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Geometrical product specifications (GPS) — Standard reference temperature for the specification of geometrical and dimensional properties

Spécification géométrique des produits (GPS) — Température normale de référence pour la spécification des propriétés géométriques et dimensionnelles

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Contents

Page

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).

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).

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.

This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 290, *Dimensional and geometrical product specification and verification*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 1:2016), which has been technically revised.

The main changes are as follows:

— clarification that the standard reference temperature value of 20 °C is of the International Scale according to the ITS-90, the *International Temperature Scale of 1990*,[5] which does not imply any change in the value;

— addition of Annex B to introduce the International Temperature according to the ITS-90 and to illustrate the implications of this document compared with the previous edition;

— removal of the references to other fundamental ISO GPS standards in the Introduction and in the ISO GPS matrix annex, Annex C.

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

This document is a geometrical product specification (GPS) standard and is to be regarded as a fundamental GPS standard (see ISO 14638).

More detailed information on the relation of this document to other standards and the GPS matrix model can be found in Annex C.

The definitions of the units, including those of length and temperature, are adopted by the General Conference of Weights and Measures (CGPM) under the authority of the Convention of the Metre. These definitions are maintained in the SI brochure[4].

The unit of length, the metre, is independent of temperature. The current definition of the metre is based on the distance light travels in a vacuum during a unit of time. However, a physical object is subject to thermal expansion and, consequently, its geometrical and dimensional properties are dependent on its temperature. Specifying a reference temperature allows the geometrical and dimensional properties of a physical object to be unambiguously stated.

Geometrical product specifications (GPS) — Standard reference temperature for the specification of geometrical and dimensional properties

1 Scope

This document defines the concepts of a reference temperature and the standard reference temperature and specifies the standard reference temperature value for the specification of geometrical and dimensional properties of an object. Some examples of geometrical and dimensional properties include size, location, orientation (including angle), form and surface texture of a workpiece.

This document is also applicable to the definition of the measurand used in verification or calibration.

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/IEC Guide 99:2007, *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/IEC Guide 99 and the following 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/

3.1
reference temperature
temperature of an object, having a uniform temperature, specified as part of the definition of a geometrical or dimensional property

Note 1 to entry: The specification of a geometrical or dimensional property is typically given in technical product documentation, for example on an engineering drawing or in a CAD file, or in the specification of the measurand (the quantity intended to be measured).

Note 2 to entry: A uniform temperature is reached at thermodynamic equilibrium.

3.2
standard reference temperature
internationally agreed-upon reference temperature

Note 1 to entry: In previous editions of this document, the term "standard reference temperature" was defined as its assigned numerical value, i.e. 20 °C. In this document and in the previous edition, the definition of the *reference temperature* (3.1) and the assignment of a standardized value to this temperature are separately addressed in Clause 4.

4 Standard reference temperature value for the specification of geometrical and dimensional properties

The standard reference temperature value for the specification of geometrical and dimensional properties shall be fixed at t_{90} = 20 °C. Unless otherwise explicitly specified, the reference temperature for geometrical and dimensional properties of workpieces shall be the standard reference temperature. See Annex A for information on the use of the reference temperature specification.

NOTE 1 t_{90} is the temperature in degrees Celsius according to the ITS-90, the *International Temperature Scale of 1990*.[5] See Annex B for more information.

NOTE 2 There is only one standard reference temperature value and it is fixed at t_{90} = 20 °C. However, this does not prevent a different (non-standard) reference temperature from being specified for all geometrical and dimensional properties of a workpiece or for a specific geometrical or dimensional property of a workpiece, provided it is explicitly stated as part of the specification.

NOTE 3 The specification of a non-standard reference temperature can increase the measurement uncertainty during verification because most dimensional measuring equipment and gauges are calibrated with their measurand defined at the standard reference temperature.

Annex A
(informative)

Use of the reference temperature specification

Specifying geometrical and dimensional properties at a single temperature value can raise questions, since:

a) the functional requirements of any physical workpiece include other temperatures;

b) verification cannot physically occur at an exact, uniform temperature.

Regarding the issue that workpiece functional requirements include other temperatures, it is important to note that a designer typically specifies not only the requirements on the geometrical and dimensional properties of the workpiece (usually at the standard reference temperature value), but also separate requirements on the material properties of the workpiece. Combining the knowledge of how a specified material behaves at different temperatures and the specified geometrical and dimensional properties at a single temperature can allow a designer to ensure a workpiece will meet geometrical and dimensional functional requirements over a range of temperatures.

Regarding the issue that any geometrical or dimensional verification inevitably occurs at a temperature different from the reference temperature, an adequate correction for that difference is necessary (see, for example, ISO/IEC Guide 99:2007, 2.3, Note 3). In some cases, the correction might be zero (i.e. no correction is performed); however, in all cases it is necessary that the lack of knowledge of the exact correction be accounted for appropriately in the measurement uncertainty [see, for example, ISO/IEC Guide 98-3:2008, 3.3.2 b)].

Most measuring systems are designed to produce measurement results specified at the standard reference temperature value of 20 °C, even though they might be operating at a different temperature. In this case, deviations from the standard reference temperature for either the measuring system or the workpiece under measurement lead to additional measurement uncertainty contributors; see ISO/TR 16015 for additional information. The term “reference temperature” should not be confused with the term “rated operating condition.”

Annex B
(informative)

The International Temperature Scale of 1990 (ITS-90)

The SI unit of temperature is the kelvin (K). The unit degree Celsius (°C) is linked by a fixed shift of scale, according to Formula (B.1):

$$t = T - T_0 \tag{B.1}$$

where T_0 = 273,15 K

or equivalently to Formula (B.2):

$$t/°C = T/K - 273,15 \tag{B.2}$$

where

T is the temperature;

t is the Celsius temperature.[5]

Because of these formulae, t and T are equivalent in a one-to-one relationship.

The temperature and the Celsius temperature are thermodynamic. However, the thermodynamic temperature is difficult to measure and the ITS-90[5] provides a practical approximation based on a sequence of temperature fixed points. The fixed points are well-defined, reproducible states of matter to which precise values of temperature are assigned (e.g. the gallium melting point is 29,764 6 °C). The fixed points temperature values and procedure for approximation between them are well established.

The ITS-90 is a practical approximation and does not provide the exact thermodynamic temperature. Studies show[6] that the difference at 20 °C is as shown in Formula (B.3):

$$T - T_{90} = t - t_{90} = 2,8 \text{ mK at } 20 °C \tag{B.3}$$

where T_{90} and t_{90} are according to the ITS-90. For steel objects – one of the most used material in engineering and in fabrication of dimensional standards – a difference of 2,8 mK in the standard reference temperature results in a relative difference in dimensions (given the coefficient of thermal expansion of steel) of approximately 3×10^{-8}, that is 0,03 µm per metre of length. This difference is usually negligible in most applications but is relevant for top-level calibration of dimensional standards.

All thermometers used in dimensional metrology and in engineering worldwide are calibrated according to the ITS-90. The previous version of this document intended that the standard reference temperature value was of the International Celsius Temperature, t_{90}. However, this was not explicitly stated and a doubt might have arisen. This document merely clarifies this with no change in the value of the standard reference temperature.