

---

---

**Control charts —**

**Part 2:  
Shewhart control charts**

*Cartes de contrôle —*

*Partie 2: Cartes de contrôle de Shewhart*



This document is a preview generated by ELS



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

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

Published in Switzerland

# Contents

Page

Foreword.....	v
Introduction.....	vi
<b>1 Scope.....</b>	<b>1</b>
<b>2 Normative references.....</b>	<b>1</b>
<b>3 Terms and definitions.....</b>	<b>1</b>
3.1 General presence.....	1
3.2 Symbols.....	1
3.2.1 For the purposes of this document, the following symbols apply.....	1
<b>4 Concepts of Shewhart control charts.....</b>	<b>3</b>
4.1 Shewhart control chart.....	3
4.2 Control limits.....	3
4.3 Process in statistical control.....	3
4.4 Action limits.....	4
4.5 Warning limits.....	4
4.6 Type 1 error.....	4
4.7 Type 2 error.....	4
4.8 Process not in control.....	4
4.9 Phase 1 of statistical process control.....	5
4.10 Phase 2 of control charts.....	5
<b>5 Types of control charts.....</b>	<b>5</b>
5.1 Types of Shewhart control charts.....	5
5.2 Control charts where no pre-specified values of process parameters are given.....	5
5.3 Control charts with respect to given pre-specified values of process parameters.....	6
5.4 Types of variables and attribute control charts.....	6
5.4.1 Variables control charts.....	6
5.4.2 Attribute control charts.....	6
<b>6 Variables control charts.....</b>	<b>7</b>
6.1 Usefulness of variables control charts.....	7
6.2 Assumption of normality.....	7
6.3 Pair of control charts.....	8
6.4 Average, $\bar{X}$ chart and range, $R$ chart or average, $\bar{X}$ chart and standard deviation, $s$ chart.....	8
6.5 Control chart for individuals, $X$ , and moving ranges, $R_m$ .....	9
6.6 Control charts for medians, $\tilde{X}$ .....	10
<b>7 Control procedure and interpretation for variables control charts.....</b>	<b>11</b>
7.1 Underlying principle.....	11
7.2 Collect preliminary data.....	11
7.3 Examine $s$ (or $R$ ) chart.....	11
7.4 Homogenization for $s$ (or $R$ ) chart.....	11
7.5 Homogenization for $\bar{X}$ chart.....	12
7.6 Ongoing monitoring of process.....	12
<b>8 Unnatural pattern and tests for assignable causes of variation.....</b>	<b>12</b>
8.1 Natural pattern.....	12
8.2 Unnatural patterns.....	13
8.2.1 General.....	13
8.2.2 Lack of control in the average chart only.....	13
8.2.3 Lack of control in the variation chart only.....	13
8.2.4 Lack of control in both average and variation charts.....	14
8.2.5 Depiction of unnatural patterns.....	14
<b>9 Process control, process capability, and process improvement.....</b>	<b>15</b>

9.1	Process control.....	15
9.2	Process capability and improvement.....	16
<b>10</b>	<b>Attribute control charts.....</b>	<b>18</b>
10.1	Attribute data.....	18
10.2	Distributions.....	18
10.3	Subgroup size.....	18
10.4	Control chart for fraction nonconforming ( $p$ chart).....	19
<b>11</b>	<b>Preliminary considerations before starting a control chart.....</b>	<b>19</b>
11.1	Choice of critical to quality (CTQ) characteristics describing the process to control.....	19
11.2	Analysis of the process.....	19
11.3	Choice of rational subgroup.....	20
11.4	Frequency and size of subgroups.....	20
11.5	Preliminary data collection.....	21
11.6	Out of control action plan.....	21
<b>12</b>	<b>Steps in the construction of control charts.....</b>	<b>21</b>
12.1	Typical format of a standard control chart form.....	21
12.2	Determine data collection strategy.....	22
12.3	Data collection and computation.....	23
12.4	Plotting $\bar{X}$ chart and $R$ chart.....	23
<b>13</b>	<b>Caution with Shewhart control charts.....</b>	<b>24</b>
13.1	General caution.....	24
13.2	Correlated data.....	26
13.3	Use of alternative rules to the three- $\sigma$ rule.....	26
<b>Annex A (informative) Illustrative examples.....</b>		<b>27</b>
<b>Annex B (informative) Practical notices on the pattern tests for assignable causes of variation.....</b>		<b>46</b>
<b>Bibliography.....</b>		<b>48</b>

## 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 process management*.

This second edition cancels and replaces the first edition (ISO 7870-2:2013), which has been technically revised.

The main changes are as follows:

- various clauses have been modified for better understanding;
- some examples for control charts have been modified;
- new examples for control charts have been included.

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](http://www.iso.org/members.html).

## Introduction

A traditional approach to manufacturing has been to depend on production to make the product and on quality control to inspect the final product and screen out items not meeting specifications. This strategy of detection is often wasteful and uneconomical because it involves after-the-event inspection when the wasteful production has already occurred. Instead, it is much more effective to institute a strategy of prevention to avoid waste by not producing unusable output in the first place. This can be accomplished by gathering process information and analysing it so that timely action can be taken on the process itself.

Dr. Walter Shewhart in 1924 developed the control chart method for controlling the quality during production. Control chart theory recognizes two kinds of variability. The first kind is random variability (also known as natural/inherent/uncontrollable variation) arising due to causes known as chance/common/random causes. This is due to the wide variety of causes that are consistently present and not readily identifiable, each of which constitutes a very small component of the total variability but none of them contributes any significant amount. Nevertheless, the sum of the contributions of all of these unidentifiable random causes is measurable and is assumed to be inherent to the process. The elimination or correction of common causes may well require a decision to allocate resources to fundamentally change the process and system.

The second kind of variability represents a real change in the process. Such a change can be attributed to some identifiable causes that are not an inherent part of the process and which can, at least theoretically, be eliminated. These identifiable causes are referred to as “assignable causes” (also known as special/unnatural/systematic/controllable causes) of variation. They may be attributable to such matters as the lack of uniformity in material, a broken tool, workmanship or procedures, the irregular performance of equipment, or environmental changes.

A process is said to be in a state of statistical control, or simply “in control”, if the process variability results only from random causes. Once this level of variation is determined, any deviation from this level is assumed to be the result of assignable causes that should be identified and eliminated.

The major statistical tool used to do this is the control chart, which is a method of presenting and comparing information based on a sequence of observations representing the current state of a process against limits established after consideration of inherent process variability. The control chart method helps first to evaluate whether a process has attained, or continues in, a state of statistical control. When the process is deemed to be stable and predictable, then further analysis regarding the ability of the process to satisfy the requirements of the customer may be conducted. The control chart also can be used to provide a continuous record of a quality characteristic of the process output while process activity is ongoing. Control charts aid in the detection of unnatural patterns of variation in data resulting from repetitive processes and provide criteria for detecting a lack of statistical control. The use of a control chart and its careful analysis leads to a better understanding of the process and will often result in the identification of ways to make valuable improvements.

# Control charts —

## Part 2: Shewhart control charts

### 1 Scope

This document establishes a guide to the use and understanding of Shewhart control chart approach to the methods for statistical control of a process.

This document is limited to the treatment of statistical process control methods using only Shewhart system of charts. Some supplementary material that is consistent with Shewhart approach, such as the use of warning limits, analysis of trend patterns and process capability is briefly introduced. However, there are several other types of control charts which can be used in different situations.

### 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

#### 3.1 General presence

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.2 Symbols

**NOTE** The ISO/IEC Directives make it necessary to depart from common SPC usage in respect to the differentiation between abbreviated terms and symbols. In ISO 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 Cambria upright and symbols in Cambria 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.

##### 3.2.1 For the purposes of this document, the following symbols apply

- |     |   |
|-----|---|
| $n$ | Subgroup size; the number of sample observations per subgroup |
| $k$ | Number of subgroups   |
| $L$ | Lower specification limit                                     |