TECHNICAL REPORT

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First edition

Guidelines for implementation of statistical process control (SPC) —

Part 3: Reference data sets for SPC software validation

Lignes directrices pour la mise en œuvre de la maîtrise statistique des processus (MSP) —

Partie 3: Jeux de données de référence pour la validation de logiciels pour MSP

PROOF/ÉPREUVE

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Foreword

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

A list of all parts in the ISO 11462 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

The test examples given in this document were developed for the assessment of SPC systems. They allow SPC software developers to evaluate their systems. Thus, the end user of those systems can be sure that the data sets are evaluated correctly with a high level of reliability. In order to cover as wide a spectrum as possible, suitable data sets were prepared individually for various constellations. The evaluation results of those data sets are documented and commented on the following pages.

The results were verified multiple times using different computer programs. This turns the data sets and the results into references for validation of the software. The data sets are listed in Annex A.

Guidelines for implementation of statistical process control (SPC) —

Part 3: Reference data sets for SPC software validation

1 Scope

This document describes examples for software validation for SPC software implementing the standards of the ISO 7870 series on control charts and the ISO 22514 series on capability and performance. In detail ISO 7870-2, ISO 22514-2 and ISO 22514-8 are covered.

It provides data sets and test results for testing the implementation of the evaluation methods described in these standards. This includes the detection of out of control situations as well as the calculation of sample statistics and process capability indices.

The test examples cover the following situations:

a) General:

— different sample and subgroup sizes accuracy of calculation for large/small numbers;

b) ISO 22514 series:

— calculation of sample statistics for location and dispersion;

— different distribution models;

c) ISO 7870-2:

— calculation of control limits;

— visualization of data (histogram, control charts);

— detection of out of control situations.

2 Normative references

There are no normative references in this document.

3 Terms and definitions, and symbols and abbreviated terms

3.1 Terms and definitions

No terms and definitions are listed in this document.

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/

3.2 Symbols and abbreviated terms

Symbols used in this document are identical to the symbols used in ISO 22514-2 and ISO 7870-2:

C_p process capability index

C_{pk} minimum process capability index

C_{pkU} upper process capability index

C_{pkL} lower process capability index

U_{CL} upper control limit

L_{CL} lower control limit

m number of subgroups

n sample size of each subgroup

P_m machine performance index

P_{mk} minimum machine performance index

P_{mkU} upper machine performance index

P_{mkL} lower machine performance index

P_p process performance index

P_{pk} minimum process performance index

P_{pkU} upper process performance index

P_{pkL} lower process performance index

T Centreline (target value) for the respective characteristic in the control charts

U upper specification limit

L lower specification limit

U_{tr} upper specification limit, transformed values

L_{tr} lower specification limit, transformed values

Abbreviated terms:

SPC statistical process control

4 Overview of the test examples

4.1 Overview

See Table 1 for an overview of the test examples.

Table 1 — Overview of test examples

Test data set number	Subclause	Distribution model	Resulting distribution	Decimal points	Total sample size	Subgroup sample size	Description of data set
1	5.1	A1	normal	4	125	5	Data follows a normal distribution with no outliers
2	5.2	A2	Weibull	3	600	3	Correct calculations for a sample following a Weibull distribution
3	5.3	B	non-normal	2	1 000	5	Normal distribution with time dependent shift of mean
4	5.4	C1	normal	2	1 000	5	Location: random normally distributed; dispersion: constant
5	5.5	C2	non-normal	2	1 000	5	Location random non-normally distributed; dispersion constant; resulting distribution non-normal
6	5.6	C3	non-normal	2	600	6	Capability indices for trend production (tool wear)
7	5.7	C4	non-normal	2	500	5	Capability indices for fix tooling (tool change)
8	5.8	D	non-normal	3	500	5	Systematic and random changes in location and dispersion - non-normal
9	5.9	A2	Rayleigh	3	500	5	Correct calculations for a sample following a Rayleigh distribution
10	5.10	A2	Weibull	0	200	5	Correct calculations for a sample following a Weibull distribution
11	5.11	C2	normal	1	30	(10)	ISO 22514-8 capability of multi-state production processes

NOTE

— The decision which distribution model fits the data and is used is up to the statistical expert. Within this document distribution models for each example are therefore assumed. The procedure to select a statistical distribution is not part of this document.

— According to ISO 22514-2 the calculation method d = 5 for the dispersion is not suited for non-normal distributions. It is calculated and given in this document even for non-normal distributions for the purpose of validating the implementation of the calculation method of d = 5.

— The resulting distributions for test 2, 9 and 10 are pre-selected models and with no means the "best natural" resulting distribution models for the same reason no goodness of fit statistics are given, knowing they will lead to reject H_0 for the pre-selected distribution models.

— Two more decimal places for sample statistics and control limits than digits of the input values. Resulting values are rounded (ISO/IEC/IEEE 60559, rounded-to-the-nearest).

— Capability index are always given with 2 digits (rounded).

— Control limits were calculated using all values in the test data set.

— All control limits were calculated using tabulated correction factors in ISO 7870-2. Using the exact quantiles of the corresponding distribution functions instead can lead to a deviation in the results <0,1 %.

— The centrelines for the control charts were chosen according to the respective statistics given by ISO 7870-2:2013, 6.1 to 6.3

— The histogram plot is not part of the validation, since the procedure is not specified in ISO 7870 series nor in ISO 22514 series. Histograms are for visualization purposes only.

— No units are given, no unit conversion has to be done.

— Time-dependent distribution models A-D are specified in ISO 22514-2.

— Internally a precision of 15 digits is used, when already calculated values are used again in further calculations.

— If the data are not normal distributed an individual chart and a MR chart cannot be used.

5 Reference data sets description and evaluation

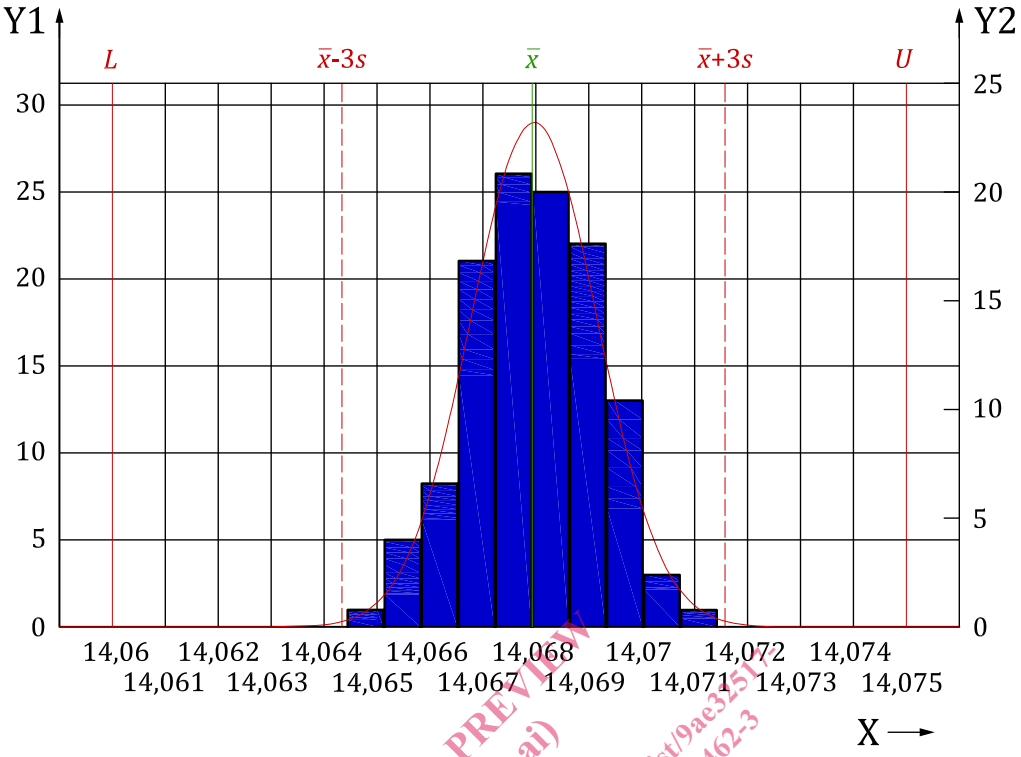
5.1 Test data set 1

5.1.1 Test data set 1 information

This set of test data is taken from a process following a normal distribution and is for checking the accuracy of calculation for control limits, sample statistics and process capabilities. A description of test data set 1 is given in Table 2. Figure 1 shows a histogram and Figure 2 a probability plot of the test data set 1 with the purpose of data visualization.

Table 2 — Description of test data set 1

Description of data input			
Distribution model	A1	Resulting distribution	Normal
Data set	Annex A, Table A.1	decimal points	4
Total sample size	125	*U*	14,075
Size of subgroups	5	*L*	14,060



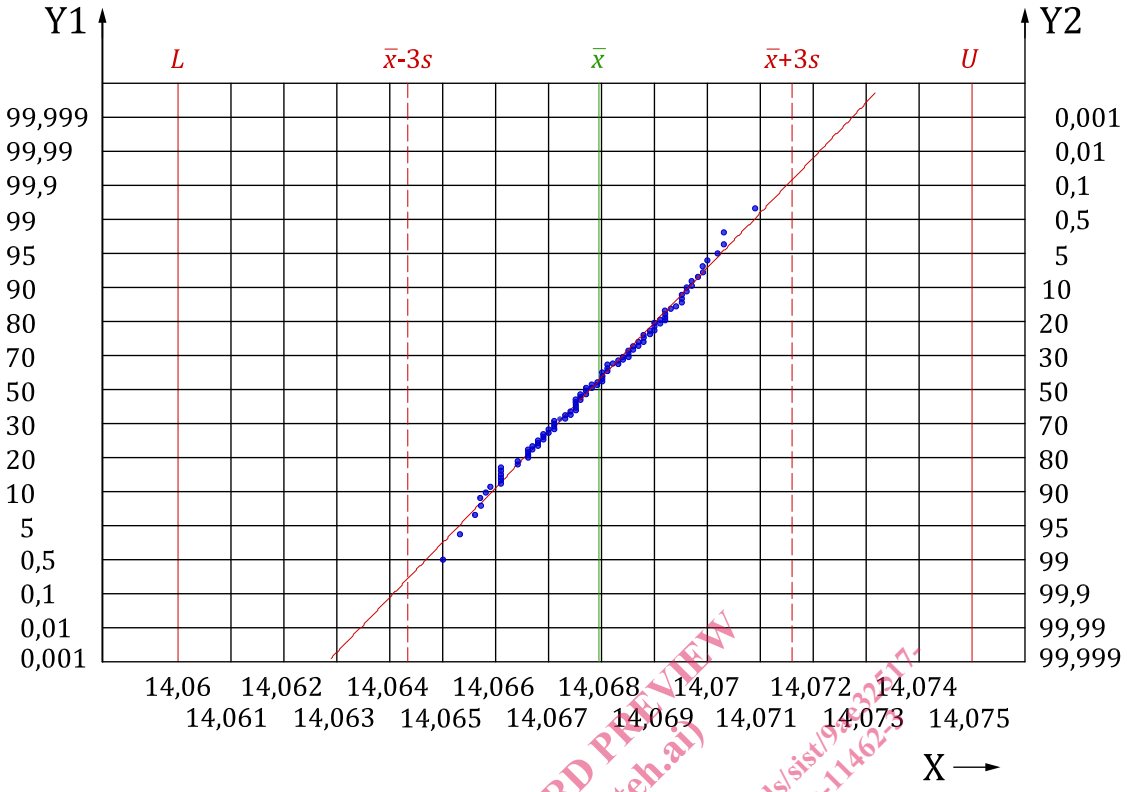
Key

X value

Y1 absolute frequency

Y2 relative frequency in %

Figure 1 — Histogram of test data set 1



Key

X value

Y1 probability in %

Y2 1-probability in %

Figure 2 — Probability plot of test data set 1

NOTE The width of the class intervals is 0,000 7.

The class interval with the highest frequency of values is from 14,067 95 to 14,068 02.

The density plot is based on the assumption of normality and estimated parameters $l = 1$, $d = 5$.

5.1.2 Test data set 1 results

5.1.2.1 List of sample statistics

Table 3 lists all sample statistics which are necessary to calculate the target values and control limits for the control charts described in ISO 7870-2 as well as the estimators for location and dispersion given in ISO 22514-2 for the calculation of the process capability indices.

Table 3 — List of sample statistics for test data set 1

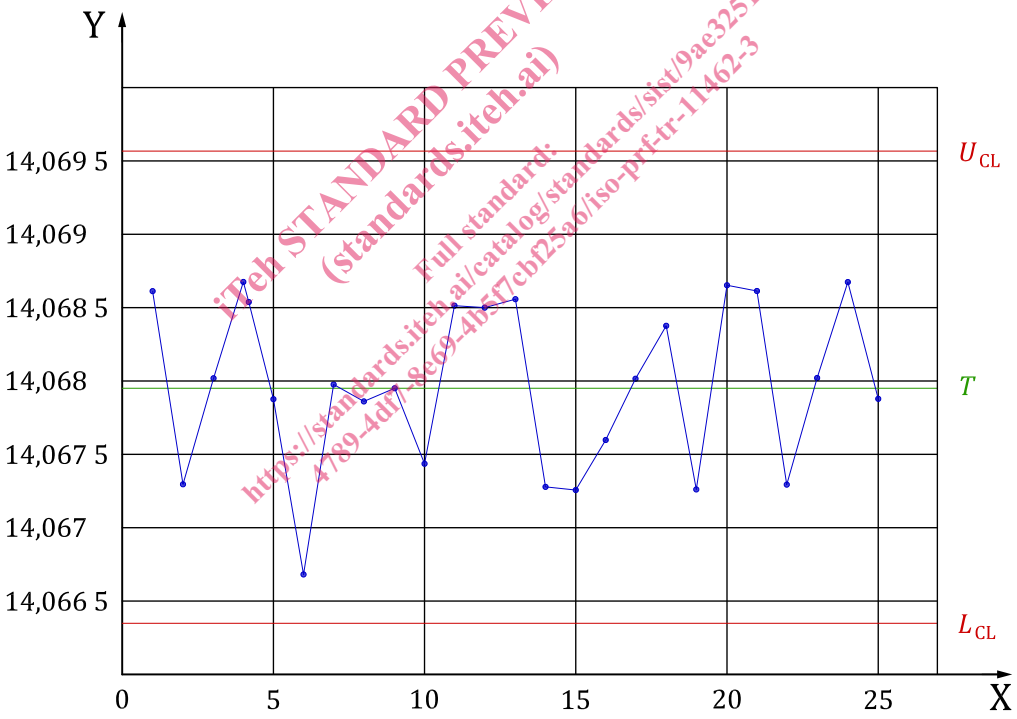
Statistic	Value	Reference
Location		
$\bar{x}$ ($l = 1$)	14,067 958	ISO 22514-2:2017, Formula (11)
$\tilde{x}$, ($l = 2$)	14,068 000	ISO 22514-2:2017, Formula (12)
$\bar{\bar{x}}$ ($l = 3$)	14,067 958	ISO 22514-2:2017, Formula (13)
$\bar{\tilde{x}}$ ($l = 4$)	14,067 828	ISO 22514-2:2017, Formula (14)

Table 3 *(continued)*

Statistic	Value	Reference
Dispersion		
$\hat{\Delta}$ $(d = 1)$	0,007 240 (normal distribution)	ISO 22514-2:2017: Formula (15)
$\hat{\sigma}$ $(d = 2)$	0,001 187	ISO 22514-2:2017, Formula (16)
$\hat{\sigma}$ $(d = 3)$	0,001 200	ISO 22514-2:2017, Formula (17)
$\hat{\sigma}$ $(d = 4)$	0,001 180	ISO 22514-2:2017, Formula (18)
$\hat{\sigma}$ $(d = 5)$	0,001 207	ISO 22514-2:2017, Formula (19)
$\overline{s}$	0,001 128	ISO 7870-2:2013, 3.2
R	0,005 900	ISO 7870-2:2013, 3.2
$\overline{R}$	0,002 744	ISO 7870-2:2013, 3.2
$\overline{R}_m$	0,001 379	ISO 7870-2:2013, 3.2

5.1.2.2 $\overline{x}$ chart

The $\overline{x}$ control chart calculated according to ISO 7870-2:2013, 6.1, is shown in Figure 3.



Key

X number of subgroup

Y mean value

Figure 3 — Mean control chart for test data set 1

The control limits are (see ISO 7870-2:2013, Table 1, using $\overline{s}$):

L_{CL} = 14,066 349

U_{CL} = 14,069 568