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State of art in standardization in GPS area

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ABSTRACT

The ISO family of standards shortly called the GPS standards is characterized. The activity of Technical Committee ISO/TC 213 that has been working towards coordinated and systematic development of international standards covering problems of dimensioning, geometrical tolerancing, surface texture and related metrology is reported. The attempts of the ISO/TC 213 to establish more mathematical, systematic and scientific basis for new standards building are emphasized. The unified model for design, manufacturing and verification based on the improved GPS language and its new concepts like surface models, geometrical features, characteristics, specification uncertainty, correlation uncertainty and operations is aimed to cover all aspects of the product development up to launch on the market.

1. Introduction

The acronym GPS for design, manufacturing and metrology engineers shall mainly stand for *Geometrical Product Specifications*. This acronym is the sub part of the name of the Technical Committee ISO/TC 213 *Dimensional and Geometrical Product Specifications and Verification*. The Committee was established in 1996, when a group of three ISO technical committees' experts, lead by Per Bennich, decided to start to cope with the problem of the contradictions, gaps and the lack of cohesion with needs of modern CAD/CAM/CAQ systems in the current set of standards devoted to dimensioning and tolerancing. The circumstances had been felicitously characterized by B. Grant, who during the 3rd ISO/TC 213 Plenary Session in June 1997 noted: *We have standardized in the past by writing "standards" filled only with examples. We have spread the practice of Geometrical Dimensioning and Tolerancing all over the world with only examples defining what it is we are doing. Now is the time to standardize by broadly applied rules which define the accepted practice as best possible in a common way across the world, taking advantage as best possible of available technology. This will*:

- *Decrease the uncertainty in the design and manufacture of products*;
- *Increase the productivity of engineering and production efforts*;
- *Increase the use of computers and other advanced technologies in design and manufacturing* [1].

Bennich formulated a new fundamental concept of *chains of standards* [2]. Each chain has six links [3,4] that shall form an unambiguous link between the drawing indication and the result of measurement. The eighteen chains of standards, each covering specific geometrical characteristic are used in complete structure—*The chain of standards matrix model* (Fig. 1). The matrix model is explained in the detail in Technical Report ISO/TR 14638 *GPS Masterplan*. Since 1996 every new GPS standard has to contain annex in which relation of the particular standard to the GPS matrix model is marked. The ISO/TR 14638 was published in 1995 and at that time many of the matrix chains were empty. That indicated lack of standards devoted to some GPS issues. It should be noted, that since 1996 the ISO/TC 213 prepared 105 new or thoroughly revised standards and over 50 documents are under development [1]. So it seems that ISO/TR 14638 should be revised and updated to show, what standards are available in particular chain links.

2. Development of the GPS standards

The development of the GPS standards is executed internationally in the ISO/TC 213 and thanks to the Vienna agreement [5], all ISO standards in the GPS field are processed parallel in Europe in its mirror committee CEN/TC 290. The GPS standards are prepared in the ISO/TC 213 by active cooperation of 24 participating countries and 28 observer countries. The ISO/TC 213 has annually two meetings and its core expert group comprises of about 30 people, however since 1996 over 150 people have served as experts. The experts represent automobile, aircraft and other high tech industry, leading measuring equipment manufacturers, universities and consulting business.

In the USA the description of a workpiece geometry for engineering purposes is called *geometrical dimensioning and tolerancing* (GDT) and is covered mainly by the National Standard ASME Y14.5 M [3,4,6,7], which latest edition was published in March 2009. The both tolerancing systems – the international and the American have a lot common, but are not

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Global GPS standards

General GPS standards

Fundamental GPS standards

	GPS characteristic/feature	Chain link number 1: Product documentation indication – codification	2: Definitions of tolerances	3: Definitions of characteristics of actual (real) feature	4: Assessment of the workpiece deviations – comparison with limits	5: Measurement equipment requirements	6: Calibration requirements – measurement standards
1	Size						
2	Distance						
3	Radius						
4	Angle						
5	Form of line independent of datum						
6	Form of line dependent on datum						
7	Form of surface independent of datum						
8	Form of surface dependent on datum						
9	Orientation						
10	Location						
11	Circular run-out						
12	Total run-out						
13	Datums						
14	Roughness profile						
15	Waviness profile						
16	Primary profile						
17	Surface imperfections						
18	Edges						

Fig. 1. Structure of the GPS matrix according to ISO/TR 14638.

fully compatible (Fig. 2). A few American experts are active in the ISO/TC 213, so a number of ASME ideas are adopted in the new ISO standards (e.g. *all around* notation for tolerancing of profile of a line/surface) and we hope, that the ANSI will also accept some ISO approaches. So it gives a chance to reduce and hopefully eliminate confusions in such industry like automotive which operates worldwide over country boundaries. The standards diversity is also a great challenge for educators and students [8].

The scope of the Technical Committee ISO/TC 213 is: *Standardization in the field of geometrical product specifications (GPSs), i.e. macro- and microgeometry specifications covering dimensional and geometrical tolerancing, surface properties and the related verification principles, measuring equipment and calibration requirements, including the uncertainty of dimensional and geometrical measurements. The standardization includes the basic layout and explanation of drawing indications (symbols)* [1].

The ISO/TC 213 activity is currently carried out in the 11 *working groups* (WGs) along with the 4 *advisory groups* (AGs) [1] and may be divided into two areas:

- Reviewing, upgrading and improving of existing GPS standards.
- Development of new standards to create the next generation of the GPS language.

  Furthermore, it is recognized that there are two metrology systems in the GPS:
- Conventional metrology based on hard gauging (calipers, micrometers, gauge blocks, surface plates, gap gauges, plug gauges, etc.).
- Digital computational metrology based on the sets of sampled points and computer software for their assessment and analysis (coordinate measuring machines, articulated arms, roundness measuring machines, etc.).

The benefits for industry expected from the work of the committee as well as the objectives and the strategies for their achievement are in the details presented in the *ISO/TC 213 Business plan* [9].

Among the number of the recently published ISO GPS documents the following should be recalled as crucial for consistent design, manufacturing and inspection:

- ISO/TS 15530-3:2004, -4:2008 GPS, Coordinate measuring machines (CMMs): Technique for determining the uncertainty of measurement – Part 3: Use of calibrated workpieces or standards – Part 4: Evaluating task-specific measurement uncertainty using simulation;
- ISO/TS 16610-...:2009 GPS, Filtration, ... (multipart technical specification);
- ISO 2692:2006 GPS – Geometrical tolerancing – Maximum material requirement (MMR), least material requirement (LMR) and reciprocity requirement (RPR);
- ISO/TS 23165:2006 GPS, Guidelines for the evaluation of coordinate measuring machine (CMM) test uncertainty;
- ISO 14978:2006 *GPS* – General concepts and requirements for GPS measuring equipment;
- ISO/TS 17450-1:2005 GPS – General concepts – Part 1: Model for geometrical specification and verification;
- ISO/TR 16570:2004 GPS: Linear and angular dimensioning and tolerancing: ± limit specifications – step dimensions, distances, angular sizes and radii;
- ISO 1101:2004 GPS – Geometrical tolerancing – Tolerances of form, orientation, location and run-out.

  Selected important drafts of ISO GPS documents which are under discussion in ISO/TC 213 are listed below:
- ISO 1101:2004/WD Amd 2 GPS – indication of special specification operators for straightness, roundness, flatness and cylindricity;

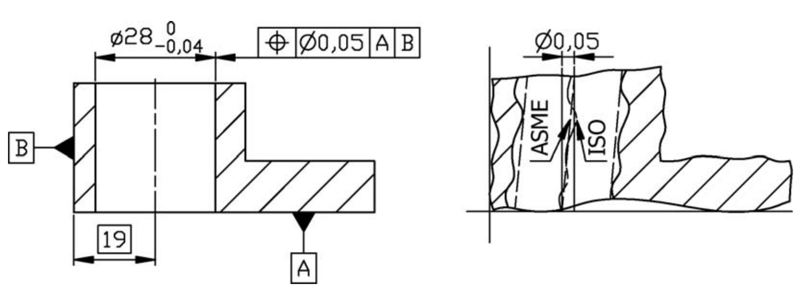

Fig. 2. The same symbol is used for the position tolerance according to ISO 1101 and the positional tolerance according to ASME Y14.5M, however interpretation is different. According to the ISO the extracted median line (the actual feature) shall be within the tolerance zone. According to the ASME the axis of the inscribed cylinder (the ideal feature) shall be contained in the tolerance zone.