TECHKON

Expectations for Inter-instrument Agreement

A previous blog post ("Consistent Color Measurement") discussed instrument settings and procedures to ensure consistent color measurement throughout the supply chain. Once these are all in place, how well will instruments agree?

All spectrophotometer manufacturers quote "repeatability" as one of their specs. This is the degree to which an instrument agrees with itself when making measurements of the same spot on the same sample, over a short period of time. Instrument repeatability is a small number, often less than 0.1 ΔE^*_{ab}. This number is misleading, since it is by far not the limiting factor. And it sets up an expectation that different instruments should agree this closely.

There have been a number of studies by researchers where different instruments have been compared. John Seymour presented a paper at TAGA 2013 where he summarized the results of seven studies. Quoting from his paper:

It's difficult to distill these studies down to a single number, but it is fair to say that 1.0 ΔE^*_{ab} is a reasonable estimate for average disagreement, and that seeing disagreement greater than 2.0 ΔE^*_{ab} is not uncommon.

Our Own Tests With 4 Instrument Models

To see where things stand **in field use**, we measured a range of printed colors. Both spot and process colors were included. Each color was measured using four spectrophotometers:

- Three X-Rite models - 939, SpectroEye, and eXact
- One Techkon SpectroDens

All instruments were within the certification from their manufacturer. The three X-Rite instruments are all XRGA certified. The fourth instrument is a Techkon SpectroDens. In each case, the print was measured at approximately the same spot.

The goal was to try and answer the following questions:

1. What is the typical variation we can expect when measuring printed colors with different instruments?
2. How does the Techkon SpectroDENS compare with X-Rite's XRGA certified instruments?

TABLE 1: Color values measured on 4 different instruments using M0 condition. Samples had little or no fluorescence.

INSTRUMENT	X-Rite 939			Techkon SpectroDens			X-Rite SpectroEye			X-Rite eXact			eXact vs. SpectroDENS
COLOR	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*	ΔE_{00}
Yellow	89.1	-5.1	108.6	89.2	-5.3	107.3	89.1	-5.6	107.5	89.2	-5.4	108.2	0.15
Yellow 012	87.4	1.5	112.2	87.2	1.4	110.9	87.6	0.9	111.7	87.6	1.0	112.3	0.39
Orange 021	61.5	63.1	89.9	61.4	62.5	88.1	61.9	62.8	87.9	61.9	62.7	89.0	0.46
Warm Red	59.4	67.3	50.3	59.4	66.9	50.1	59.9	66.9	50.8	60.0	66.7	50.9	0.65
Red 032	54.9	72.4	40.9	54.7	72.4	40.6	55.4	72.4	41.2	55.5	72.1	40.6	0.74
Rubine Red	44.4	77.0	9.2	44.7	77.0	10.3	44.8	77.3	9.9	44.5	77.1	9.5	0.38
Rhodamine Red	52.7	75.4	-11.3	52.7	74.8	-10.6	53.2	75.3	-10.0	53.1	75.3	-10.4	0.46
Purple	48.3	66.1	-34.1	48.6	65.4	-32.7	48.5	66.5	-33.3	48.5	66.4	-33.5	0.31
Violet	24.5	39.6	-58.7	24.5	38.7	-57.7	25.3	38.9	-57.1	25.0	39.3	-57.9	0.44
Process Blue	44.5	-33.2	-53.6	44.3	-34.1	-53.2	44.5	-31.9	-54.7	44.4	-33.0	-53.9	0.52
Green	56.6	-77.9	2.5	56.7	-77.2	2.4	56.7	-77.6	1.0	56.8	-77.7	1.6	0.39
Black	13.7	1.2	2.1	13.5	1.1	2.3	14.5	1.1	1.9	14.2	1.1	2.1	0.50
Process Yellow	90.1	-7.2	89.8	90.0	-7.2	88.9	90.2	-7.7	89.4	90.3	-7.4	89.5	0.22
Process Magenta	48.3	74.8	-1.0	48.5	74.4	0.1	48.7	75.2	-0.2	48.7	75.0	-0.4	0.30
Process Cyan	59.0	-37.3	-44.9	59.1	-38.0	-44.4	58.7	-36.7	-45.6	58.8	-37.2	-44.9	0.48
Process Black	13.5	0.2	0.7	12.8	0.2	0.9	14.4	0.3	0.7	14.4	0.2	0.7	0.99

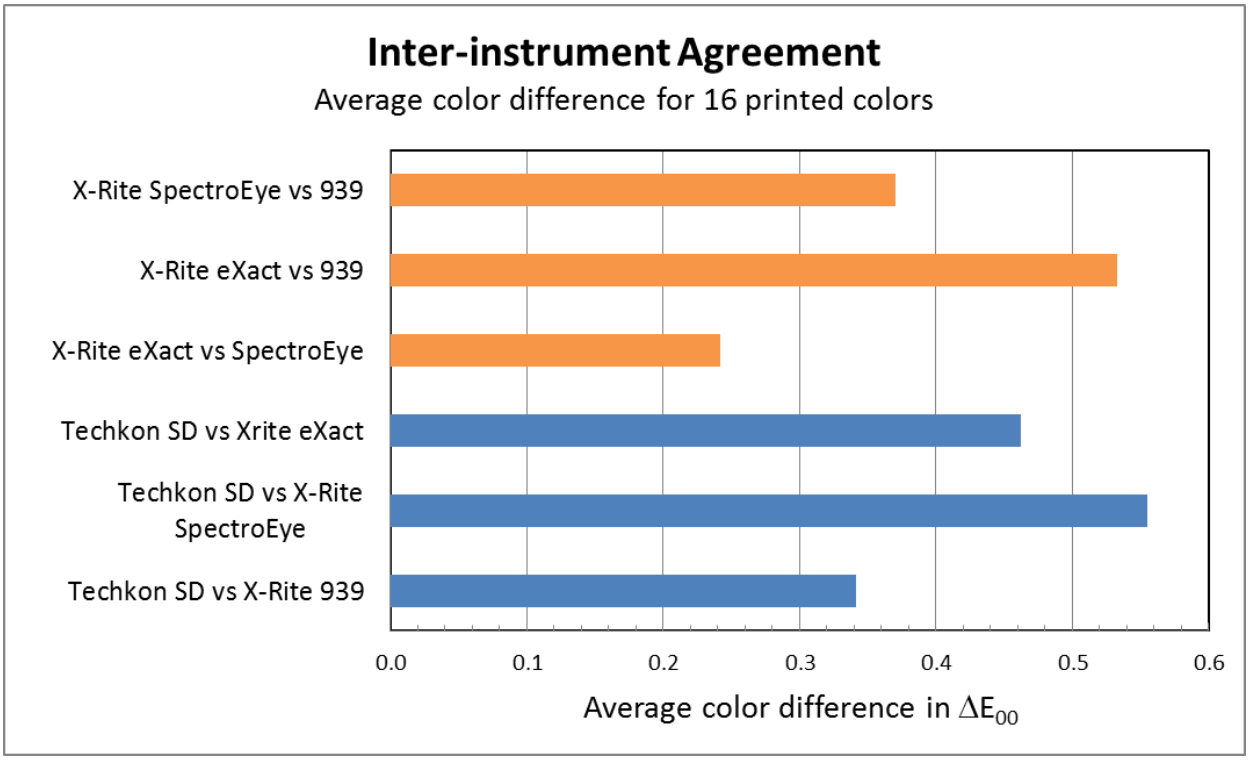

FIGURE 1: Blue bars show inter-instrument agreement between Techkon SpectroDENS and three different X-Rite models. Orange bars show inter-instrument agreement between three different XRGA certified X-Rite models in field use.

We reduced the measurement data to color differences in ΔE_{00} between 6 different pairs of instruments. Three of these pairs were between Techkon SpectroDENS and X-Rite models. The other three pairs were between the X-Rite models themselves. In this exercise, average color differences in ΔE_{00} ranging from 0.24 to 0.55 were found when considering all 16 colors. The maximum color difference in ΔE_{00} for any color between any pair of instruments was 1.06. This represents what can be expected in commercial practice for certified and well-maintained instruments. The variation between instruments is within expected tolerance for printing of brand colors (color difference in ΔE_{00} of 2.0 to 3.0). **It is worthwhile to note that the Techkon SpectroDENS agrees with the X-Rite units almost as well as the X-Rite instruments agree amongst themselves.**

What about M1?

All previous measurements were under M0 mode, and on samples with little or no fluorescence. What about M1 measurements on fluorescent samples? Dave Wyble et al. measured fluorescent reference tiles with seven M1 instruments from three instrument manufacturers, including Techkon. These reference tiles were also measured by the Canadian national standards lab, NRC. The results showed a broader dispersion among the eight instruments in M1 mode for the most highly fluorescent samples than we would see in M0 measurement condition. This paper titled ""Investigation of the Implementation Aspects of the M1 Condition" was presented at 2015 TAGA by Wyble and Seymour and will be published soon. We hope to further explore the topic of inter-instrument agreement in the presence of fluorescence and UV light in a separate post.

What is XRGA?

When X-Rite joined with GretagMacbeth in 2006, they had to deal with a unique problem. They now needed to harmonize the measurements from instruments that had been designed and manufactured by different companies on different continents. The acronym “XRGA” was coined to brand this effort of reconciling measurements to a newly adopted common reference point. It is not a universal standard, but an internal reference point used by X-Rite to calibrate different instrument models in adherence to standards (ISO 13655, in particular). Other instruments developed according to ISO standards that are calibrated according to best practice manufacturing processes can be expected to agree with each other as well as XRGA instruments. (More about XRGA here)

In Conclusion

1. Inter-instrument agreement is important where production samples are compared to reference data set that was obtained from a different device. If the standard and sample

can be measured on the same device, there is normally no need to be concerned about inter-instrument agreement.

2. We found that print samples measured on different instrument models can typically be expected to vary by average ΔE_{00} of 0.5 for M0. With fluorescent samples, the M1 measurement condition shows somewhat larger variations according to a recent study by Wyble and Seymour.
3. From our data collected using field instruments in normal pressroom use conditions, we observed that Techkon SpectroDENS agrees with the X-Rite units about as well as X-Rite instruments agree amongst themselves.

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