TEQ Training & Consulting GmbH | Dr.-Ing. Gunter Effenberger| November 2012

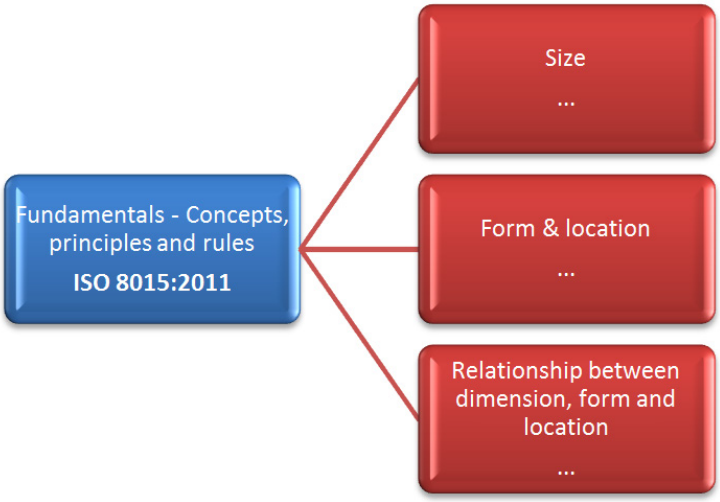
Geometrical Product Specifications (GPS) – ISO 8015 Basic GPS standard

Preface

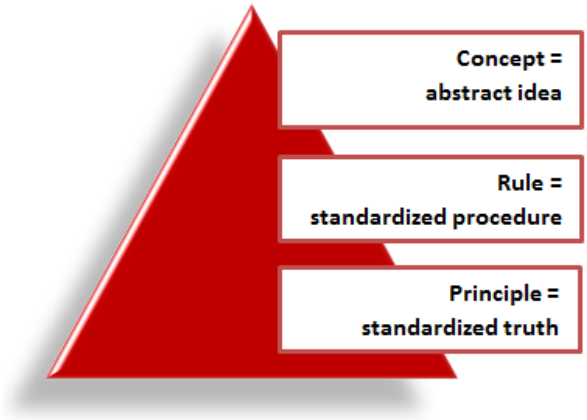
The first article of this series provided an overview of all fundamental standards of the GPS concept required to describe geometrical characteristics. This article presents the basic standard ISO 8015 and illustrates its "umbrella function" for the entire series of GPS standards. We do not intend to discuss every single aspect of this standard but try to focus on the contents the author considers relevant for the purpose of defining specifications, especially of creating drawings, and interpreting them.

The status of ISO 8015 in the GPS concept

The introduction to ISO 8015 considers its function to be "fundamental" since it affects all other standards in the GPS matrix system including global, general and supplementary standards. Based on its function as a basic standard, the following diagram only shows it as a superior element of the collection of "geometric dimensioning and tolerancing" standards.



The title of this standard already implies that it contains concepts, principles and rules describing and defining fundamental and comprehensive aspects and, due their specification in an official standard, issues relevant to liability; applying this standard is an acknowledged rule of technology. This general standard interprets the meaning of the terms "concept", "principle" and "rule" as follows.



However, please note that the text of this standard only describes a single concept, no principles at all but 13 fundamental principles and 3 rules.

Fundamental assumptions for the reading of specifications on drawings

The heading of the 4th chapter literally reflects the authors' efforts to implement their intentions neither as a principle nor as a rule. This fact is highly regrettable since the "assumptions for the reading of drawings" are of such vital importance that we rather hoped for clear "rules for the creation of drawings".

1st assumption	**Functional limits** • Functional limits are based on a comprehensive analysis. • It is either an experimental or theoretical analysis. • The known functional limits do not include any uncertainty.
2nd assumption	**Tolerance limits** • The tolerance limits comply with the functional limits.
3rd assumption	**Workpiece functional level** • The workpiece whose characteristics are within the tolerance limits functions. • The workpiece whose characteristics are not within the tolerance limits does not function.

The 2nd assumption deserves an additional comment. The reader of the drawing has to assume that the product developer or design engineer is not addicted to safety thinking. He thus specified tolerance limits that are narrower than the functional limits. There are numerous real-life examples where the engineering department had narrowed the tolerances and in the end, this restriction led to major difficulties and incurred high process costs as soon as these characteristics were linked to process capability requirements.

Principle 1: Invocation principle

Once a portion of the ISO GPS system is "invoked" in a product documentation, the entire ISO GPS system is invoked. In the past, the "TOLERANCING ISO 8015" indication was necessary and common practice to mark that the independence principle applied. This information was usually given in the title block or near the title block. However, this is not mandatory since you "invoke" the system by quoting a different GPS standard. International standards published by ISO/TC 213 define the entire ISO GPS system (see ISO/TR 14638). Only if you invoked a different, e.g. corporate or strictly national guideline on a drawing or in a documentation, this guide is the equivalent to the ISO GPS standard concerned.

Example 1

GPS system invoked without quoting ISO 8015

Size ISO1445		Surface ISO 1101 ISO 1302	Scale	
			Material	
	Date	Name	Description	

Example 2

GPS system not invoked (see also example 7)

Size ASME Y 14.5		Surface	Scale	
			Material	
	Date	Name	Description	

Principle 3: Definitive drawing principle

The drawing as a synonym for the total package of documentation specifying the workpiece is definitive. All specifications shall be indicated on the drawing using GPS symbology. Requirements not specified on the drawing cannot be enforced. Since drawings normally provide the basis for the contents of supply agreements, the application of the GPS system leads to a certain degree of contractual liability. It is important to be aware of this fact while creating product specifications.

Principle 5: Independency principle

The main information of the 1986 version of ISO 8015 “Tolerancing Principle” about the principle of independency was just taken over into the new version; however ISO left out some clear graphics of the previous version helping to illustrate some facts and they shortened the section about the independency principle considerably. Each GPS requirement of a geometric element or a relationship between geometric elements shall be met independently. Exceptions to this independency principle are only permissible when you indicate the specification modifier on the drawing, either next to the respective characteristics or globally for the entire drawing (e.g. Ⓜ for ISO 2692, CZ for ISO 1101 or Ⓔ for ISO 14405-1).

Principle 7: Default principle

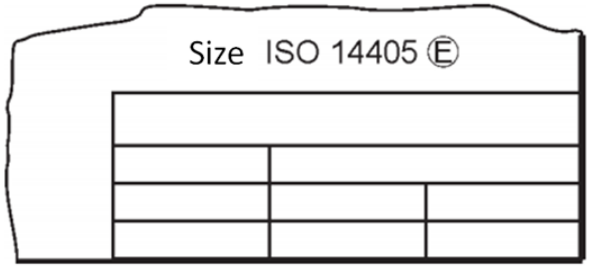
Any geometrical product specifications are communicated in the form of drawing indications; they are referred to as specification operators in the GPS concept. The product developer or design engineer uses the indications on a drawing to define the functional level.

The entire specification operator can be based on the specifications of fundamental GPS standards.

Example 3
Ø20 h11 means that the standard specification operator “local size in the form of a two-point size” according to ISO 14405-1 applies without this standard indicated on the drawing.
You may even use different standard specification operators by indicating specification modifiers next to the respective characteristic.

Example 4
Ø20 h11 Ⓖ means that the standard specification operator “least squares size” according to ISO 14405-1 applies.
You may even use company-specific specification operators or operators deviating from the agreed standard (e.g. by indicating them near the title block of the drawing).

Example 5



The envelope requirement – and not the two-point size as a standard specification operator - applies to all geometric elements on the drawing.

Principle 8: Reference condition principle

This principle establishes the well-known interpretation that all geometric elements are considered to apply at 20 °C - the reference temperature defined in ISO 1. The workpiece is thus examined at this temperature in consideration of material and operating conditions; its quality assessment also refers to this temperature. The “cleanliness” of the workpiece demanded by this principle (free of contaminants) is a matter of interpretation and thus too unspecific. It is often required to specify additional requirements concerning the cleanliness of the workpiece surface on the drawing in order to be able to quantify and thus evaluate cleanliness.

Principle 10: Duality principle

You will not be able to understand all principles of this standard while reading it for the first time. Especially principle 10 makes it necessary to translate the very precise wording into a clear statement.

The mentioned operator concept implies that an entire specification operator is available and thus an entire drawing indication providing a clear specification of a characteristic’s measurands and, if required, technical boundary conditions. You have to define the specification operator as early as while designing the workpiece.

The verification operator refers to the type of measurement or inspection realized for the workpiece inspection. This verification operator is thus defined in test planning or immediately before the start of the measurement and assigned to the respective specification operator.

In case the verification operator conforms to the specification operator, i.e. you measure the workpiece in the same way as demanded, there is no measurement uncertainty component caused by the measurement procedure. If the verification operator does not conform to the specification operator, you measure the workpiece differently and will thus have to consider a measurement uncertainty component caused by the measurement procedure. ISO 8015 refers to this uncertainty component as method uncertainty.

The duality principle explains that the specification operator shall be defined independently of any measurement procedure or measuring device while all standards on measurement procedures to be applied are included by invoking the GPS-system (principle 1). However, the GP specification does not dictate which verification operators are acceptable. The acceptability of a verification operator is only evaluated based on its measurement uncertainty.

Example 6

A geometric element is defined as a fit with Ø20 h11 Ⓔ *and serves as a specification operator. A ring gauge for the maximum material limit and a snap gauge for the minimum material limit are applied as verification operators in the inspection of the fit. The condition of the gauges (tool wear) and the operators’ skills (in handling the tool) affect the measurement uncertainty considerably.*

It is also worth mentioning that certain metrological issues can be assigned to the specification operator: in an inspection with coordinate measuring machines e.g. the selected reference element, filter type, transmission band of the filter, probe element specifications and notes on how to record geometric elements. However, this is only necessary when these factors deviate from defaults defined in different GPS standards on measurement procedures.

The last principle this article wants to describe is principle 13.

Principle 13: Responsibility principle

The essence of principle 13 is that the design engineer is responsible for a clear description of the geometric components of the workpiece function by means of appropriate specification operators (drawing indications). The design engineer / product developer bears the sole responsibility for an ambiguous interpretation of the function caused by the selected type of specification operator.

The choice of an appropriate verification operator is based on measurement uncertainty. The party in charge of quality inspections (proving conformance or non-conformance with specifications) is responsible for selecting this verification operator; however, ISO 8015 refers to ISO 14253-1 here.

The next chapter of ISO 8015:2011 deals with rules for the indication of default specification operators. As soon as a drawing refers to a general GP specification, such as ISO 1101, ISO 1302 or ISO 5459, you shall apply and interpret specification operators as defined in this standard. It is, however, of utmost importance that the ISO standard defining the respective default specification operator is always the latest (official) version of the standard at the time the drawing was created.

In case you have to indicate previous versions of such GP specifications, you have to specify them unambiguously, i.e. “TOLERANCING ISO 8015:1986” instead of “TOLERANCING ISO 8015”. This will be necessary in situations where you revised an old drawing and this drawing is now valid with the respective modifications; however, not translated into the updated series of GPS standards and understanding of the GPS concept.

However, if you want to apply an altered default GP specification that is not an ISO GPS standard, the drawing indication in or near the title block shall contain at least the following information:

Note: “TOLERANCING ISO 8015”, modifier (AD), name of the applicable document

Example 7

TOLERANCING ISO 8015 (AD) ASME Y14.5:2009

Size ISO1445		Surface ISO 1101 ISO 1302	Scale	
			Material	
	Date	Name	Description	

Interpretation: This document invokes and applies the American standard for geometric tolerancing ASME Y14.5. You may thus define the standard even more specifically as is shown in example 2.

The modifier (AD) refers to altered default in this context.

Conclusion

ISO 8015 lives up to its role as a fundamental standard of the GPS system. Its contents are acceptable and of utmost importance, especially in order to tackle questions of liability in consequence of wrong drawing indications or interpretations.

Prospect

The next article of this series will deal with the GPS standard for linear and non-linear sizes ISO 14405 Part 1 and Part 2.

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