INTERNATIONAL STANDARD

**ISO 14253-1**

Second edition
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# Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

## Part 1: Decision rules for proving conformity or nonconformity with specifications

*Spécification géométrique des produits (GPS) — Vérification par la mesure des pièces et des équipements de mesure —*

*Partie 1: Règles de décision pour prouver la conformité ou la non-conformité à la spécification*



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# Foreword

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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. www.iso.org/directives

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

This second edition cancels and replaces the first edition (ISO 14253-1:1998), which has been technically revised.

ISO 14253 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment*:

— *Part 1: Decision rules for proving conformity or nonconformity with specifications*

— *Part 2: Guidance for the estimation of uncertainty in GPS measurement, in calibration of measuring equipment and in product verification*

— *Part 3: Guidelines for achieving agreements on measurement uncertainty statements*

— *Part 4: Background on functional limits and specification limits in decision rules* [TS]

— *Part 5: Uncertainty in testing indicating measuring instruments*

— *Part 6: Generalized decision rules for the acceptance and rejection of instruments and workpieces* [TR]



# Introduction

This part of ISO 14253 is a geometrical product specifications (GPS) standard and is to be regarded as a global GPS standard (see ISO/TR 14638). It influences the chain links 4, 5 and 6 of all chains of general GPS standards.

The ISO/GPS Masterplan given in ISO/TR 14638 gives an overview of the ISO/GPS system of which this document is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this document and the default decision rules given in this document apply in ISO/GPS, unless otherwise indicated.

For more detailed information on the relation of this part of ISO 14253 to other standards and the GPS matrix model, see Annex A.

The estimated measurement uncertainty is to be taken into account when providing evidence for conformity or nonconformity with specification.

The problem arises when a measurement result falls close to the upper or lower specification limit. In this case it is not possible to prove conformity or nonconformity with specifications, since the measurement result plus or minus the expanded measurement uncertainty includes one of the specification limits.

Therefore, a supplier/customer agreement should be foreseen in order to solve the problems which could arise. This part of ISO 14253 explains how to handle specification and measurement uncertainty and establishes decision rules for proving conformity or nonconformity with specification.

# Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment —

# Part 1: Decision rules for proving conformity or nonconformity with specifications



## 1 Scope

This part of ISO 14253 establishes the rules for determining the conformity or nonconformity with a given tolerance for a characteristic of a workpiece (or a population of workpieces) or limits of maximum permissible errors for a metrological characteristic of a measuring equipment, taking into account the measurement uncertainty.

These rules are different for tolerances to individual workpieces and tolerances to workpiece populations.

It also gives rules on how to deal with cases where a clear decision (conformity or nonconformity with specification) cannot be taken, i.e. when the measurement result falls within the uncertainty range (see 3.23) that exists around the specification limits.

This part of ISO 14253 applies to specifications defined in general GPS standards (see ISO/TR 14638), i.e. standards prepared by ISO/TC 213, including:

— workpiece/population of workpieces specifications (usually given as an upper tolerance limit or a lower tolerance limit or both), and;

— measuring equipment specifications (usually given as maximum permissible errors).

This part of ISO 14253 only applies for characteristics expressed as numerical quantity values.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

ISO 9000:2005, *Quality management systems — Fundamentals and vocabulary*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3534-2, ISO 9000, ISO/IEC Guide 98-3 and ISO/IEC Guide 99 and the following apply.

**3.1**
**tolerance**
*T*
difference between the upper and lower *tolerance limits* (3.3)

Note 1 to entry: The tolerance is a quantity without sign.

Note 2 to entry: A tolerance may be two-sided or one-sided. The tolerance zone does not necessarily include the nominal value.

[SOURCE: ISO 3534-2:1993, 1.4.4, modified — The two notes to entry have been added.]

**3.2**
**tolerance zone**
**tolerance interval**
variate values of the characteristic between and including the *tolerance limits* (3.3)

[SOURCE: ISO 3534-2:1993, 1.4.5]

**3.3**
**tolerance limits**
**limiting values**
specified values of the characteristic giving upper and/or lower bounds of the permissible value

[SOURCE: ISO 3534-2:1993, 1.4.3]

**3.4**
**maximum permissible measurement error**
**MPE**
maximum permissible error
limit of error
extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system

Note 1 to entry: Usually, the term "maximum permissible errors" or "limits of error" is used where there are two extreme values.

Note 2 to entry: The term "tolerance" should not be used to designate "maximum permissible error".

[SOURCE: ISO/IEC Guide 99:2007, definition 4.26, modified — The abbreviated term, MPE, has been added.]

**3.5**
**specification**
*tolerance* (3.1) on a workpiece characteristic or population characteristic or the *maximum permissible error* (3.4) of a measuring equipment characteristic

Note 1 to entry: A specification should refer to or include drawings, patterns or other relevant documents and indicate the means and the criteria whereby conformity can be checked.

**3.6**
**specification zone**
specification interval
variate values of the workpiece characteristic or population characteristic or the measuring equipment characteristic between and including the *specification limits* (3.7)

**3.7**
**specification limit**
*tolerance limit* (3.3) of a workpiece characteristic or population characteristic or *maximum permissible error* (3.4) of a measuring equipment characteristic

**3.8**
**upper specification limit**
**USL**
specified value giving either:

— the upper boundary of the permissible values of the *tolerance limits* (3.3) of a workpiece characteristic or population characteristic; or

— the upper boundary of the permissible values of the permissible errors of a measuring equipment characteristic

**3.9**
**lower specification limit**
**LSL**
specified value giving either:

— the lower boundary of the permissible values of the *tolerance limits* (3.3) of a workpiece characteristic or population characteristic; or

— the lower boundary of the permissible values of the permissible errors of a measuring equipment characteristic

**3.10**
**measurand**
*Y*
quantity intended to be measured

[SOURCE: ISO/IEC Guide 99:2007, definition 2.3, modified — The notes are not reproduced. The symbol has been added.]

**3.11**
**measurement result**
result of measurement
*y*
set of quantity values being attributed to a *measurand* (3.10) together with any other available relevant information

[SOURCE: ISO/IEC Guide 99:2007, definition 2.9, modified — The notes are not reproduced. The symbol has been added.]

**3.12**
**nominal value**
designated value of a characteristic in a given design specification or drawing

**3.13**
**measurement uncertainty**
uncertainty of measurement
uncertainty
non-negative parameter characterizing the dispersion of the quantity values being attributed to a *measurand* (3.10), based on the information used

[SOURCE: ISO/IEC Guide 99:2007, definition 2.26, modified — The notes are not reproduced.]

**3.14**
**standard measurement uncertainty**
standard uncertainty of measurement
standard uncertainty
*measurement uncertainty* (3.13) expressed as a standard deviation

[SOURCE: ISO/IEC Guide 99:2007, definition 2.30, modified — The notes are not reproduced.]

**3.15**
**combined standard measurement uncertainty**
combined standard uncertainty
*standard measurement uncertainty* (3.14) that is obtained using the individual standard measurement uncertainties associated with the input quantities in a measurement model

[SOURCE: ISO/IEC Guide 99:2007, definition 2.31, modified — The note is not reproduced.]

**3.16**
**expanded measurement uncertainty**
expanded uncertainty
*U*
product of a *combined standard measurement uncertainty* (3.15) and a factor larger than the number one

[SOURCE: ISO/IEC Guide 99:2007, definition 2.35, modified — The notes are not reproduced. The symbol has been added.]

**3.17**
**coverage factor**
*k*
number larger than one by which a *combined standard measurement uncertainty* (3.15) is multiplied to obtain an *expanded measurement uncertainty* (3.16)

[SOURCE: ISO/IEC Guide 99:2007, definition 2.38, modified — The notes are not reproduced. The symbol is added.]

**3.18**
**complete measurement result**
*y*'
*measurement result* (3.11) including the *expanded measurement uncertainty* (3.16)

Note 1 to entry: The complete measurement result is expressed by the equation given in Clause 4.

**3.19**
**conformity**
fulfilment of a requirement

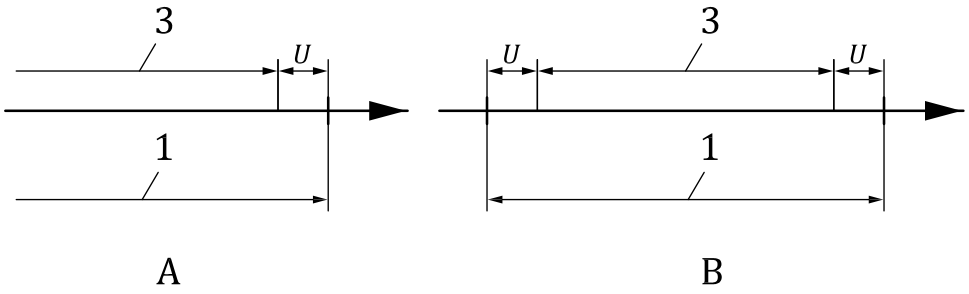
Note 1 to entry: The term "conformance" is synonymous but deprecated.

[SOURCE: ISO 9000:2005, definition 3.6.1]

**3.20**
**conformity zone**
*specification zone* (3.6) reduced by the *expanded measurement uncertainty* (3.16)

Note 1 to entry: The specification is reduced by the expanded measurement uncertainty at the *upper specification limit* (3.8) and/or the *lower specification limit* (3.9).

Note 2 to entry: See Figure 1.




**Key**

A one-sided specification
B two-sided specification
1 specification zone
3 conformity zone

**Figure 1 — Conformity zone**

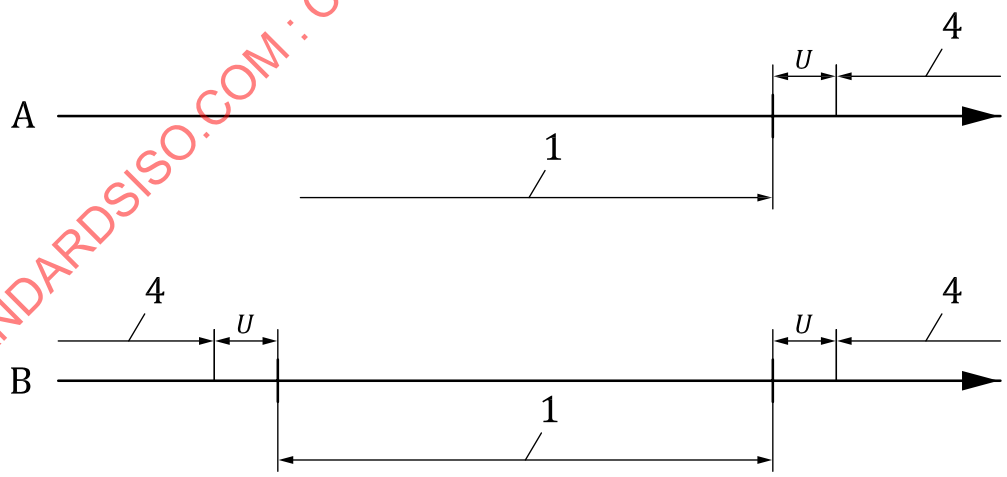
**3.21**
**nonconformity**
non-fulfilment of a requirement

[SOURCE: ISO 9000:2005, definition 3.6.2]

**3.22**
**nonconformity zone**
zone(s) outside the *specification zone* (3.6) extended by the *expanded measurement uncertainty* (3.16)

Note 1 to entry: The specification is extended by the expanded measurement uncertainty, *U*, at the *upper specification limit* (3.8) and/or the *lower specification limit* (3.9).

Note 2 to entry: See Figure 2.




**Key**

A one-sided specification
B two-sided specification
1 specification zone
4 nonconformity zone

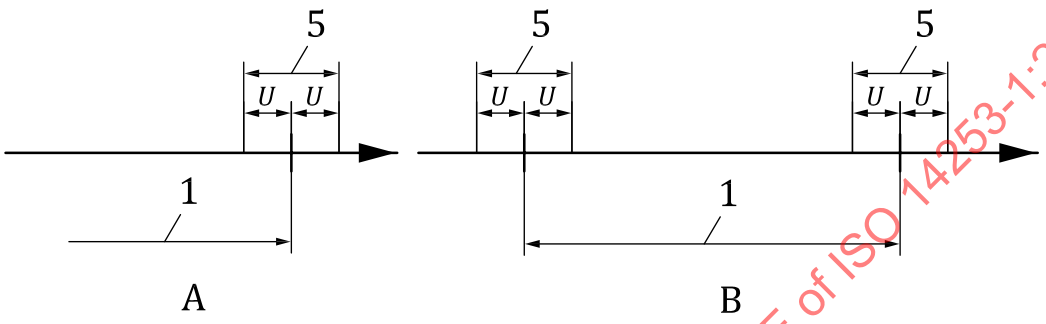
**Figure 2 — Nonconformity zone**

**3.23**
**uncertainty range**
range(s) close to the *specification limit(s)* (3.7) where neither *conformity* (3.19) nor *nonconformity* (3.21) can be proved taking into account the *measurement uncertainty* (3.13)

Note 1 to entry: The uncertainty range(s) is(are) located around the specification limit (one-sided specification) or specification limits (two-sided specification) and has the width of 2 × *U*.

Note 2 to entry: The measurement uncertainty on the upper and lower side of the measurement result may be of different magnitudes.

Note 3 to entry: See Figure 3.




**Key**
A one-sided specification
B two-sided specification
1 specification zone
5 uncertainty range

**Figure 3 — Uncertainty range**

**3.24**
**population**
totality of items under consideration

Note 1 to entry: An item in the field of GPS can be seen as a value of a GPS global characteristic defined on one workpiece (see ISO 25378).

[SOURCE: ISO 3534-1:2006, definition 1.1, modified—The notes are not reproduced. Note 1 to entry is added.]

## 4 General

The measurand is different when it corresponds to an individual characteristic (workpiece characteristic) or to a population characteristic, implicating different measurement uncertainties.

NOTE 1 The uncertainty of the estimate of a workpiece characteristic is different from the uncertainty of the estimate of the population characteristic (e.g. the uncertainty of an individual value is different from the uncertainty of an average value).



For the purposes of this part of ISO 14253, the measurement uncertainty is estimated and evaluated according to the GUM, consequently, the measurement uncertainty is expressed as the expanded measurement uncertainty, $U$ (see ISO 14253-2):

$$U = k \times u_c \tag{1}$$

with a default coverage factor being $k = 2$.

NOTE 2 If required, a different coverage factor can be assigned by agreement between customer and supplier (see Clause 6).

The complete measurement result is expressed as:

$$y' = y \pm U \tag{2}$$

In Figure 4, the complete measurement result, $y'$, is illustrated as a symmetrical interval of expanded measurement uncertainty, $U$, around a measurement result, $y$.

It is recommended that the customer and supplier agree on the estimated uncertainty value(s).

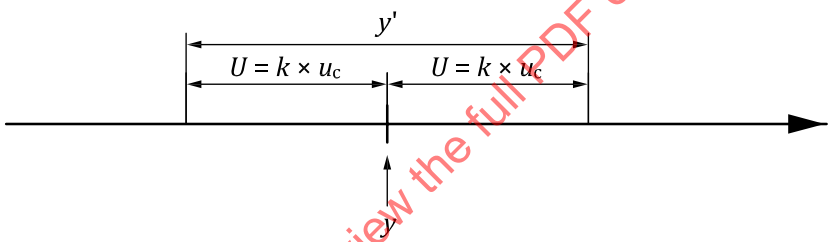



**Figure 4 — Result of a measurement, $y$, and complete measurement result, $y'$**



## 5 Proving conformity and nonconformity with specifications

### 5.1 General

The following rules are default rules for proving conformity and nonconformity with specifications, i.e. rules which are in force when no other rules are agreed upon between supplier and customer.

When the modifier Ⓢ is placed after the tolerance values, then population specifications are given and shall be taken into account to define the conformity or nonconformity. The tolerance placed before the Ⓢ modifier applies for each workpiece of the population. Indications placed after the modifier Ⓢ apply to the population of the workpieces.

When the modifier Ⓢ is not indicated after the tolerance values, then no population specifications are required. This tolerance applies for each item of the population.

The modifier Ⓢ indicates that there is one or more population specifications linked to the individual specification, having in common the definition of the global characteristic taken from one workpiece. Each population specification is defined as a calculated parameter from the set of values obtained on the population of workpieces (e.g. a maximum, a mean value, a standard deviation).

The conformity shall be established when all the specifications (individual specification and population specification) are satisfied. The default rules for proving conformity and nonconformity for individual specification and population specification are the same after the extent of the uncertainty range has been determined (see Clause 6).

Other rules may be agreed upon between supplier and customer, in which case they shall be made as special agreements and be included in the documentation (see Clause 6).

It is recommended that the following rules always be applied for the most important specifications controlling the function of the workpiece or the measuring equipment. Other less restrictive rules may be used, by special agreement between the parties, for less important requirements.

In the design or specification phase, e.g. on an engineering drawing, the terms "in specification" and "out of specification" (see 1 and 2 in Figure 5, line C) designate the areas separated by the sharp borderlines:

— LSL and USL for a two-sided specification;

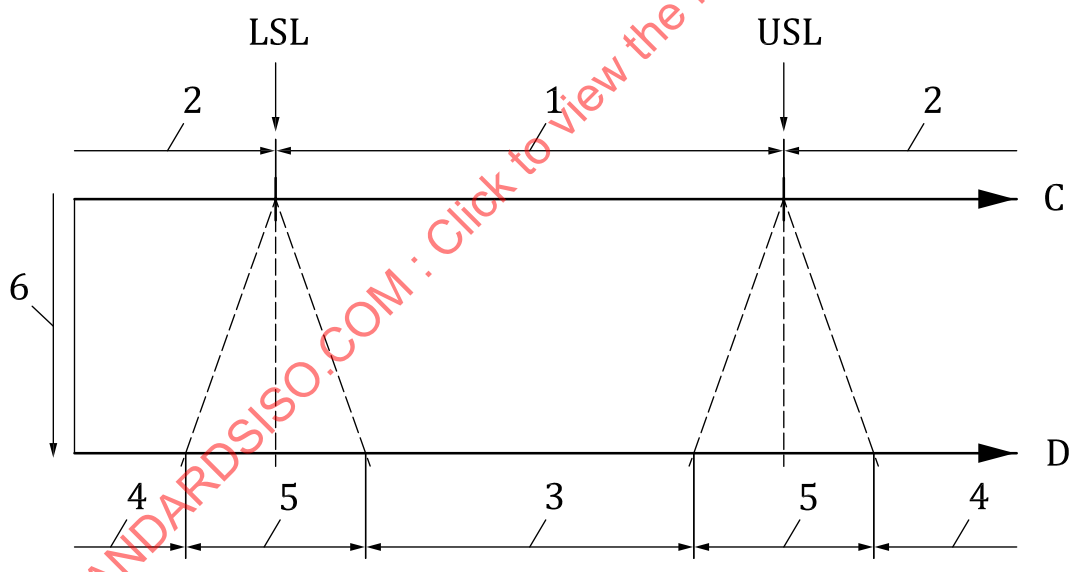
— either LSL or USL for a one-sided specification.

NOTE For simplification, the text and figures in this clause only illustrate a two-sided specification.

In the production or verification phase, the meaning of the terms "in specification" and "out of specification" are complicated by the ever-existing measurement uncertainty. The sharp borderlines (from the design phase) are transformed into uncertainty ranges. Consequently, the conformity and nonconformity zones are reduced by the estimated measurement uncertainty by means of the uncertainty range (see D in Figure 5).

The specifications for a workpiece or a measuring equipment are given under the assumption that they are respected, so that no workpiece or measuring equipment is out of specification.

In practice, in the verification phase, the estimated measurement uncertainty shall be taken into account to prove the conformity or nonconformity with a given specification.




**Key**

C design/specification phase
D verification phase
1 specification zone (in specification)
2 out of specification
3 conformity zone
4 nonconformity zone
5 uncertainty range
6 increasing measurement uncertainty, *U*

**Figure 5 — Measurement uncertainty: the uncertainty range reduces the conformity and nonconformity zones**

A given specification (LSL and/or USL) is invariable and is defined by the drawing indication and the respective chain of standards (see ISO/TR 14638) or by the detailed description of the characteristic of the measurement equipment (e.g. in a standard) and the indicated value of the maximum permissible error (MPE).

Measurement uncertainty (the expanded measurement uncertainty) is variable and is controlled by several uncertainty components in the measuring process (see ISO 14253-2).

Consequently, the sizes of the conformity and the nonconformity zones are variable and depend on the expanded measurement uncertainty, $U$.

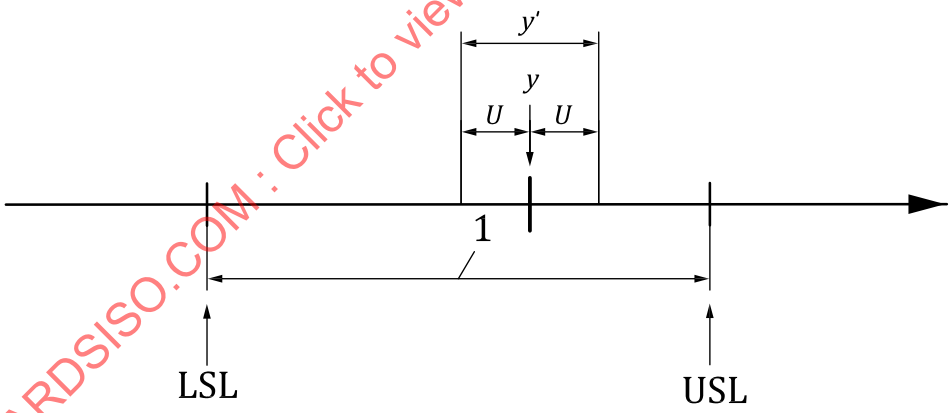
## 5.2 Rule for proving conformity with specifications

Conformity with a specification (specified tolerance or MPE) is proved when the complete measurement result, $y'$, falls within the tolerance zone of a workpiece characteristic or within the maximum permissible error of a measuring equipment characteristic (see Figure 6).

$$\mathrm{LSL} \le y - U \text{ and } y + U \le \mathrm{USL} \tag{3}$$

The same conformity can be proved similarly when the measurement result, $y$, falls within the tolerance zone of a workpiece characteristic or within the maximum permissible error of a measuring equipment characteristic reduced on either side by the expanded measurement uncertainty, $U$, i.e. the conformity zone (see Figure 7).

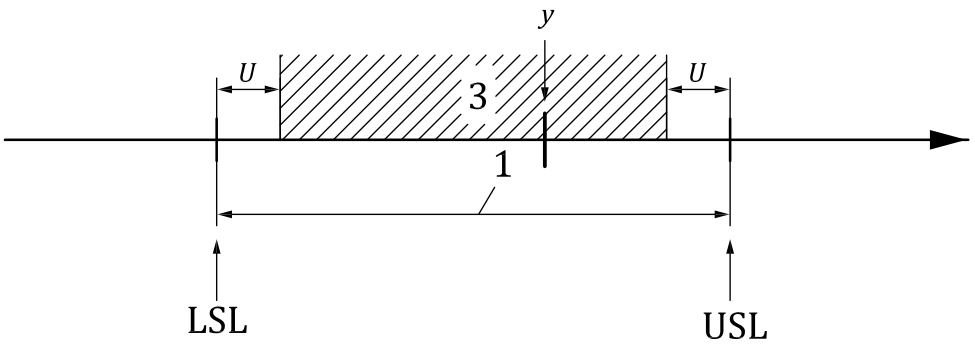
$$\mathrm{LSL} + U \le y \le \mathrm{USL} - U \tag{4}$$




**Key**

1 specification zone

**Figure 6 — Conformity with specification is proved**




**Key**

1 specification zone

3 conformity zone

**Figure 7 — Conformity with specification is proved**

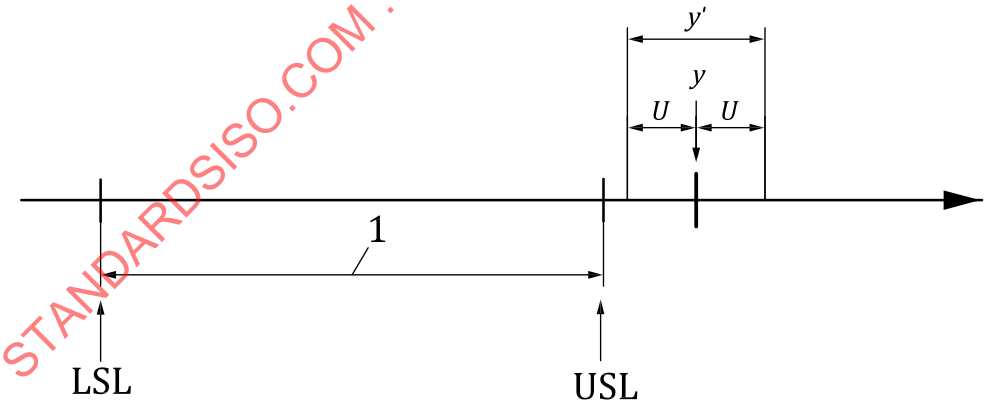
The size of the conformity zone is directly linked to the given specification (LSL and USL) and the actual expanded measurement uncertainty, *U*.

Consequently, workpieces or measuring equipment can be accepted if conformity with the specification is proved by applying the above rule.

## 5.3 Rule for proving nonconformity with specifications

Nonconformity with a specification (specified tolerance or MPE) is proved when the complete measurement result, *y'*, falls outside the tolerance zone of a workpiece characteristic or outside the maximum permissible error of a measuring equipment characteristic (see Figure 8).

$$y + U \leq \text{LSL or USL} \leq y - U \tag{5}$$




**Key**

1 specification zone

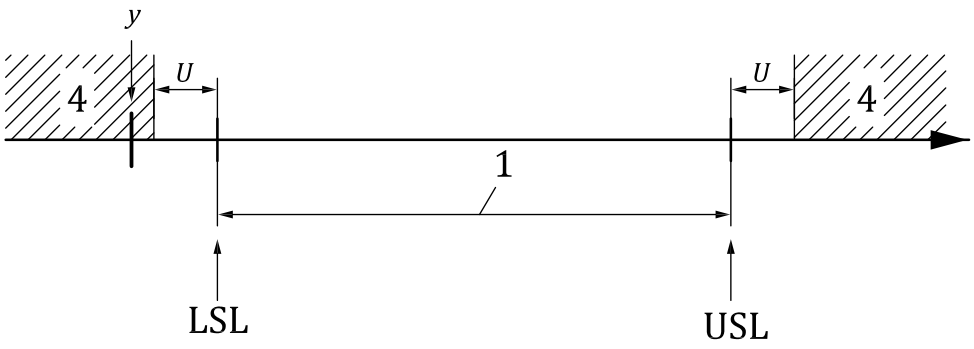
**Figure 8 — Nonconformity with specification is proved** (USL ≤ *y* – *U*)

The same nonconformity can be proved similarly when the measurement result, *y*, falls outside the tolerance zone of a workpiece characteristic or outside the maximum permissible error of a measuring equipment characteristic increased on either side by the expanded measurement uncertainty, *U*, i.e. the nonconformity zone (see Figure 9).

$$y \leq \text{LSL} - U \text{ or } \text{USL} + U \leq y \tag{6}$$






**Key**

1 specification zone

4 nonconformity zone

**Figure 9 — Nonconformity with specification is proved** ($y \leq \mathrm{LSL} - U$)

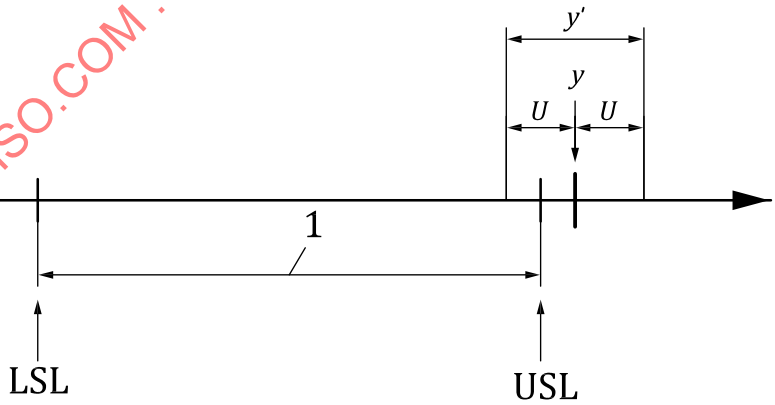
The nonconformity zone is directly linked to the given specification (LSL and USL) and the actual expanded measurement uncertainty, $U$.

Consequently, workpieces or measuring equipment can be rejected if nonconformity with specification is proved applying the above given rule.

## 5.4 Uncertainty range

Neither conformity nor nonconformity with a specification can be proved when the complete measurement result, $y'$, includes one of the tolerance limits of a workpiece or the maximum permissible error of a measuring equipment (see Figure 10).

$$y - U < \mathrm{LSL} < y + U \text{ or } y - U < \mathrm{USL} < y + U \tag{7}$$




**Key**

1 specification zone

**Figure 10 — Neither conformity nor nonconformity with specification can be proved** ($y - U < \mathrm{USL} < y + U$)

The same situation occurs when the measurement result, $y$, falls within one of the uncertainty ranges (see Figure 11).

$$\mathrm{LSL} - U < y < \mathrm{LSL} + U \quad \text{or} \quad \mathrm{USL} - U < y < \mathrm{USL} - U \tag{8}$$