INTERNATIONAL STANDARD

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Plain bearings — Quality characteristics — Calculation of machine and process capabilities

Paliers lisses — Caractéristiques de qualité — Calcul de la capabilité de la machine et du procédé

Reference number
ISO 12303:1995(E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 12303 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 5, *Quality analysis and assurance*.

Annex A of this International Standard is for information only.

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Plain bearings — Quality characteristics — Calculation of machine and process capabilities

1 Scope

This International Standard specifies for plain bearings details of the calculation of machine and process capabilities for quantitative (variable) quality characteristics in accordance with ISO 12302.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 12302:1993, *Plain bearings — Quality characteristics — Statistical process control (SPC).*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 machine capability: A measure relating the actual performance of a machine to specified requirements. It is normally expressed as an index, viz. C_m, C_{mk}.

3.2 process capability: A measure relating the actual performance of a process to specified requirements. It is normally expressed as an index, viz. C_p, C_{pk}.

3.3 statistical process control (SPC): Control of quality characteristics of plain bearings during the production process by means of statistical techniques in order to comply with quality requirements.

3.4 quality characteristic: Characteristic by means of which the quality of a plain bearing is assessed.

4 Symbols and abbreviations

C_m	Machine capability index (spread only)
C_{mk}	Machine capability index (spread and setting)
C_p	Process capability index (spread only)
C_{pk}	Process capability index (spread and setting)
d_2	Factor
G	Judgement of normality
LL	Lower specified limit
UL	Upper specified limit
k	Number of subgroups
n	Subgroup size
R	Subgroup range
$\overline{R}$	Arithmetic mean of subgroup ranges
x_i	Observations (readings)
$\bar{x}$	Arithmetic mean of observations (readings)
$\bar{\bar{x}}$	Arithmetic mean of subgroup means
σ	Standard deviation
$\hat{\sigma}$	Estimated standard deviation

5 Machine and process capabilities as part of an SPC implementation programme

5.1 Machine capability

Machine capability studies are for evaluating the performance of a machine. They give only a short-term indication. They do not identify special cause effects in the process. A machine capability study is normally carried out on an uninterrupted run of parts of a predetermined sample number and would normally be undertaken prior to assessing process capability. Machine capability can only be determined when a normal distribution exists.

5.1.1 Machine capability index (spread only), C_m

The C_m index is a value used to determine the spread ratio of the machine.

For the general case:

$$C_m = \frac{\text{specified tolerance}}{\text{machine spread}}$$

For a normal distribution:

$$C_m = \frac{\text{specified tolerance}}{6\sigma}$$

5.1.1.1 Preliminary precautions

a) A minimum of 50 pieces should preferably be tested.

b) Set the machine at the midpoint of the tolerance of the characteristic to be checked.

c) For the study, use parts which have been manufactured consecutively.

5.1.1.2 Test for normality

5.1.1.2.1 Graphical test using probability paper (for an example, see figure A.1)

a) Fill in the measured values in the frequency tabulation of the probability paper.

b) Check the histogram for normal distribution.

c) Determine the arithmetic mean, $\bar{x}$, and standard deviation, σ.

d) Determine the cumulative frequency values and plot points on the probability paper.

e) Draw a straight line on the graph which best fits the experimental data. If a straight line can be fitted through the experimental points, the normality can be accepted. Otherwise, it shall be rejected and the formulae for C_m and C_{mk} do not apply.

5.1.1.2.2 Statistical test

a) Arithmetic mean of observations (readings), $\bar{x}$, is given by

$$\bar{x} = \frac{\sum x_i}{n}$$

b) Standard deviation, σ, is given by

$$\sigma = \sqrt{\frac{1}{n-1}\sum (x_i - \bar{x})^2}$$

5.1.1.2.3 Normal distribution test

a) Judgement of normality, G, is given by

$$G = \frac{\sum (x_i - \bar{x})^3}{n\sigma^3}$$

Limiting values $\pm$ 0,5

b) Machine capability index, C_m, is given by

$$C_m = \frac{\text{UL} - \text{LL}}{6\sigma}$$

5.1.2 Machine capability index (spread and setting), C_{mk}

The C_{mk} index is a value used to determine the spread of the machine and the setting of the mean value of the frequency distribution within the limits of the specification.

The value of C_{mk} is given by

$$C_{mk} = \frac{\text{UL} - \bar{x}}{3\sigma} \quad \text{or} \quad \frac{\bar{x} - \text{LL}}{3\sigma}$$

whichever is the smaller value.

The value of C_{mk} should be $\geqslant$ 1,33 (1,67).

5.2 Process capability

Process capability indices are more representative of the quality level achieved, since the effects of equipment, materials, methods, environment and time are taken into account.

Process capability can only be determined when a normal distribution exists.

5.2.1 Process capability index (spread only), C_p

The C_p index is a value used to determine the spread of the manufacturing process.

a) A minimum of 100 observations (readings) is needed. Gather observations from k subgroups of n consecutive parts, taken at regular intervals over a significant period of time.

b) Arithmetic mean of observations (readings), $\bar{x}$, is given by

$$\bar{x} = \frac{\sum x_i}{n}$$

c) Subgroup range, R, is given by

$$R = x_{i,\,max} - x_{i,\,min}$$

d) Arithmetic mean of subgroup means, $\bar{\bar{x}}$, is given by

$$\bar{\bar{x}} = \frac{\sum \bar{x}}{k}$$

e) Arithmetic mean of subgroup ranges, $\bar{R}$, is given by

$$\bar{R} = \frac{\sum R}{k}$$

f) Estimated standard deviation, $\hat{\sigma}$, is given by

$$\hat{\sigma} = \frac{\bar{R}}{d_2}$$

where the factor d_2 is given in table 1.

g) Process capability index, C_p, is given by

$$C_p = \frac{UL - LL}{6\hat{\sigma}}$$

5.2.2 Process capability index (spread and setting), C_{pk}

The C_{pk} index is a value used to determine the spread of a manufacturing process and the setting of the mean value of the frequency distribution within the limits of the specifications.

The value of C_{pk} is given by

$$C_{pk} = \frac{UL - \bar{\bar{x}}}{3\hat{\sigma}} \text{ or } \frac{\bar{\bar{x}} - LL}{3\hat{\sigma}}$$

whichever is the smaller value.

The value of C_{pk} should be $\geqslant 1$ (1,33).

Table 1 — Constant for calculation of estimated standard deviation

Subgroup size n	Factor[1] d_2
2	1,128
3	1,693
4	2,059
5	2,326
6	2,534
7	2,704
8	2,847
9	2,970
10	3,078

1) Confidence level of 99,73 %.

Annex A
(informative)

Example of graphical test using probability paper

Figure A.1 gives an example of a graphical test for crush height.

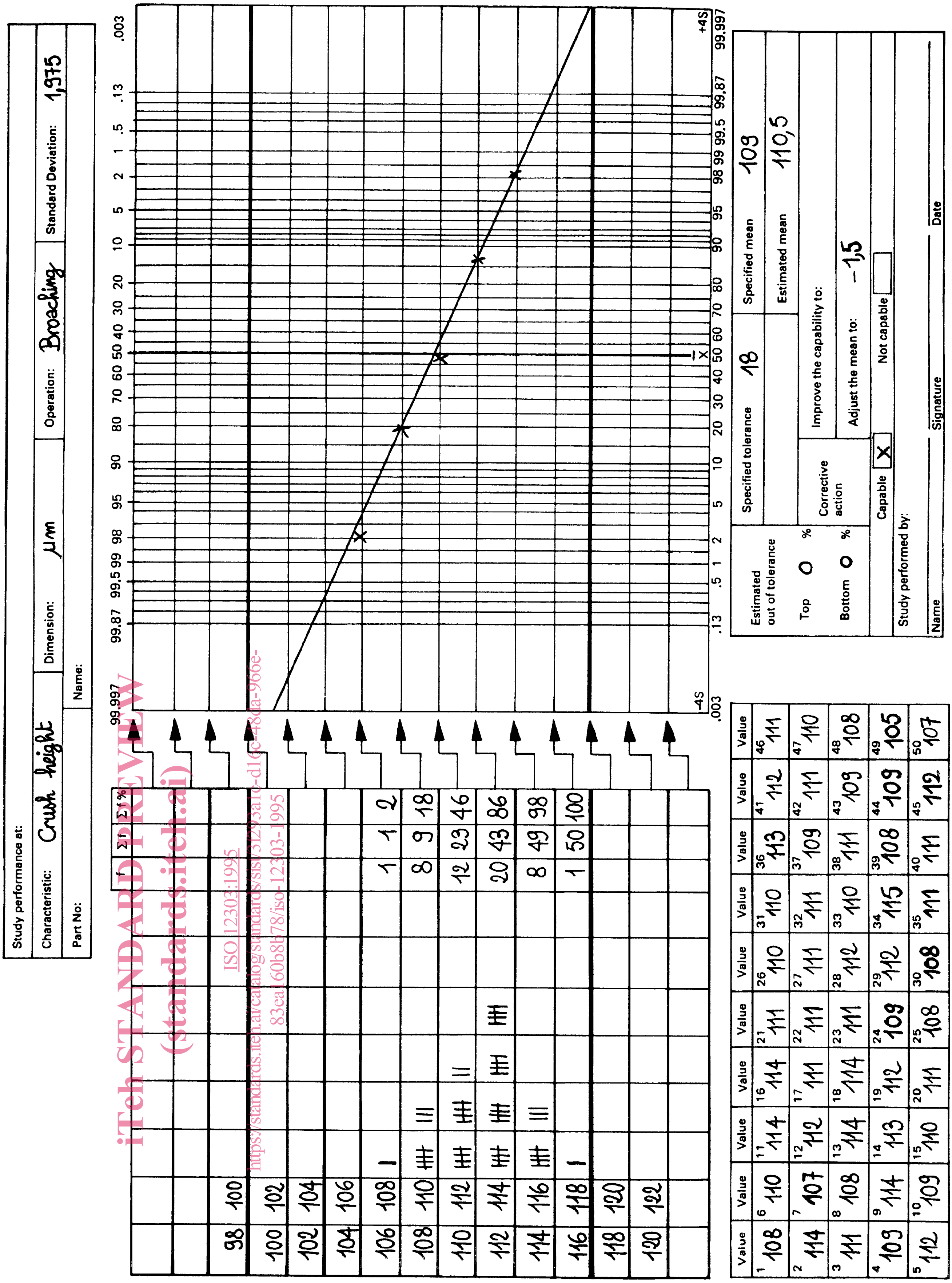

Figure A.1 — Example of a graphical test for crush height

ICS 21.100.10

Descriptors: bearings, plain bearings, production, quality, quality control, statistical quality control, rules of calculation.

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