Reasons and solutions for inaccurate shade results from sintered zirconia

Objective:
To identify the reasons for inaccurate or unintended shade results when sintering full contour zirconia restorations milled from a pre-shaded disc or a white disc that requires dipping in a coloring liquid

Conclusion:
Different coloring systems from different manufacturers naturally produces different shade results. Inaccurate results for pre-shaded discs or white discs used with their matching color liquids (such as Origin Live zirconia and Origin Chroma color liquids) comes from the difference in PT (Performance Temperature) between ovens. PT could be either higher or lower than the ST (Set Temperature).

Solutions
If you do not get the intended shade with the ORIGIN Live Multi pre-shaded disc, adjust the oven temperature so that the ST produces the required PT (this process is described further in this article). Non pre-shaded (white) disc users should either 1) adjust the oven temperature, or 2) use a stronger chroma level (60) or a lighter chroma level (80) that has been adjusted from the standard chroma level (70) liquid.

Problem: The shade differs depending on the oven's PT (Performance Temperature).
The following picture shows the varying shade results based on the PT (Performance Temperature) of four different ovens (the set temperature is the same on all four). All four of these ovens are from the same manufacturer and are the same model but have different purchase dates varying from 1 to 3 years. During 3 years of service in the laboratory, the heating elements ($MOSi_2$) have been replaced on an irregular basis for each oven as needed. The same zirconia disc, processing technique and sintering cycle (full contour fast) were used.

< Sintering Result >

	Oven #4	Oven #3	Oven #2	Oven #1 (Standard)
Intended shade	A3	A3	A3	A3
Actual shade result	A3.2	A2	A3.5	A3
	darker shade	lighter shade	darker shade	right shade
ST (Set Temperature)	1550 °C	1550 °C	1550 °C	1550 °C
PT (Performance Temperature)	Lower than 1550 °C	Higher than 1550 °C	Much lower than 1550 °C	Corresponds to ST 1550 °C

Four different sintering ovens (identical models from the same manufacturer) produced different shade results from the same zirconia disc. This is due to the different PT (performance temperature) of each oven even though the four ovens have the same ST (set temperature).

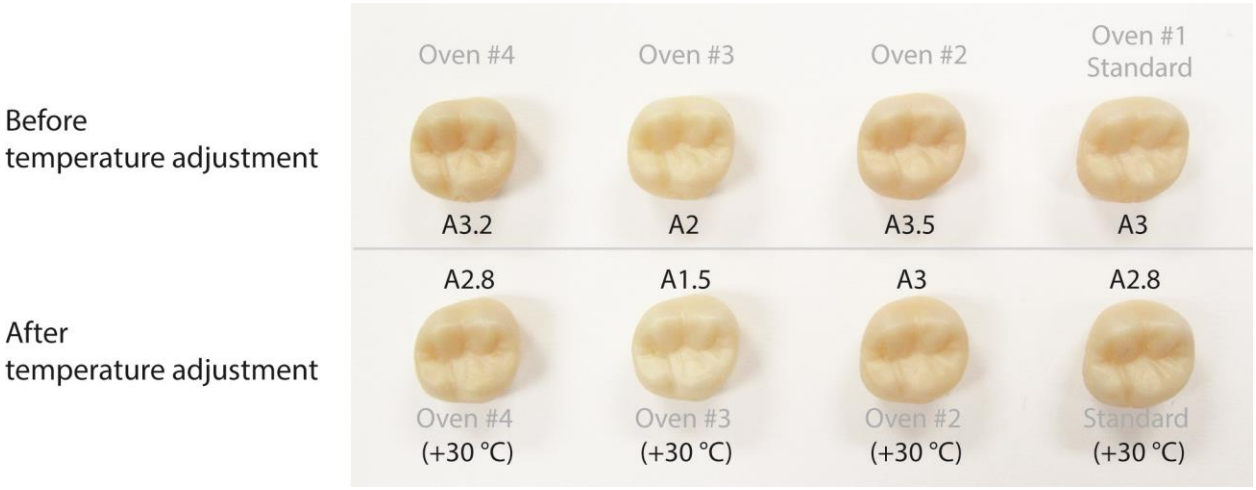
What is PT (Performance Temperature)?

It is an actual temperature at which the oven is operating. Ovens are factory set but can change depending on many circumstances such as how long the oven has been in service without calibration and life of heating elements. The easiest way to measure the PT of a laboratory oven is to use a PTCR - Process Temperature Control Ring (www.ferro.com). The principle is as follows - the higher the sintering temperature, the more the control ring shrinks. This is a very precise measuring method and B&D Dental offers test rings for free to laboratories that are testing the ORIGIN Live zirconia system.

After utilizing the PTCR, the case is re-introduced as follows:

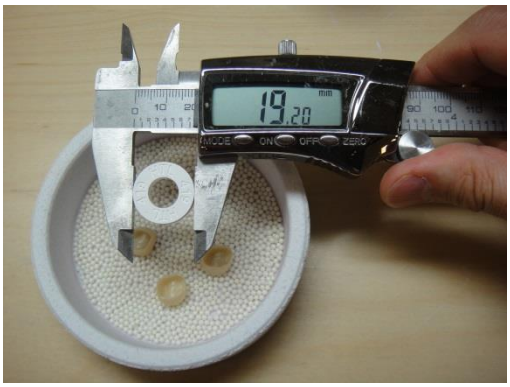
We raised the ST (Set Temperature) of all four ovens by 30 °C to see how the shades change. (This printed image cannot show the exact details and difference that trained technicians can discern.)

< Sintering Result>



	Oven #4	Oven #3	Oven #2	Standard
Intended shade	A3	A3	A3	A3
Actual shade results				
Before temperature raise	A3.2	A2	A3.5	A3
After temperature raise	A2.8	A1.5	A3	A2.8
Ceramic Ring Diameter				
Before temperature adjustment	> 19.11mm	< 19.11 mm	> 19.11mm	19.11 mm
After temperature adjustment	< 19.11mm	< 19.11 mm	19.11mm	< 19.11 mm

How do I measure the PT (Performance Temperature)?

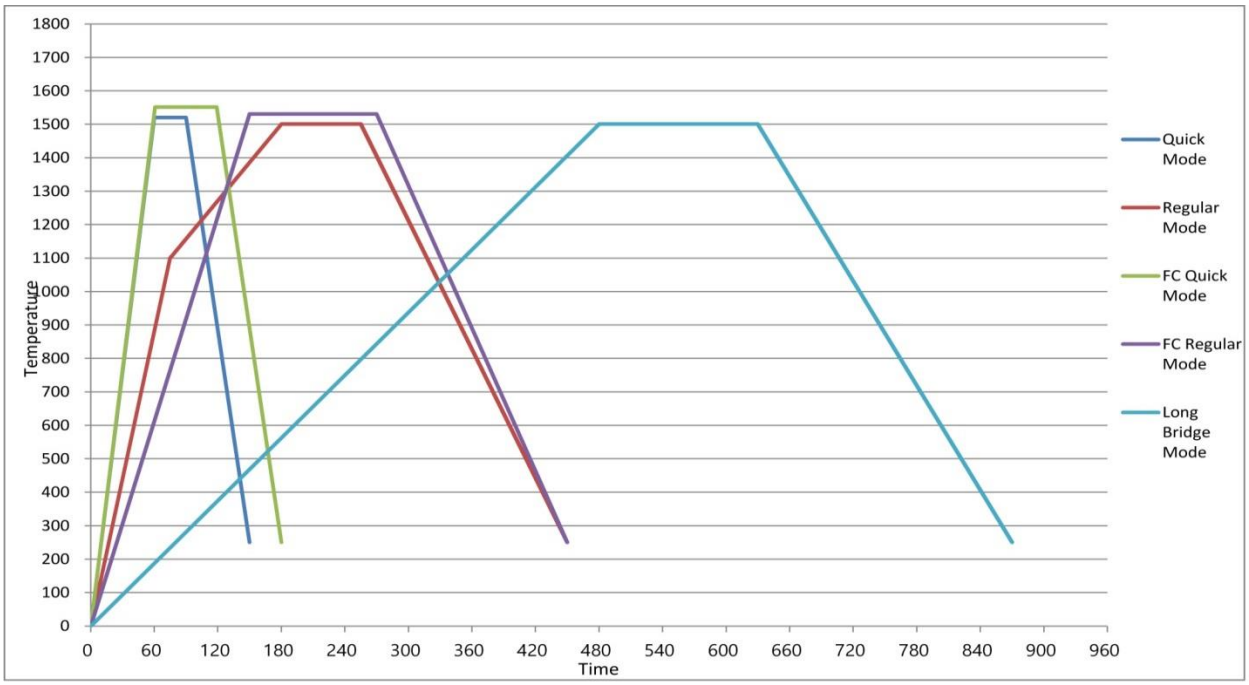


Put one PTCR (Process Temperature Control Ring) in the sintering tray with your full contour zirconia crown. The original diameter before sintering is 19.90mm. After sintering, measure the diameter of the sintered ring (as shown in the picture to the left) 3 times and record the smallest number. The number should be about 19.20mm (±0.05mm depending on the ceramic ring batch). This is the right temperature that corresponds to the original set temperature of 1550 °C and produces the intended shade.

If the measured number is larger than 19.20(±0.05)mm it means that the sintering temperature is not high enough and the ring has not shrunk enough. As a result, the shade comes out a little darker (or stronger) than the intended shade. If the ring is smaller than 19.20(±0.05)mm then it means that your oven actually performs at a higher temperature level and you will get lighter shades than the intended shade.

The ORIGIN Live zirconia shade system (both pre-shaded discs and white discs with coloring liquids) was developed based on the PT of 1550 °C (a sintered ring diameter of 19.20(±0.05)mm utilizing the Control Rings). Therefore, in order to get the correct results with the ORIGIN live zirconia, repeat the sintering temperature adjustment using the control rings until you get the ring diameter of 19.20(±0.05)mm and the label the program as the ORIGIN Live cycle in your oven settings.

<ORIGIN LIVE zirconia sintering schedule>



	Quick Mode		Regular Mode		FC Quick Mode		FC Regular Mode		Long Bridge Mode	
	Temperature	Time	Temperature	Time	Temperature	Time	Temperature	Time	Temperature	Time
T1	1520	60	1100	75	1550	60	1530	150	1500	480
T2	1520	0	1100	0	1550	0	1530	0	1500	0
T3	1520	0	1500	105	1550	0	1530	0	1500	0
T4	1520	30	1500	75	1550	80	1530	120	1500	150
T5	250	60	250	195	250	60	250	180	250	240
	2.5 hour		7.5 hour		3.2 hour		7.5 hour		14.5 hour	

Conclusion

	ORIGIN LIVE Multi-layered colored disc	ORIGIN LIVE non pre-colored white disc
When shades are darker (stronger) than you intended	Raise the oven temperature until you get the right shades	(Option1) Raise the oven temperature until you get the right shades
		(Option 2) Use liquid level 80
When shades are lighter (lower chroma) than you intended	Lower the oven temperature until you get the right shades	(Option1) Lower the oven temperature until you get the right shades
		(Option 2) Use liquid level 60