics or attributes 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 and either the binomial or the Poisson distribution is assumed. Each of these distributions has a single parameter that must be monitored for stability of the process. 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 (see [Figure 1](#)).



**Key**

- X subgroup number
- Y number nonconforming
- 1  $L_{CL}$
- 2  $n\bar{p}$
- 3  $U_{CL}$

**Figure 1 — np Chart (see ISO 7870-2)**

In case that products are manufactured at more than one location, product from each line or system of production shall be considered separately.

The percent of nonconformities can be calculated based on one of the four different charts.



## 5.2 Aspects about establishing specifications

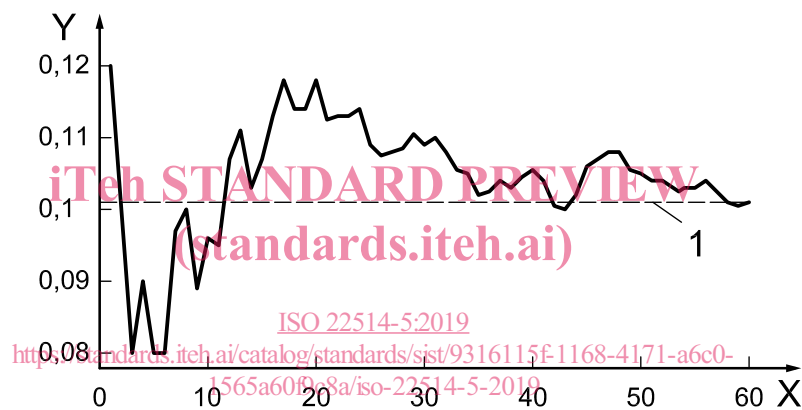
The product specifications shall be defined in a way that allows the organization to judge between parts or characteristics fulfilling the requirements, and parts or characteristics not acceptable within an acceptable measurement uncertainty (see ISO 22514-7).

## 5.3 Sample size

Samples are subgroups of collected items obtained from the process. Attributive data from the characteristics of these items should be computed and plotted on a control chart. It can be the number of nonconformities using a *c*-chart or a *u*-chart, or the proportion of nonconforming units using a *np* chart or a *p* chart.

No general rules can be laid down for the frequency of subgroups or the subgroup size. The frequency can depend upon the cost of taking and analysing samples and the size of the subgroup can depend upon practical considerations.

A cumulative chart can indicate when enough data has been collected to provide a stable estimate of the process quality level (NHU), see [Figure 2](#).



### Key

- X number of samples
- Y nonconformances per hundred units (NHU)
- 1 average NHU

Figure 2 — Cumulative NHU (see ISO/TR 18532)

## 6 Process analysis

### 6.1 Process variation

Process capability is a measure of inherent process variability. It represents the variation that remains after all known removable assignable causes have been eliminated. If the process is monitored using a control chart, the control chart shows an in-control state (see ISO 7870-1 for further information).

Capability of attribute characteristics is regarded as being related to the proportion of output that occurs within the product specification tolerances. Since a process in statistical control can be described by a predictable distribution, the proportion of out-of-specification outputs can be estimated. As long as the process remains in statistical control, it continues to produce the same proportion out-of-specification.

In case of calculation of capability, it is necessary to plot data on an attribute control chart and to check the chart for statistical control.