

Investigation of detail resolution on basic shapes and development of design rules

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Test conditions and test geometries describe the general test frame

Test conditions

Maschine / Layer thickness

- P390 / 0.15mm

Material

- PA2200

Exposure Type

- Mechanic standard

PSW3.3

Material dependent scaling

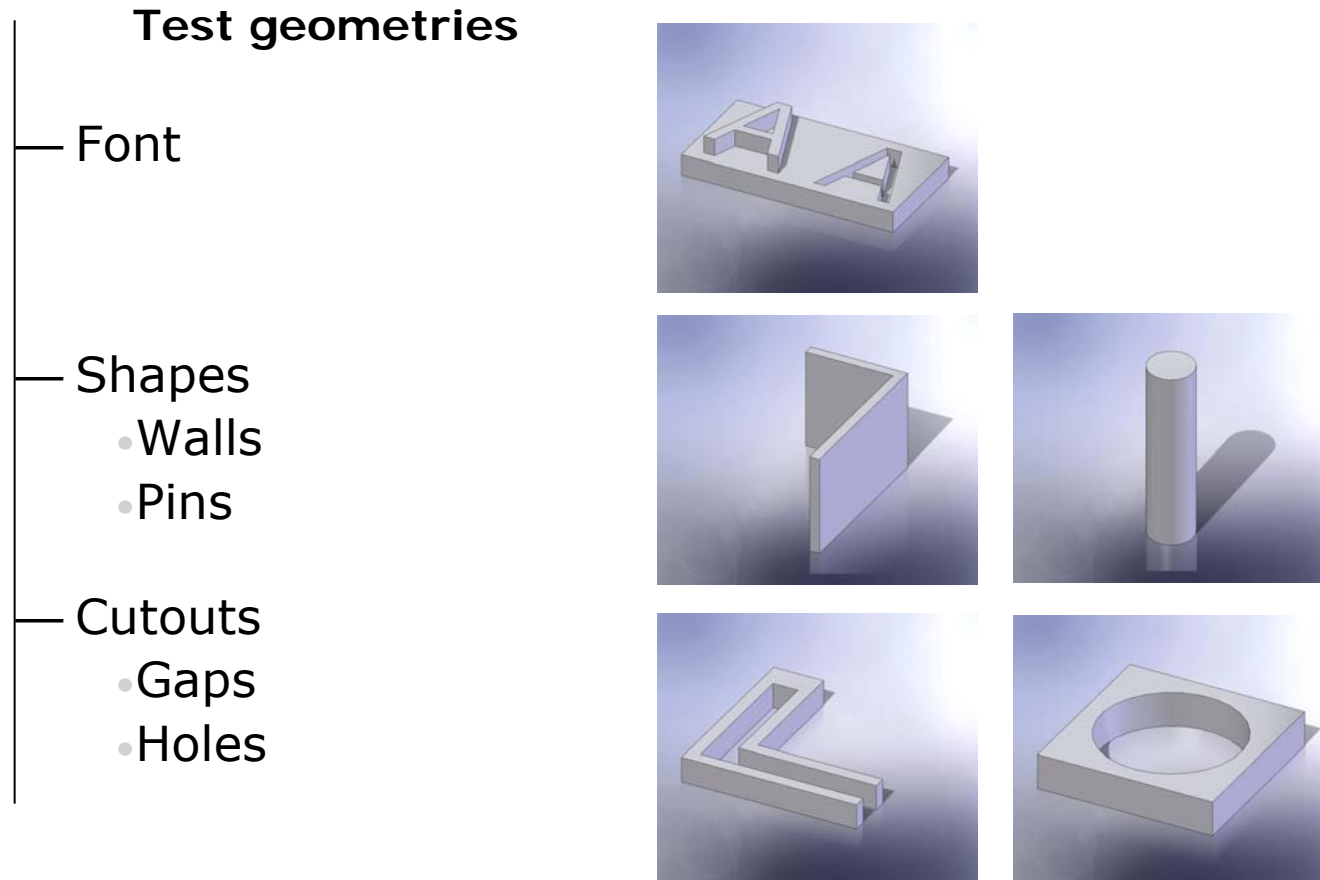
- X: 3.2%
- Y: 3.2%
- Z (0): 2.2%
- Z (600): 1.6%

Beam offset

- 0.33mm



Test conditions and test geometries describe the general test frame



Please see test parts to judge the labeling quality



Font test specifications

Font type

- Arial

Small font size

- 8pt to 14pt

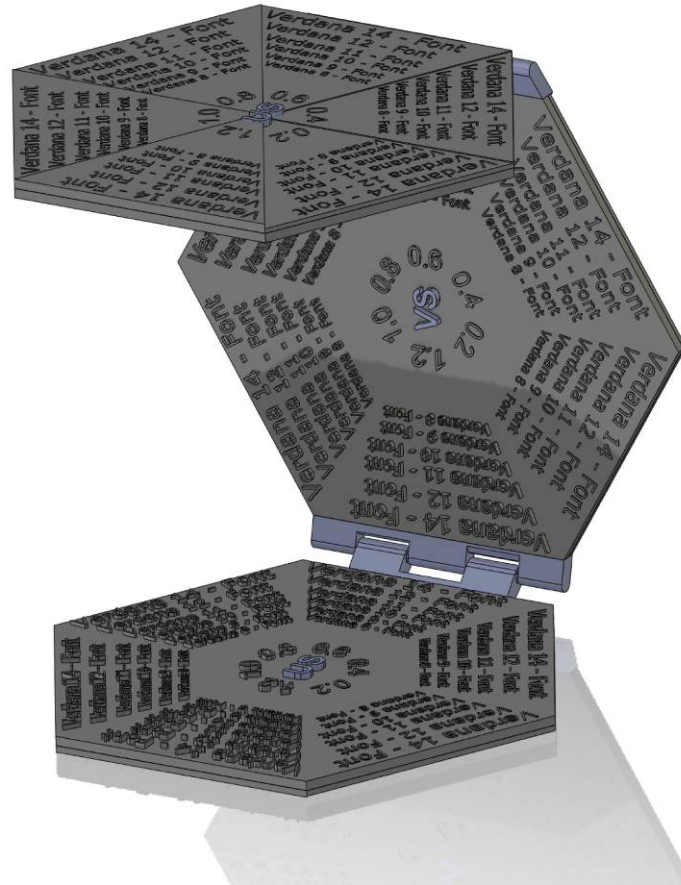
Letter height outside & inside

- 0.2mm to 1.2mm

Orientation

- Vertical
- Horizontal UpSkin
- Horizontal DownSkin

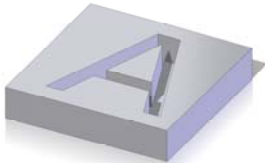
Test results subjective



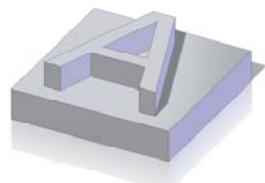
VerticalSkin orientation offers very detailed labeling quality



Design Chart - VerticalSkin



vs		inside [mm]													
		>1,2	1,2	1,1	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	>0,1
font size [pt]	<6														
	6														
	8		Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	9		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	10		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	11		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	12		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	14		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	>14														

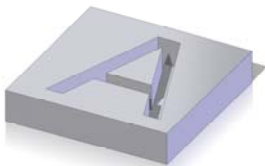


vs		outside [mm]													
		>1,2	1,2	1,1	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	>0,1
font size [pt]	<6														
	6														
	8		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	9		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	10		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	11		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	12		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	14		Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	>14														

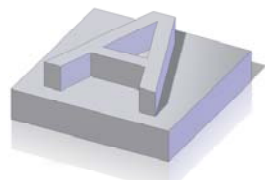
Font in UpSkin orientation shows rather low labeling quality



Design Chart - upskin



US		inside [mm]													
		>1,2	1,2	1,1	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	>0,1
font size [pt]	<6														
	6														
	8		Red		Red		Red		Red		Red		Red		
	9		Red		Red		Red		Red		Red		Red		
	10		Red		Red		Red		Red		Red		Red		
	11		Red		Red		Red		Red		Red		Red		
	12		Red		Red		Red		Red		Red		Red		
	14		Red		Yellow		Yellow		Yellow		Yellow		Yellow		
	>14														

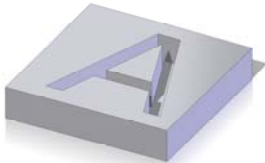


US		outside [mm]													
		>1,2	1,2	1,1	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	>0,1
font size [pt]	<6														
	6														
	8		Red		Red		Red		Red		Red		Red		
	9		Red		Red		Red		Red		Red		Red		
	10		Red		Red		Red		Red		Red		Red		
	11		Red		Red		Red		Red		Red		Red		
	12		Red		Red		Red		Red		Red		Red		
	14		Green		Green		Green		Green		Green		Green		
	>14														

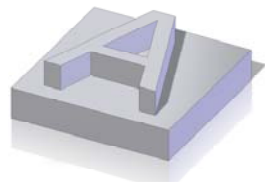
Font in DownSkin orientation shows good labeling quality



Design Chart - Downskin

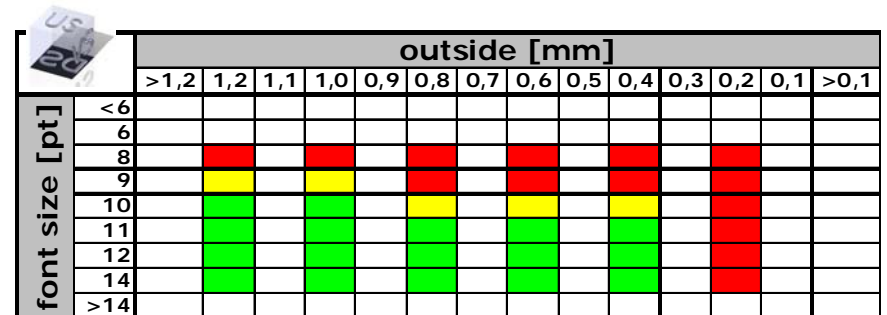
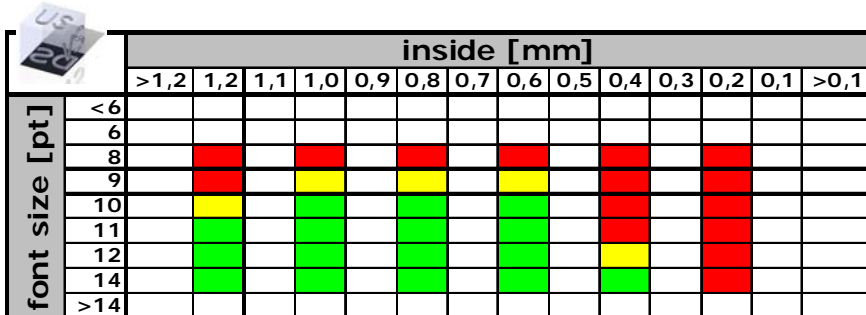
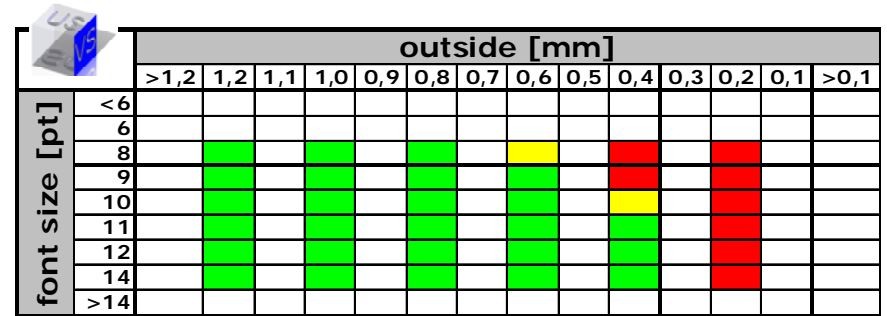
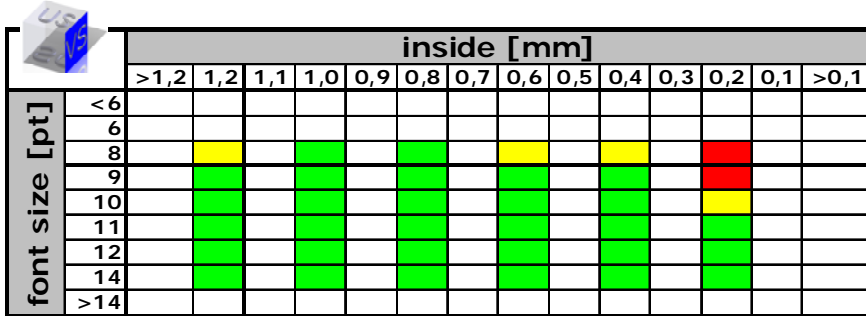
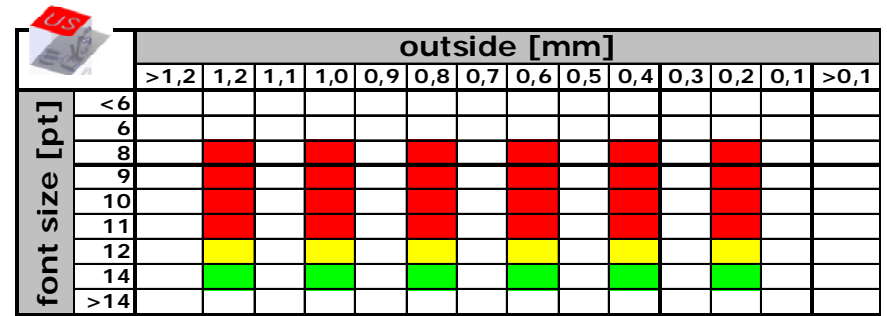
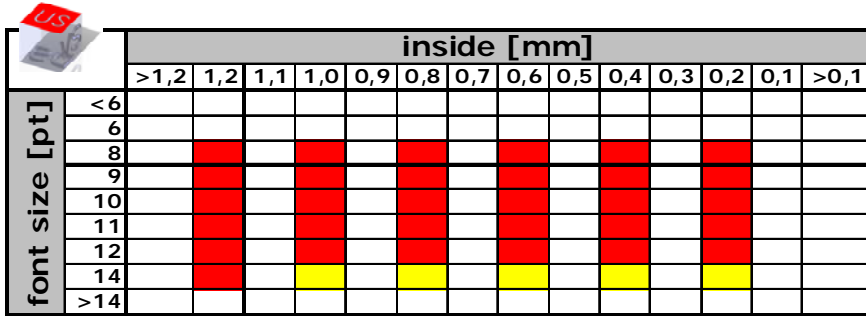


DS		inside [mm]													
		>1,2	1,2	1,1	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	>0,1
font size [pt]	<6														
	6														
	8		Red		Red		Red		Red		Red		Red		
	9		Red		Yellow		Yellow		Yellow		Red		Red		
	10		Yellow		Green		Green		Green		Red		Red		
	11		Green		Green		Green		Green		Red		Red		
	12		Green		Green		Green		Green		Yellow		Red		
	14		Green		Green		Green		Green		Green		Red		
	>14														



DS		outside [mm]													
		>1,2	1,2	1,1	1,0	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	>0,1
font size [pt]	<6														
	6														
	8		Red		Red		Red		Red		Red		Red		
	9		Yellow		Yellow		Red		Red		Red		Red		
	10		Green		Green		Yellow		Yellow		Yellow		Red		
	11		Green		Green		Green		Green		Green		Red		
	12		Green		Green		Green		Green		Green		Red		
	14		Green		Green		Green		Green		Green		Red		
	>14														

Overview of inside & outside font in all basic orientations



Summary Fonts



- Higher detail resolution on VerticalSkin and DownSkin
- Design chart is a suggestion how required information for designers can look like
- Are you interested in the test geometry ?

The analysis of basic shapes creates fundamental design information

Wall test specifications

Wall thickness

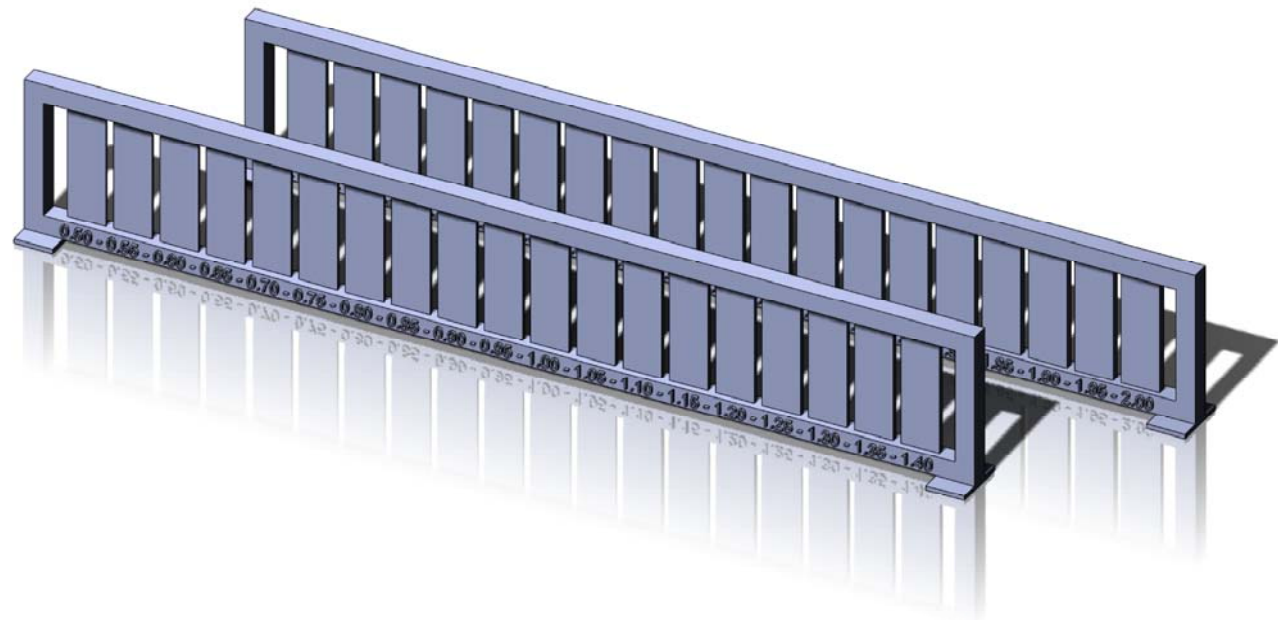
- 0.50mm to 2.00mm
- in 0.05mm steps

Orientation

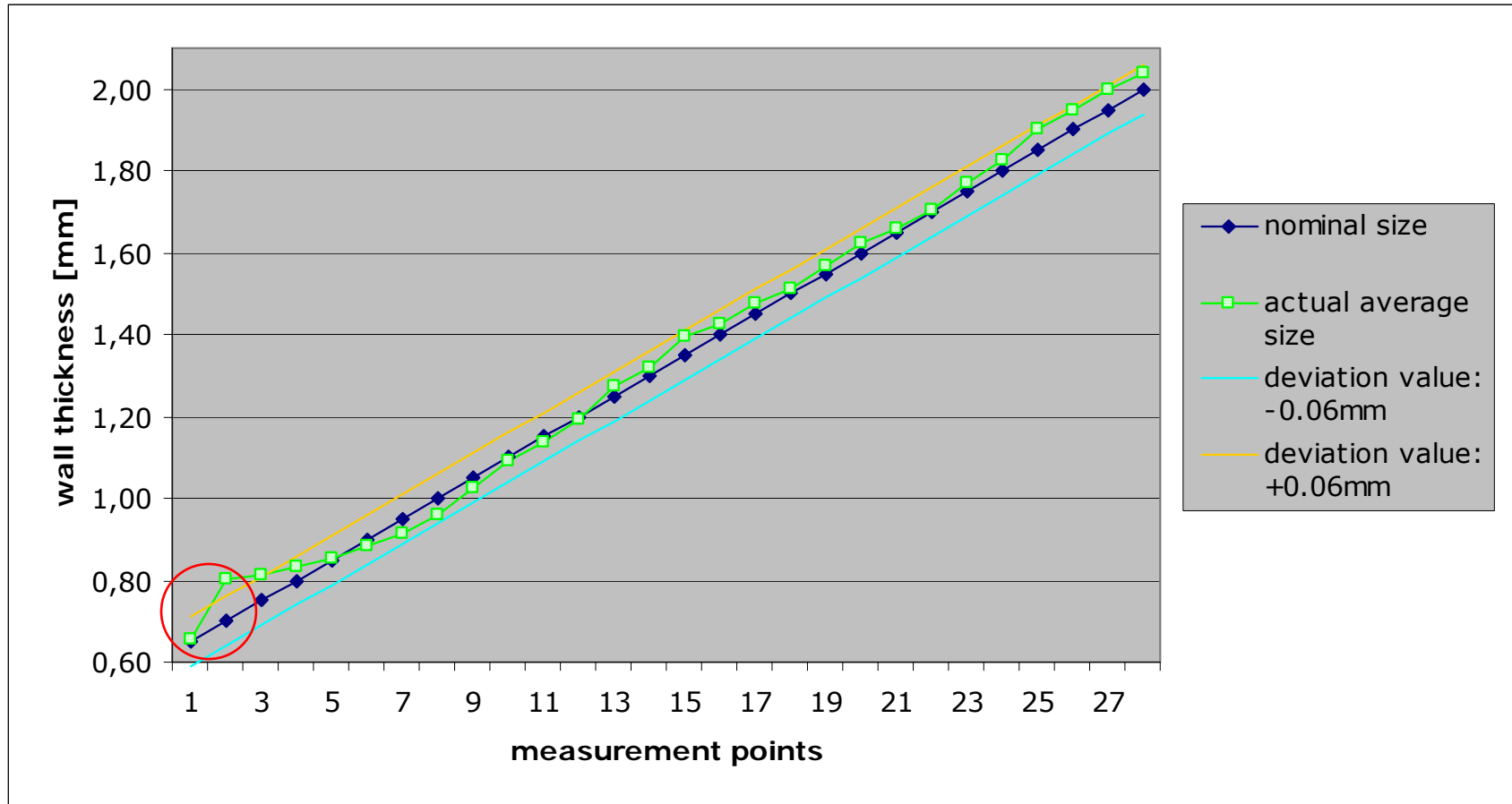
- Vertical

Position

- X-direction
- Y-direction
- 30° to X-direction



The investigated test parts showed a max. deviation of $\pm 0.06\text{mm}$



Switch from edge to contour exposure increase deviation up to 0.1mm



Exposure type:

Edge

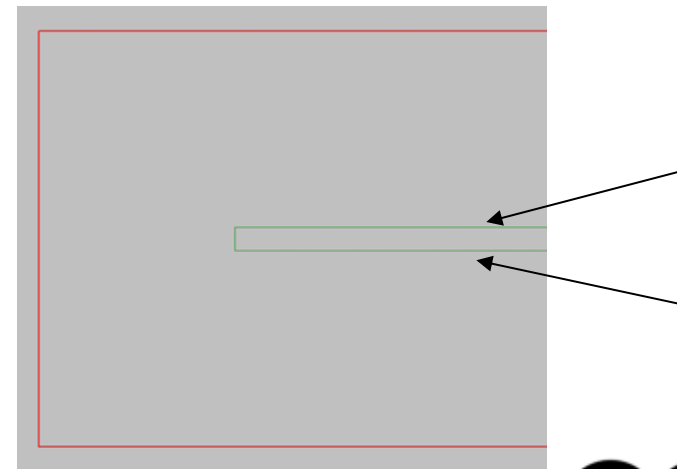
Nominal geometry

Contour

Wall thickness:

0.65mm

0.70mm



Summary walls



- Reliable minimum value: $\geq 0.80\text{mm}$
- Maximum deviation $\pm 0.06\text{mm}$
- Keep in mind that switch from edge to contour can cause higher deviation

The analysis of basic shapes creates fundamental design information

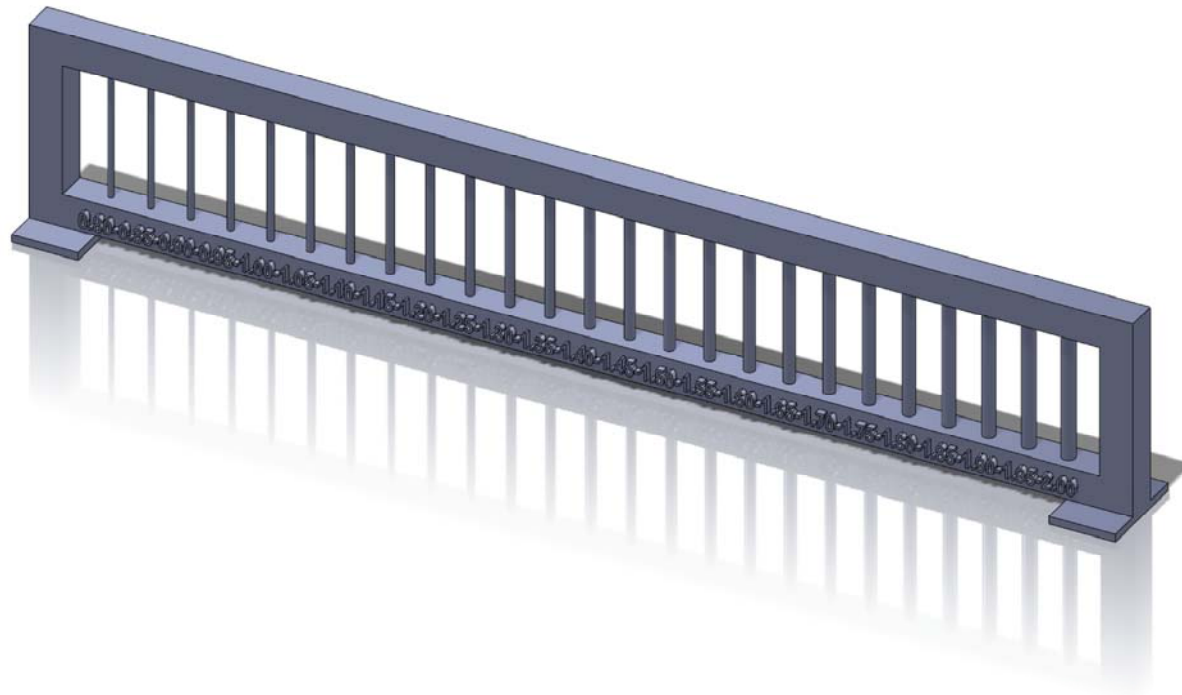
Pins test specifications

Pin diameter

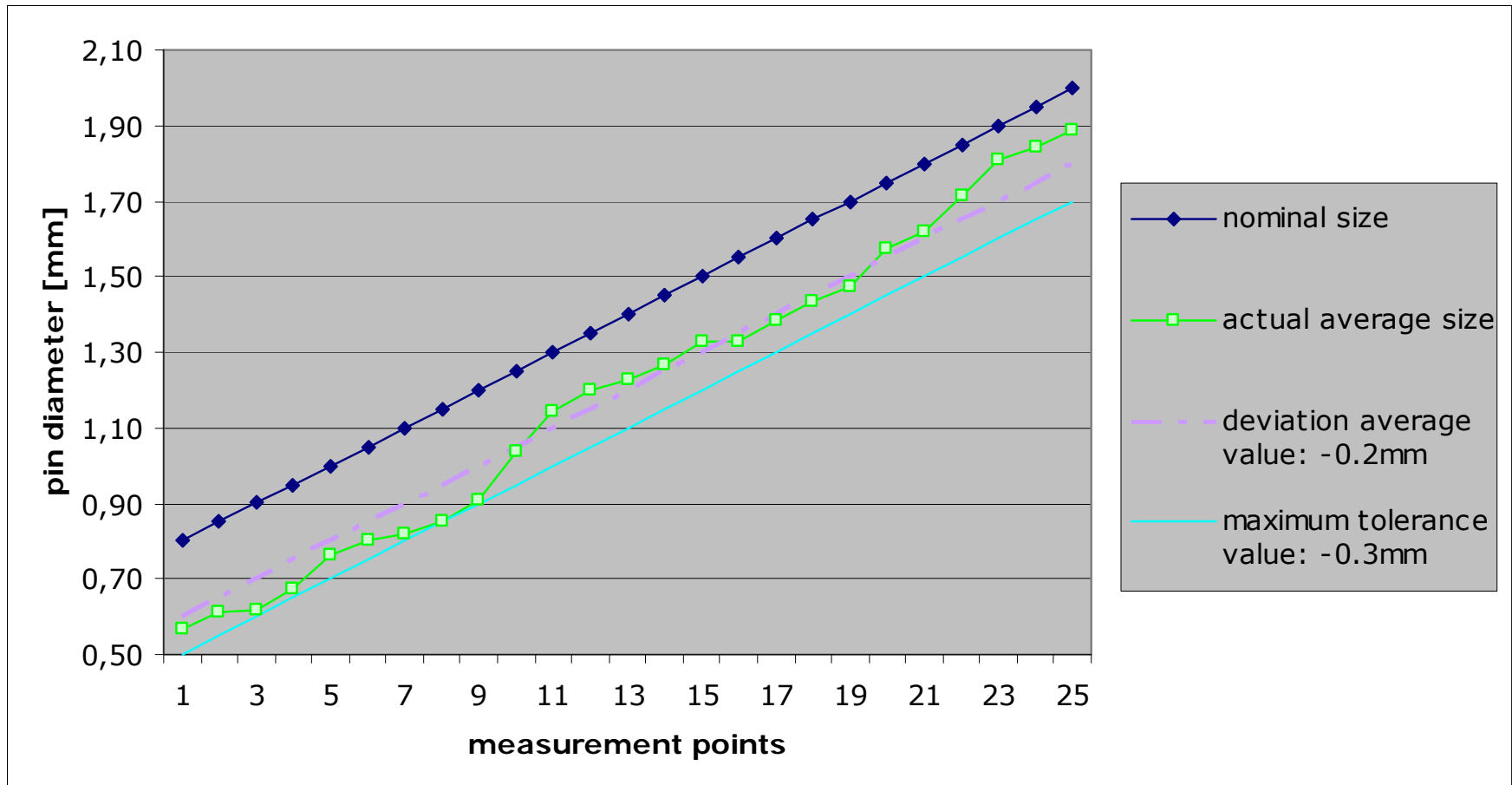
- 0.80mm to 2.00mm
- In 0.05mm steps

Orientation

- Vertical



The investigated pins showed an average deviation of -0.2mm



Summary pins



- Reliable minimum diameter: $\geq 0.8\text{mm}$
- Average deviation: -0.2mm
- Maximum deviation value: -0.3mm
- Smaller diameters can produce unexpected results

The analysis of basic shapes creates fundamental design information

Gap test specifications

Gap size

- Length: 10mm
- Width: 0.50mm to 2.00mm
- in 0.1mm steps

Wall thickness

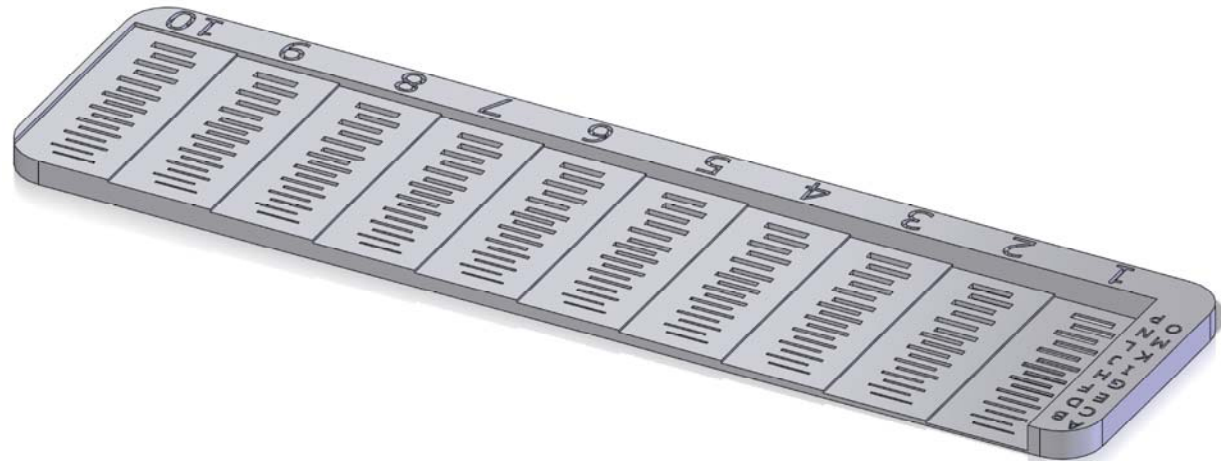
- 0.30mm to 6.00mm

Orientation

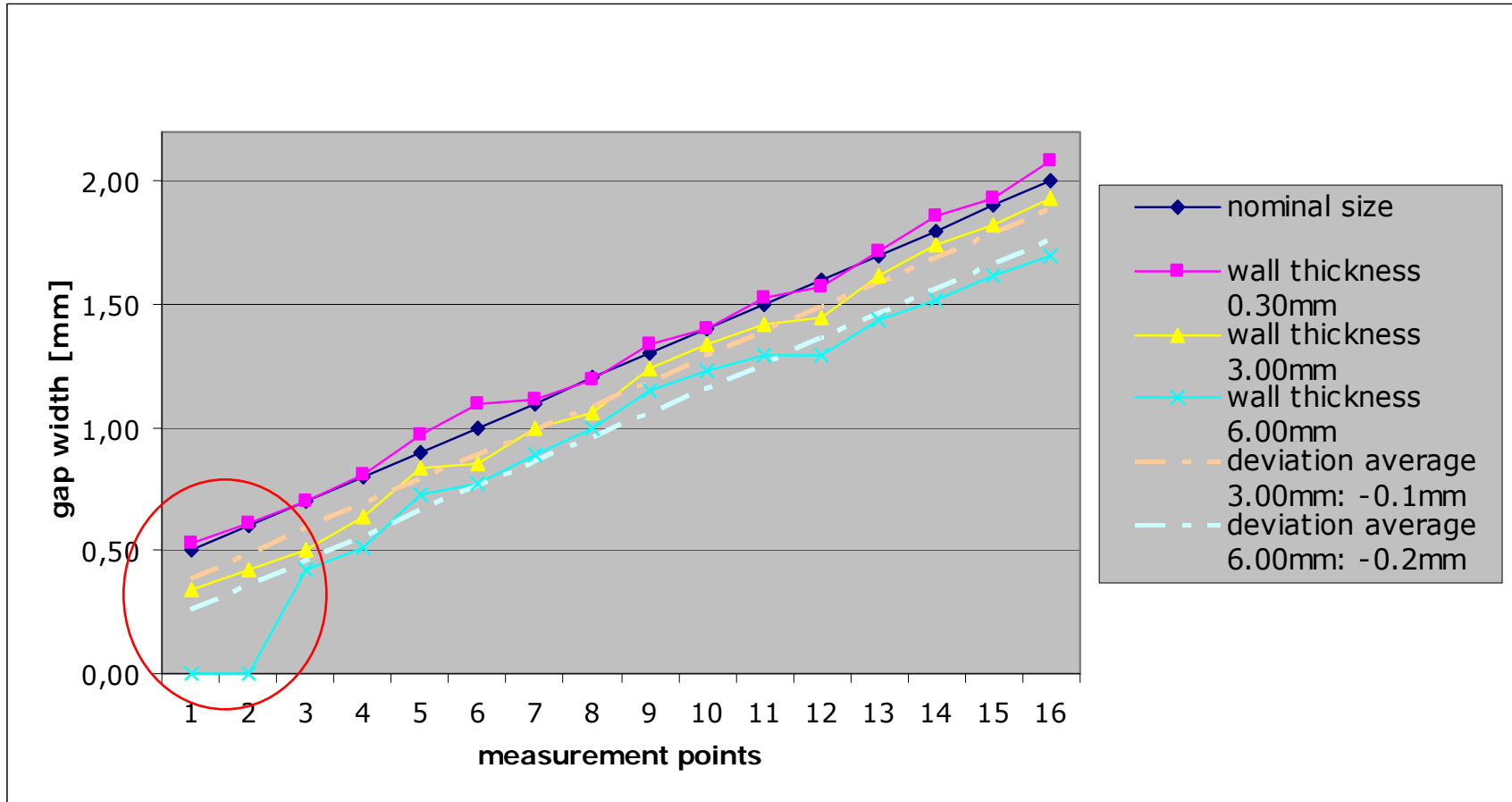
- Horizontal

Position

- X-direction
- Y-direction
- 30° to X-direction



The gap deviation rises with increasing wall thickness

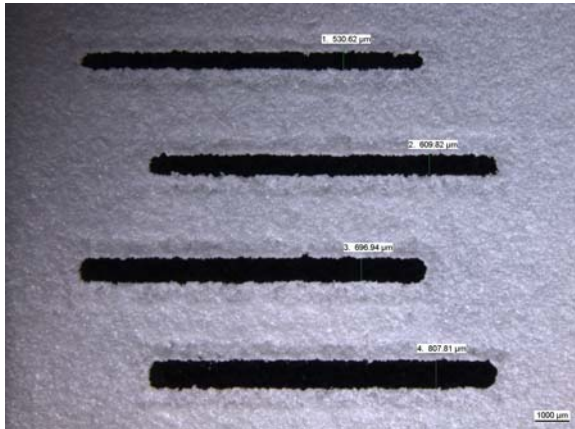


The gap deviation rises with increasing wall thickness

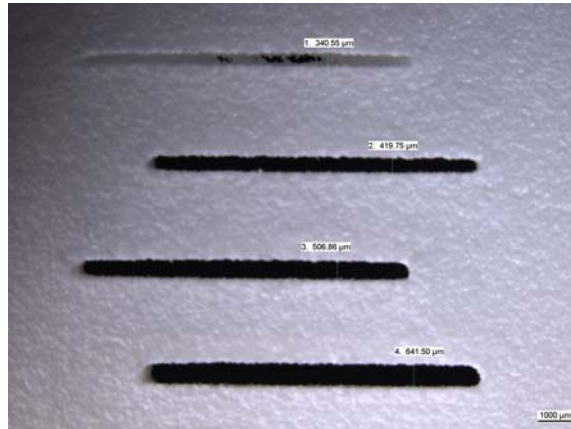


Gap width [mm]:

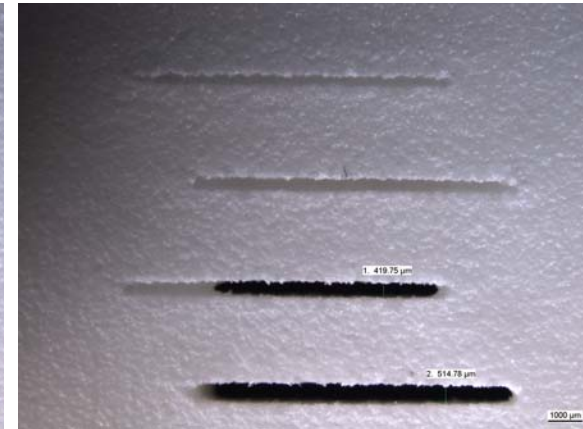
0.5
0.6
0.7
0.8



Wall thickness: 0.30mm



3.00mm



6.00mm

The design chart shows the usable area in the relation gap size/ wall thickness



		Wall thickness [mm]																				
		0,3	0,6	0,9	1,2	1,5	1,8	2,1	2,4	2,7	3,0	3,3	3,6	3,9	4,2	4,5	4,8	5,1	5,4	5,7	6,0	
gap width [mm]	0,5																					
	0,6																					
	0,7																					
	0,8																					
	0,9																					
	1,0																					
	1,1																					
	1,2																					
	1,3																					
	1,4																					
	1,5																					
	1,6																					
	1,7																					
	1,8																					
1,9																						
2,0																						

Summary gaps



- reduce wall thickness for higher detail resolution
- Gap quality is a function of gap size/ wall thickness
- Design chart shows performance of gap in order to remove loose powder

The analysis of basic shapes creates fundamental design information

Hole test specifications

Hole diameter

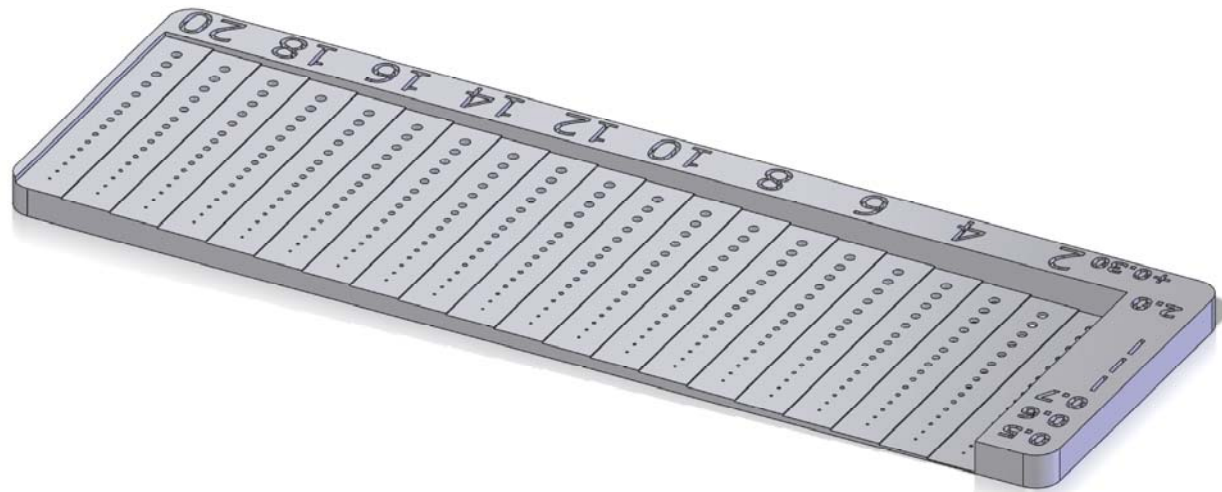
- 0.50mm to 2.00mm
- in 0.1mm steps

Wall thickness

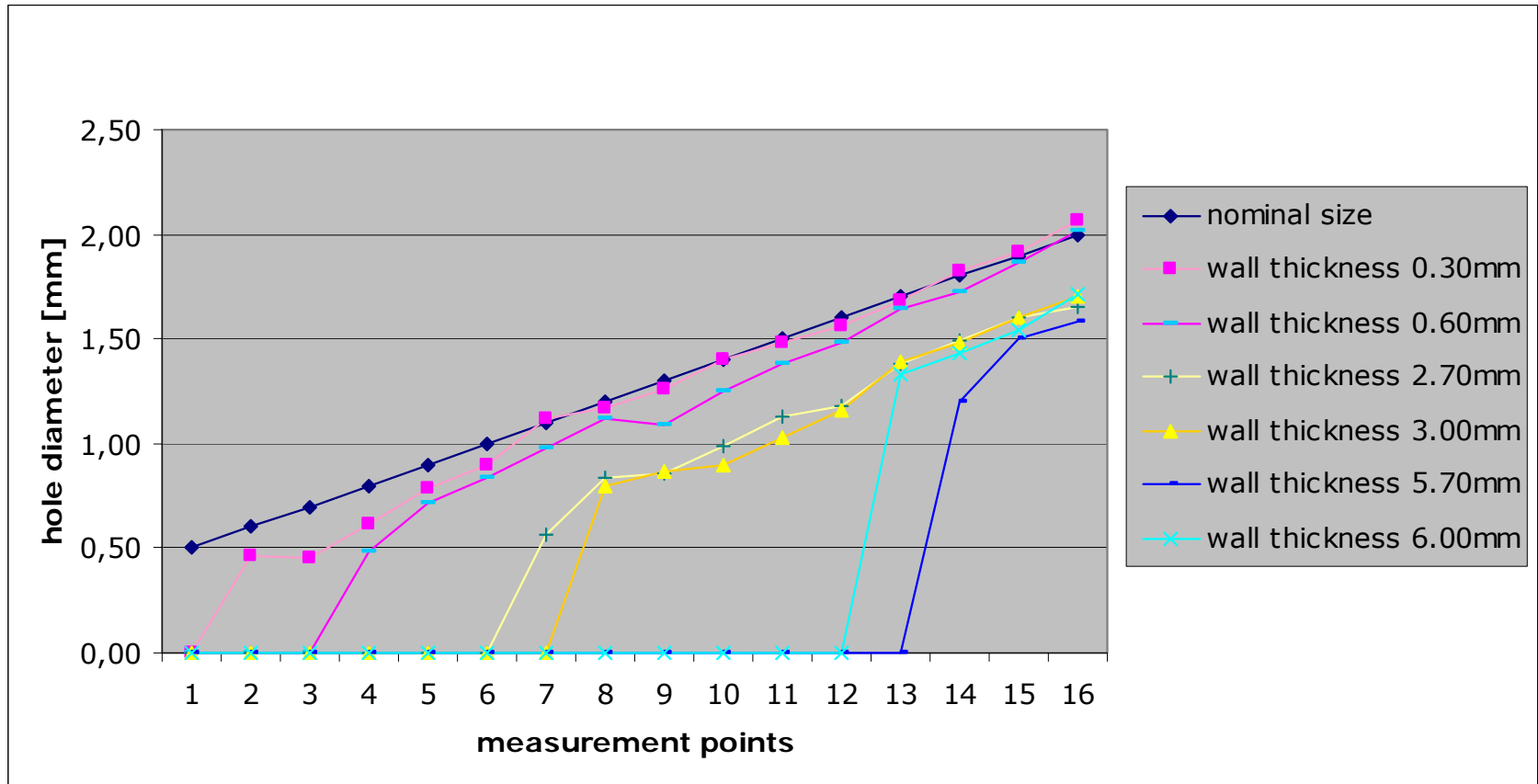
- 0.30mm to 6.00mm
- in 0.3mm steps

Orientation

- Horizontal



The hole accuracy depends heavily on the wall thickness



The hole accuracy depends heavily on the wall thickness



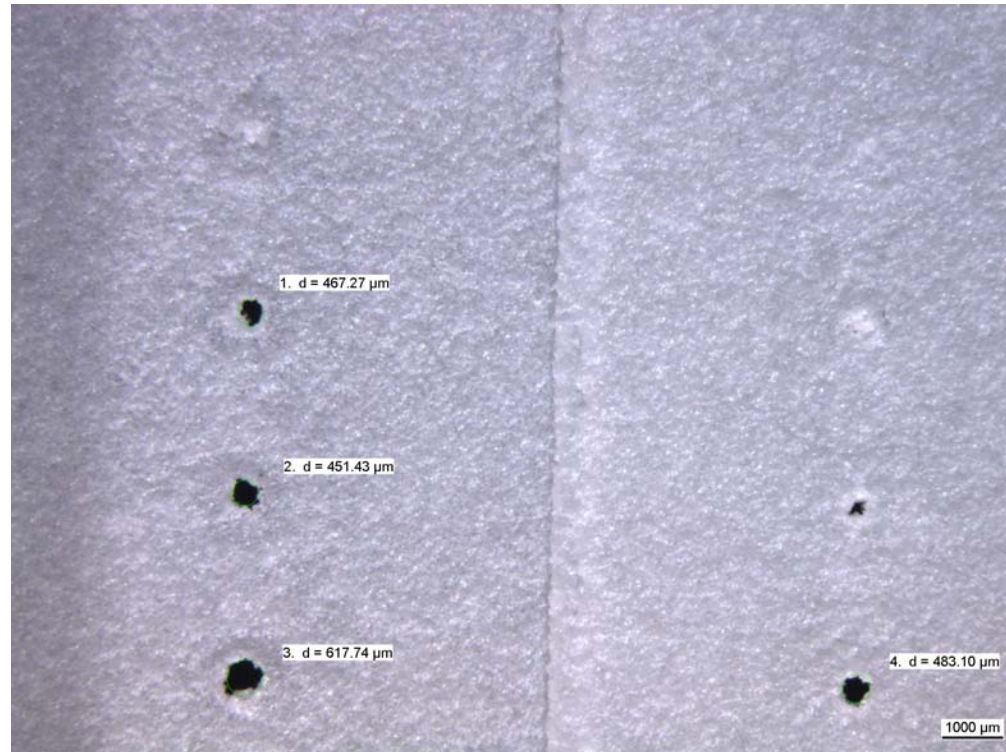
Hole diameter:

0.5mm

0.6mm

0.7mm

0.8mm



Wall thickness: 0.30mm

0.60mm

The design chart shows the usable area in the relation wall thickness / hole size

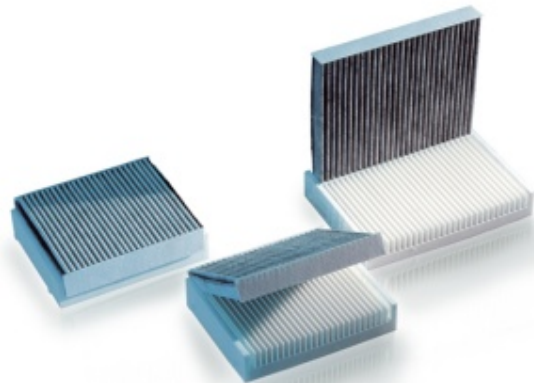


		Wall thickness [mm]																				
		0,3	0,6	0,9	1,2	1,5	1,8	2,1	2,4	2,7	3,0	3,3	3,6	3,9	4,2	4,5	4,8	5,1	5,4	5,7	6,0	
diameter [mm]	0,5	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	
	0,6	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	0,7	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	0,8	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	0,9	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	1,0	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	1,1	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	1,2	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	1,3	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	1,4	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	1,5	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red	Red
	1,6	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red	Red
	1,7	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Red	Red
	1,8	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red	Green
	1,9	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
2,0	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	

Summary holes



- For higher detail resolution reduce wall thickness or rather increase hole diameter
- Be aware of close relationship between hole diameter and wall thickness
- More investigation to express this function as an aspect ratio summarize in one number



Any shape • Anytime • Anywhere

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