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The Performance of Various Calibrations When Measuring Certified Ceramic Colour Standards.

By

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Summary

The opal tile calibration and certified ceramic tile calibration without glass in the optical path were validated with certified ceramic standards. The WRONZ Reference Wool calibration gave results 4 to 8 tristimulus units lower than the certified values for the yellow tile, provided by the National Physical Laboratory (U.K.).

Conducting the calibration with the glass in the optical path did not fully compensate for the presence of the glass. These calibrations were approximately one unit lower than the calibrations without the glass.

In light of the results the wool industry will need to decide whether it wants to change the colour space measurements for wool or not.

Introduction

Recent studies, using calibration material other than WRONZ Reference Wool, have indicated significant differences in measurement results for both wool and ceramic tile samples when colour instruments are calibrated with spectralon(1) or a ceramic tile(2) compared to the WRONZ Reference Wool.

At the IWTO Raw Wool Group Meeting in New Delhi, a Working Group was formed to address a number of issues as follows:

- what is the reason for the difference in readings when one uses a Reference Wool calibration and a Spectralon calibration;
- should the cover glass be in place during calibration or not; and

- should there be restrictions on the design of the specimen holder.

The Working Group reported to the Meeting in Nice in December, 1994[3] that further research was required with respect to quantifying the differences that arise from measuring:

- wool behind glass;
- tiles behind the same glass; and
- tiles without the glass being present.

This report examines the effects of calibrating with, and without, the glass in the optical path. By using tiles that had been previously certified by National Physical Laboratory (NPL) in the United Kingdom, it is possible to comment on the accuracy of the calibrations performed. For a calibration to be deemed accurate in terms of measuring a standard tile, it must produce X, Y and Z results that are within $\pm$0.5 units of the certified values for the tile.

Materials and Method

The instrument used for the study was the BYK Gardener TCM with a purpose-built wool sample holder. One essential feature of the design of the sample holder is that the measurement plane (ie: the position that samples are placed for measurement) is identical for measurements made with tiles (with or without glass in the optical path) and wool.

Six different calibrations were performed using the three standards as follows:

(i) Russian Opal Tile (without glass);
(ii) Russian Opal Tile (with glass);
(iii) Ceramic Tile (without glass);
(iv) Ceramic Tile (with glass);
(v) WRONZ Reference Wool (without glass)#
(vi) WRONZ Reference Wool (with glass)#

The application of the WRONZ Reference Wool as a standard requires the calibration to be transferred to a cream-coloured ceramic tile working standard. The assigned values include the presence of the glass in the sample holder. It is the working standard that enables the “without glass” calibration to be examined.

Four certified colour tiles (yellow, green, brown and blue) were measured using the six calibrations described above. For the “without glass” calibrations, the glass was absent when the tiles were measured and for the “with glass” calibrations, the glass was included when the tiles were measured.

Results and Discussion

The certified X, Y and Z values for the blue, green, yellow and brown coloured tiles are reported in Appendix 1a. The X, Y and Z values obtained when the same four tiles were measured using the six different calibrations are presented in Appendix 1b, along with the corresponding differences from the certified values and the differences in measurements with and without the glass. The average results for all the four tiles are summarised in Table 1 below.

Table 1 : Average values (X,Y,Z) for the six calibrations and their deviations (DX,DY,DZ) from the certified values for the four tiles.

		X	Y	Z	DX	DY	DZ
Opal Tile	without glass	44.79	46.45	46.19	0.14	0.13	0.09
	with glass	42.34	43.90	43.39	-2.31	-2.42	-2.71
	difference	2.45	2.55	2.80			
Ceramic Tile	without glass	44.56	46.21	46.39	-0.09	-0.11	0.30
	with glass	43.09	44.64	45.50	-1.56	-1.68	-0.60
	difference	1.47	1.57	0.90			
Reference	without glass	39.07	40.41	41.07	-5.59	-5.91	-5.03
Wool	with glass	37.84	39.76	40.20	-6.82	-6.56	-5.90
	difference	1.23	0.64	0.87			

From Table 1, it can be concluded that when glass is not included in the optical path the opal tile and ceramic tile calibrations both measure certified ceramic tiles within the expected tolerances of ±0.5 units whereas the pseudo Reference Wool calibration measures 5 to 6 units lower than the certified values.

When the glass is included in the optical path, the measurements for both the ceramic tile and opal tile calibrations produced lower results; 0.6 to 1.7 lower for the ceramic tile calibration and 2.3 to 2.7 lower for the opal tile calibration. The average values for the Reference Wool calibration were much lower, 6 to 7 units, when compared to the certified values. This indicates that calibrating with glossy ceramic tiles behind glass does not fully compensate for the effect of the glass/tile interface.

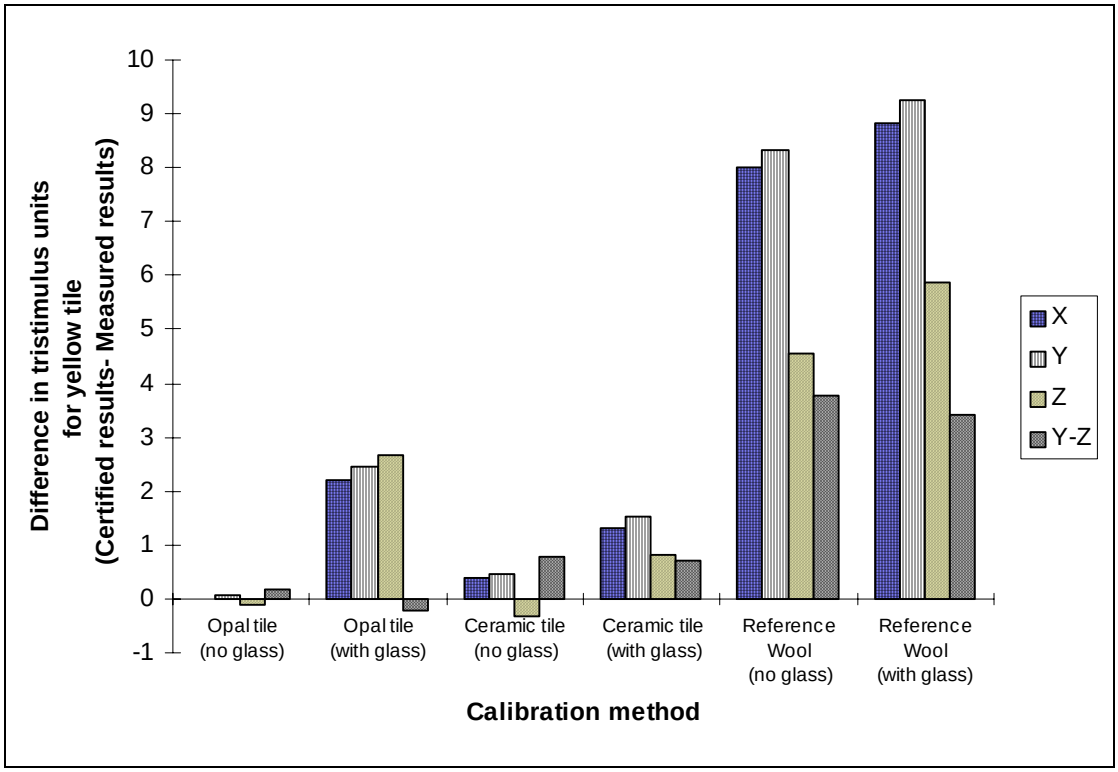
The differences due to the glass can be seen in Table 1 by examining the difference in tristimulus values "without glass" and "with glass". The opal tile calibration exhibited differences from 2.5 to 2.8 units whereas the ceramic tile and Reference Wool (Cream ceramic tile working standard) showed differences from 0.9 to 1.6 and 0.6 to 1.2 respectively. A close inspection of the use of the opal tile in conjunction with the glass revealed that the tile did not fully cover the port due to its physical size and consequently the results may have been influenced by stray light from the room. Thus, if one ignores the opal tile differences, the effect of the glass is to decrease the tristimulus values by 1.1 units on average.

A closer examination of the differences from the certified values presented in Appendix 1b reveals that the values for the Reference Wool calibrations vary much more with the colour of the different tiles than either the opal tile or ceramic tile. Hence, it was considered appropriate to only summarise the data for the yellow tile, which was closest to the colour space of interest for wool. The results are tabulated in Table 2 and are shown graphically in Figure 1. Although the results for the blue, brown and green tiles have not been presented graphically, they closely reflect the results for the yellow tile.

Table 2 : Average values (X,Y,Z) for the six calibrations and their deviations (DX,DY,DZ) from the certified values for the yellow tile only.

		X	Y	Z	DX	DY	DZ
Opal Tile	without glass	61.97	63.22	42.24	0.01	-0.07	0.11
	with glass	59.75	60.83	39.46	2.21	2.46	2.67
	difference	2.22	2.39	2.78			
Ceramic Tile	without glass	61.56	62.83	42.45	-0.40	-0.46	0.32
	with glass	60.64	61.78	41.32	-1.32	-1.51	-0.81
	difference	0.92	1.05	1.13			
Reference Wool	without glass	53.95	54.97	37.59	-8.01	-8.32	-4.54
	with glass	53.14	54.02	36.27	-8.82	-9.27	-5.86
	difference	0.81	0.95	1.32			

Figure 1 : Differences between measured tristimulus values and certified tristimulus values for the yellow tile measured under different calibrations.



The results for the yellow tile on its own follow the same general patterns as has been discussed for the average over all four tiles. The biggest change is for the Reference Wool calibrations where the differences from the certified values have increased to about 8 and 9 units for X and Y with only small changes to the differences in Z.

The differences are of a similar magnitude to the previously reported differences between Reference Wool calibrations and other certified reference standards such as spectralon[1] and a ceramic tile[2] which are summarised in Table 3.

Table 3 : Average Differences Between a Reference Wool Calibration and Other Certified Reference Standards when Measuring Ceramic Tiles that were close to the Colour of Wool.

REFERENCE STANDARD	DIFFERENCES BETWEEN CALIBRATIONS WHEN MEASURING TILES		
	DX	DY	DZ
SPECTRALON	8.0	8.8	3.3
CERAMIC TILE	10.8	11.1	10.6

The use of Certified Ceramic tiles as the basis for judging agreement could be argued to prejudice the findings in favour of a ceramic tile reference as they are clearly closer in surface properties to the opal tile and the ceramic tile than wool. The Reference Wool is claimed to be traceable back to an opal tile or more recently a ceramic tile. The differences that have been reported appear to arise more from the procedures used to assign the values to the wool rather than the physical differences between wool and ceramic surfaces. The assigned values for the Reference Wool include the effects of the WRONZ wool cell[4] whereas the opal and ceramic tile assigned values do not.

The wool industry will have to decide whether to move closer to the colour space defined by stable ceramic standards or, if some other Certified Reference Standard is to be permitted, maintain some link back to the colour space currently defined by the WRONZ Reference Wool. Changing to Certified Reference Standards would mean that the tristimulus values could increase by about 8 to 10 units. As a significant number of growers, traders and processors have built up experience with the current measurements it is likely they would not wish to see any change. A compromise position could be to include on the Certificate the tristimulus values that relate to the Ceramic Standards and include the WRONZ Reference Wool Equivalent values in a similar way that both Wool Base and Commercial Yields appear on the yield Certificate

Conclusions

The opal tile and ceramic tile calibrations without glass in the optical path have been successfully validated with other certified ceramic standards. The Reference Wool calibration was shown to have significant biases in measuring these certified standards. The biases were of a similar magnitude to differences already reported .

The calibration with glass in the optical path was shown to not completely compensate for the presence of the glass. The expected bias in the tristimulus values arising from the glass not being fully taken into account was of the order of one unit lower in the normal colour space for clean scoured wool compared to the 8 to 10 units lower introduced through the Reference Wool.

The wool industry will need to decide whether it wishes to maintain the current system of calibration in the knowledge that the colour space will be specific to the wool standard.

References

1. Reed, P. J., Baird, K. and Marler, J. W. . "Colour measurement of wool: An international round trial evaluating three calibration procedures". IWTO Tech. Cttee. New Dehli Meeting, March 1994. Report No 13

2. Reed, P. J. and Marler, J. W. . "Calibration of colour instruments with a certified ceramic tile and the WRONZ reference wool". IWTO Tech. Cttee. Nice Meeting, December 1994. Report No. 12

3. Marler, J.W. IWTO Tech. Cttee. Raw Wool Group, Appendix 6., 1994

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Appendix 1a : Coloured tile certified values

Certified tile tristimulus values			
Tile	**X**	**Y**	**Z**
Blue	44.88	46.33	73.31
Green	37.49	44.44	46.69
Yellow	61.96	63.29	42.13
Brown	34.27	31.22	22.26
Average	44.65	46.32	46.10

Appendix 1b : Results of coloured tile measurements under different calibrations.

			Tile measurements			Differences from certified values		
Calibration	**Glass in Optical Path**	**Tile**	**X**	**Y**	**Z**	**DX**	**DY**	**DZ**
Opal tile	No	Blue	45.07	46.55	73.31	0.19	0.22	0.00
		Green	37.64	44.59	46.67	0.15	0.15	-0.02
		Yellow	61.97	63.22	42.24	0.01	-0.07	0.11
		Brown	34.49	31.42	22.53	0.22	0.20	0.27
		Average	44.79	46.45	46.19	0.14	0.13	0.09
Opal tile	Yes	Blue	42.44	43.81	70.14	-2.44	-2.52	-3.17
		Green	35.11	41.90	43.50	-2.38	-2.54	-3.19
		Yellow	59.75	60.83	39.46	-2.21	-2.46	-2.67
		Brown	32.07	29.05	20.46	-2.20	-2.17	-1.80
		Average	42.34	43.90	43.39	-2.31	-2.42	-2.71
Ceramic tile	No	Blue	44.96	46.40	73.65	0.08	0.07	0.34
		Green	37.49	44.40	46.87	0.00	-0.04	0.18
		Yellow	61.56	62.83	42.45	-0.40	-0.46	0.32
		Brown	34.22	31.20	22.60	-0.05	-0.02	0.34
		Average	44.56	46.21	46.39	-0.09	-0.11	0.30
Ceramic tile	Yes	Blue	43.35	44.57	73.52	-1.53	-1.76	0.21
		Green	35.84	42.71	45.72	-1.65	-1.73	-0.97
		Yellow	60.64	61.78	41.32	-1.32	-1.51	-0.81
		Brown	32.54	29.50	21.43	-1.73	-1.72	-0.83
		Average	43.09	44.64	45.50	-1.56	-1.68	-0.60
WRONZ Ref. Wool (Cream tile)	No	Blue	39.48	40.58	65.24	-5.40	-5.75	-8.07
		Green	32.83	38.78	41.42	-4.66	-5.66	-5.27
		Yellow	53.95	54.97	37.59	-8.01	-8.32	-4.54
		Brown	30.00	27.30	20.01	-4.27	-3.92	-2.25
		Average	39.07	40.41	41.07	-5.59	-5.91	-5.03
WRONZ Ref. Wool (Cream tile)	Yes	Blue	38.12	39.04	65.09	-6.76	-7.29	-8.22
		Green	31.54	37.47	40.45	-5.95	-6.97	-6.24
		Yellow	53.14	54.02	36.27	-8.82	-9.27	-5.86
		Brown	28.54	25.82	18.97	-5.73	-5.40	-3.29
		Average	37.84	39.76	40.20	-6.82	-6.56	-5.90