Surface Texture – a critical part of geometrical tolerancing to ensure product performance, life- time and minimize environmental impact

GEOMETRICAL TOLERANCANCING AND SURFACE TEXTURE

the Manufacturing R&D Cluster Conference on May 9, 2023

Stefan Rosén, Toponova ab, Halmstad

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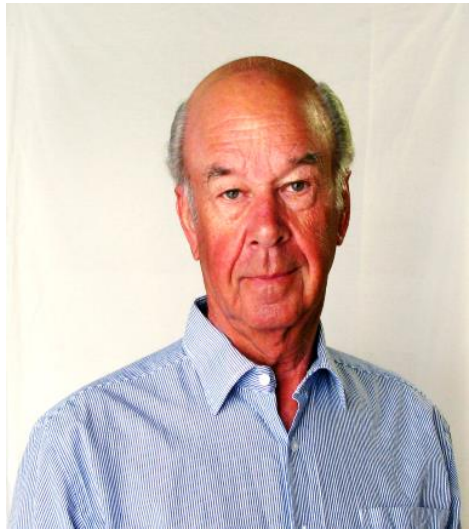
Your team when it comes to ISO GPS, metrology and surface texture

STANDARD DEVELOPER 2023

"The spider in the web when it comes to developing methods to control and verify correct surface texture of products for manufacturing companies”

Stefan Rosén

- Founded toponova ab in 1994 in Halmstad.
- Expert in ISO GPS, metrology and surface texture.
- Member of the SIS working group for ISO GPS, metrology and surface texture. SIS/ TK 507 AG6
- Managed more then 2.000 projects for more than 200 customers



"The expert who translates the customer's requirements for surface quality into the right requirements for drawing and method for quality control"

John Westberg

- Lives in Gothenburg, previously worked at Volvo Cars
- Today runs his own consulting firm, Metrology West,
- Expert in ISO GPS, Chairman of the SIS working group for ISO GPS, measurement technology and surface texture. SIS/ TK 507 AG6
- Chair of the ISO working group for ISO GPS, metrology and surface texture. ISO/ TC 213 WG16

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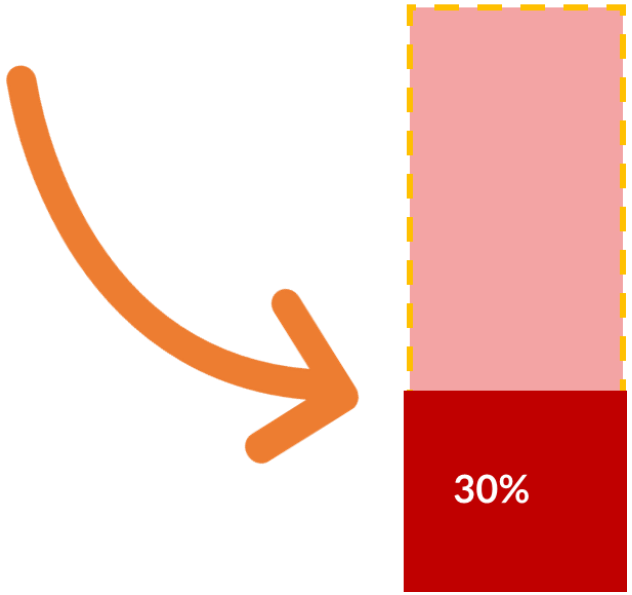

The cost of poor quality can be 10-30% of the company's annual turnover*

*Sörqvist L. “Difficulties measuring the cost of poor quality”. 2012-12-03
http://www.sandholm.se/Artiklar/difficulties.asp

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In manufacturing, geometrical deviations always occur that effects workpiece quality

Geometrical deviations can be both large or microscopically small.

Deviations can be wrong shape, different surface, deviating angles, too small radii and to sharp edges, etc...

It is often these deviations that make the product look and feel different and, in the worst case, not even work as intended.

Therefore, geometrical deviations must be controlled, to ensure functional and quality requirements.

Workpieces with different geometrical deviations

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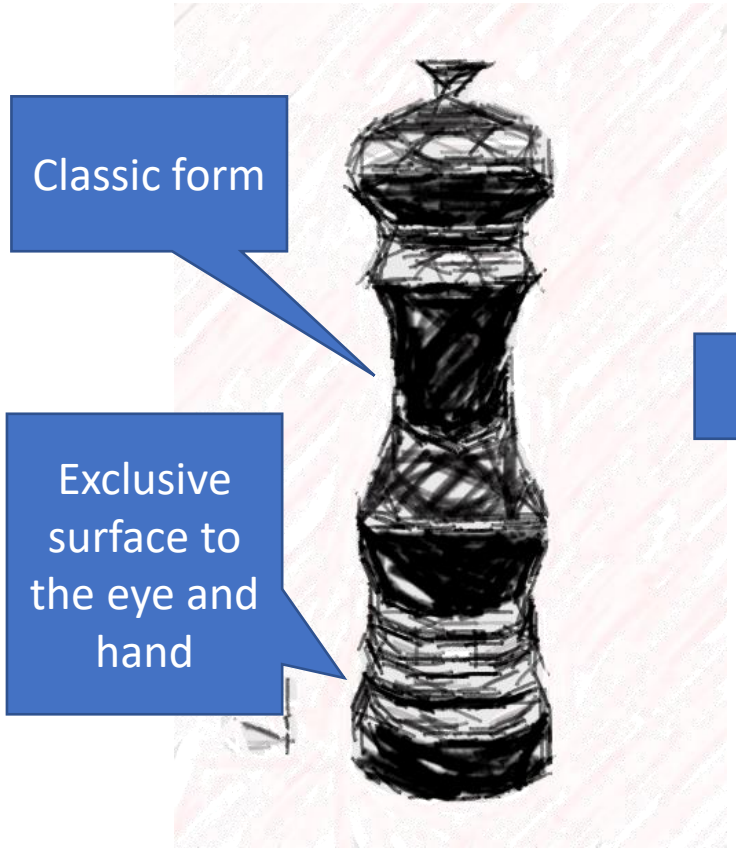
When designing a product, the designer draw a nominal model of the product with perfect geometry and surface

Design intent



Nominal 3D model drawn in CAD software (Computer Aided Design)

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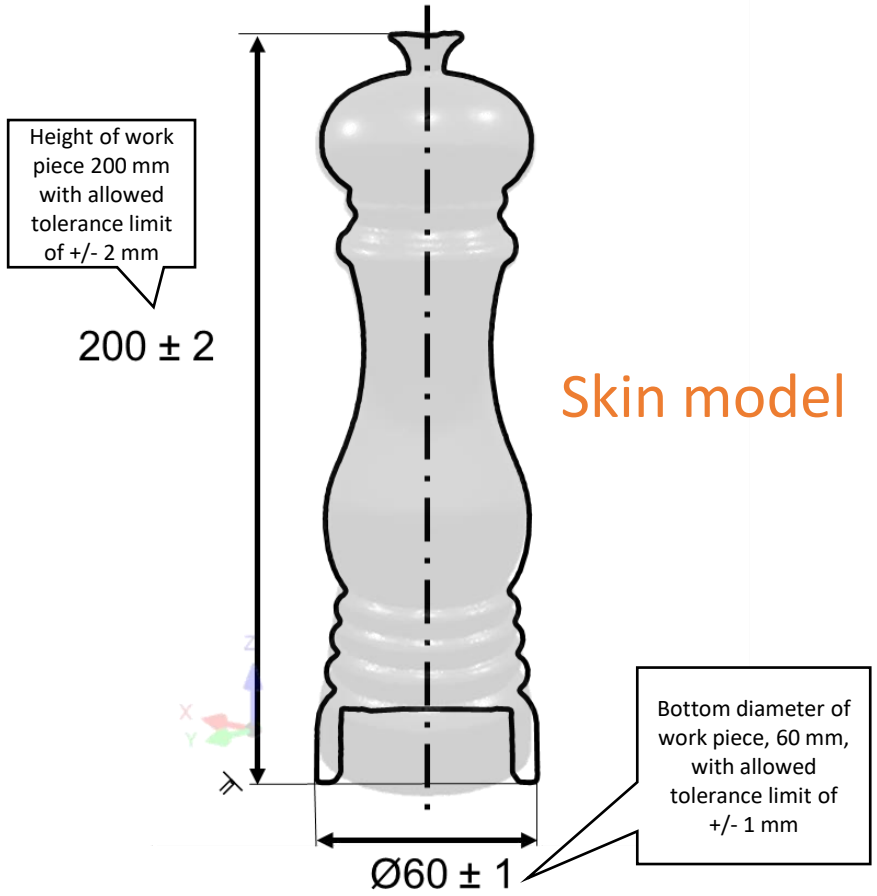
To control allowed geometrical deviations, designer adds tolerances to the nominal model

Geometrical tolerance is an important part of the designer's work, it is now the designer specifies within which limits the geometric deviations are allowed to secure product functionality, as intended when designing product.

Geometric deviations are indicated on the digital model by different symbols, depending on the type of deviation.

In ISO system for geometrical tolerances, ISO GPS, model with tolerances, is called skin model



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The surface of the workpiece is often an important part of geometry and must be controlled

The surface is the outer surface of the workpiece in contact with the surroundings. An outer surface can also have important function requirements inside a workpiece.

Deviations on the surface, is the result from the manufacturing process and material used.

Surfaces are often designed with intent and designer must consider surface deviations and how to control them.

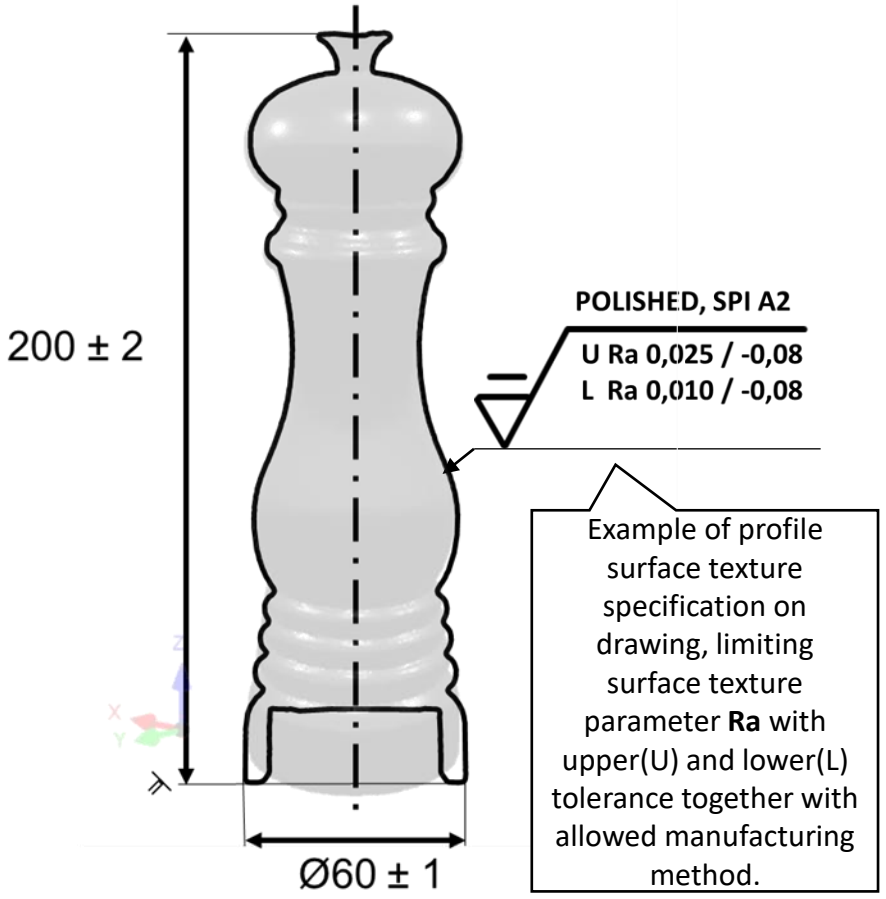
To control surface deviations on skin model, symbol for surface texture is used

Surface texture is the measure of surface deviations, without form of the workpiece.

Surface texture, is a geometrical feature, specified on drawing using symbols.

Workpieces often have many surfaces with different requirements and must be specified individually.

A complete ISO standardized toolbox is available for functional characterization of surface deviations/surface texture.



Example of profile surface texture specification on drawing, limiting surface texture parameter **Ra** with upper(U) and lower(L) tolerance together with allowed manufacturing method.

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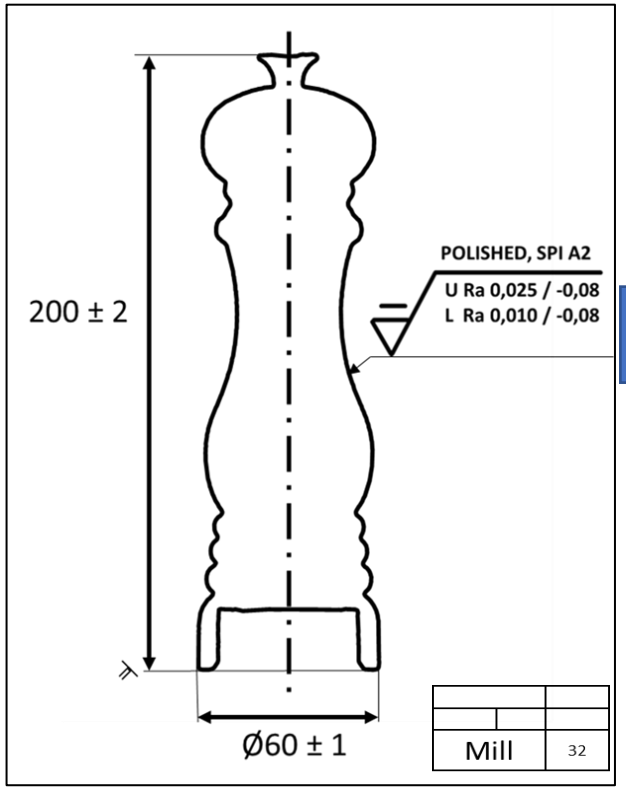
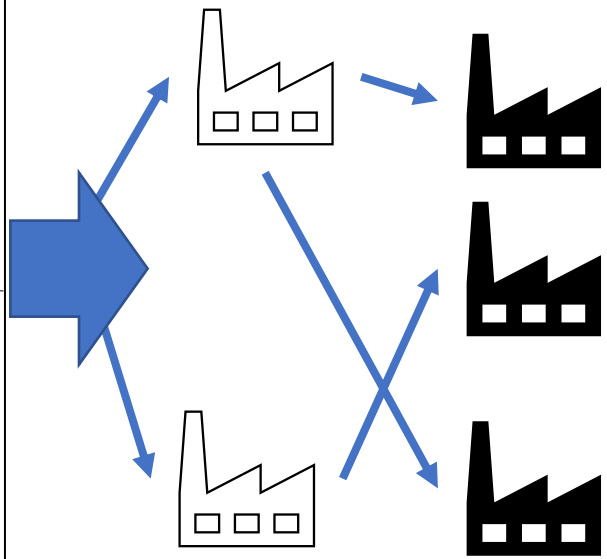
With complete specification of product geometrical deviations, manufacturing companies can communicate and control, correct product quality and avoid surprises

Skin model



Manufacture



Finished workpieces

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GEOMETRICAL PRODUCT SPECIFICATIONS- ISO GPS

The toolbox for specifying and communicating the geometry of products on technical drawings

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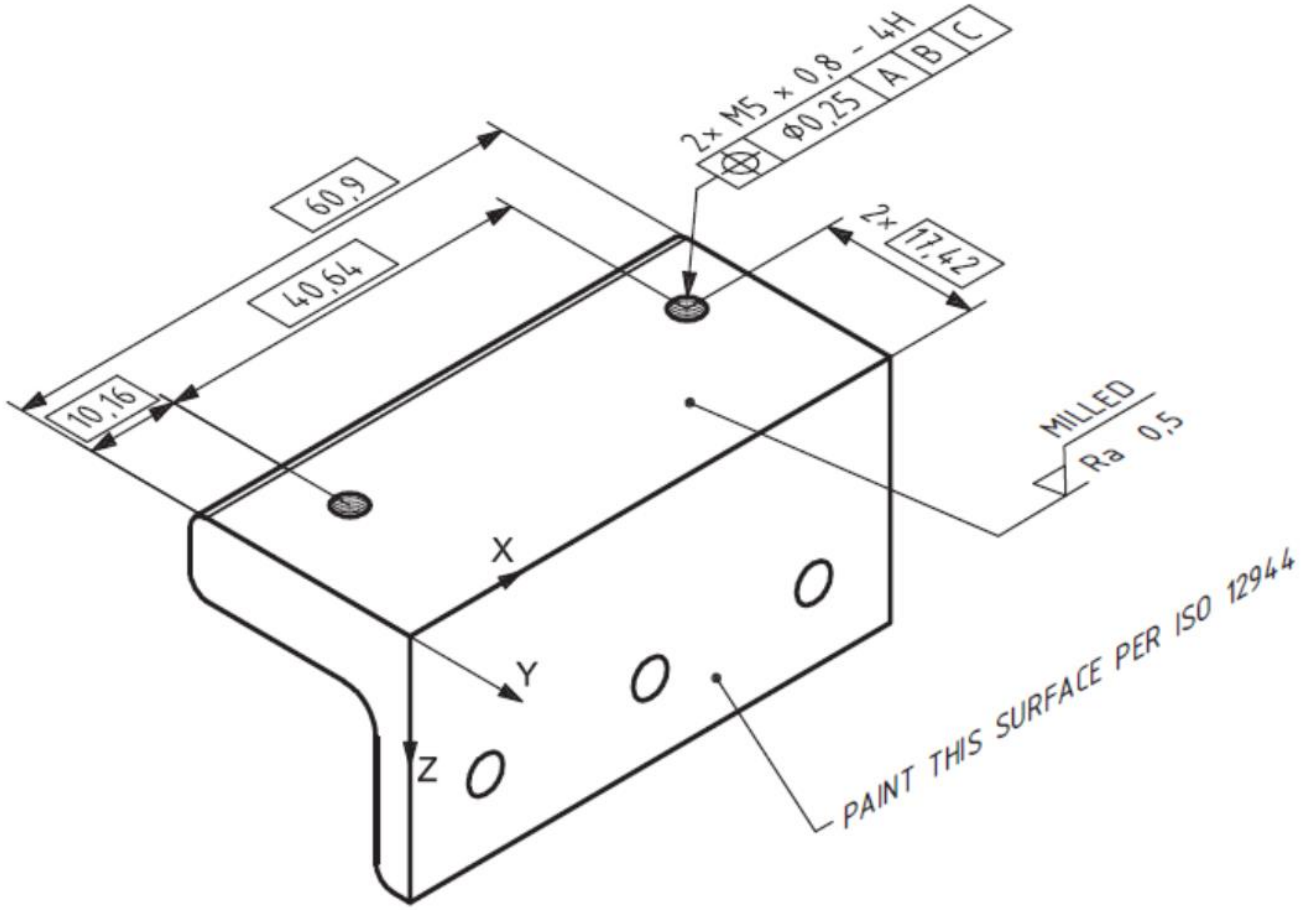
Product geometry and surface texture, are communicated on drawing, using an international symbolic language, called ISO GPS



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ISO GPS: ISO system for geometrical tolerances

The ISO system for geometrical tolerances is called:
"Specification of geometrical specifications and verifications" in brief "ISO GPS“

It has been monitored and developed for thirty years by the ISO/TC 213 Committee
It was previously managed by three separate ISO committees
Currently, it includes about 200 standards

the International Organization for Standardization, own the registered trademarks for their short name, "ISO".

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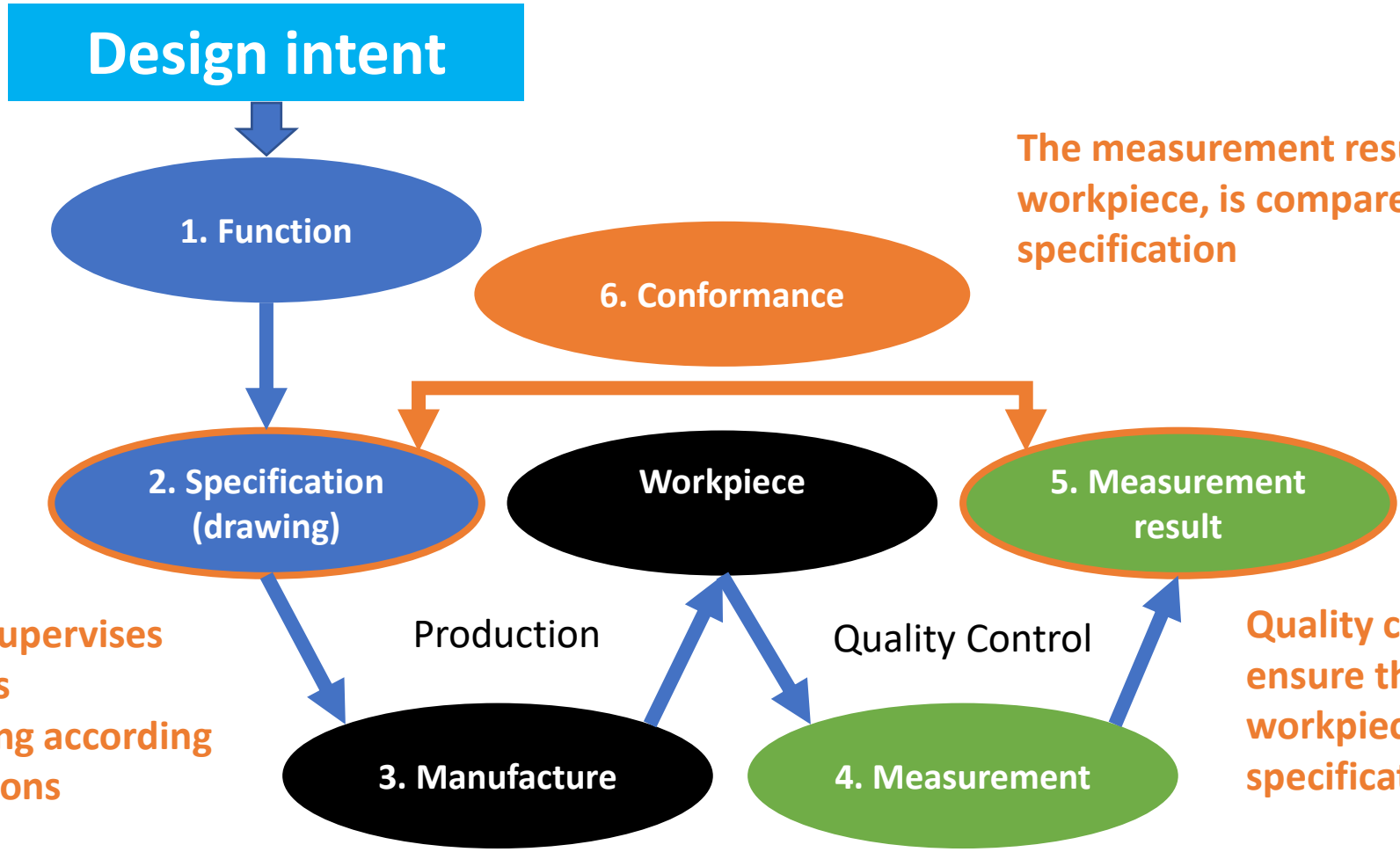
From design to approved product, ISO GPS offers a framework for specifying and verifying product geometry and surface texture on drawing



Designer translates functional requirements into specifications.

The measurement result from finished workpiece, is compared against specification

Production supervises and conducts manufacturing according to specifications

Quality control measure and ensure that processes and workpiece meet product specification

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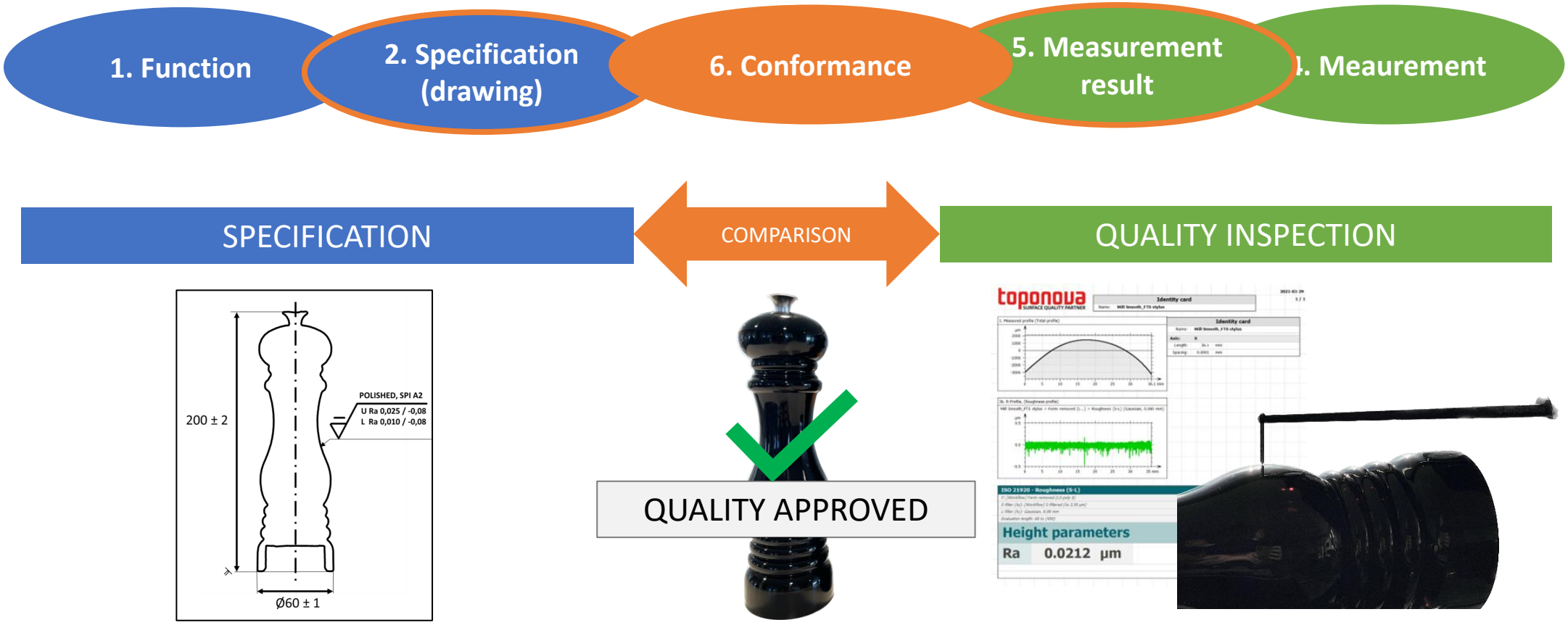
The framework consists of standards, related to specification and verification, as well as how to compare and approve the workpiece



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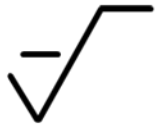
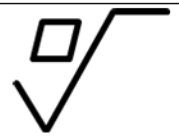
To organize the standards, a matrix of seven chain links is used, where each geometrical characteristic has its own chain of standards covering specification (A-C), verification (E-G) and compliance (D)

TOPONOVA 2023-03-15	Chain links						
	A	B	C	D	E	F	G
	Symbols and indications	Feature requirements	Feature properties	Conformance and non-conformance	Measurement	Measurement equipment	Calibration
Size							
Distance							
Form							
Orientation							
Location							
Run-out							
Profile surface texture							
Areal surface texture							
Surface imperfections							

Surface texture is an example of full ISO GPS chain link with standards covering specification, verification and conformance

TOPONOVA 2023-03-15	Chain links						
	A	B	C	D	E	F	G
	Symbols and indications	Feature requirements	Feature properties	Conformance and non-conformance	Measurement	Measurement equipment	Calibration
Profile surface texture	ISO 21920-1	ISO 21920-2	ISO 21920-3	ISO 14253-xx	ISO 21920-3	ISO 25178-600	ISO 25178-700
			ISO 16610-2x			ISO 25178-6xx	ISO 12179
			ISO 16610-3x				
			ISO 16610-4x				
Areal surface texture	ISO 25178-1	ISO 25178-2	ISO 25178-3	ISO 14253-xx	ISO 25178-3	ISO 25178-600	ISO 25178-700
			ISO 16610-2x			ISO 25178-6xx	
			ISO 16610-3x				
			ISO 16610-4x				

In December 2021, the previous standard for profile surface texture, ISO 1302, withdrawn and replaced by ISO 21920

	toponova ab	Specifikation		ISO GPS Chain: Surface Texture	Verifikation		
	1 Symbols and Indication	2 Feature requirement	3 Feature properties	4 Conformance and non-conformanc	5 Measurement	6 Measurement Equipmer	7 Calibration
Profile surface texture before 2022-01-01	ISO 1302:2002	ISO 4287:1997	ISO 4288:1996	ISO 4288:1996	ISO 4288:1996	ISO 3274:1996	ISO 5436-1:2000
		ISO 4287 Cor 1:1998	ISO 4288 Cor 1:1998	ISO 4288 Cor 1:1998	ISO 4288 Cor 1:1998	ISO 3274 Cor 1:1998	ISO 5436-2:2012
Obsolete 2021-12-31		ISO 4287 Cor 2:2005	ISO 12085:1996	ISO 14253-1:2013	ISO 12085:1996	ISO/TR 14253-6:2012	ISO 12179:2000
		ISO 4287 Amd 1:2009	ISO 12085 Cor 1:1998	ISO 14253-2:2011	ISO 12085 Cor 1:1998	ISO 14406:2010	ISO 12179 Cor 1:2003
		ISO 12085:1996	ISO 13565-1:1996	ISO 14253-2 Cor 1:2013	ISO/TR 14253-6:2012	ISO 14978:2006	ISO 14978:2006
		ISO 12085 Cor 1:1998	ISO 13565-1 Cor 1:1998	ISO 14253-3:2011	ISO/TR 16015:2003	ISO 14978 Cor 1:2008	ISO 14978 Cor 1:2008
		ISO 13565-1:1996	ISO/TS 14253-4:2013 rules	ISO/TS 14253-4:2013		ISO/TR 16015:2003	ISO/TR 16015:2003
		ISO 13565-1 Cor 1:1998	ISO 14406:2010	ISO/TR 14253-6:2012		ISO/TS 16610-1:2006	
		ISO 13565-2:1996	ISO/TS 16610-1:2006			ISO/TS 16610-20:2006	
		ISO 13565-2 Cor 1:1998	ISO/TS 16610-20:2006			ISO 16610-21:2011	
		ISO 13565-3:1998	ISO 16610-21:2011			ISO/TS 16610-22:2006	
			ISO/TS 16610-22:2006			ISO/TS 16610-28:2010	
			ISO/TS 16610-28:2010			ISO/TS 16610-29:2006	
			ISO/TS 16610-29:2006			ISO/TS 16610-30:2009	
			ISO/TS 16610-30:2009			ISO/TS 16610-31:2010	
			ISO/TS 16610-31:2010			ISO/TS 16610-32:2009	
			ISO/TS 16610-32:2009			ISO/TS 16610-40:2006	
			ISO/TS 16610-40:2006			ISO/TS 16610-41:2006	
			ISO/TS 16610-41:2006			ISO/TS 16610-49:2006	
			ISO/TS 16610-49:2006			ISO 16610-71:2014	
			ISO 16610-71:2014			ISO 16610-85:2013	
			ISO 16610-85:2013				

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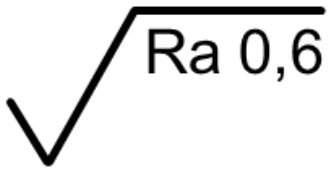
New symbol for profile surface texture is introduced with ISO 21920-1

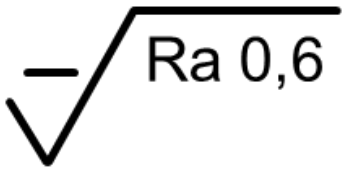
Profile surface texture symbols



ISO 1302

Old and withdrawn 2021-12-31

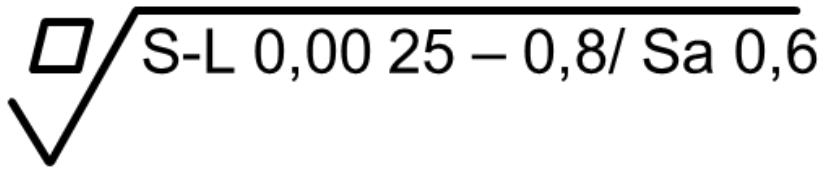
NEW!



ISO 21920

New 2022-01-01

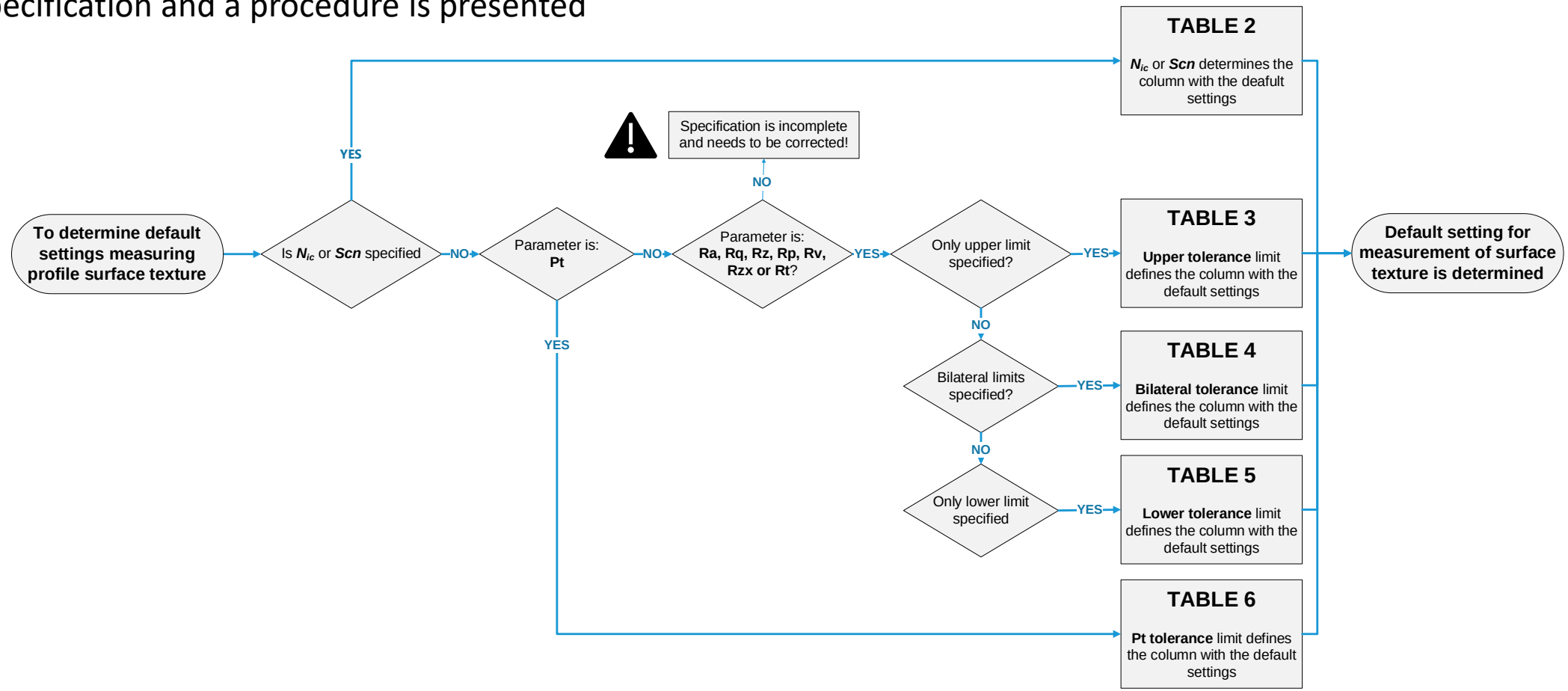
Areal (3D) surface texture symbol



ISO 25178

Most important change is that specification on drawing defines default settings for measurement

- In new ISO 21920-3, default measurement settings are defined by drawing specification and a procedure is presented



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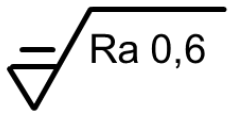
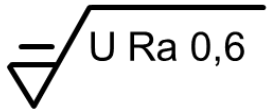
Example in new ISO 21920-3, default settings for measurement of Rz, Ra, Rp, Rv, Rq, Rzx and Rt given with upper tolerance

Table 3

Upper tolerance limit defines the column with the default settings: **Ra, Rq, Rz, Rp, Rv, Rzx och Rt**





	Setting class				
	Sc1	**Sc2**	**Sc3**	**Sc4**	**Sc5**
Specified parameter	**Upper tolerance limit (U) of the specified parameter**				
Rz, µm	U ≤ 0,16	0,16 < U ≤ 0,8	0,8 < U ≤ 16	16 < U ≤ 80	U > 80
Ra, µm	U ≤ 0,02	0,02 < U ≤ 0,1	0,1 < U ≤ 2	2 < U ≤ 10	U > 10
Rp, µm	U ≤ 0,06	0,06 < U ≤ 0,3	0,3 < U ≤ 6	6 < U ≤ 30	U > 30
Rv, µm	U ≤ 0,10	0,10 < U ≤ 0,5	0,5 < U ≤ 10	10 < U ≤ 50	U > 50
Rq, µm	U ≤ 0,032	0,032 < U ≤ 0,16	0,16 < U ≤ 3,2	3,2 < U ≤ 16	U > 16
Rzx, µm	U ≤ 0,23	0,23 < U ≤ 1,15	1,15 < U ≤ 23	23 < U ≤ 115	U > 115
Rt, µm	U ≤ 0,26	0,26 < U ≤ 1,3	1,3 < U ≤ 26	26 < U ≤ 130	U > 130
Profile L-filter nesting index N_{ic} (cut-off λ_c) mm	0,08	0,25	0,8	2,5	8

	Setting class				
	Sc1	**Sc2**	**Sc3**	**Sc4**	**Sc5**
Evaluation length l_e, mm	0,4	1,25	4	12,5	40
Profile S-filter nesting index N_{is} (cut-off λ_s) µm	2,5	2,5	2,5	8	25
Maximum sampling distance d_x µm	0,5	0,5	0,5	1,5	5
Maximum nominal tip radius r_{tip} µm	2	2	2	5	10
Only for section length parameters, for example Rz, Rp, Rv					
Section length l_{sc} mm	0,08	0,25	0,8	2,5	8
Number of sections n_{sc}	5	5	5	5	5

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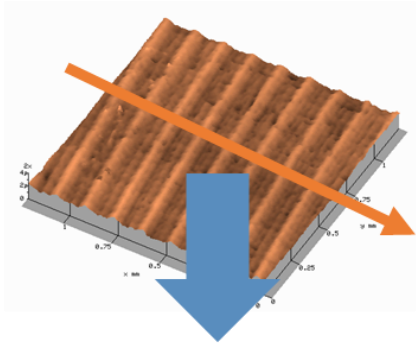
In old standard, ISO 1302 and 4288, default settings for verification were defined by measuring on workpiece and introduced verification uncertainty

SURFACE ROUGHNESS TO BE MEASURED
-selection of measuring conditions by measuring on test object

Periodic profiles

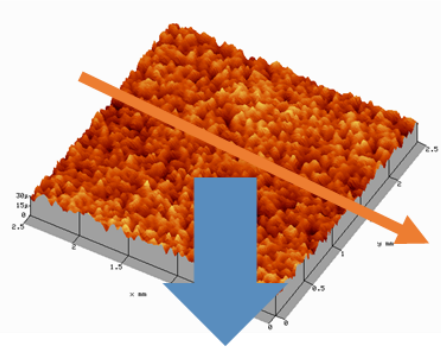


Mean spacing of roughness profile elements

Measuring conditions, ISO 4288; 3274

Filter cut-off:	**Lc**
Filter cut-off:	**Ls**
Sampling length:	**lr**
Evaluation length:	**ln**
Tracing length:	**lt**
Stylus tip radius (max)	**rtip max**
Max sampling distance	**dx max**

Non-periodic profiles



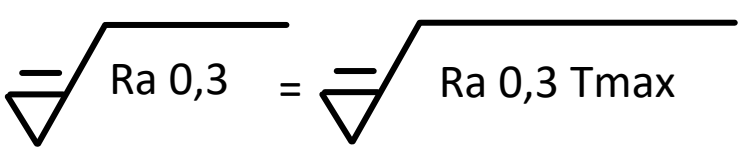
Ra, Rq, Rsk, Rku, Rdq and material ratio curve parameters

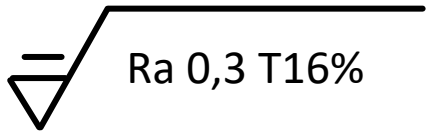
or

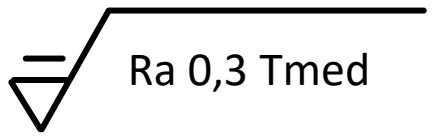
Rz, Rv, Rp, Rc and Rt

RSm (mm)	Lc (mm)	Ls (µm)	lr / ln / lt (mm)	rtip max / dx max (µm)	Ra (µm)	Rz (µm)
> 0,013-0,04	0,08	2,5	0,08 / 0,40 / 0,48	2 / 0,5	> 0,006-0,02	> 0,025-0,1
> 0,04-0,13	0,25	2,5	0,25 / 1,25 / 1,50	2 / 0,5	> 0,02- 0,1	> 0,1-0,5
> 0,13-0,4	0,8	2,5	0,80 / 4,00 / 4,80	2 or 5 / 0,5	> 0,1- 2,0	> 0,5-10
> 0,4-1,3	2,5	8	2,50 / 12,5 / 15,0	5 /1,5	>2,0-10,0	> 10-50
> 1,3-4,0	8	25	8,00 / 40,0 / 48,0	10 / 5,0	>10,0-80,0	> 50-200

Second import change with ISO 21920-3, is that default tolerance acceptance rule is changed to ”max” rule







Tmax	T16%	Tmed
”Max” rule **DEFUALT RULE IF NOT SPECIFIED**	**”16 %” rule**	**”Median” rule**
According to the MAX rule, no measured value may exceed the specification.	According to the 16% rule. First value must not exceed 70% of specified value.	According to the median rule, the median of all measured values must meet the specification.
The max rule is the default and applies with or without the 'Tmax' symbol	The 16% rule only applies if the 'T16%' symbol is specified	At least three measured values shall be used to apply the Median rule. If the median value for more measurements is to be used, this may be specified as "other requirements", ORn
The `Tmax' symbol is used to avoid misunderstanding of the specification.	In ISO 1302, 16% is the default, even if it is not specified	The median rule applies when the 'Tmed' symbol is specified in the specification

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With the ISO GPS toolbox, manufacturing companies have access to standardized tools to specify and control product geometry on drawing and avoid quality surprises

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