The GPS Philosophy and the Globalisation of Industrial Products

Dott. Ing. Michele Deni

International Organisation for Standardisation
Organisation Internationale de Normalisation
International Normenorganisation

ISO/TC 213/WG 10
Coordinate measuring machines
http://ds.dk/isotc213
E-mail: hhk@dk

ISO/TC 60/WG 2
Gears

American Society for Precision Engineering
Member

Sustainer

Associate Editor

Precision Engineering
The ISO GPS is a new approach to provide basic tools to develop a common language to be adopted in the:

• Design Geometrical Definitions
• Specification Limits (Tolerancing) Classification
• Inspection methods
• Final, Conformity Assessment Rules of Acceptance
ISO/TC 3-10-57/JHG

Harmonization of ISO/TC 3, ISO/TC 10 and ISO/TC 57 definitions on:

Limits and fits, technical drawings, product definitions, dimensioning, tolerancing, properties of surfaces and metrology

Secretariat: Danish Standards Association
The GPS Philosophy and the Globalisation of Industrial Products

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The GPS Philosophy and the Globalisation of Industrial Products

THE NEEDS

IDEA
Object to be produced

CAE
Virtual Object

CAM
DMIS

Numerical Information

ISO
APT

CNC
FMS
Physical realization of the object

Compliance Verify
ISO GPS SPC

Geometric Parametric Information
Numerical Information

ISO APT

Dimensional Verify
CMM DME
The revolution is thinking that, any Design Specification is “Incomplete“ as due to unavoidable Verification processes, that could be Functionality, Moutability, or Measurement Verifications, four types of Uncertainties will arise in the end.

Specifications on the “blue print” are self consistent, and following those specifications gives the acceptability of the final product.

Specifications on the “blue print” are incomplete, as the acceptability of the final product pass through an unavoidable Verification.

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## TENETS AND PRINCIPLES

### GPS PHILOSOPHY

**ISO/TR 14638**
This Technical Report contains the Masterplan of the hierarchy in which the GPS Standards are organized, which consist in the Fundamental, Global, General and Complimentary Standards containing the basic principles and the general tenets.

**ISO/TS 17450-1**
This Technical Specification, which is part of global GPS documents, contains the model for geometrical Specification, used in the design of assemblies and individual parts, that will deal to compliant measurement procedures.

**ISO/TS 17450-2**
This Technical Specification is another global GPS document, and contains the basic issues for the development of the overall system which is based on the four “Tenets”.

**ISO/14253-1**
As this Standard is probably well known from the Experts, shortly we say that it is very important and it is globally accepted in the Industrial Environment as well at the level of Legal Metrology, as the rules for the Conformity assessment are clearly defined.

**ISO/TS 14253-2**
This Paper gives a general rule of how find the best Verification Operators compliant to a stated Specification, this is known as the “PUMA” method.
### General GPS Matrix

**General GPS chains of standards**
1. The *Size* chain of standards
2. The *Distance* chain of standards
3. The *Radius* chain of standards
4. The *Angle* chain of standards
5. The *Form of a line* (independent of a datum) chain of standards
6. The *Form of a line* (dependent of a datum) chain of standards
7. The *Form of a Surface* (independent of a datum) chain of standards
8. The *Form of a Surface* (dependent of a datum) chain of standards
9. The *Orientation* chain of standards
10. The *Location* chain of standards
11. The *Circular run-out* chain of standards
12. The *Total run-out* chain of standards
13. The *Datum’s* chain of standards
14. The *Roughness profile* chain of standards
15. The *Waviness profile* chain of standards
16. The *Primary profile* chain of standards
17. The *Surface defects* chain of standards
18. The *Edges* chain of standards

### Complementary GPS Matrix

**Complementary GPS chains of standards**

**A. Process specific tolerance standards**

A1. The *Machining* chain of standards
A2. The *Casting* chain of standards
A3. The *Welding* chain of standards
A4. The *Thermal cutting* chain of standards
A5. The *Plastic moulding* chain of standards
A6. The *Metallic and inorganic coating* chain of standards
A7. The *Painting* chain of standards

**B. Machine element geometry standards**

B1. The *Screw thread* chain of standards
B2. The *Gears* chain of standards
B3. The *Splines* chain of standards
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#### ISO/TR 14638

<table>
<thead>
<tr>
<th>GLOBAL STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 370, 10209-3, 10579, VIM, GUM</td>
</tr>
</tbody>
</table>

#### GENERAL GPS STANDARDS

<table>
<thead>
<tr>
<th>Chain link number</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometrical character of feature</td>
<td>Geometric sub-characteristic of feature or parameters</td>
<td>Product documentation indication - Modification</td>
</tr>
<tr>
<td>Definition of tolerances - Theoretical definition and values</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Size

<table>
<thead>
<tr>
<th>&quot;Step&quot; distance (height)</th>
<th>129 (R), 286-1, 406-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance between real or derived feature and derived feature</td>
<td>286-1, 286-2, 1829</td>
</tr>
</tbody>
</table>

#### Distance

<table>
<thead>
<tr>
<th>014660-1, 0-2</th>
</tr>
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<tr>
<td>129 (R), 406</td>
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#### Radius

<table>
<thead>
<tr>
<th>014660-1, 0-2</th>
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<tbody>
<tr>
<td>129 (R)</td>
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<tr>
<td>Angle between real features</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

#### Form of line independent of datum

<table>
<thead>
<tr>
<th>Profile any line</th>
<th>Real feature (line)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straightness</td>
<td>1101 (R), 012780-1</td>
</tr>
<tr>
<td>Roundness</td>
<td>1101 (R), 6318 (W)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profile any line</th>
<th>Derived feature (line)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straightness</td>
<td>1101 (R), 2692 (R)</td>
</tr>
<tr>
<td>Roundness</td>
<td>1101 (R)</td>
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#### Form of line dependent of datum

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<thead>
<tr>
<th>Profile any line</th>
<th>Real feature (profile of any line)</th>
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</thead>
<tbody>
<tr>
<td>Flatness</td>
<td>1101 (R)</td>
</tr>
<tr>
<td>Cylindricity</td>
<td>1101 (R)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profile any surface</th>
<th>Derived feature (profile of any line)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatness</td>
<td>1101 (R), 3040</td>
</tr>
<tr>
<td>Cones</td>
<td>1101 (R), 2692 (R)</td>
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#### Definitions for actual feature-characteristic or parameter

<table>
<thead>
<tr>
<th>Assessment of the deviations of the workplace - Comparison with tolerance limits</th>
<th>Measurement equipment requirements</th>
<th>Calibration requirements - Measurement standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit gauges</td>
<td>1938 (R), 3670 (R)</td>
<td>1938 (R), 3670 (R)</td>
</tr>
<tr>
<td>Indicating measuring instruments</td>
<td>1938 (R)</td>
<td>3650 (R)</td>
</tr>
</tbody>
</table>

#### Notes

- ISO draft standard in progress (W0, CD or DIS)
- XXXXX = ISO number not yet known (numbered YY)

(R) = Revision in progress (W) = To be with drawn
These tools are based on the characteristics of features, on the constraints between features, and on operations used for the creation of different geometrical features.

The machined parts derived from the same drawing are imperfect, with errors relative to size, form, deviation, position; so here we have the problem of how to get a set of parameters for each feature present on the workpiece, which could be comparable with the ideal ones on the drawing.

In Coordinate Metrology the problem was solved with the introduction of a new entity which is the “Substitute Geometrical feature”.

This approach is possible only in the case of, what I call, “Metrology in Predefined Geometry” as the mathematical formalization of the measured part must be known “a priori”.

The designer first defines a part of perfect ideal form with shape and dimensions, with tolerance specifications, that best fit the functionality of the final product.

In this document (ISO/TS 17450-1) all the definitions related to geometrical features and their geometrical characteristics, are reported.

In a future evolution which is being considered from some Researchers, a new Specification and Verification approach, could be the right solution for many problems, this is the VD&T, Vectorial Dimensioning and Tolerancing.
The designer first defines a part of perfect ideal form with shape and dimensions, with tolerance specifications, that best fit the functionality of the final product.
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ISO/TS 17450-2

Function → Specification → Verification

Correlation uncertainty

Specification uncertainty

Method uncertainty

Implementation uncertainty

Measurement Uncertainty

Compliance Uncertainty

Total Uncertainty
A measurement with low Uncertainty is of little value, when Correlation or Specification Uncertainty is large.

The responsibility of designers will be strongly accounted in the Production Process.

The Specification Process is the first to take place, and is on the responsibility of the Designer.

The Verification Process follows the Specification, and is done implementing the actual Specification Operator in an actual Verification Operator.
The concept of the Uncertainty as an Economic Factor is evident, and the decision rules for who is going to pay the uncertainty related to measurements are clear.
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ISO/TS 14253-2

PUMA Method
CONCLUSIONS

Four levels of Uncertainty will arise:

- Correlation Uncertainty
- Specification Uncertainty
- Compliance Uncertainty
- Measurement Uncertainty

The GPS will be a very useful tool for people involved in the Verification process, in order to better address the responsibilities in the production environment and be able to evaluate the amount of risk related to an action of acceptance or rejection.
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CONCLUSIONS (2)

An important contribution introduced from the ISO/GPS, is a major involvement of Designers and Specificators, which finally become also partially responsible of the success of the Verification Process.

Specification and Verification are two aspects of the same thing, which is the successful realisation of final product, in a Global Industrial Environment.

Specification and Verification Uncertainty is a relevant Economic factor.