
**Geometrical product specifications
(GPS) — Systematic errors and
contributions to measurement
uncertainty of length measurement due
to thermal influences**

*Spécifications géométriques des produits (GPS) — Erreurs
systématiques et contributions à l'incertitude de mesure de la longueur,
dues aux influences thermiques*



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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.

ISO/TR 16015 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

Introduction

This Technical Report is a geometrical product specification (GPS) document and is to be regarded as a global GPS document (see ISO/TR 14638). It influences chain links 4, 5 and 6 of the chains of standards.

For more detailed information on the relationship of this Technical Report to other standards and to the GPS matrix model, see Annex C.

Uncertainty in temperature measurement and measurement at other than the standard reference temperature lead to uncertainty in the length measurement results. In addition, measurements at other than the standard reference temperature leads to systematic error in the measurement result.

The principle addressed by this Technical Report is that most materials expand or contract when their temperatures are changed. If the temperature at which the measurement is made is the standard reference temperature, the nominal thermal expansion is zero but uncertainty in the measurement of temperature leads to uncertainty in the measurement result. If length measurements are made at temperatures other than the standard reference temperature, there will be a resulting differential thermal expansion. This can arise both when the measuring instrument is adjusted, as by comparison with a working standard, and when it is used to measure the workpiece.

If the temperatures and the response to thermal changes of the workpiece, the working standard, and the measuring instrument are known, a correction can be made for differential thermal expansion. It is impossible to know exactly either the temperatures or the response; thus, there will be an uncertainty in the correction and in the measurement result. This Technical Report shows how to calculate the relevant systematic error and evaluate the thermal contribution to the measurement uncertainty.

The resulting standard uncertainty component due to thermal effects shall be combined in the usual manner (see GUM) in order to evaluate the combined standard uncertainty for a measurement.

When necessary, an appropriate decision rule (e.g. an acceptable fraction of workpiece tolerance or that embodied in ISO 14253-1) can be invoked so that the consequence of the thermally-induced dimensional uncertainty on workpiece conformance decisions can be determined.

ISO/TR 16015 is developed in support of ISO 1.

It is recognized that this Technical Report, developed in support of ISO 1, will have to be brought in line with ISO/TS 17450-2, but at the time of publication this presentation was the only practical one possible.

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Geometrical product specifications (GPS) — Systematic errors and contributions to measurement uncertainty of length measurement due to thermal influences

1 Scope

This Technical Report defines procedures for the determination of errors, appropriate corrections and the evaluation of measurement uncertainty contributors due to thermal influences in the performance of length measurements for geometrical product specification (GPS), when

- the mean temperature is the standard reference temperature,
- the mean temperature is not the standard reference temperature and where the mean is taken over time and space,
- temperature varies with time.

Three cases are considered:

- a) the mean temperature is the standard reference temperature;
- b) the mean temperature is not the standard reference temperature and the user makes corrections;
- c) the mean temperature is not the standard reference temperature and the user makes no corrections.

This Technical Report provides the specialized details for the analysis of thermal influence when broader analyses, such as those in accordance with ISO/TS 14253-2, show that thermal effects are significant contributors to the measurement uncertainty, systematic error or both. While temperature gradients are not covered in detail, some information is given (see Annex A).

2 Normative references

The following referenced documents are indispensable for the application 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 1, *Geometrical Product Specifications (GPS) — Standard reference temperature for geometrical product specification and verification*

Guide to the Expression of Uncertainty in Measurement (GUM). BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1st edition, 1993, corrected and reprinted in 1995

International Vocabulary of Basic and General Terms in Metrology (VIM). BIPM, IFCC, IEC, ISO, IUPAC, IUPAP, OIML, 2nd edition, 1993