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DOES THE ANNULAR ILLUMINATION PROVIDE MORE ACCURATE MEASUREMENTS ?

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Abstract:

In the printing industry today, generally bi-directional geometry is used for both spectrophotometric and densitometric measurements of prints. The growing popularity of special effects in printing, such as the use of metallic inks and foils used in package printing, may also require the integration of spherical measurement devices (using multi-angle spectrophotometers) capable of reading both colour and appearance information to compensate for the diffuse reflection component of the light – basically to ensure correct measurements of shiny colourful metallic prints that bi-directional spectrophotometers can only read as black. The authors undertook an independent study of today's most popular portable spectrophotometers on the market to measure the results and determine whether there were, in fact, real benefits to this new geometry. This article outlines their findings.

Keywords:
spectrophotometry, densitometry, illumination, colour measurement, ring optics

1 OBJECTIVES OF RESEARCH

In the printing industry today, generally bi-directional geometry is used for both spectrophotometric and densitometric measurements of prints. The growing popularity of special effects in printing, such as the use of metallic inks and foils used in package printing, may also require the integration of spherical measurement devices (using multi-angle spectrophotometers) capable of reading both colour and appearance information to compensate for the diffuse reflection component of the light – basically to ensure correct measurements of shiny colourful metallic prints that bi-directional spectrophotometers can only read as black. However, in the realm of traditional spectrophotometry, technological innovation is allowing for better, more accurate results of special effect measurements through the use of ring-optics. The authors undertook an independent study of today's most popular portable spectrophotometers on the market to measure the results and determine whether there were, in fact, real benefits to this new geometry. This article outlines their findings.

2 RESEARCH METHODS

Many popular measurement devices used in the industry today are equipped with 45°x:0° or 0°:45°x measuring geometry, which means that the illumination, or the detection of reflection, points in one direction using one beam of light, as is the case with the Techkon SpectroDens. X-Rite handheld spectrophotometers such as SpectroEye, the 500 Series portable spectrophotometers, 939 and i1Pro are notable exceptions. X-Rite uses illumination at the 45° annular position, which results in measuring geometry that is 45°a:0° - otherwise indicated as *ring-optics* in the technical specifications of these spectrophotometers.

The forty-five degree annular illumination of these devices practically ensures that the structure of the measured sample does not cause any problems during measurement reading. Below is an examination that shows the differences between uni-directional illumination (ring-optics) in practice.

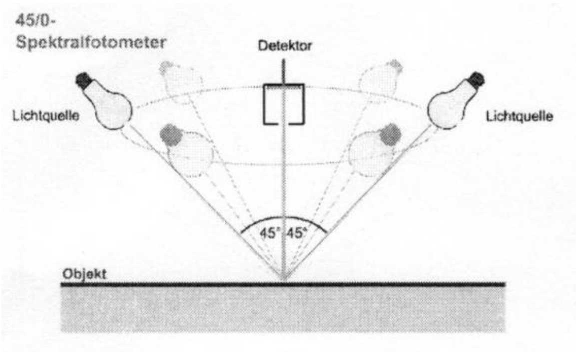

Figure 1 : Ring optics illumination

We controlled testing included measurements of structured samples using both a Techkon SpectroDens spectrophotometer and an X-rite SpectroEye spectrophotometer and analyzed the repeatability of each in relation to the measuring directions.

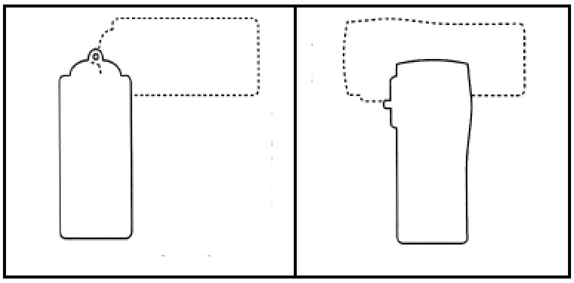

Figure 2: Schematics of measurements completed in the first position and at 90°

Table 1: Well-known densitometers and spectrophotometers, measurement geometries and measuring apertures

Instrument type	**Manufacturer**	**Measurement geometry**	**Aperture size, mm**
SpectroEye	X-Rite	45^oa:0^o	ϕ 4,5 or 3,2
SpectroLino	X-Rite	45^oa:0^o	ϕ 4,5
500 Series	X-Rite	45^oa:0^o	ϕ 3,4 or ϕ 2 or ϕ 6 or 1,6x3,2
939	X-Rite	45^oa:0^o	ϕ 4 or ϕ 8 or ϕ 16
i1Pro	X-Rite	45^oa:0^o	ϕ 4,5
SpectroDens	Techkon	0^o:45^ox	ϕ 3 or 1,5 x 1,5 or 2,5 x 1,0

Notes:[1] GretagMacbeth / X-Rite D19C and SpectroLino are discontinued.

3 SUMMARY OF RESULTS

The results below are taken from different prints measured on artboards, heat-set prints and various copy-papers. The positioning of the devices for measurement was determined based on the structure of the substrate – for artboards measurements were taken in the direction of the embossing, in the case of heat-set prints and copy papers measurement were taken along the grain – and in both cases a second measurement was done at 90° to the original. The following statistical results can be highlighted from the measurement-series of the CIE-L*a*b* colour differences (See the Table 2 below).

When measuring the artboards with the Techkon SpectroDens instrument, the differing angles of measurement resulted in an average of 2-4 ΔE colour difference. When using the X-Rite SpectroEye equipped with ring optics, the measurements taken resulted in ΔE differences of <0.6- < 1.0.

When measuring the heat-set prints and blank copy-papers, the differences were smaller but again not negligible between the two devices:

Techkon SpectroDens ΔE between 0.4-1.6 difference;

X-Rite SpectroEye spectrophotometer: ΔE between 0.2 – 0.7 difference.

Table 2: Statistical results of differences between measurement-series (10-10) taken at right angles (D50/2º/Black backing)

Statistical attributes	**Print samples**					**Reference standard***
	1	**2**	**3**	**4**	**5**	
	ΔE^*_{ab}, CIELAB color differences					
X-Rite SpectroEye						
ΔE^*_{ab} (average)	0,54	0,42	0,47	0,28	0,22	0,07
ΔE^*_{ab} (max)	0,92	0,75	0,74	0,53	0,62	0,14
ΔE^*_{ab} (68%)	0,67	0,52	0,55	0,34	0,26	0,10
Techkon SpectroDens						
ΔE^*_{ab} (average)	2,26	2,74	0,62	0,35	1,17	0,06
ΔE^*_{ab} (max)	3,29	3,88	1,41	0,76	1,60	0,21
ΔE^*_{ab} (68%)	2,45	2,90	0,81	0,40	1,32	0,11

Measured prints: 1: embossed artboard printed with dark green, 350 g/m²; 2: micro-corrugated bord, 350 g/m² printed with light green color; 3: heat-set print (52 g/m² LWC paper printed with red color); 4: heat-set print (60 g/m² LWC paper printed with yellow color); 5: copy-paper, 80 g/ m² (unprinted, white).

- OMH white ceramic tile

4 CONCLUSION

The ring optics provides more accurate measurements.

Seeing from the results of this study, the positioning orientation of the instrument makes a big difference in the veracity of the resulting measurement.

Instruments using uni-directional geometry result in higher ΔE differences than those with ring-optics.

5 REFERENCE

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