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Geometrical product specifications (GPS) — Surface texture: Areal —

Part 73: Terms and definitions for surface defects on material measures

Spécification géométrique des produits (GPS) — État de surface: surfacique —

Partie 73: Termes et définitions pour les défauts de surface sur les mesures matérialisées

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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 (see www.iso.org/directives).

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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*.

A list of all parts in the ISO 25178 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

0.1 General

This document is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences chain link F of the chain of standards on profile surface texture, areal surface texture and surface imperfections.

The ISO GPS masterplan given in ISO 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. The default decision rules given in ISO 14253-1 apply to specifications made in accordance with this document, unless otherwise stated.

For more detailed information on the relation of this document to the GPS matrix model, see Annex B.

This document is based on the premise that a material measure has a real geometrical surface which is a realization of an ideal or nominal surface, which in turn can in most cases be regarded as a simple mathematical concept: for example a plane, a sphere, a step function or a sinusoidal shape. In each case there will be an associated precisely known quantity, which is used when the material measure is measured by a surface texture-measuring instrument in one or more operations during the calibration and set-up of that instrument.

Any portion of the measuring surface of the material measure at which the real surface deviates from the ideal nominal surface is therefore more or less undesirable, and is here denoted by the term *defect*.

0.2 Relationship to ISO 8785

ISO 8785 was intended to apply to all types of surface, whether functional or otherwise. Examples of functional surfaces are: brake disks, cylinder linings, optical lens and mirror surfaces, fluid pipe couplings, marine propeller blades and artificial hip joints. In each case, the surface has to perform one or more definite jobs and, consequently, the choice of method of manufacture and the type of surface geometry, together with a certain range of parameter values which are specified for it, are usually a compromise between conflicting requirements which might not all be perfectly fulfilled. The functional surface can then be measured in order to find out how closely it matches the parameter values which have been specified.

However, this is not the same as determining how well the surface functions. In many cases it is not obvious exactly what the ideal profile shape from the point of view of best function would be. Therefore, it is possible that a surface which deviates from the specified profile in some places actually performs better than one which has no deviations. For this reason, ISO 8785 used the general term *imperfections*, which does not suggest undesirability, in preference to the term *defects*, which does suggest this.

Unlike ISO 8785, this document does not deal with any classes of defect, other than geometrical, that might appear upon the surfaces of material measures. Examples of other classes of defect are: unwanted variations in such physical properties as:

— surface hardness;

— surface colour;

— electrical properties.

For the purposes of this document, no instance of such an unwanted variation in a physical property is considered to be a defect unless it coincides spatially with the area of a geometrical defect. For information on variations in surface colour, see Annex A.

0.3 Relationship to ISO 5436-1 and ISO 25178-70

The material measures and calibration specimens which are described in ISO 5436-1 and ISO 25178-70 are not functional surfaces as described in 0.2. Material measures exist only in order to be measured;

there are no physical jobs which they have to do. They are physical representations of a mathematically simple shape, which is therefore the ideal shape and which can be specified precisely.

Any deviation from this ideal shape is therefore undesirable, and so the term *defect* is preferable to the term *imperfection.* It is possible for a single calibration specimen to be used in two or more different applications, but for each application there exists a theoretically ideal shape, although certain features of the ideal might be more important in one application than in the other.

For example, a sinusoidal roughness specimen can be used to check Ra or RSm parameter values. In the first application it is more important that the sinusoidal specimen exhibits uniformity of amplitude (peak height) than uniformity of wavelength (peak spacing), but in the second application it is the other way around. The fact that the calibration specimen can be used in two different applications does not make it a functional surface; it is still a measurement standard which exists only in order to be measured.

0.4 Defining defects by reference to *geometrical shape* rather than *cause*

ISO 8785:1998, Clause 4, contains several descriptions of surface imperfections in terms which make reference to the *cause* of the imperfection, instead of just their geometrical shape. This can create the following difficulties when applying these descriptions in practice:

a) the possibility of confusion, in cases where a feature has the shape of one type of imperfection, but has the cause of a different one;

b) in many cases, particularly with very small features at the limits of visibility, the cause might be unknown and hard to discover;

c) it becomes more difficult to translate the terms into other languages.

In this document the emphasis is on geometrical shape, and three terms will be defined corresponding to the cases in which the deviation is upwards from the surface (outward defect, 3.2.6), downwards into the surface (inward defect, 3.2.7) or neither upward nor downward (neutral defect, 3.2.8). However, there is one exception: it is necessary to define one special type of defect (negative defect, 3.2.9) which sometimes appears on material measures that have been manufactured by one of the widely-used methods of replication and which appears on such a replicated material measure as the result of a corresponding defect on the surface of the mother mould (often called a *negative*), which produced the replica.

0.5 Terms for ways of responding to defects

Consistent with the general idea that defects are undesirable, this document contains a section which defines terms for all possible responses to the presence of defects. It does not specify which of these responses should be applied in any particular situation, it simply defines terms and names for them, and thus enables users, manufacturers, calibration metrologists and writers of other standards documents to state their own policies and procedures clearly and unambiguously.

0.6 Defect as a portion of the surface rather than a property of the whole surface

A defect is a *geometrical feature* limited by natural boundaries (in the language of ISO 8015:2011, 5.4 and ISO 22432:2011, 3.2), that is *non-ideal* and *real* (ISO 22432:2011, 3.2.2). In this document a defect is considered to be a *portion* of the physical surface of a geometrical measurement standard, rather than a *property* of the whole surface. This is necessary in order to distinguish between three common responses to the presence of defects on a measurement standard, responses which are easily confused with each other if they are not precisely defined. They are:

— first, to *remove* the defect (by either physically cutting it off the measuring area or else discarding data points in the software);

— second, to *avoid* the defect (by redefining the limits of the measuring area);

— third, to *repair* the defect (by either reworking or cleaning the specimen, or else retouching data in the software).

In the absence of strict definitions for the terms *remove, avoid* and *repair,* the widely-used term *remove* is ambiguous. However, it is important to distinguish between repairing and removing defects as defined in this document, because many users of specimens and writers of procedures and policies will want to forbid one of these while allowing or requiring the other to be done.

0.7 Parties involved: manufacturer, customer, user

Typically, in the case of material measures used in surface texture measurement, the manufacturer of the material measures will sell them to a customer who simply acts as a distributor, by selling them on, or including them as accessories, to end users who will ultimately use them to check surface measuring instruments. Each of these three parties plays a different role in the identification and handling of defects, and for this reason all three terms are used here.

0.8 Inapplicability of the definitions presented in this document to the case of functional surfaces

The statements in 0.6 make it difficult to extend the application of the new definitions to the case of functional surfaces. In most instances it is not possible to *remove* defects from functional surfaces or to *avoid* them; instead, the only option is to *repair* them or *modify* them. For example, the scratched part of a lens cannot be removed from the lens, or the corroded part of a ship propeller from the propeller. *Removing* or *avoiding* defects (as here defined) is only possible in the case of geometrical measurement standards, where the extent of the measuring area can be redefined or have parts cut away from it.

0.9 Normative and non-normative aspects of this document

All of the definitions presented in 3.2 are normative insofar as this document specifies the vocabulary which is to be used whenever reference is made to geometrical defects on the surfaces of material measures.

In addition, 3.3 is normative. Of the six ways defined for responding to defects, at least one has to be selected. (At least one because, although 3.3.1 to 3.3.4 are mutually exclusive, 3.3.5 and 3.3.6 are not. It is possible to decide to ignore defects and then to go on to measure them by chance.)

However, nothing in this document prevents any customer making additional specifications concerning the physical properties of the surface of any physical measurement standard. Customers may specify the hardness or the colour, for example, in addition to specifying the geometrical properties. If the specimen supplied does not conform to those additional specifications then the customer can refuse to buy it even if its geometrical product specifications are completely fulfilled.

Geometrical product specifications (GPS) — Surface texture: Areal —

Part 73: Terms and definitions for surface defects on material measures

1 Scope

This document defines classes of geometrical defects that might be present on the surfaces of material measures and calibration specimens conforming to ISO 5436-1 and ISO 25178-70, and defines terms for ways of responding to these defects.

This document is applicable as follows:

a) to help customers and users of material measures for surface metrology specify their nominal features (ideal geometrical properties) when obtaining them from manufacturers and suppliers;

b) to enable users of material measures to formulate their own rules and policies for responding to the occurrence of defects in such a way as to minimize the uncertainty of their own measurements;

NOTE Such policies are required in ISO/IEC 17025:2017, 7.2.1.1, 7.2.1.3, 7.3.1 and 7.8.5 c) and d), for example.

c) to enable calibration laboratories and their customers to agree on a common policy on how to treat defects on a material measure that has been sent for calibration;

d) to educate users of material measures about the different significance and importance of different kinds of defect;

e) for other GPS standards which make reference to the issue of selection of measuring locations, or selection of areas to be measured or avoided in measurement.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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/

3.1 General terms and definitions

3.1.1
measuring surface
part of the surface of a calibration specimen over which measurements will be made

3.1.2
defect
<material measures> part of the measurement standard's geometrical feature (non-ideal surface) on which the geometrical shape and geometrical dimensions deviate from those on the nominal feature (ideal surface) *either* by an amount greater than some agreed or stated maximum value, *or*, in the absence of any such agreed or stated maximum value, by an amount greater than what is typical or characteristic for the processes used in manufacturing the measurement standard

Note 1 to entry: The measurement standards and material measures with which this document deals are understood to be those which are specified in ISO 5436-1 and ISO 25178-70. Any reference to the geometrical profile of a surface measurement standard in a 2-D application is understood to also apply to the 3-D surface of such a standard in a 3-D application, and vice versa, unless stated otherwise.

Note 2 to entry: A defect is identified with a portion of the physical surface, rather than with a physical or geometrical property of such a portion. It is thus possible for an entire specimen to be a defect, and this should be taken into account when talking about removing defects.

Note 3 to entry: This definition acknowledges the fact that any surface measurement standard with a non-random surface will show small marks resulting from the manufacturing process and will deviate from the ideal or nominal surface. Because such imperfections are unavoidable and therefore expected, they are not counted as defects unless they are larger than what is normal or typical for the manufacturing process used. In the case of certain critical features there might exist stated manufacturing tolerances for what is and what is not acceptable, in which case these tolerances will be the limit below which deviations shall not count as defects. In most cases, however, stated tolerances do not exist, and the criterion for a deviation to count as a defect will be simply: does it exceed in size that which is normal or characteristic of the method of manufacture employed? Examples of unavoidable deviations from perfection are: rounding of corners on any specimen which is supposed to show sharp corners, such as step-height specimens or waffle-plate specimens; polishing scratches on the surface of a glass flat or a sphere; cutting tool marks on a turned metal surface; gaps in a groove which has been etched into silicon; and bending (form error) present on specimens which are supposed to be (ideally) flat.

Note 4 to entry: The information in Note 3 to entry on small deviations which are an unavoidable consequence of the manufacturing process, and which therefore are not considered to be defects, is consistent with ISO 25178-70:2014, Clause 5: "The real integral surface of a standard shall have a scale limitation specified and features outside this limitation shall be considered not to affect the measurement."

3.2 Terms and definitions for classes of defects

3.2.1
effective defect
defect whose deviations are large enough, when measured under defined conditions, to influence the measured value and/or the uncertainty of the measurand of interest

3.2.2
ineffective defect
defect which is not an effective defect

Note 1 to entry: A defect which is effective with respect to one set of measuring conditions might be ineffective with respect to a different set of conditions. For example, a stain on a measurement standard might be ineffective when that standard is measured by a stylus instrument and yet be effective when that standard is measured by certain types of non-contacting optical instruments.

3.2.3
visible defect
defect whose presence upon a surface can be detected by the naked eye

3.2.4
invisible defect
defect whose presence upon a surface cannot be detected by the naked eye

3.2.5
cosmetic defect
visible defect which is also an ineffective defect

Note 1 to entry: The relationship between effective and visible defects is shown in Figure 1.

visible and effective	invisible but effective
visible but ineffective (cosmetic)	invisible and ineffective

Figure 1 — Venn diagram of the set of all defects subdivided according to visibility/invisibility and effectiveness/ineffectiveness

3.2.6
outward defect
defect which has the effect of raising the profile in the region of the defect (as compared with where the profile would have been if there were no deviation)

3.2.7
inward defect
defect which has the effect of lowering the profile in the region of the defect

3.2.8
neutral defect
defect which is neither an inward nor an outward defect

3.2.9
negative defect
outward (very rarely inward) defect on positive replica specimen, which is the result of inward (outward) defect on the negative mother, or master surface, from which that replica was made

Note 1 to entry: Any negative defect will have a cross-sectional shape which is the exact top-bottom inversion of the shape of the corresponding defect on the negative mother surface.

3.2.10
Gestalt defect
cosmetic defect which cannot be identified (recognised) on the corresponding profile or surface representation (cannot be seen under magnification)

Note 1 to entry: A Gestalt defect typically consists of a number of ineffective defects, each of which considered alone is invisible, which are arranged on the surface in a pattern or structure which is visible. This pattern, however, would be invisible if the same individual defects were arranged differently (e.g. randomly).

3.3 Terms and definitions for ways of responding to defects

3.3.1
removing
<defect> discarding the defective portion of the surface, either by physical removal (cutting away) or else, in software, by discarding the corresponding datapoints

3.3.2
avoiding
<defect> redefining the outer limits of the measuring area so as to exclude the defective part of the surface

3.3.3
repairing
<defect> restoring the defective profile to the intended or theoretically exact shape, either by physical interference (cleaning, reworking) or else, in software, retouching

3.3.4
altering
modifying
<defect> changing the surface topography of a defect without repairing it

Note 1 to entry: Usually the consequence of an unsuccessful attempt to repair a defect is an alteration or modification in this sense.

Note 2 to entry: An attempt to repair a visible but ineffective (i.e. cosmetic) defect on a physical specimen might sometimes result in altering the defect so that it becomes an invisible but effective defect.

3.3.5
measuring
<defect> obtaining measurement data from a defective part of the surface, either by intention or by accident, followed by making use of the resulting data which might correspond to one or more defects, without removing, repairing or altering any defect

3.3.6
ignoring
<defect> measuring the surface of the measurement standard while paying no regard to whether the portion of the surface being measured includes any defects or not

Note 1 to entry: Without the definition in 3.3.6, three possible interpretations of the term to ignore a defect would present themselves a priori: a) to measure the surface while deliberately avoiding areas which are visibly defective; b) to measure the surface and then to discard either all the data or else just the portion which corresponds to the defect; c) to measure the surface and to retain all the resulting data as though there were no defect at all.

In terms of the definitions presented in this document, case a) above corresponds to avoiding the defect as defined in 3.3.2, and case b) corresponds to removing the defect as defined in 3.3.1. Case c) is the only instance of ignoring a defect as defined in 3.3.6.

Note 2 to entry: The six ways of responding to defects defined above (3.3.1 to 3.3.6) are exhaustive, because outside these alternatives there is no other way to deal with a defect. The six ways are also mutually exclusive, with the exception of 3.3.5 and 3.3.6; it is possible for a defect to be both ignored and measured. However, it is also possible for a defect to be ignored and not measured; and it is possible for a defect to be measured and not ignored.