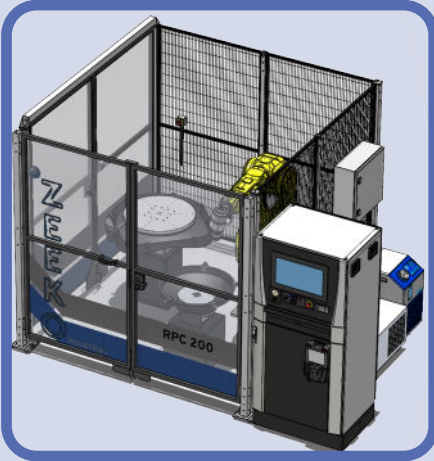


Micron perfect polishing - From your existing CNC Machinery



**Shape Adaptive Grinding
(SAG)**

**Robot Polishing Cell
(RPC)**

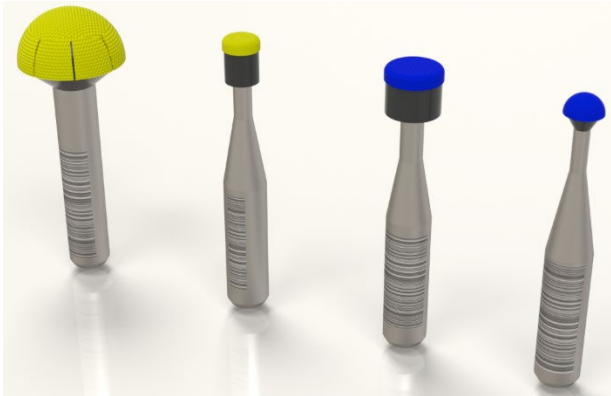
ZephyrCAM Software

Contents

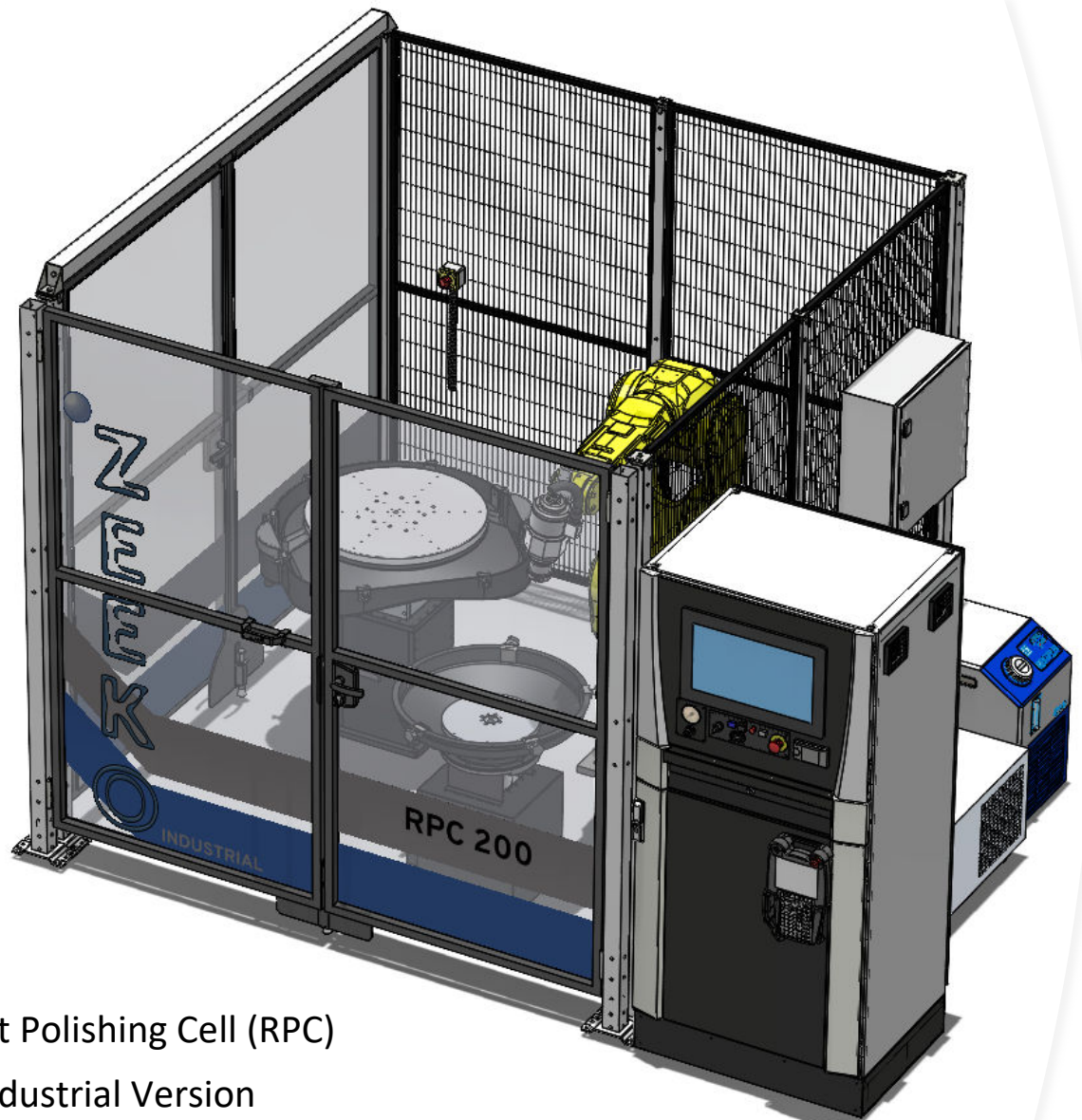
1. Introduction	3
2. ZephyrCAM Software Range	4
3. Robot Polishing Cell (RPC) Industrial Range	5
4. What is the Zephyr SAG process?	6
5. SAG Tool Structure	8
6. SAG Cloths.....	9
7. Tool Geometries.....	11
8. How to choose a tool?	12
9. ZephyrSAG Range.....	14
10. Zephyr Polishing Range.....	18
11. Safe Process Parameters.....	22
12. Accessories.....	25
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13. CONSTANT FORCE TOOL	Error! Bookmark not defined.

1. Introduction

This booklet is a starters guide to the ZephyrCAM SAG process as developed by Zeeko Ltd. This guide will allow users to understand the benefits of the ZephyrCAM SAG process, as well how to run the process and which tools to use and when.



SAG Tools



Robot Polishing Cell (RPC)
- Industrial Version

2. ZephyrCAM Software Range



ZephyrCAM Pro



ZephyrCAM Industrial Plus

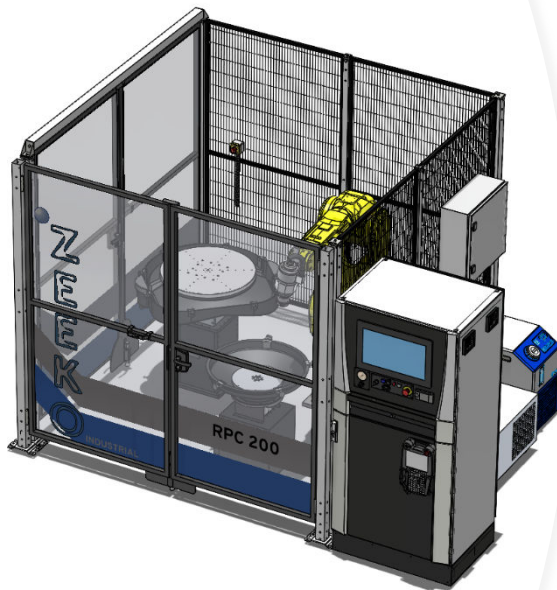


ZephyrCAM for Robots



ZephyrCAM Lite

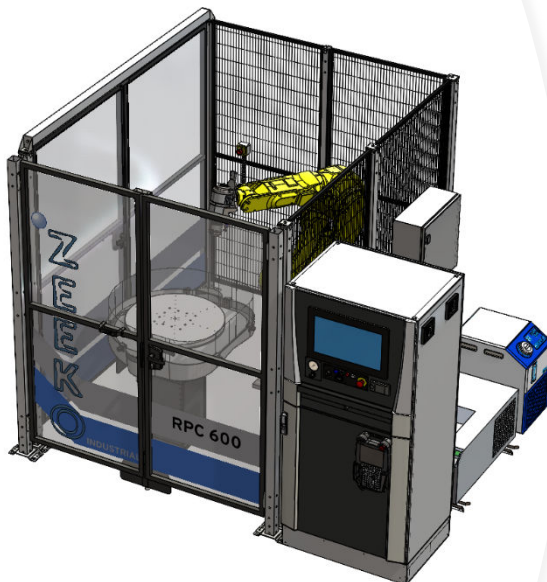
3. Robot Polishing Cell (RPC) Industrial Range



RPC 600 (S)

Shown with:

- M20 Robot with 200 H Axis
- Dual 200mm Rotary/600mm Fixed Table option
- Thumag Slurry Unit
- SMC Chiller
- Cabinet for other options (Vacuum, etc.)



RPC 600 (F)

Shown with:

- M20 Robot with 200 H Axis
- 600mm Fixed Table option
- Thumag Slurry Unit
- SMC Chiller
- Cabinet for other options (Vacuum, etc.)



RPC 600 (S)

Shown with:

- M710 Robot with 600 H Axis
- 600mm Rotary Table option
- Thumag Slurry Unit
- SMC Chiller
- Cabinet for other options (Vacuum, etc.)

4. What is the Zephyr SAG process?

The Shape Adaptive Grinding (SAG) process was developed by Zeeko between 2014 and the present as a novel process for precision grinding of freeform surfaces. The SAG process can achieve optical finish while maintaining high removal rates as compared to traditional CNC polishing.

A SAG tool can be described as a semi-elastic tool which is driven along the surface by a numerically controlled machine tool. The SAG-tool consists of a rigid metal stem, an elastic rubber layer which is coated with an abrasive layer. The single abrasive particles are held by the bond material.

Characteristic for SAG tools is the elastic tool body, which allows compliance with the freeform surface. The elastic body is covered with an abrasive cloth containing the rigid pellets. It is inside these pellets where the actual abrasive grains are bound.

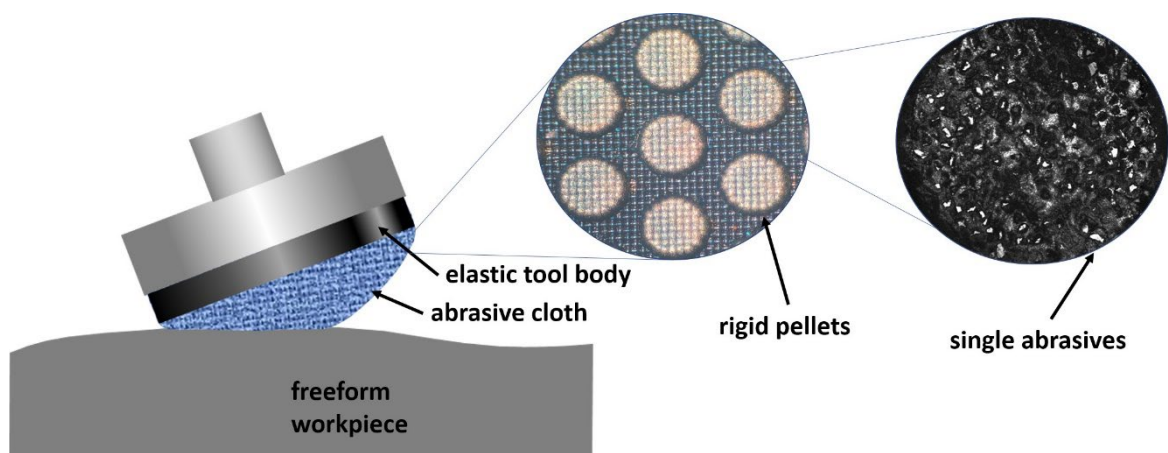


Figure 2-1 Example of the structure of a SAG tool

In Shape Adaptive Grinding the tool is pressed, while rotating, into the workpiece by a certain distance, which is called tool offset. It's this offset which creates the pressure that's needed for the grinding. Increasing the tool offset will also result in a larger contact area between tool and workpiece, which is called grinding spot.

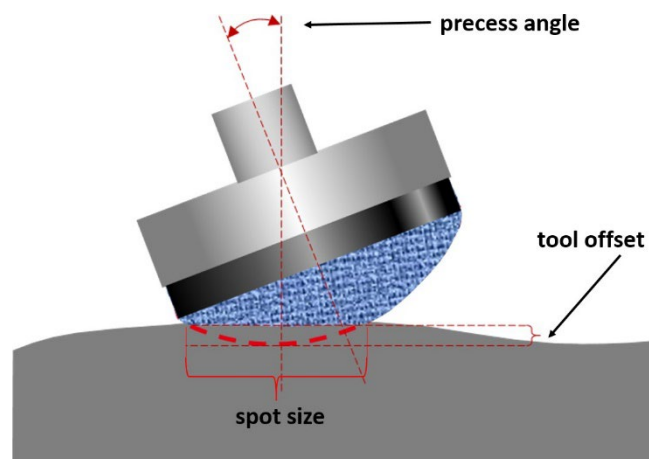


Figure 2-2 How the SAG tools are used

When using bonnet tools or ball-on-stick-tools, a precess angle can be applied. A precess angle is a change in the orientation of the spindle away from the surface normal. A greater precess angle leads to the contact spot being further away from the rotatory axes of the tool.

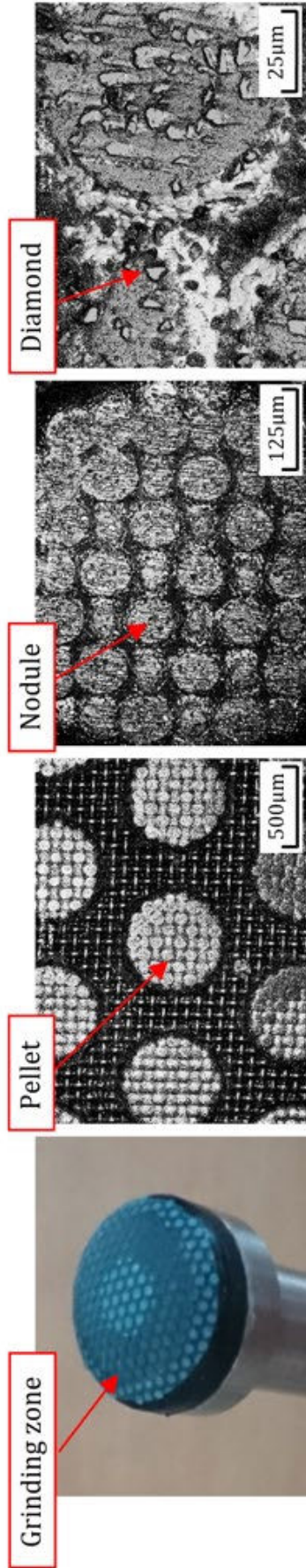
Choosing a larger tool leads to bigger spot sizes for the same offset. A larger spot size means grinding on a bigger area which increases the removal rate and decreases process time.

Shape adaptive grinding is a process that's conceptually situated between polishing and grinding. In the following we would like to highlight some of these conceptual comparisons to provide a better understanding of the process.

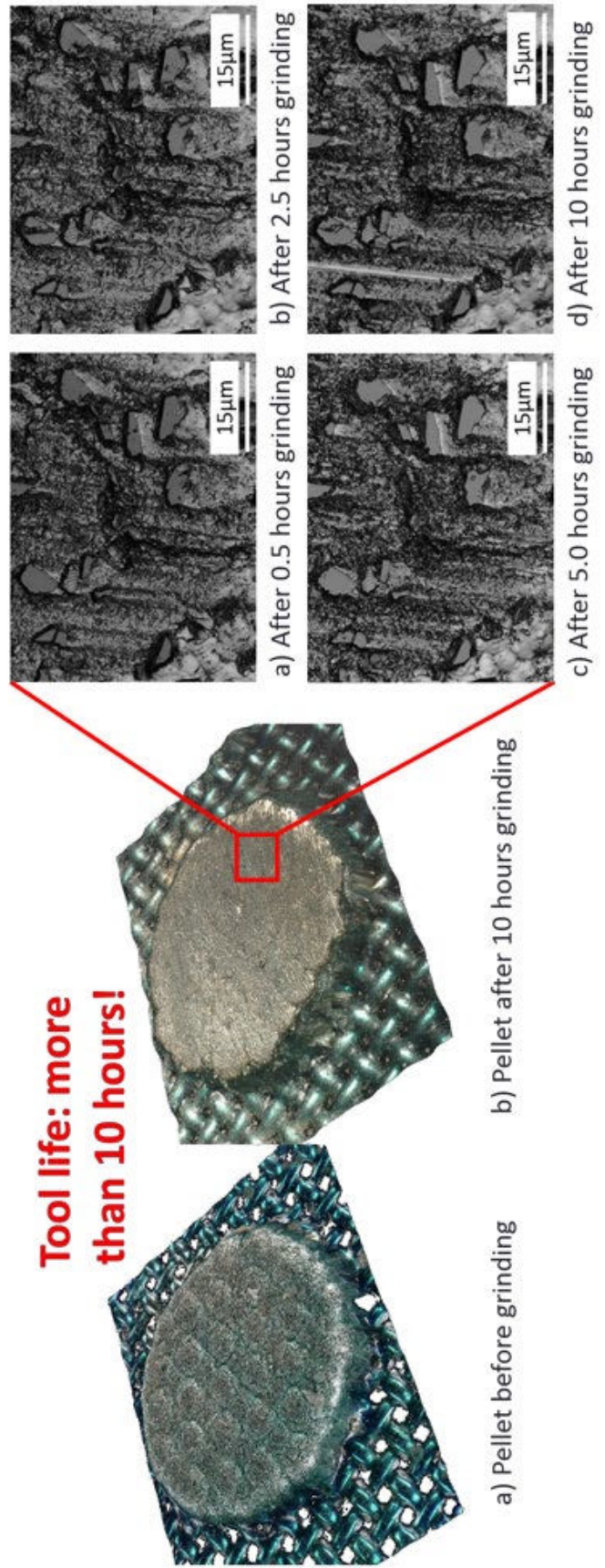
The most prominent difference between SAG and classical grinding is the contact between tool and workpiece. As the contact in classical grinding (with a grinding wheel) can be imagined much like a cut, as seen in milling or drilling processes, this contact takes place for SAG across an arc. The removal process takes place in this area, which we call the contact spot or grinding spot. This important conceptual difference implies that we need to look at certain parameters differently than what we are used to from the classical grinding process.

5. SAG Tool Structure

• The structure of SAG tools: **Pellets** (0.5mm) > **Nodules** (80µm) > **Abrasives** (3-40µm).



• Even when grinding Silicon Carbide, the **number and shape of abrasives** remains stable for more than **10 hours**.



Tool life: more than 10 hours!

6. SAG Cloths

Zeeko is offers tools that come with two types of cloth resin bonded tool and nickel bonded tools.

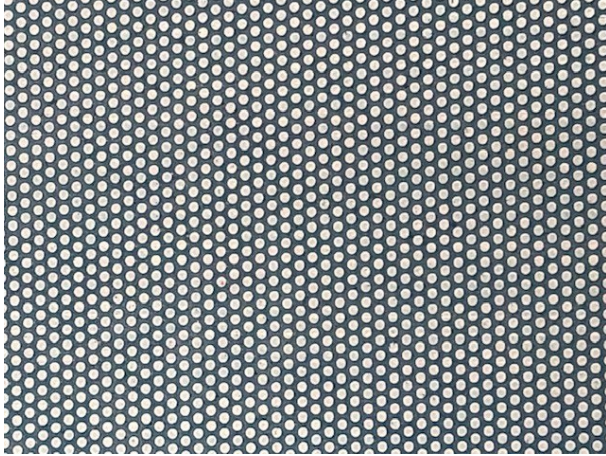


Figure 3-1 Nickel Bonded (NBD)

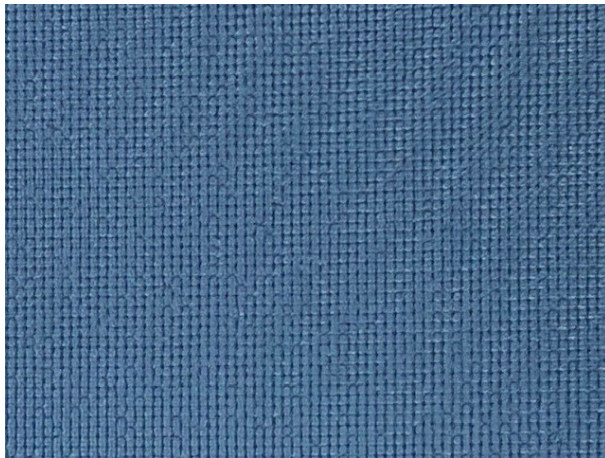
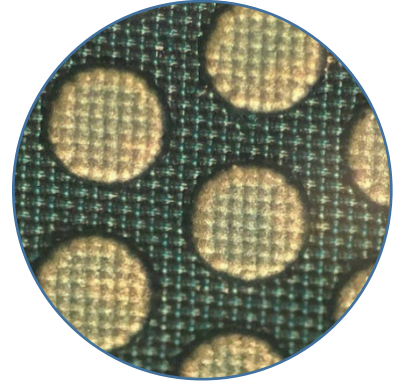
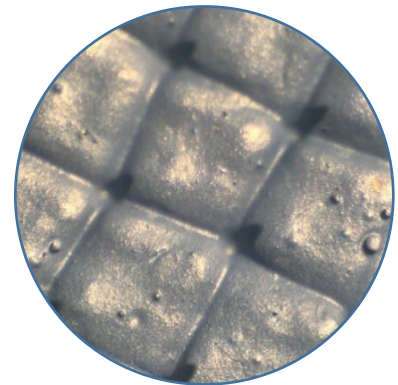
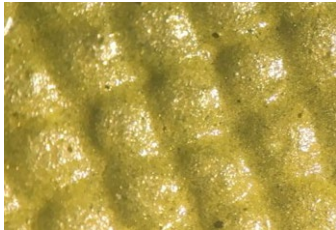

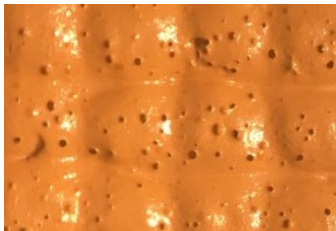
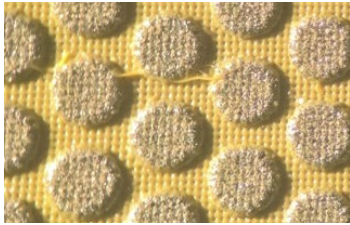



Figure 3-2 Resin Bonded (RBD)



Properties of Bond Materials	
Nickel Bond	Resin Bond
<ol style="list-style-type: none"> 1. Higher wear resistance 2. Higher thermal conductivity, 3. Higher material removal 	<ol style="list-style-type: none"> 1. Higher resistance against impacts 2. Higher rotational velocity 3. Higher quality surface finish

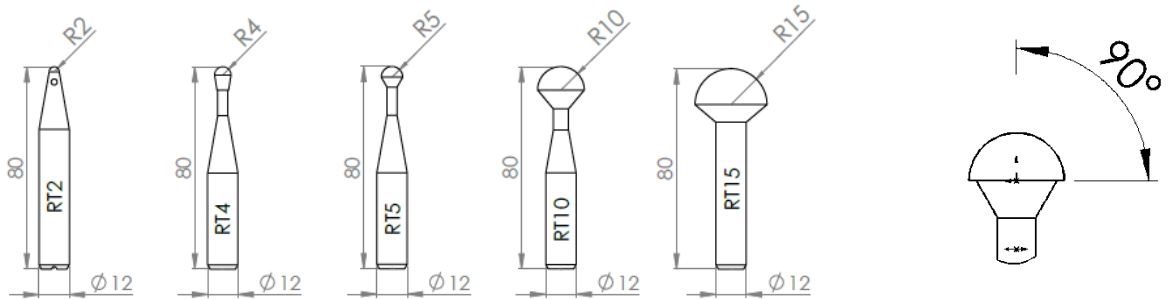
Resin Bonded Cloth			
Grit Size	Colour	Image	Description
40um	Yellow/Green		This cloth is used for removing machining marks left by former processes. It has a high removal rate at the cost of surface finish and potential crack induction for brittle materials.
9um	Blue		This cloth can achieve high removal rates. It is used for corrective polishing as well as for the removal of cracks induced by higher grit size tools. The resin bonded 9um cloth creates a slightly better surface than its nickel counterpart.
3um	Orange		This cloth is mainly used for finishing runs. It creates the best surface finish among the cloths listed. This comes at the cost of a low removal rate compared to the other cloths in this comparison.

Nickel Bonded Cloth			
Grit Size	Colour	Image	Description
40um	Yellow/Green		This cloth is used to remove machining marks of former processes. It has a high removal rate at the cost of surface finish and brittle removal.
9um	Blue		The 9um nickel bonded cloth has a slightly higher removal rate than is resin counterpart. This cloth is a good choice for form correction and cracks removal.

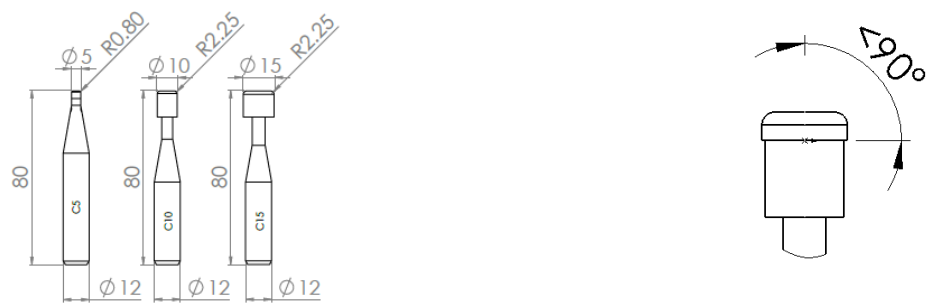
7. Tool Geometries

There are multiple different tool geometries available in the ZephyrSAG tooling range. Each has a different working area as shown below. Any tool geometry can be paired with any SAG cloth.

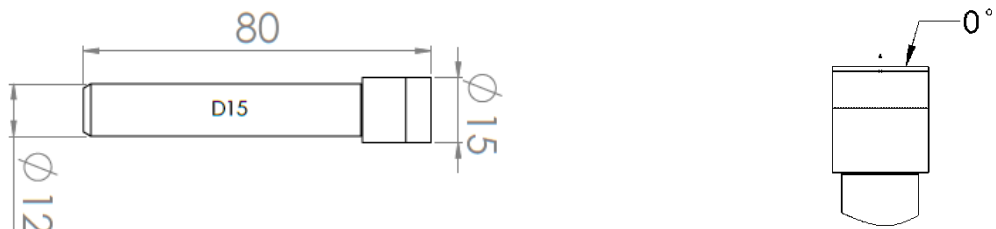
Teardrop (RT)



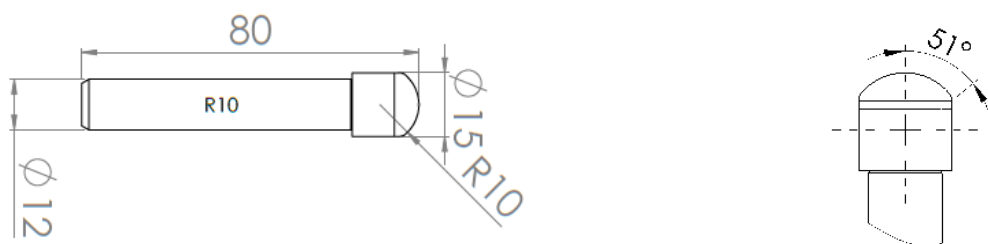
Cap (C)



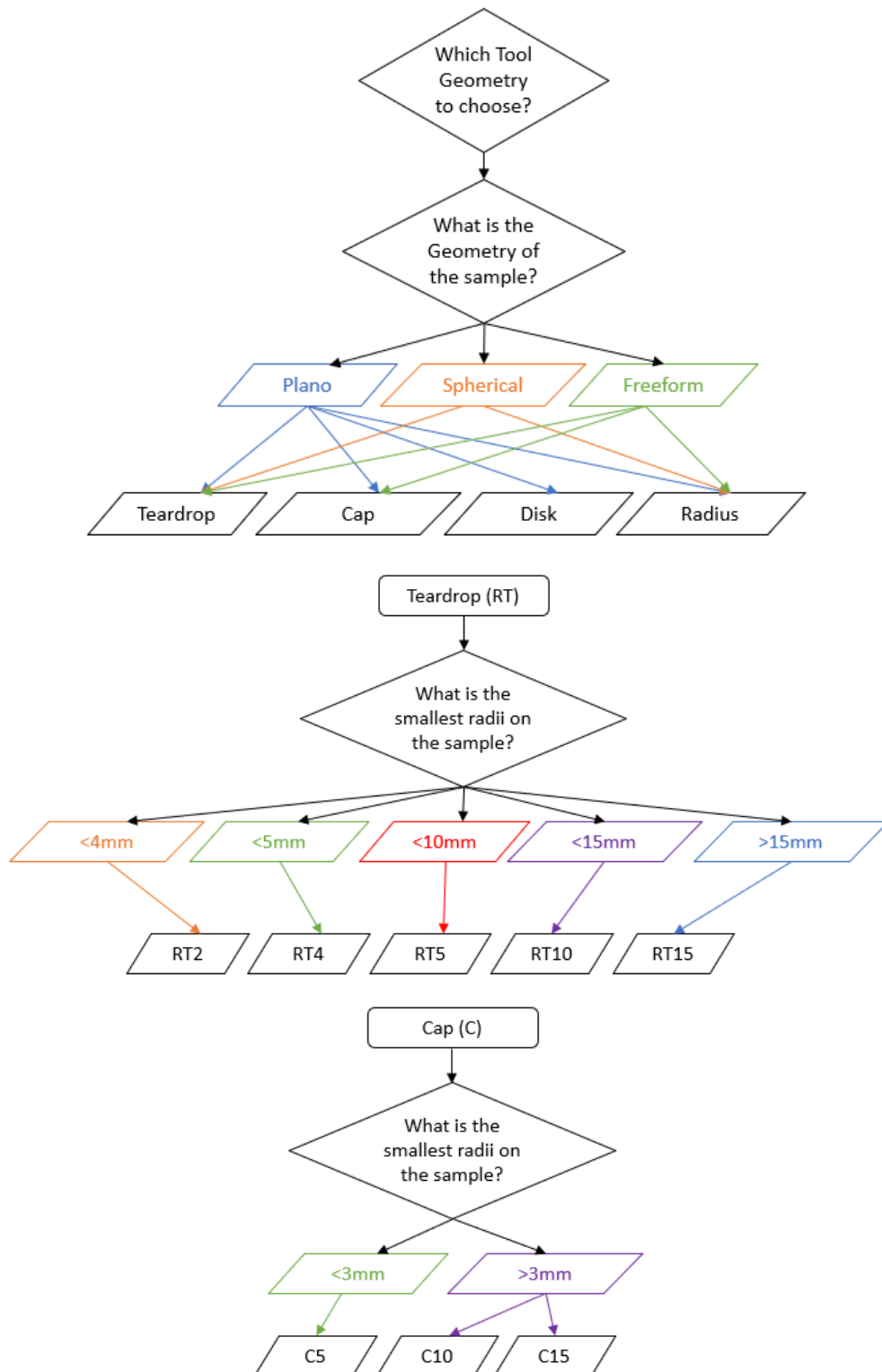
Disk (D)



Radius (R)



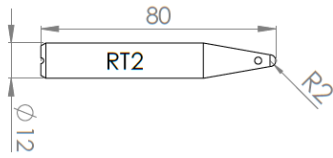
8. How to choose a tool?



ORDERING CODE	SS	RT	15	D40	NBD	S12	
HARDNESS RANGE							
Super soft	SS						
Standard	[]						
TOOL SERIES							
Teardrop		RT					
Bonnet		R					
Disc		D					
Cap		C					
Concave		CCV					
TOOL SIZE /mm							
			2				
			4				
			5				
			10				
			15				
			20				
			40				
			<i>On most tooling this refers to the tool radius. On cap tools it refers to diameter.</i>				
GRIT SIZE							
40				D40			
9				D9			
3				D3			
N/A				[]			
				<i>Grit size only applicable on RBD and NBD tooling.</i>			
MATERIAL							
Resin Bond					RBD		
Nickel Bond					NBD		
LP66.					LP6		
HDP					HDP		
Uninap					NAP		
Zeeko Blue					ZKB		
No Cloth					[]		
TOOLSHAFT							
12mm						S12	
None (bonnet only)						[]	
						<i>All tooling with tool radius ≤15mm must come on a 12mm tool shaft.</i>	

9. ZephyrSAG Range

Teardrop (RT) – Standard ZephyrSAG Range



Resin Bond (RBD)

RT2D40RBDS12

RT2D9RBDS12

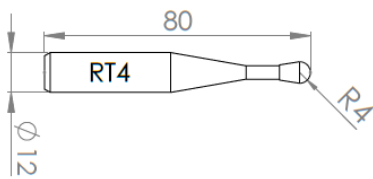
RT2D3RBDS12

Nickel Bond (NBD)

RT2D40NBDS12

RT2D20NBDS12

RT2D9NBDS12



Resin Bond (RBD)

RT4D40RBDS12

RT4D9RBDS12

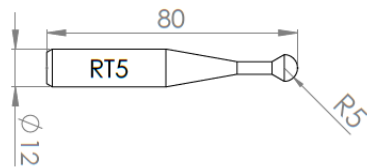
RT4D3RBDS12

Nickel Bond (NBD)

RT4D40NBDS12

RT4D20NBDS12

RT4D9NBDS12



Resin Bond (RBD)

RT5D40RBDS12

RT5D9RBDS12

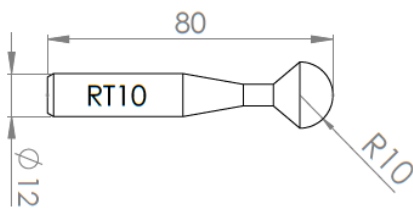
RT5D3RBDS12

Nickel Bond (NBD)

RT5D40NBDS12

RT5D20NBDS12

RT5D9NBDS12



Resin Bond (RBD)

RT10D40RBDS12

RT10D9RBDS12

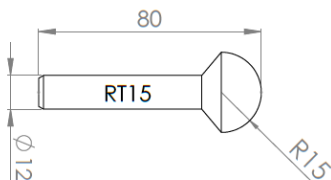
RT10D3RBDS12

Nickel Bond (NBD)

RT10D40NBDS12

RT10D20NBDS12

RT10D9NBDS12



Resin Bond (RBD)

RT15D40RBDS12

RT15D9RBDS12

RT15D3RBDS12

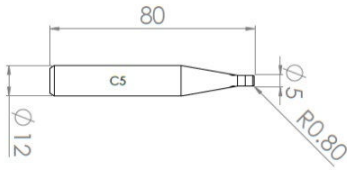
Nickel Bond (NBD)

RT15D40NBDS12

RT15D20NBDS12

RT15D9NBDS12

Cap (C) – Standard ZephyrSAG Range



Resin Bond (RBD)

Nickel Bond (NBD)

C5D40RBDS12

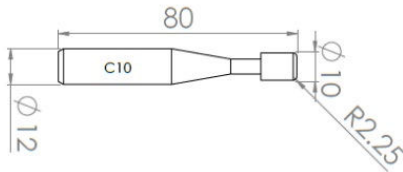
C5D40NBDS12

C5D9RBDS12

C5D20NBDS12

C5D3RBDS12

C5D9NBDS12



Resin Bond (RBD)

Nickel Bond (NBD)

C10D40RBDS12

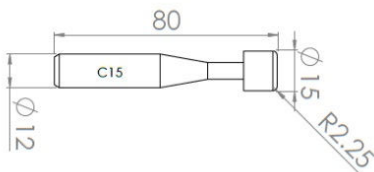
C10D40NBDS12

C10D9RBDS12

C10D20NBDS12

C10D3RBDS12

C10D9NBDS12



Resin Bond (RBD)

Nickel Bond (NBD)

C15D40RBDS12

C15D40NBDS12

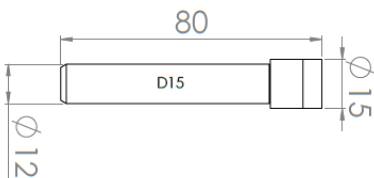
C15D9RBDS12

C15D20NBDS12

C15D3RBDS12

C15D9NBDS12

Disk (D) – Standard ZephyrSAG Range



Resin Bond (RBD)

Nickel Bond (NBD)

D15D40RBDS12

D15D40NBDS12

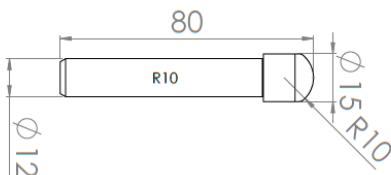
D15D9RBDS12

D15D20NBDS12

D15D3RBDS12

D15D9NBDS12

Radius (R) – Standard ZephyrSAG Range



Resin Bond (RBD)

Nickel Bond (NBD)

R10D40RBDS12

R10D40NBDS12

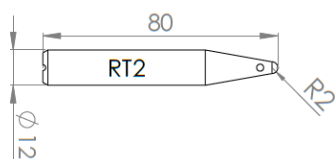
R10D9RBDS12

R10D20NBDS12

R10D3RBDS12

R10D9NBDS12

Teardrop (RT) – Supersoft ZephyrSAG Range



Resin Bond (RBD)

SSRT2D40RBDS12

SSRT2D9RBDS12

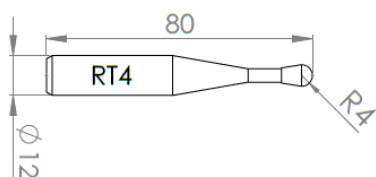
SSRT2D3RBDS12

Nickel Bond (NBD)

SSRT2D40NBDS12

SSRT2D20NBDS12

SSRT2D9NBDS12



Resin Bond (RBD)

SSRT4D40RBDS12

SSRT4D9RBDS12

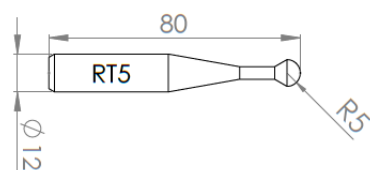
SSRT4D3RBDS12

Nickel Bond (NBD)

SSRT4D40NBDS12

SSRT4D20NBDS12

SSRT4D9NBDS12



Resin Bond (RBD)

SSRT5D40RBDS12

SSRT5D9RBDS12

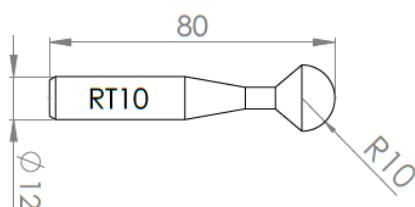
SSRT5D3RBDS12

Nickel Bond (NBD)

SSRT5D40NBDS12

SSRT5D20NBDS12

SSRT5D9NBDS12



Resin Bond (RBD)

SSRT10D40RBDS12

SSRT10D9RBDS12

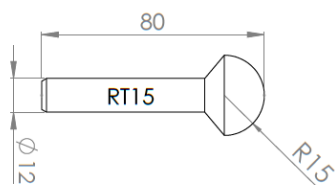
SSRT10D3RBDS12

Nickel Bond (NBD)

SSRT10D40NBDS12

SSRT10D20NBDS12

SSRT10D9NBDS12



Resin Bond (RBD)

SSRT15D40RBDS12

SSRT15D9RBDS12

SSRT15D3RBDS12

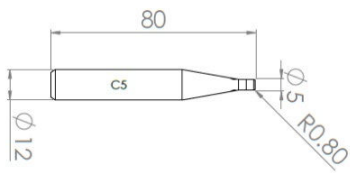
Nickel Bond (NBD)

SSRT15D40NBDS12

SSRT15D20NBDS12

SSRT15D9NBDS12

Cap (C) – Supersoft ZephyrSAG Range



Resin Bond (RBD)

Nickel Bond (NBD)

SSC5D40RBDS12

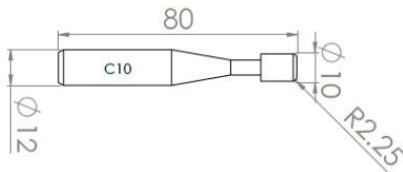
SSC5D40NBDS12

SSC5D9RBDS12

SSC5D20NBDS12

SSC5D3RBDS12

SSC5D9NBDS12



Resin Bond (RBD)

Nickel Bond (NBD)

SSC10D40RBDS12

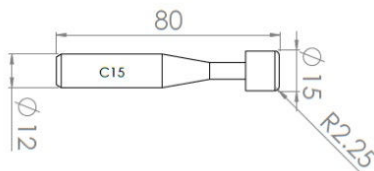
SSC10D40NBDS12

SSC10D9RBDS12

SSC10D20NBDS12

SSC10D3RBDS12

SSC10D9NBDS12



Resin Bond (RBD)

Nickel Bond (NBD)

SSC15D40RBDS12

SSC15D40NBDS12

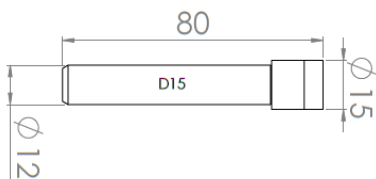
SSC15D9RBDS12

SSC15D20NBDS12

SSC15D3RBDS12

SSC15D9NBDS12

Disk (D) – Supersoft ZephyrSAG Range



Resin Bond (RBD)

Nickel Bond (NBD)

SSD15D40RBDS12

SSD15D40NBDS12

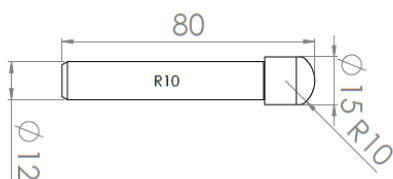
SSD15D9RBDS12

SSD15D20NBDS12

SSD15D3RBDS12

SSD15D9NBDS12

Radius (R) – Supersoft ZephyrSAG Range



Resin Bond (RBD)

Nickel Bond (NBD)

SSR10D40RBDS12

SSR10D40NBDS12

SSR10D9RBDS12

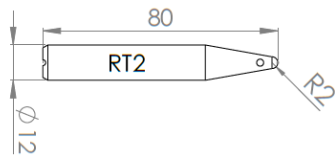
SSR10D20NBDS12

SSR10D3RBDS12

SSR10D9NBDS12

10. Zephyr Polishing Range

Teardrop (RT) – Standard Zephyr Polishing Range



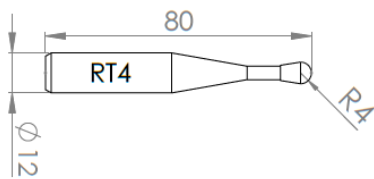
Polyurethane

ZEEKOBLUE

RT2LP66S12

RT2ZKOBLUES12

RT2HDPUS12



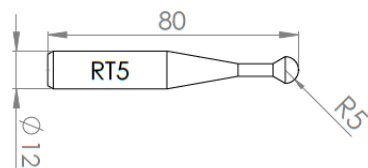
Polyurethane

ZEEKOBLUE

RT4LP66S12

RT4ZKOBLUES12

RT4HDPUS12



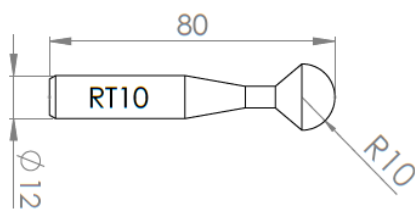
Polyurethane

ZEEKOBLUE

RT5LP66S12

RT5ZKOBLUES12

RT5HDPUS12



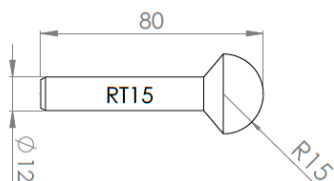
Polyurethane

ZEEKOBLUE

RT10LP66S12

RT10ZKOBLUES12

RT10HDPUS12



Polyurethane

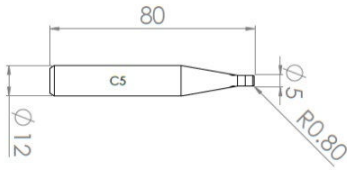
ZEEKOBLUE

RT15LP66S12

RT15ZKOBLUES12

RT15HDPUS12

Cap (C) – Standard Zephyr Polishing Range



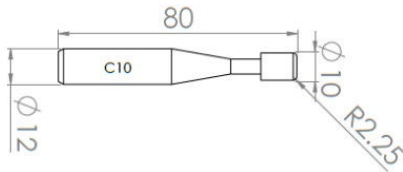
Polyurethane

ZEEKOBLUE

C5LP66S12

C5ZKOBLUES12

C5HDPUS12



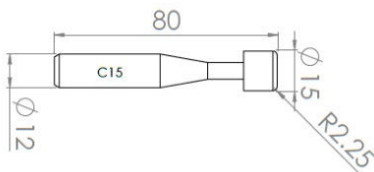
Polyurethane

ZEEKOBLUE

C10LP66S12

C10ZKOBLUES12

C10HDPUS12



Polyurethane

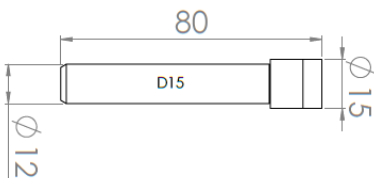
ZEEKOBLUE

C15LP66S12

C15ZKOBLUES12

C15HDPUS12

Disk (D) – Standard Zephyr Polishing Range



Polyurethane

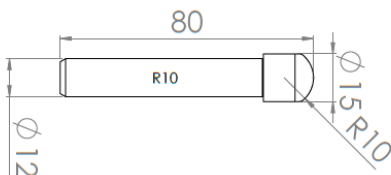
ZEEKOBLUE

D15LP66S12

D15ZKOBLUES12

D15HDPUS12

Radius (R) – Standard Zephyr Polishing Range



Polyurethane

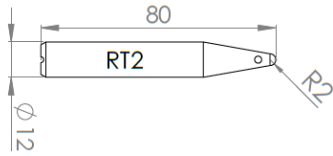
ZEEKOBLUE

R10LP66S12

R10ZKOBLUES12

R10HDPUS12

Teardrop (RT) – Supersoft Zephyr Polishing Range



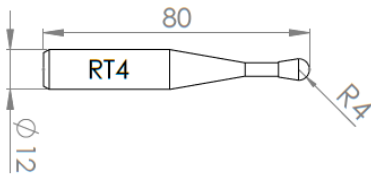
Polyurethane

ZEEKOBLUE

SSRT2LP66S12

SSRT2ZKOBLUES12

SSRT2HDPUS12



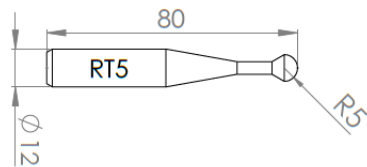
Polyurethane

ZEEKOBLUE

SSRT4LP66S12

SSRT4ZKOBLUES12

SSRT4HDPUS12



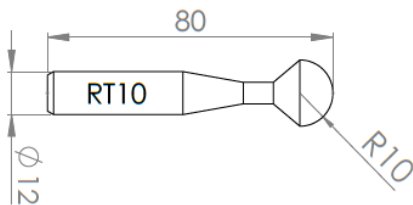
Polyurethane

ZEEKOBLUE

SSRT5LP66S12

SSRT5ZKOBLUES12

SSRT5HDPUS12



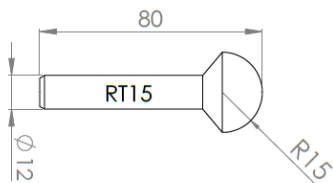
Polyurethane

ZEEKOBLUE

SSRT10LP66S12

SSRT10ZKOBLUES12

SSRT10HDPUS12



Polyurethane

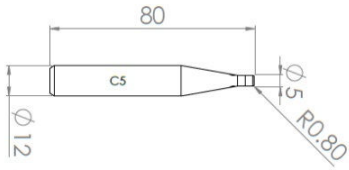
ZEEKOBLUE

SSRT15LP66S12

SSRT15ZKOBLUES12

SSRT15HDPUS12

Cap (C) – Supersoft Zephyr Polishing Range



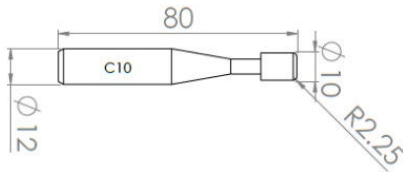
Polyurethane

ZEEKOBLUE

SSC5LP66S12

SSC5ZKOBLUES12

SSC5HDPUS12



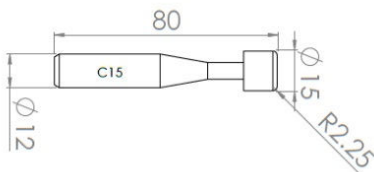
Polyurethane

ZEEKOBLUE

SSC10LP66S12

SSC10ZKOBLUES12

SSC10HDPUS12



Polyurethane

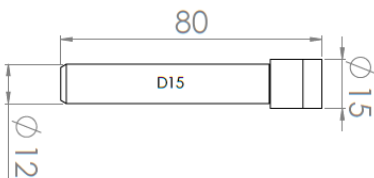
ZEEKOBLUE

SSC15LP66S12

SSC15ZKOBLUES12

SSC15HDPUS12

Disk (D) – Supersoft Zephyr Polishing Range



Polyurethane

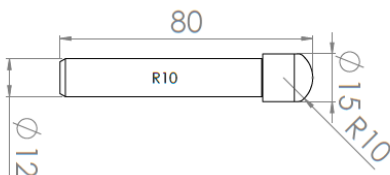
ZEEKOBLUE

SSD15LP66S12

SSD15ZKOBLUES12

SSD15HDPUS12

Radius (R) – Supersoft Zephyr Polishing Range



Polyurethane

ZEEKOBLUE

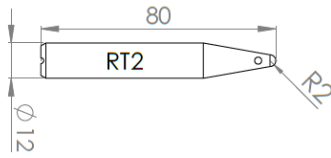
SSR10LP66S12

SSR10ZKOBLUES12

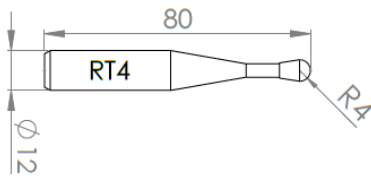
SSR10HDPUS12

11. Safe Process Parameters

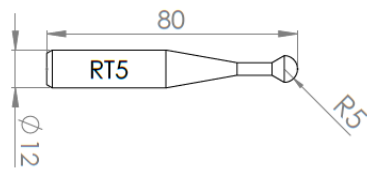
Teardrop (RT) – Standard ZephyrSAG Range



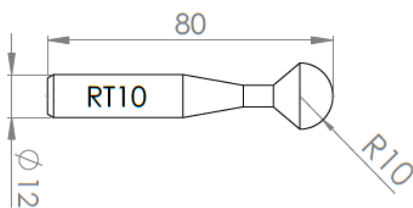
<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.1	0.1
Tool Offset	0.15	0.15
Tool Feed	100 – 3000 mm/min (IRP Machines)	100 – 3000 mm/min (IRP Machines)
Tool Spindle	50-3000 rpm 50-24000 rpm (Robodrill)	50-3000 rpm 50-24000 rpm (Robodrill)



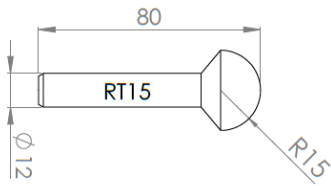
<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.15	0.15
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM



<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.17	0.17
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

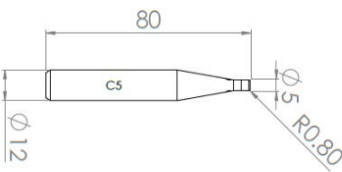


<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.35	0.35
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

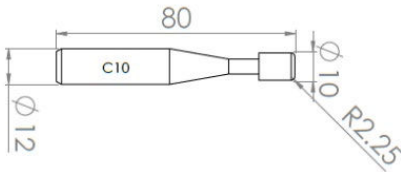


<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.35	0.35
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

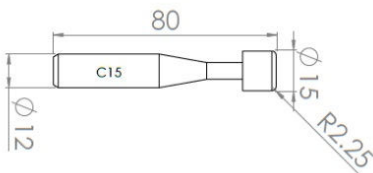
Cap (C) – Standard ZephyrSAG Range



<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.25	0.25
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

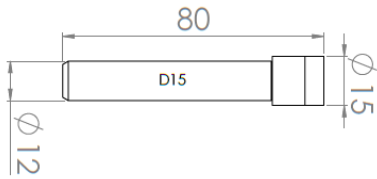


<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.35	0.35
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM



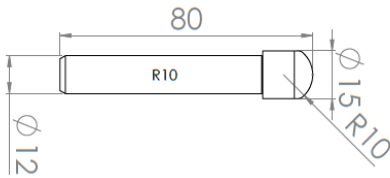
<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.5	0.5
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

Disk (D) – Standard ZephyrSAG Range



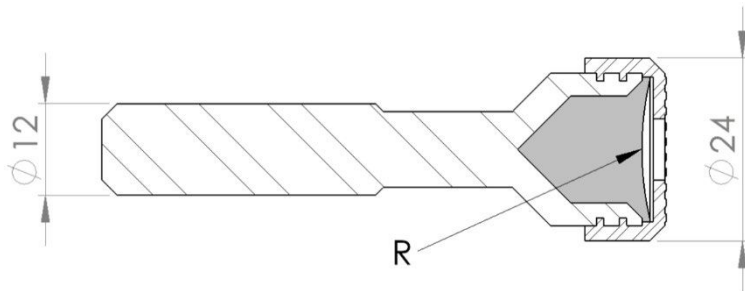
<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.5	0.5
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

Radius (R) – Standard ZephyrSAG Range



<u>Parameter</u>	<u>Resin</u>	<u>Nickel</u>
Track Spacing	0.25	0.25
Tool Offset	0.3	0.3
Tool Feed	500mm/min	500mm/min
Tool Spindle	10,000-12,000 RPM	6000-10,000 RPM

NEW - Bespoke Concave Radius Tool

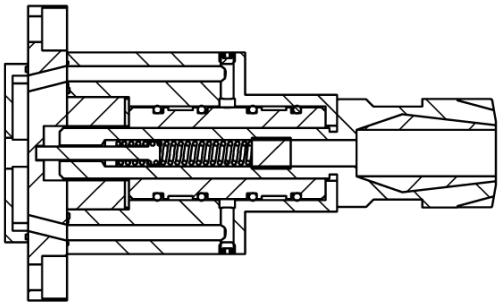
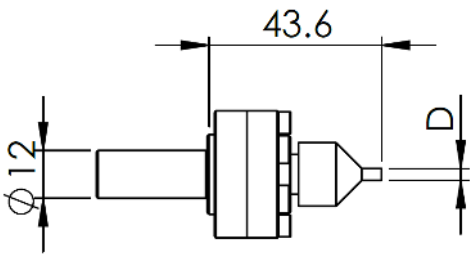


Tool for concave spherical surfaces

Enabling you to print inserts at a specific radius for the part being polished.

12. Accessories

1.1 Specialist Toolholders

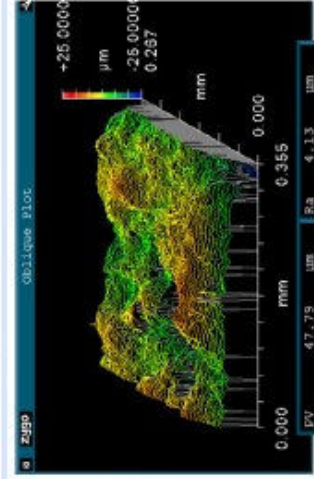
Assembly	Part Number	Description
<p>Constant Force Toolholder (CFT) 12mm shank</p>  <p>If a STEP File is required, please email Zeeko info@zeeko.co.uk</p> <p>Zeeko's selection of Constant Force Tool Holders utilise latest precision air bushings to provide a linear range of motion to the tool head during machining operations. They have been designed specifically to work alongside our RPC machine range to counteract any vertical "Nodding", an issue often found in 6-axis robot arms, so that a near constant force can be applied at the polishing spot. We also see uses in parts with particularly large surface deviation, where the tool can follow any surface imperfections while still maintaining a similar polishing spot size.</p>	<p>YB100-000009</p>	<p>This CFT toolholder is normally only used with pitch tools, but can (with special tools and under special direction) be recommended for use with small SAG tools.</p> <p>It mounts directly to the front face of the 200/400 H-axis (with Schunk chuck removed). It requires dialing in to ensure correct performance. It is to be used with 12mm tool shafts (held in a collet)</p> <p>The Constant Force Tool Range currently has a variety of mounting options for machines and is constantly evolving as we improve existing designs and trial new ones.</p>
<p>Spring Loaded CFT for use with Pitch tools</p> 	<p>LB100-000007</p>	<p>Designed for use without an air supply, this Spring loaded CFT allows for pitch polishing on any machine tool capable of holding the 12mm shank. Various tip sizes (D) available from 3mm to 10mm.</p>

“SAG” Grinding of manufactured workpiece: Roughness

Finishing of titanium alloy (Ti4Al6V) component produced by Selective Laser Sintering.



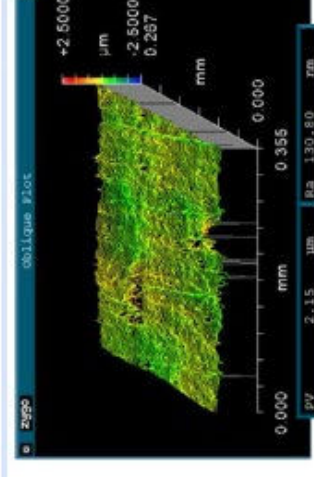
(a) As received



Roughness: Ra 4130 nm



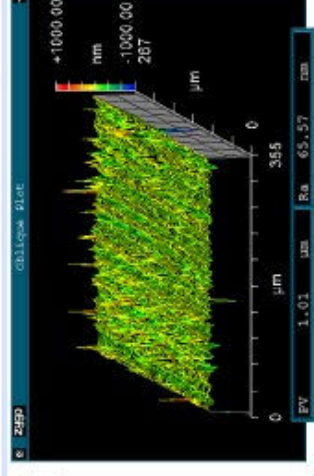
(b) Nickel bonded 40 μm



Ra 130 nm



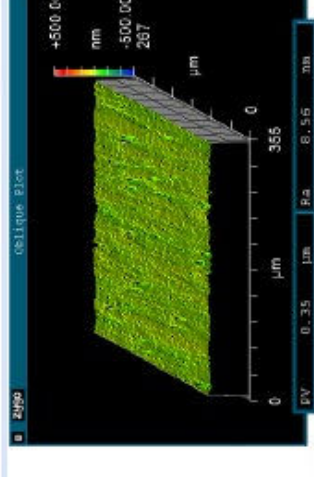
(c) Nickel bonded 9 μm



Ra 65 nm



(d) Resin bonded 3 μm

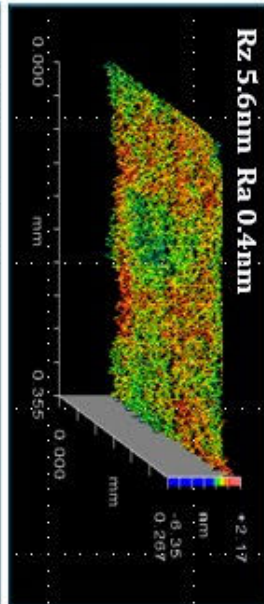
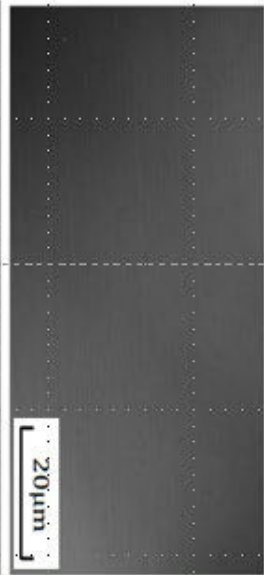
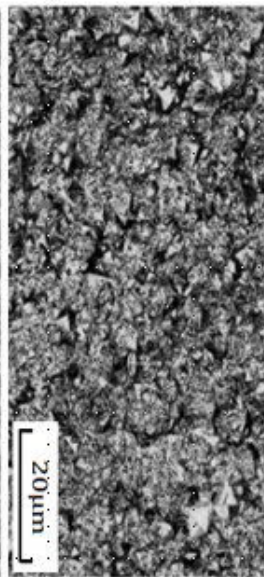


Ra 8 nm

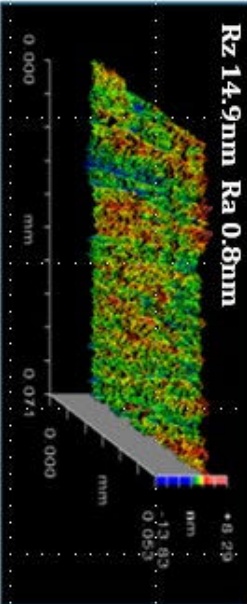
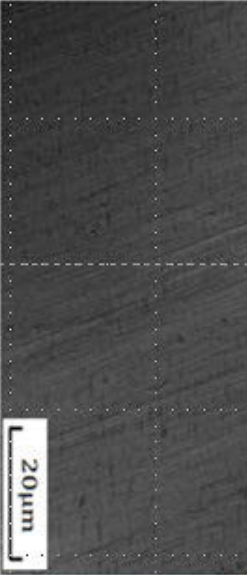
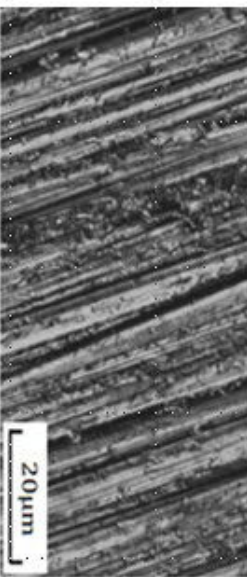
Starting Condition

SAG Finished Condition

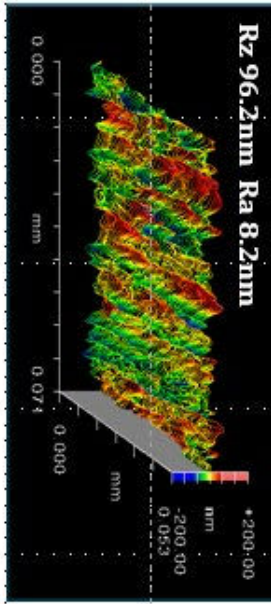
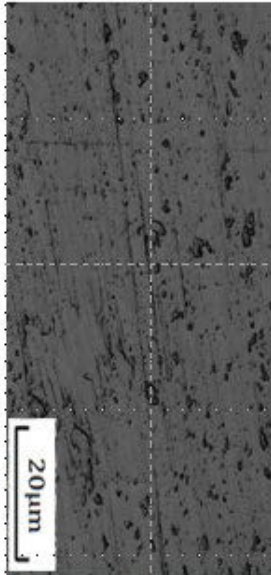
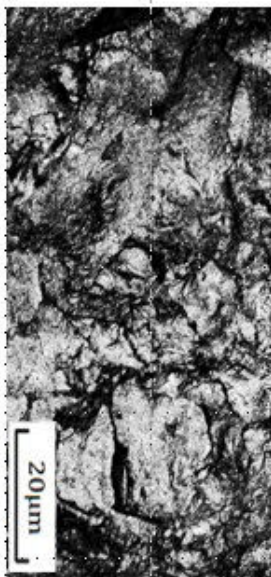
CVD SiC



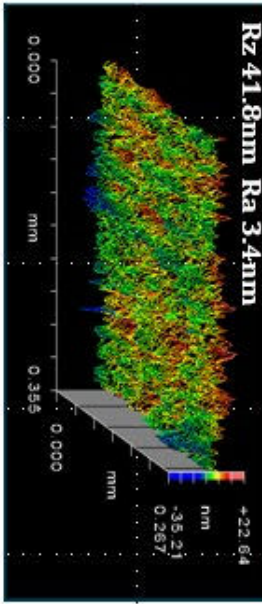
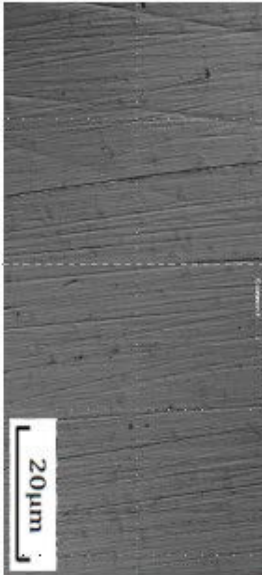
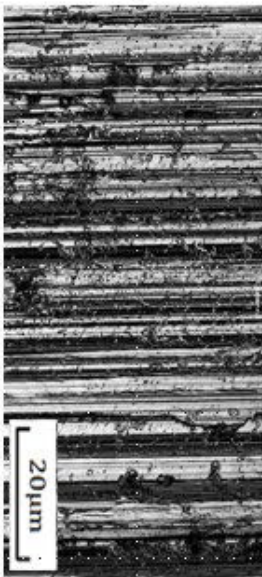
Stavax



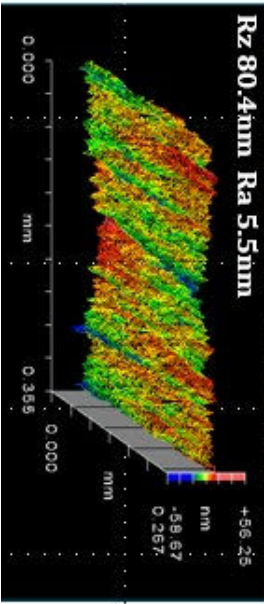
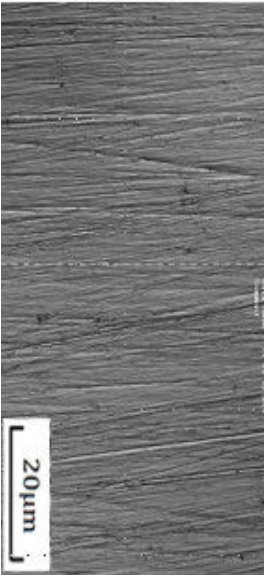
Ti6Al4V



Co-Cr



Inconel





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