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A Research Monograph of the

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Introduction

IDEAlliance's G7 is a calibration method developed to support the GRACoL specification. The "G" refers to calibrating grey values and the "7" refers to the seven primary colors: cyan, magenta, yellow, black, red, green, and blue.

G7 is a press calibration method that uses near neutral as the criterion. An innovation of G7 is that it defines substrate-corrected grey reproduction aim points to achieve a consistent visual grey scale which can be applied to diverse substrates and different printing methods. It defines tonality using Neutral Print Density Curves (NPDC) instead of traditional dot gain (TVI) measurements.

G7 Master Printers are qualified by IDEAlliance based on their ability to print to G7 standards. As of September 2010, there were 512 qualified G7 Master Printers. These companies are concentrated mainly in North America with a smaller but growing number in Asia (Fazzi, 2010).

Since G7 contains aim points but lacks associated tolerances, it is not a fully defined specification. In order to advance G7 toward a fully defined specification, this research assessed 85 P2P25x characterization data sets submitted by 85 G7 Master Printers with respect to variations of paper white, process ink and overprint solids, and grey reproduction conformance.

This research studied the G7 method using the GRACoL (2006) data set as a part of the specification. ISO 12647-2 was also used as a reference to help study G7 tolerances.

Executive Summary

The IDEAlliance database analyses accomplished their primary objectives, with the following results:

Paper White Assessment

Excessive variation was found in b^* rather than in L^* and a^*. Close to one-half of the 85 submitted papers were out of conformance. If paper white conformance is not required, there is a need to implement corrected aims for solids and grey.

Process Ink and Overprint Solids Assessment

More than 80% of the cyan, magenta, and yellow solids and over 90% of the black solids conformed to 5 ΔE^*_{ab}. Close to 60% of the RGB overprint solids conformed to 5 ΔE^*_{ab}. Sixty-six percent of the submissions in the database passed CMYK job-wise conformance, while only 21% of the submissions passed both CMYK and RGB job-wise conformance. Therefore, larger tolerances for RGB overprint solids are necessary.

G7 Grey Reproduction Assessment

Both a^* and b^* values migrate towards zero as grey darkens. However, large chroma differences appear in the shadow areas. Sixty-eight percent of the printer data sets passed the current G7 Pass/Fail criteria. The maximum ΔC_h [1] at quarter-tone, mid-tone, and three-quarter-tone were 2 ΔC_h, 3 ΔC_h, and 4 ΔC_h, respectively, for the printer data sets that passed the criteria.

1 - Formerly ΔF^*.

Background

The G7 Master Printers database consists of 85 sets of spectral reflectance data measured from a P2P25x characterization target (see Figure 1.)

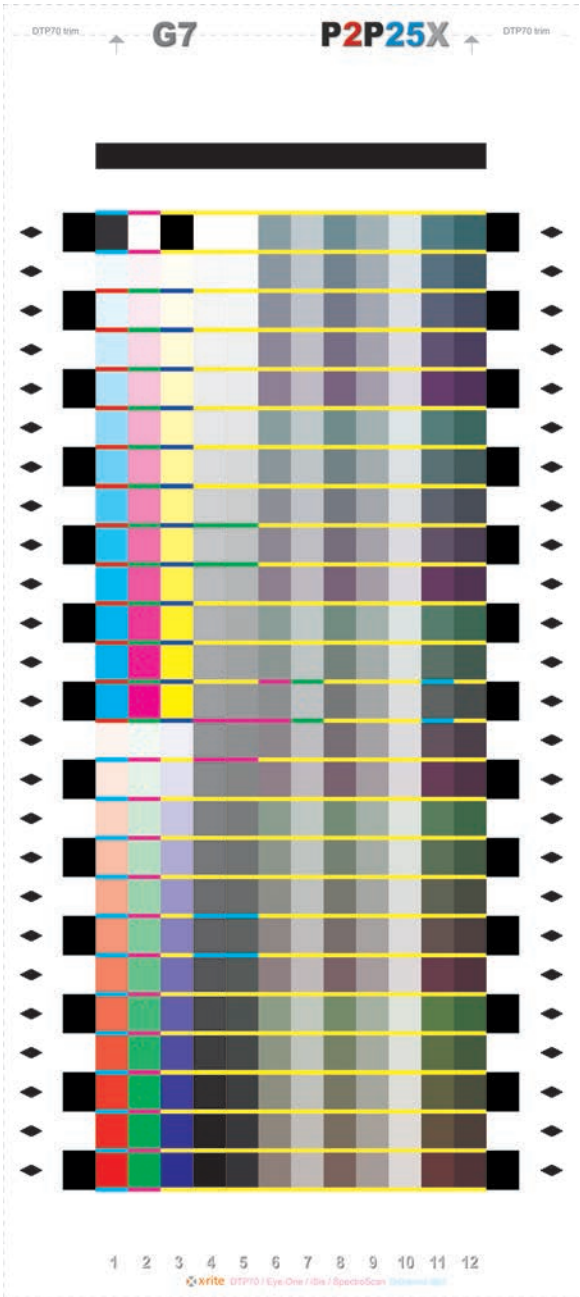

Figure 1. P2P25x characterization target

Most of the data sets were measured using a single X-Rite i1 iO spectrophotometer, with only 4 data sets measured using an X-Rite i1 iSis spectrophotometer. All the samples were measured using white backing with UV included conditions.

All of the spectral reflectance data was converted to CIELAB (D50, 2-degree standard observer). There are three paper white measurement patches, two quarter-tone grey (25C, 19M, 19Y) patches, two mid-tone grey (50C, 40M, 40Y) patches, two three-quarter-tone grey (75C, 66M, 66Y) patches, and two grey solid (100C, 100M, 100Y) patches on the P2P25x target. The spectral reflectance data was averaged before converting to CIELAB values in the data analyses. Matlab was used to perform the data analyses and graphing.

Three topics were studied: paper white, process ink and overprint solids, and grey reproduction conformance. For each topic, objectives are stated followed by the procedures used, the results obtained, and a discussion of major findings.

Paper White Assessment

Objective

To assess the paper white variation and conformance of the G7 database.

Procedure

The paper white assessment procedures were as follows:

1. Plot histograms of L^*, a^*, and b^*.

1. Plot a scatter diagram of a^* and b^*.

2. Compare the paper white measurement data with the aim values specified in G7 (see Table 1) and plot the cumulative frequency distribution (CRF curves).

Table 1. Aim values for GRACoL 2006 Coated 1 Paper and the tolerance per ISO 12647-2:2004/Amd 1:2007 under white backing measurement condition with D50 illuminant and 2-degree standard observer

Category	L^*	a^*	b^*
GRACoL 2006 Coated 1 Paper	95	0	-2
Tolerance	± 3	± 2	± 2

3. Assess the paper white variation and conformance.

Results

L^* Variation and Conformance

Figure 2 shows the lightness distribution of the 85 papers. As seen in the graph, only 2 out of 85 papers (2%) are out of conformance according to the aim values of GRACoL 2006 Coated 1 Paper.

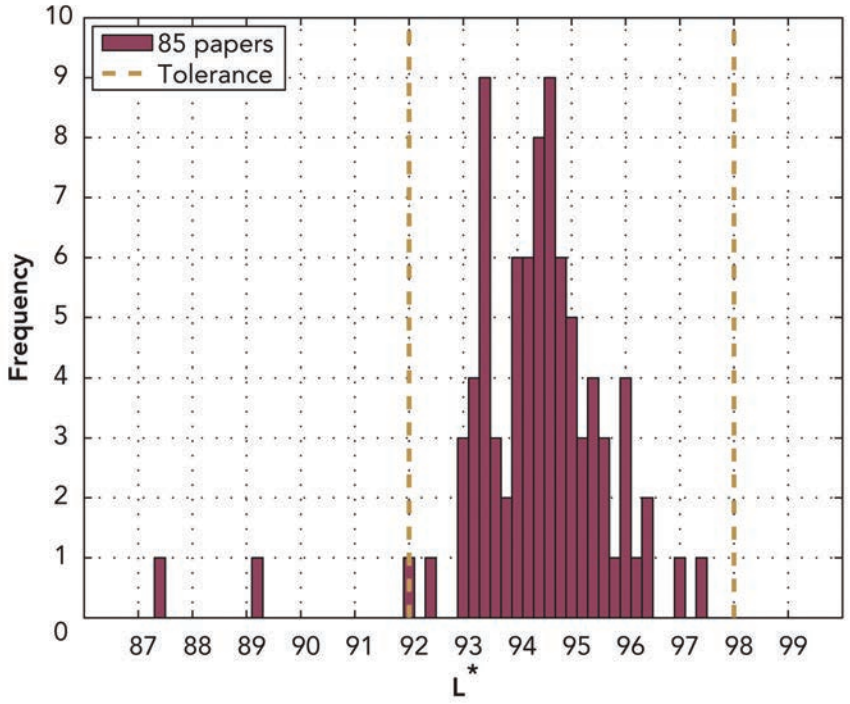

Figure 2. L^* histogram of the 85 papers

Figure 3 shows the cumulative distribution of the L^* values. Ninety percent were within 2 ΔL^*.

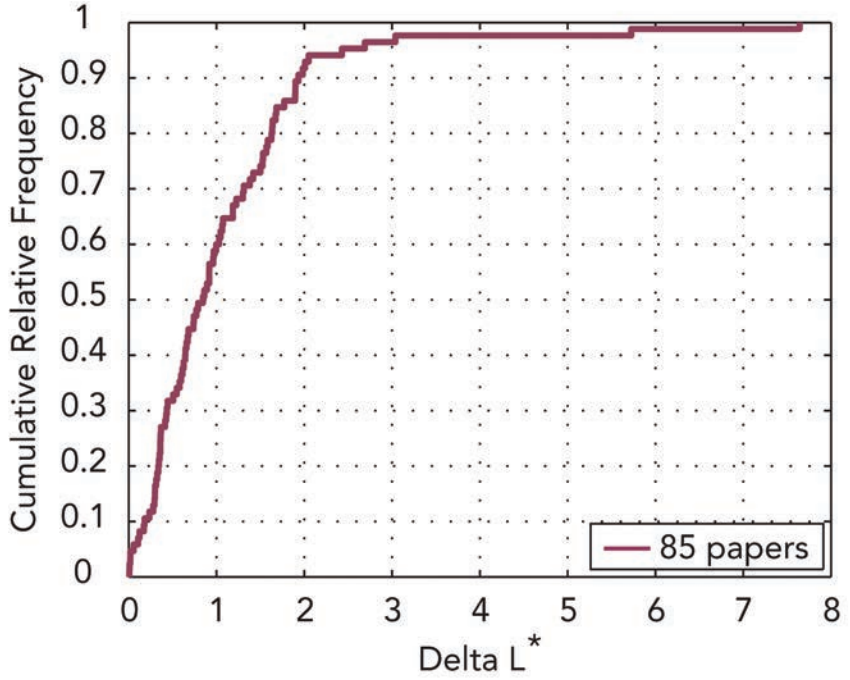

Figure 3. Cumulative relative frequency (CRF) of delta L^* of the 85 papers

a* and b* Variation and Conformance

The a* values of the 85 paper whites varied from -0.3 to 2.4 and the b* values were between -7.6 and 2.6. The range of a* values was 2.7 and the range of b* values was 10.2, which indicates that most a* values were within tolerance while b* values had a large variation (see Figure 4).

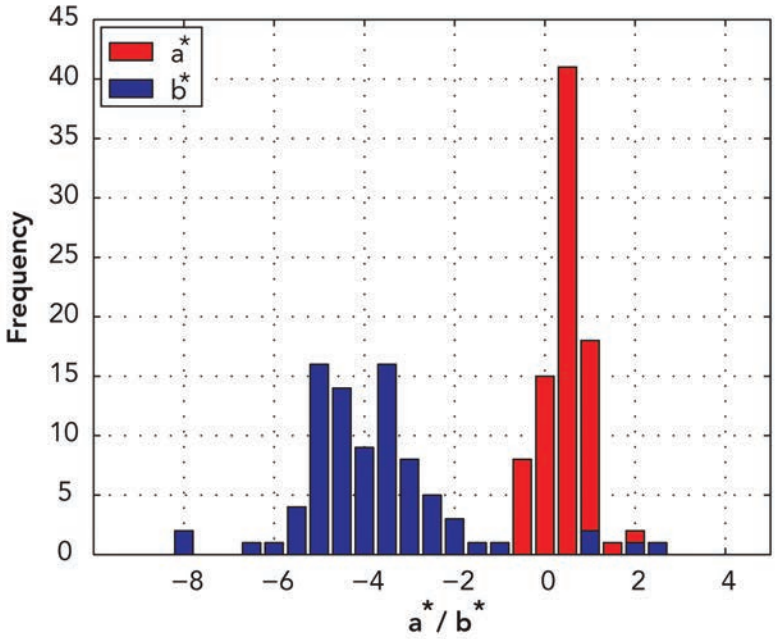

Figure 4. Histogram of a* and b* values of the 85 papers

Figure 5 shows the scatter plot of the 85 submitted papers. Most of the submitted papers were more bluish than the aims specified in ISO 12647-2:2004/Amd 1:2007. Forty-three out of 85 papers (51%) were in conformance.

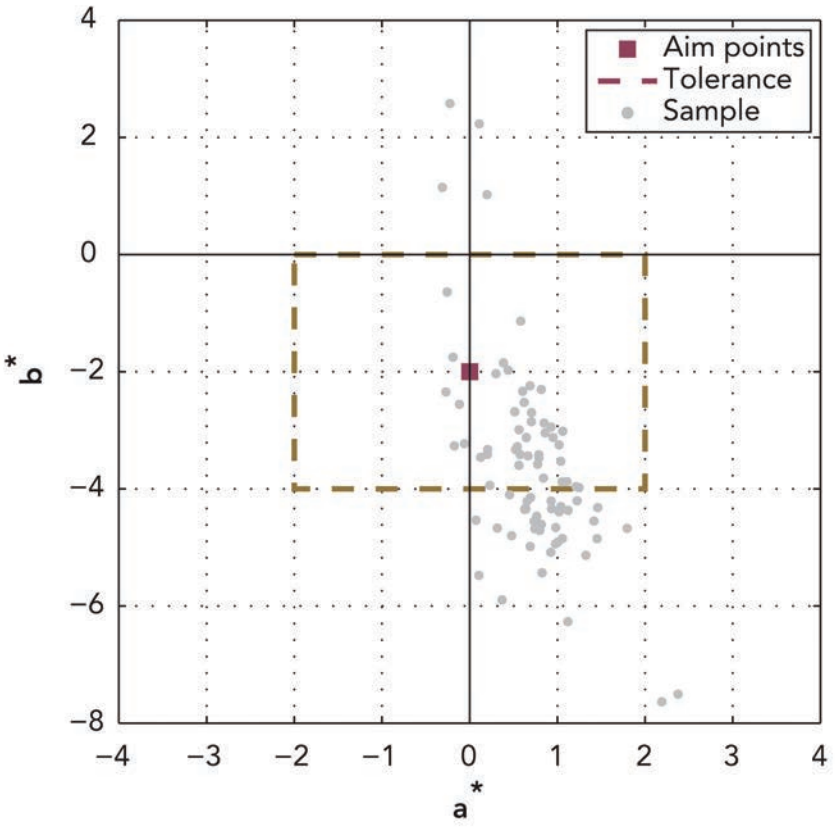

Figure 5. Chroma distribution of the 85 papers

Discussion

Paper white is the 'fifth color' in four-color printing and is a significant element in printed color reproduction. As seen from the results, variation in b^* is larger than that in L^* and a^*, which implies that OBA (Optical Brightening Agent) is widely used.

Based on these 85 sets of data, close to one half of the papers were out of conformance. Thus, if paper white conformance is not a requirement, then substrate-corrected aims for solids and near neutral triplets need to be implemented before assessment.

Process Ink and Overprint Solids Assessment

Objectives

1. To assess the conformance of process ink and overprint solids to the following aims:
    a. Process solid aims as specified in GRACoL.
    b. Overprint solids (RGB) aims as specified in ISO 12647-2:2004/Amd 1:2007.
    c. 5 ΔE^*_{ab} is the tolerance for solids and overprint conformance in this study.
2. To assess the conformance of process ink and overprint solids by job.

Procedure

1. Compute ΔE^*_{ab} between CMYKRGB solids and published aims (see Table 2) to characterize their variation.
2. Assess solid and overprint conformance by color via the use of ΔE^*_{ab} cumulative distributions.
3. Assess solid and overprint conformance by job. A job is considered in conformance when all solid colors, i.e., CMYK, are in conformance.

Table 2. Aim values of CMYK solids per GRACoL 2007 specification and RGB solids and tolerance per ISO 12647-2:2004/Amd 1:2007 under D50 illuminant, 2-degree standard observer, and white backing measurement conditions

Category	L^*	a^*	b^*
Cyan	55	-37	-50
Magenta	48	74	-3
Yellow	89	-5	93
Black	15	0	0
Red (M+Y)	47	68	48
Green (C+Y)	50	-68	25
Blue (C+M)	24	17	-46
Tolerance	5 ΔE^*_{ab}		

Results

CMYK Solids Conformance

Figure 6 shows the ΔE^*_{ab} histograms of the process ink solids compared to the aim values shown in Table 2. The specified tolerance (5 ΔE^*_{ab}) is shown as the red dotted line in the graphs.

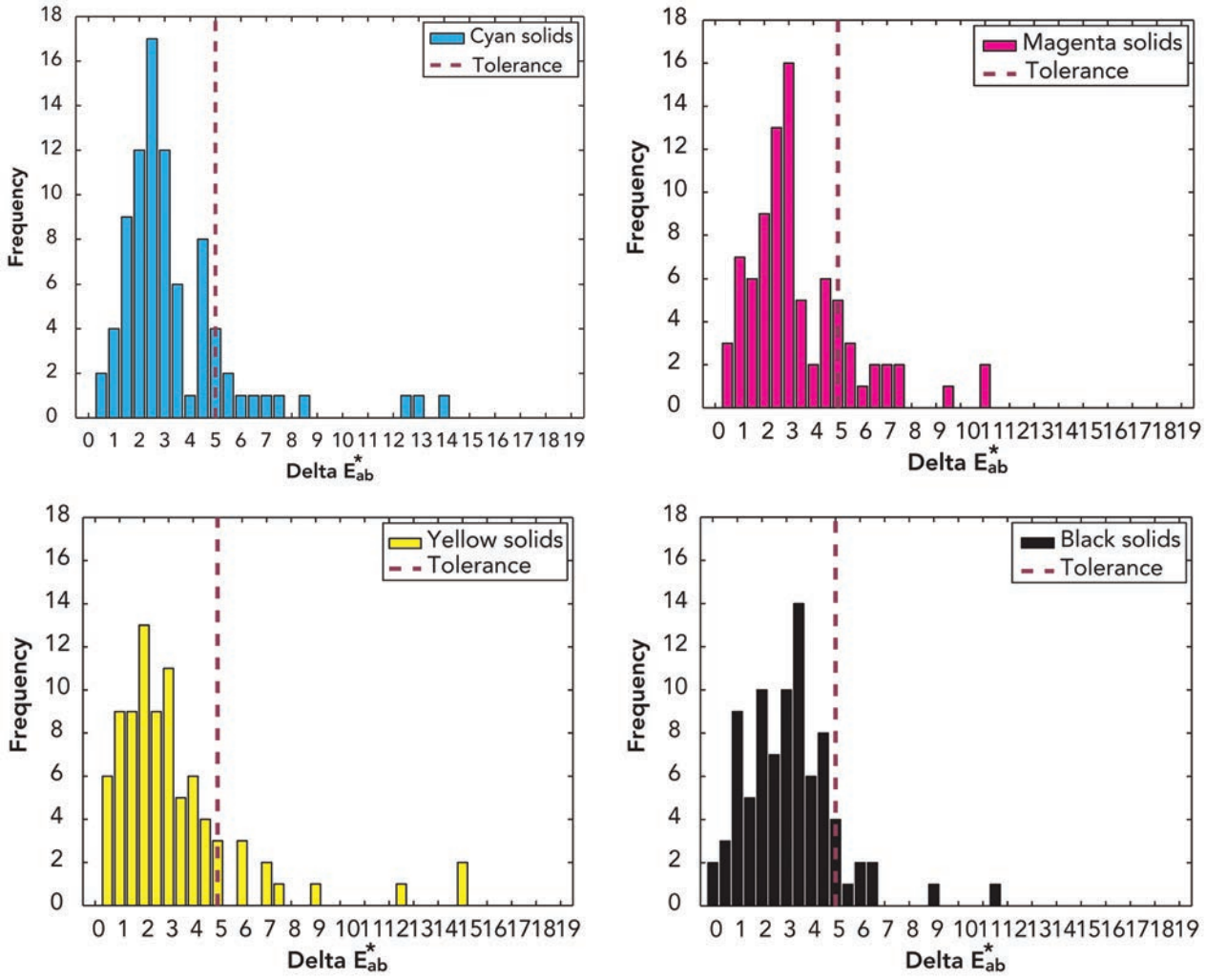

Figure 6. ΔE^*_{ab} histograms of the process ink solids

As seen in Figure 6, 84% of the cyan, 79% of the magenta, 85% of the yellow, and 92% of the black ink solids were within 5 ΔE^*_{ab} of their aim values.

The cumulative distributions of CMYK solids shown in Figure 7 indicate that 90% of the cyan and yellow solids were below 6 ΔE^*_{ab} and 90% of the magenta solids were below 7 ΔE^*_{ab}.

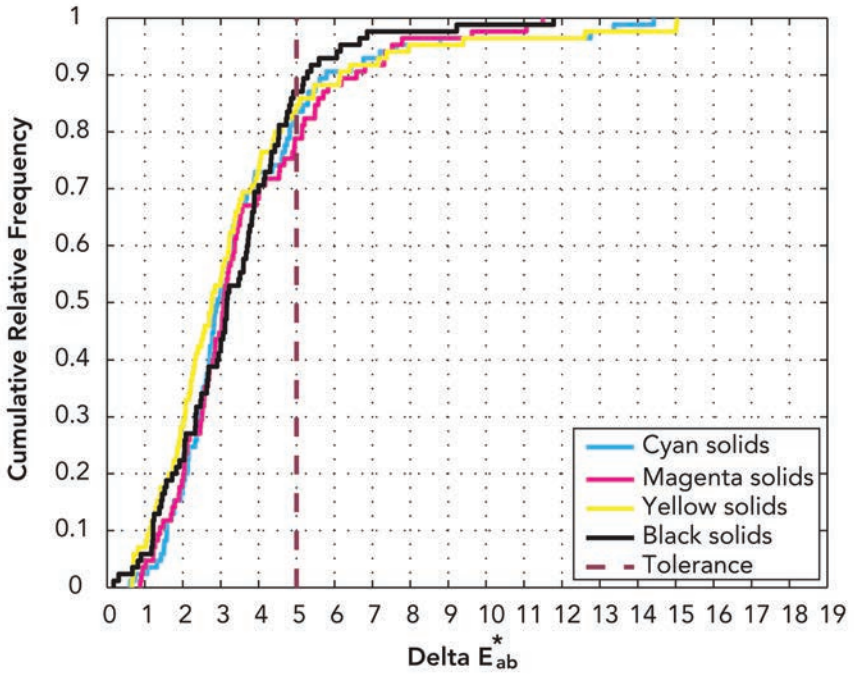

Figure 7. CRF curves showing the ΔE^*_{ab} distribution of CMYK solids compared with the aim values specified in GRACoL 2007

RGB Solids Conformance

Figure 8 shows the ΔE^*_{ab} histograms of the overprint solids. Seventy-three percent of the red solids, 43% of the green solids, and 59% of the blue solids were within 5 ΔE^*_{ab}.

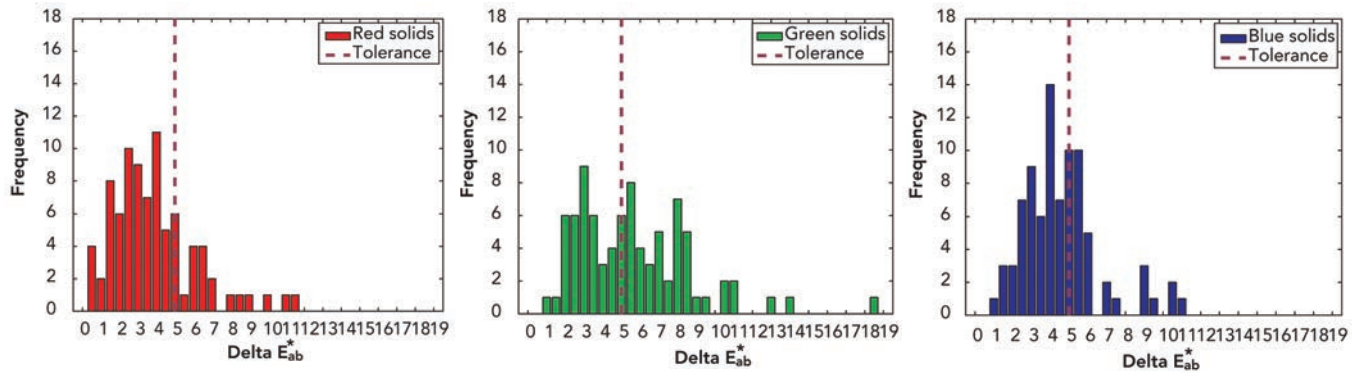

Figure 8. ΔE^*_{ab} histograms of the overprint ink solids

Figure 9 shows the CRF curves of color difference between RGB solids and their specified aim values. Ninety percent of the red solids were below 7 ΔE^*_{ab}, 90% of the blue solids were below 7.5 ΔE^*_{ab}, and 90% of the green solids were below 9 ΔE^*_{ab}.

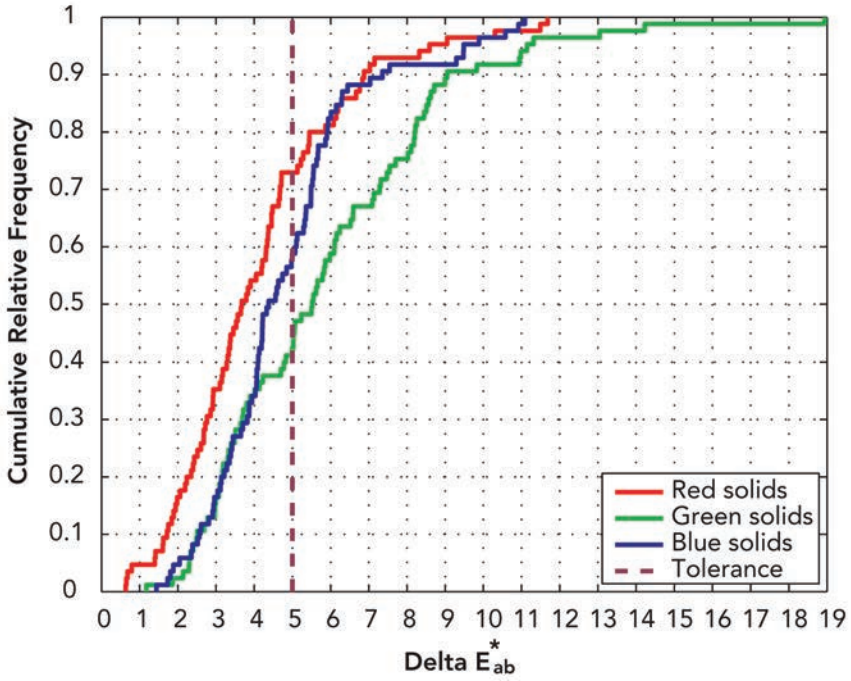

Figure 9. CRF curves showing the ΔE^*_{ab} distributions of RGB solids compared with the aim values specified in ISO 12647-2:2004/Amd 1:2007

CMYK and RGB Solids Job-wise Conformance

A job is considered to be in conformance when the color differences of the CMYK solids are all within 5 ΔE^*_{ab}. Table 3 summarizes job-wise conformance for the 85 data sets submitted. As this table shows, 56 out of 85 G7 Master Printer submissions (66%) demonstrated job-wise conformance to GRACoL 2007.

Moreover, 19 out 85 of the submissions (22%) demonstrated both CMYK and RGB conformance within 5 ΔE^*_{ab}.

Table 3. CMYK solids conformance according to GRACoL 2007 specification†

No.	C	M	Y	K	Pass?	R	G	B
1	4	3	1	1	Y	2	5	8
2	3	3	4	5	Y	3	4	2
3	2	4	5	4	Y	3	8	10
4	3	3	4	5	Y	3	9	3
5	1	7	4	4	N	5	5	4
6	2	2	2	4	Y	1	9	6
7	3	5	5	5	Y	7	10	5
8	2	6	1	5	N	5	3	6
9	3	2	4	1	Y	9	8	6
10	5	3	6	12	N	4	6	5

No.	C	M	Y	K	Pass?	R	G	B
11	1	3	3	2	Y	3	4	3
12	2	3	8	1	N	4	5	6
13	9	11	9	6	N	12	11	9
14	2	1	1	4	Y	7	4	3
15	3	1	4	4	Y	1	7	3
16	2	2	1	4	Y	5	9	5
17	3	5	2	3	Y	8	4	5
18	1	2	3	0	Y	2	5	3
19	5	7	2	5	N	4	6	5
20	5	5	3	3	Y	3	7	5
21	13	10	15	3	N	2	5	4
22	4	3	3	6	N	5	5	5
23	2	2	3	3	Y	1	2	4
24	14	11	15	4	N	5	8	3
25	3	4	4	5	Y	6	3	4
26	5	3	2	2	Y	3	5	6
27	2	4	4	4	Y	5	3	6
28	3	3	2	1	Y	2	7	5
29	3	2	1	4	Y	2	3	4
30	3	2	2	2	Y	2	6	2
31	8	3	2	0	N	4	14	11
32	5	3	2	3	Y	1	9	5
33	4	5	2	4	Y	2	8	5
34	3	2	3	4	Y	4	2	3
35	5	3	2	2	Y	3	5	4
36	1	4	2	3	Y	4	6	6
37	3	1	3	2	Y	3	3	3
38	3	1	2	6	N	3	2	4
39	5	8	4	1	N	1	7	11
40	2	3	2	3	Y	4	4	4
41	5	3	2	1	Y	5	6	4
42	7	2	1	1	N	4	11	9
43	5	2	3	7	N	2	8	7
44	1	2	1	2	Y	5	3	4
45	5	7	3	4	N	4	9	5
46	3	5	1	2	Y	3	3	7
47	5	2	1	3	Y	2	3	4
48	2	3	3	5	Y	2	3	4
49	3	5	5	4	Y	3	6	5
50	3	5	5	4	Y	4	7	5

No.	C	M	Y	K	Pass?	R	G	B
51	3	6	2	5	N	5	5	6
52	4	6	2	1	N	5	7	5
53	3	1	3	5	Y	3	7	2
54	5	3	1	2	Y	2	5	4
55	4	2	2	1	Y	2	3	3
56	7	8	5	3	N	6	8	5
57	3	3	7	1	N	9	6	9
58	6	3	2	2	N	4	8	5
59	2	7	5	3	N	6	3	4
60	2	1	4	7	N	6	2	3
61	3	1	1	1	Y	4	2	3
62	2	3	1	5	Y	3	4	3
63	2	3	4	2	Y	7	13	1
64	2	6	2	3	N	7	3	6
65	3	5	3	2	Y	4	6	4
66	3	2	2	2	Y	3	6	4
67	2	4	13	4	N	5	3	2
68	2	3	3	3	Y	7	1	2
69	3	1	2	2	Y	3	11	6
70	13	4	7	3	N	11	11	6
71	3	5	1	2	Y	4	2	11
72	6	3	3	1	N	4	6	3
73	4	3	3	3	Y	6	7	6
74	3	1	1	4	Y	3	3	3
75	3	2	3	5	Y	4	3	3
76	2	5	3	3	Y	3	6	4
77	2	1	3	2	Y	2	4	2
78	3	3	4	4	Y	10	19	3
79	3	3	6	5	N	3	2	4
80	2	3	5	4	Y	4	8	5
81	4	3	2	3	Y	3	4	4
82	2	5	3	4	Y	4	4	6
83	1	4	3	3	Y	1	6	6
84	6	3	1	4	N	2	9	6
85	3	3	6	9	N	7	8	4

†The numbers in red are out of conformance.

Discussion

Table 4 shows the percentage of CMYK and RGB conformance and the 90% ΔE^*_{ab} values (n = 85). CMY solids conformance was around 80% to 90%, while black solid conformance was over 90%. RGB conformance was relatively lower than CMYK solids conformance, which implies that a larger ΔE^*_{ab} tolerance will be required if RGB conformance is a requirement.

Table 4. Percentage of CMYK and RGB conformance to GRACoL with their 90% ΔE^*_{ab} values

Color	Pass 5ΔE^*_{ab}	90% ΔE^*_{ab}
Cyan	84%	6 ΔE^*_{ab}
Magenta	79%	7 ΔE^*_{ab}
Yellow	85%	7 ΔE^*_{ab}
Black	92%	5 ΔE^*_{ab}
Red	73%	7 ΔE^*_{ab}
Green	48%	7.5 ΔE^*_{ab}
Blue	60%	9 ΔE^*_{ab}

G7 Grey Reproduction Assessment

Objectives

1. To evaluate G7 grey reproduction variation.
2. To evaluate grey reproduction conformance based on the current G7 Pass/Fail criteria.
3. To evaluate grey reproduction conformance using a new method based on quarter-tone (25C, 19M, 19Y), mid-tone (50C, 40M, 40Y), and three-quarter-tone (75C, 66M, 66Y) patches (the three near-neutral triplet method).

Procedures

Analysis of Grey Reproduction Variation

1. Plot measured a^* and b^* values of CMY triplets as a function of percent dot. All 25 triplets in Column 5 of the P2P target were plotted.
2. Plot a^* and b^* values of the following five CMY triplets as a scatter diagram: (4C, 3M, 3Y), (25C, 19M, 19Y), (50C, 40M, 40Y), (75C, 66M, 66Y), and (100C, 100M, 100Y).

Analysis of Grey Reproduction Performance Based on the G7 Pass/Fail Criteria

1. Compute grey ramp aims based on the actual paper color using the following equations:

$$a^* = a^*_{paper} \times \frac{100 - C\%}{100} \quad (1)$$

$$b^* = b^*_{paper} \times \frac{100 - C\%}{100} \quad (2)$$

2. Evaluate the cumulative distribution of ΔC_h using the following equation:

$$\Delta C_h = \sqrt{(a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2} \quad (3)$$

3. Compute the weighted ΔC_h ($w\Delta C_h$ [2]) values for all 23 triplets using the following equation:

$$w\Delta C_h = \sqrt{(a^*_{sample} - a^*_{reference})^2 + (b^*_{sample} - b^*_{reference})^2} \times \left(1 - \max\left(0, \frac{C\% - 50}{50} \times 0.75\right)\right) \quad (4)$$

4. Evaluate $w\Delta C_h$ conformance based on the G7 Pass/Fail criteria. The average $w\Delta C_h$ should be less than or equal to 1.5 and the maximum ΔC_h should be less than or equal to 3.0.

2 - Formerly $w\Delta F^*$.

Note: An evaluation of ΔL^* is omitted because there is no published method for determining L^* aims.

Analysis of Grey Reproduction Conformance Based on the Three Near-Neutral Triplet Method

1. Evaluate CRF curves of ΔC_h at (25C, 19M, 19Y), (50C, 40M, 40Y), and (75C, 66M, 66Y) for data sets passing the G7 Pass/Fail criteria.
2. Find the maximum ΔC_h for each triplet.
3. Apply these ΔC_h values as the tolerance for pass/fail at the triplets.
4. Compare the two methods.

Results

Grey Ramp Distribution

Figure 10 shows the variance of the 25 steps of a^* and b^* values of the CMY grey triplets on the P2P25x test target. As seen from the graph, the values around 0% reflect the variation of the paper white. As grey darkens, a^* and b^* values migrate towards zero, but the shadow tones vary widely.

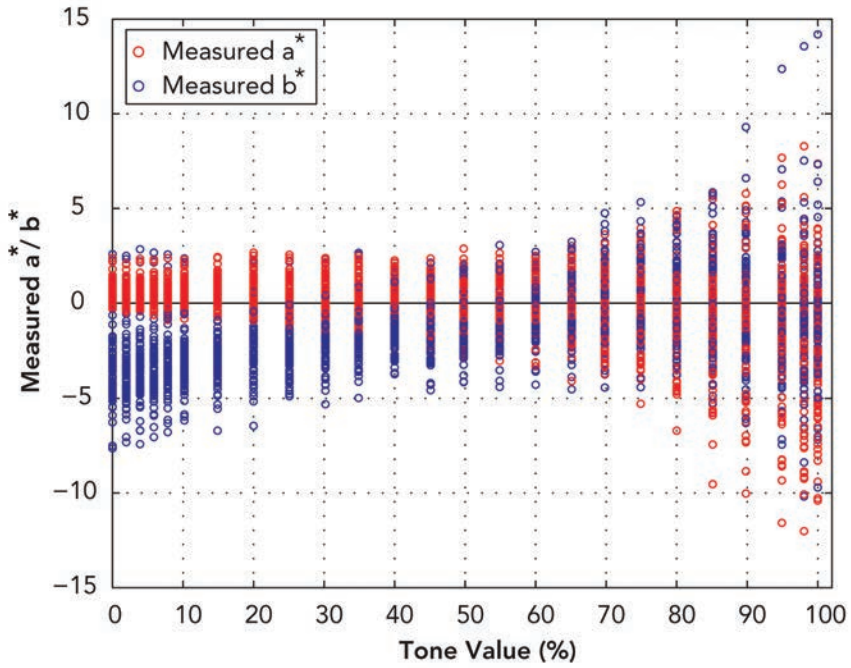

Figure 10. Chroma distribution of the CMY grey scale on the P2P25x test target

Figures 11, 12, 13, 14, and 15 show the distributions of a^* and b^* values for the CMY triplets of (4C, 3M, 3Y), (25C, 19M, 19Y), (50C, 40M, 40Y), (75C, 66M, 66Y), and (100C, 100M, 100Y).

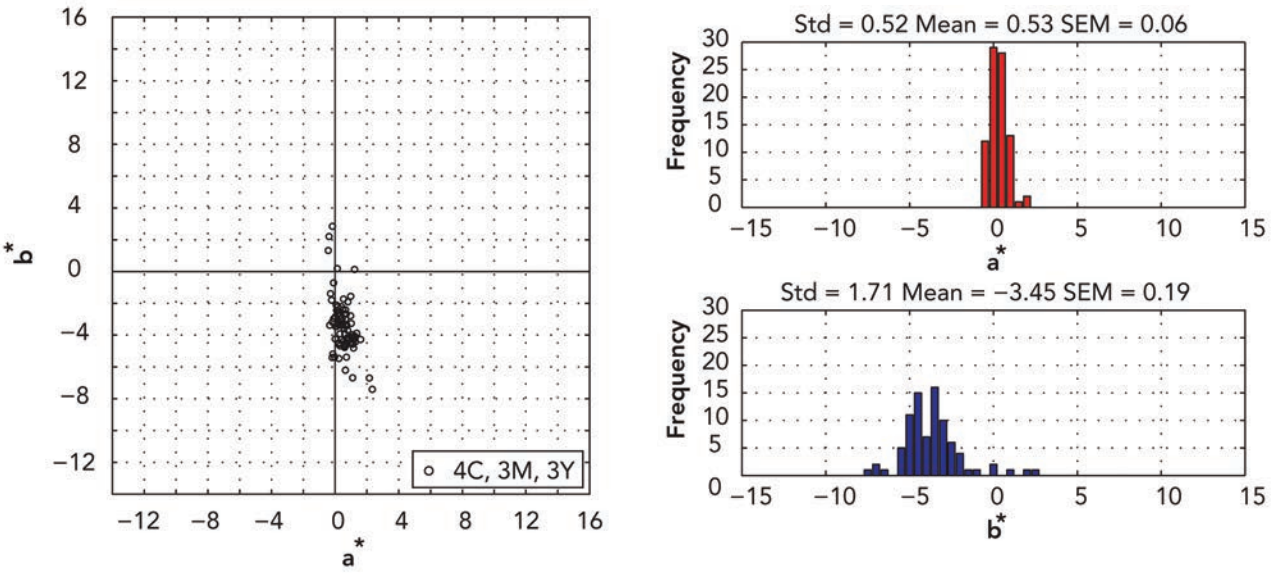

Figure 11. Chroma distribution of the (4C, 3M, 3Y) grey

As seen in Figure 11, the a^* values of the paper white were gathered around zero and the b^* values were mostly spread between -3 and -6, which indicates that the paper white had a bluish cast at the CMY triplet of (4C, 3M, 3Y). The mean value of a^* was 0.53 and its SEM (Standard Error of the Mean) was 0.06. The mean value of b^* was -3.45 and its SEM was 0.19.

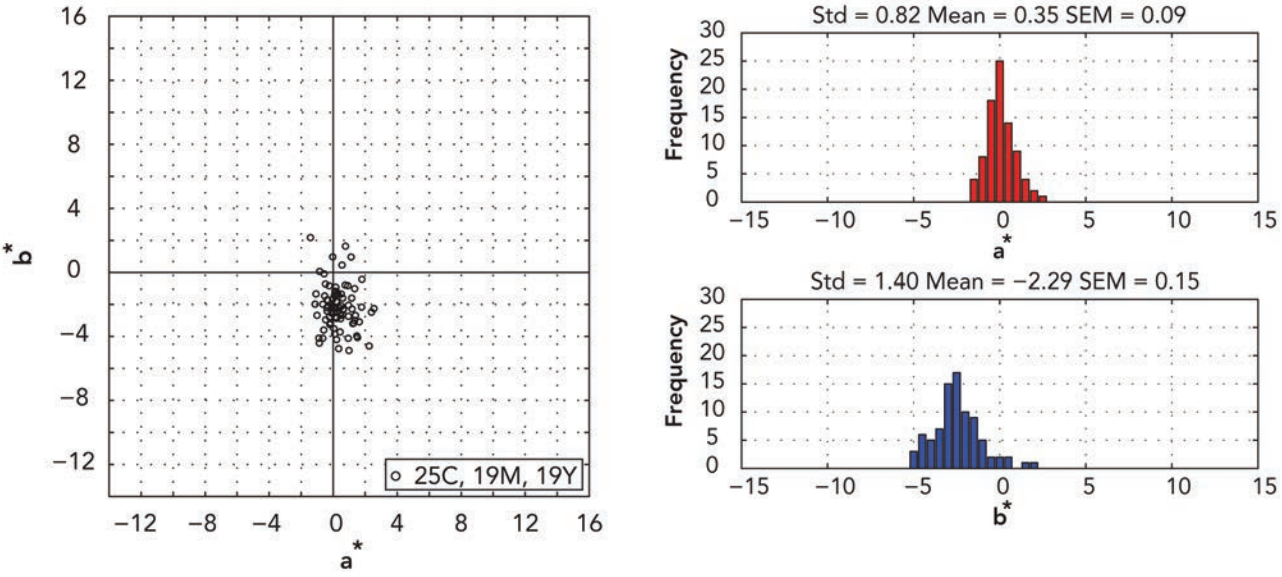

Figure 12. Chroma distribution of the (25C, 19M, 19Y) grey

Figure 12 shows the distribution of a^* and b^* values for the quarter-tone grey (25C, 19M, 19Y). Compared with Figure 11, the distribution of a^* values was more spread out and the distribution of b^* values moved towards the right. As seen from the scatter plot, the overall effect was to move the printed triplet closer to neutral. The standard deviation of a^* was 0.82 with a mean was 0.35 and an SEM of 0.09. The standard deviation of b^* was 1.40 with a mean of -2.29 and an SEM of 0.15.

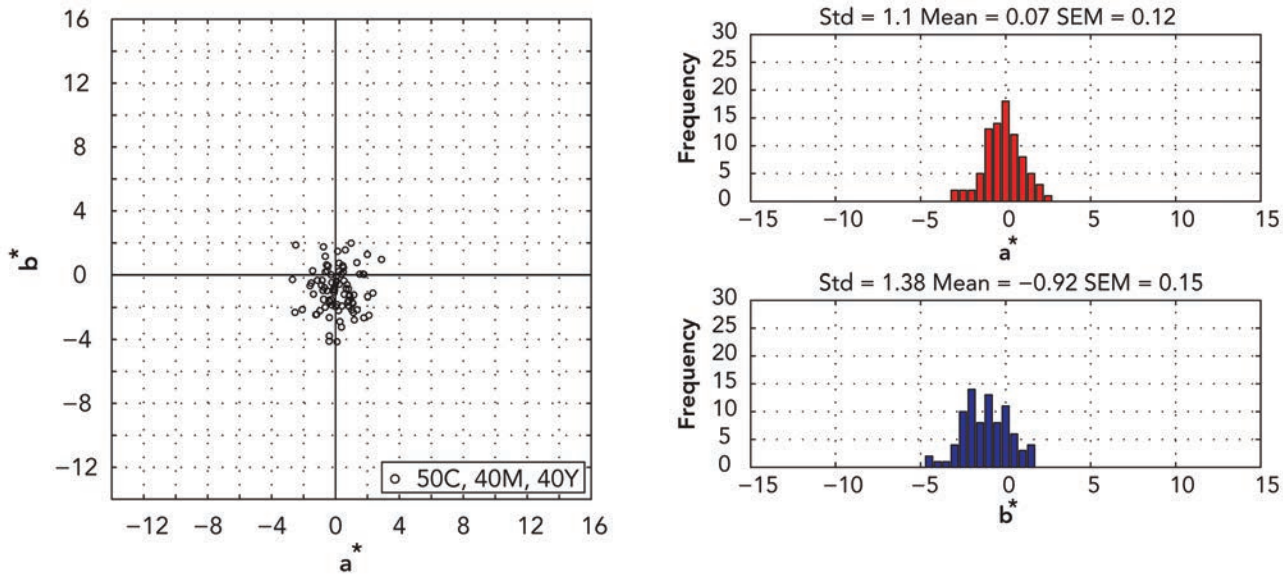

Figure 13. Chroma distribution of the (50C, 40M, 40Y) grey

As the grey darkened, the mid-tone grey (50C, 40M, 40Y) became more neutral (see scatter plot in Figure 13). The mean value of a^* shrank to 0.07, with a standard deviation of 1.1 and an SEM of 0.12. The b^* distribution was much closer to zero as compared to the highlight greys. Its mean value moved to -0.92 with a standard deviation of 1.38 and an SEM of 0.15.

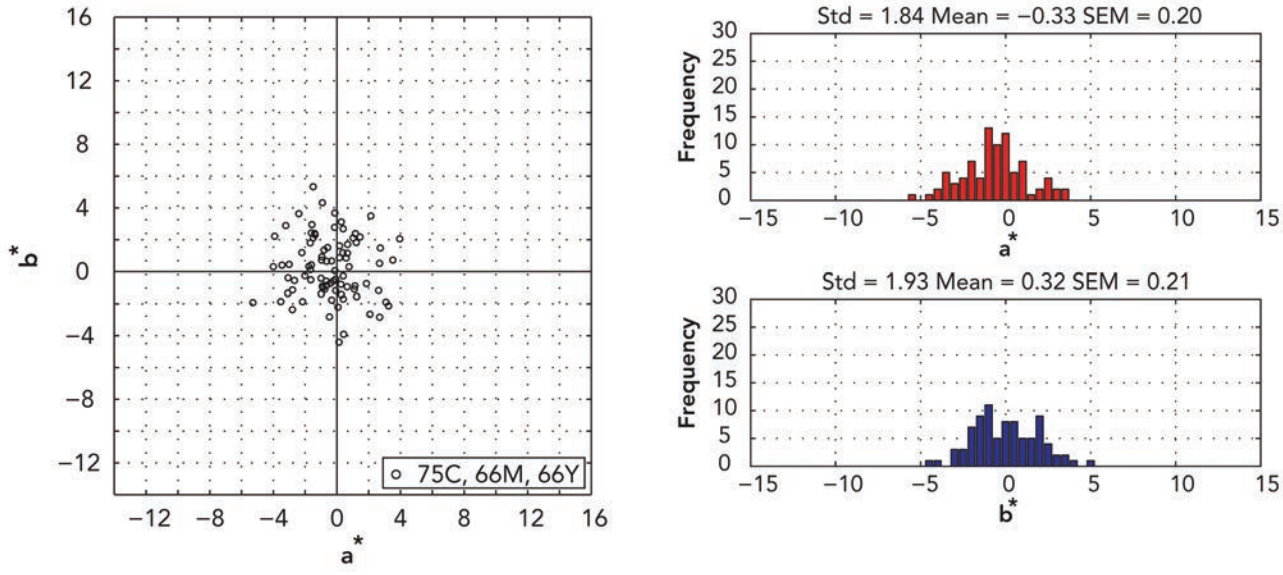

Figure 14. Chroma distribution of the (75C, 66M, 66Y) grey

When grey darkened to the three-quarter tone (75C, 66M, 66Y), the scatter plot shows that the colorimetric values of grey gathered around zero but spread out more (see Figure 14). The mean value of a^* was -0.33 with an SEM of 0.20. The standard deviation for this distribution was 1.84. The mean value of b^* was 0.32, with an SEM of 0.21 and a standard deviation of 1.93.

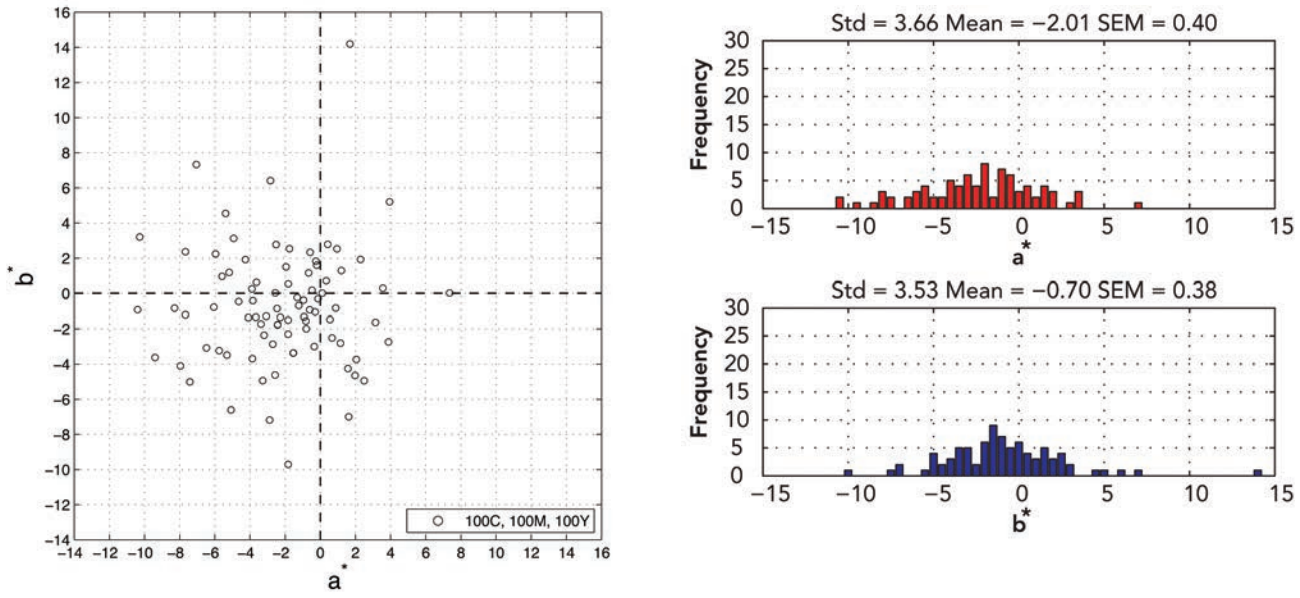

Figure 15. Chroma distribution of the (100C, 100M, 100Y) grey

Figure 15 shows the chroma distribution of the CMY solids (100C, 100M, 100Y). The mean value of the a^* distribution was -2.01, the standard deviation was 3.66, and the SEM was 0.40. The mean value of the b^* distribution was -0.7, the standard deviation was 3.53, and the SEM was 0.38.

Table 5 compares the mean and standard deviation of a^* and b^* values on paper white, quarter-tone, mid-tone, three-quarter-tone, and solid grey. The standard deviation of b^* values were larger than a^*, except in the CMY solids. This indicates that b^* has more variance than a^*. Moreover, the b^* mean values shifted from bluish towards neutral as the grey darkened. The mean values of a^* were all around neutral except for the CMY solid.

Table 5. Mean and standard deviation of a^* and b^* on paper white, quarter-tone, mid-tone, three-quarter-tone, and solid grey

Patch type	Mean		Standard deviation	
	a^*	b^*	a^*	b^*
Paper white	0.7	-3.5	0.5	1.7
Quarter-tone	0.4	-2.3	0.8	1.4
Mid-tone	0.1	-0.9	1.1	1.4
Three-quarter-tone	-0.3	0.3	1.8	1.9
CMY solid	-2.0	-0.7	3.7	3.5

Variance Between Measured a* and b* Values and Substrate-Corrected Colorimetric Aims (SCCA)

The substrate-corrected colorimetric aim (SCCA) is the aim computed based on the substrate color. Figure 16 shows the difference between the measured a* and b* values of CMY triplets and aim values based on each paper color. A large variance occurred on the shadow area. However, the variance in the highlight area improved, which indicates the substrate-corrected method had an impact on the highlight area and less of an impact on the shadow area.

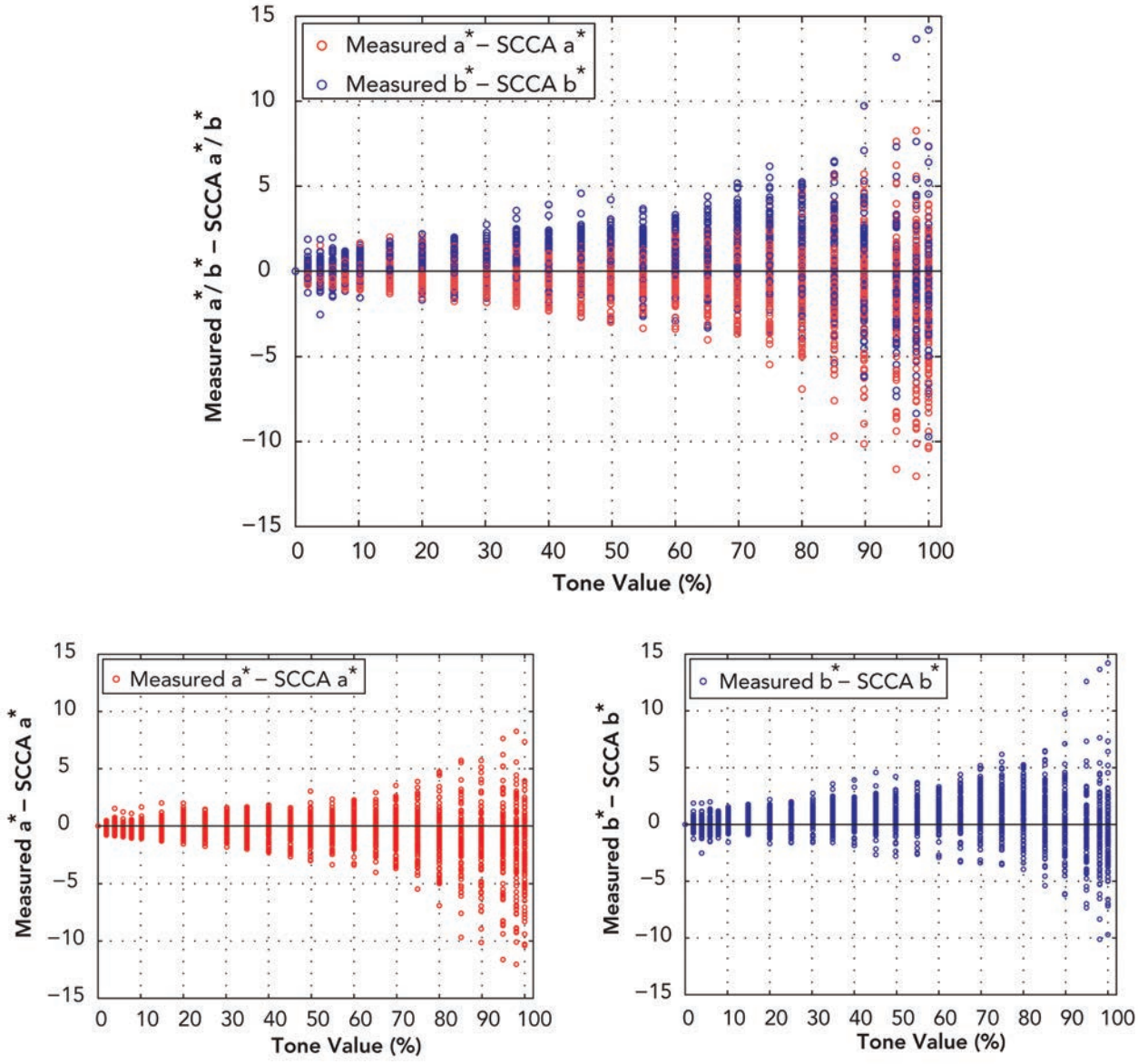

Figure 16. Variance between measured a* and b* values and aim values

In-depth Look at Grey Reproduction Conformance Curves

Figure 17 shows a sample of thumbnail of grey reproduction conformance curves from the data set (see Appendix A for all 85 grey reproduction conformance thumbnail curves). The patterns selected demonstrate a range of behaviors: (a) good convergence from highlight to mid-tone and then to shadow, (b) good convergence from highlight to mid-tone and poor performance at shadow, and (c) poor convergence. The first row shows the grey reproduction performance on bluish paper and the second shows it on yellowish paper.

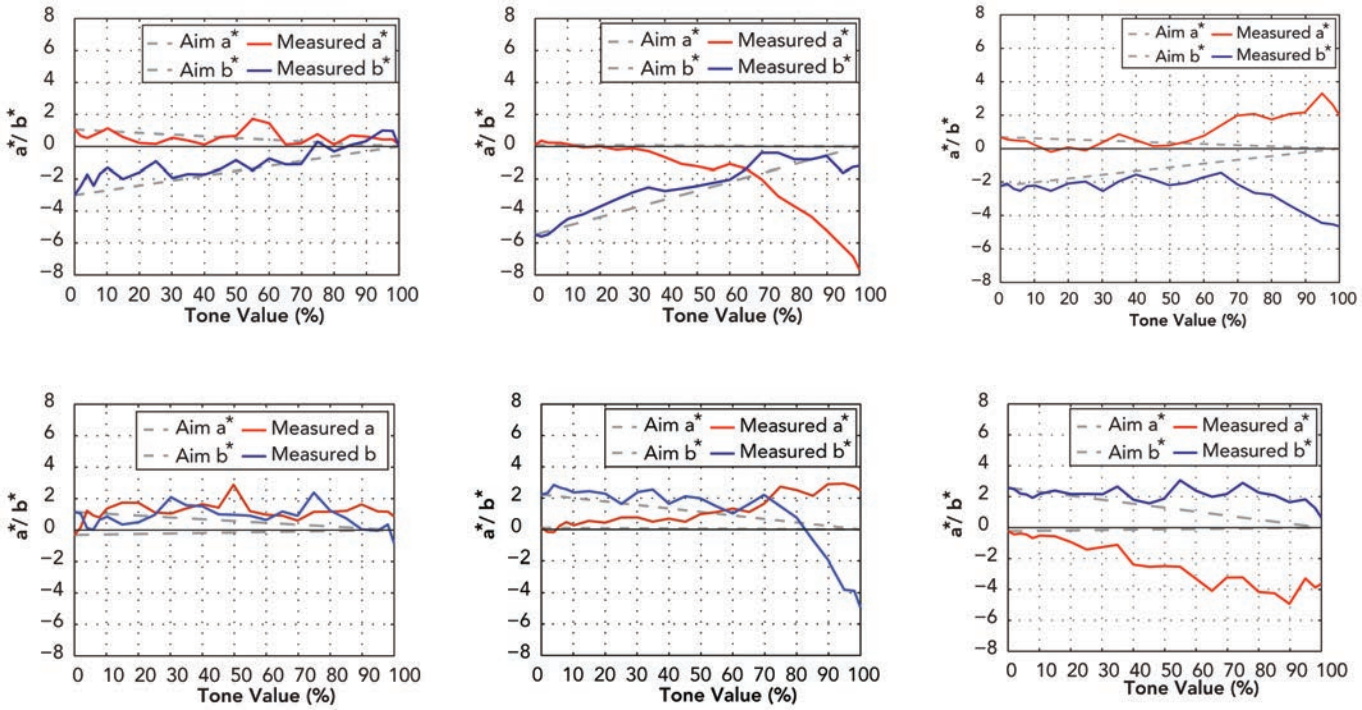

Figure 17. Grey reproduction conformance curves

Grey Reproduction Conformance Based on G7 Pass/Fail Criteria

The *G7 Master Program Pass/Fail Requirements for G7 Master Status* (IDEAlliance, 2009b), sets the threshold for conformance at an average weighted ΔC_h ($w\Delta C_h$) of 1.5 and a peak $w\Delta C_h$ of 3.0.

The results are shown in Table 6. Of the 85 G7 Master Printer submissions, 58 (68%) passed this criteria and 27 (32%) failed.

Table 6. G7 Pass/Fail conformance‡

No.	Average $w\Delta C_h$	Max $w\Delta C_h$	Pass?	No.	Average $w\Delta C_h$	Max $w\Delta C_h$	Pass?
1	1.9	3.5	N	44	1.0	1.6	Y
2	1.5	2.7	Y	45	0.9	1.9	Y
3	1.4	2.8	Y	46	1.1	2.8	Y
4	1.5	3.5	N	47	0.9	2.3	Y
5	1.5	2.5	Y	48	1.3	2.8	Y
6	0.7	1.5	Y	49	1.2	2.3	Y
7	0.9	1.8	Y	50	1.9	3.4	N
8	1.9	4.6	N	51	1.5	2.9	Y
9	1.0	1.8	Y	52	0.9	2.6	Y
10	1.4	3.0	Y	53	1.5	3.7	N
11	1.7	3.5	N	54	0.8	2.0	Y
12	1.0	2.2	Y	55	0.9	1.6	Y
13	1.0	2.0	Y	56	1.2	3.6	N
14	0.9	1.5	Y	57	0.8	1.7	Y
15	1.2	3.2	N	58	1.7	2.7	N
16	0.7	1.5	Y	59	1.4	2.5	Y
17	1.1	3.2	N	60	1.4	2.4	Y
18	1.2	2.5	Y	61	0.8	1.6	Y
19	1.7	3.5	N	62	0.6	1.1	Y
20	1.2	2.6	Y	63	1.6	3.2	N
21	0.6	1.3	Y	64	2.1	3.2	N
22	0.4	1.0	Y	65	0.9	1.5	Y
23	0.9	2.1	Y	66	1.3	2.4	Y
24	1.8	4	N	67	0.8	1.3	Y
25	1.7	2.9	N	68	1.3	2.6	Y
26	1.3	2.6	Y	69	1.4	3.2	N
27	1.2	2.1	Y	70	1.0	1.8	Y
28	1.3	2.8	Y	71	1.3	1.9	Y
29	1.3	3.0	Y	72	0.8	2.0	Y
30	1.1	2.4	Y	73	1.1	2.3	Y
31	2.2	4.6	N	74	1.5	2.5	Y
32	1.1	2.9	Y	75	0.7	1.3	Y
33	1.6	3.2	N	76	1.0	2.3	Y
34	0.7	1.4	Y	77	1.8	3.1	N
35	1.6	3.2	N	78	1.8	4.1	N
36	1.4	3.5	N	79	0.9	2.1	Y
37	1.1	2.4	Y	80	0.8	2.2	Y

No.	Average $w\Delta C_h$	Max $w\Delta C_h$	Pass?	No.	Average $w\Delta C_h$	Max $w\Delta C_h$	Pass?
38	1.8	3.7	N	81	1.6	3.1	N
39	1.3	3.1	N	82	1.5	2.6	Y
40	1.9	3.5	N	83	1.0	1.7	Y
41	0.6	1.6	Y	84	1.5	2.7	Y
42	1.7	2.9	N	85	0.6	1.1	Y
43	0.7	2.1	Y				

‡Numbers shown in red did not pass.

Discussion

ISO/WD 12647-2:2010 uses three near-neutral triplets—quarter-tone, mid-tone, and three-quarter-tone—to assess grey reproduction conformance. Thus, the questions to be answered include, "Would using the three-near-neutral-triplet method yield a similar result to the G7 Pass/Fail criteria?" and "What should the tolerance be?"

Figure 18 shows the cumulative distribution of all passed data. The max ΔC_h values are around 2 ΔC_h, 3ΔC_h and 4 ΔC_h at the quarter-tone, mid-tone, and three-quarter-tone respectively.

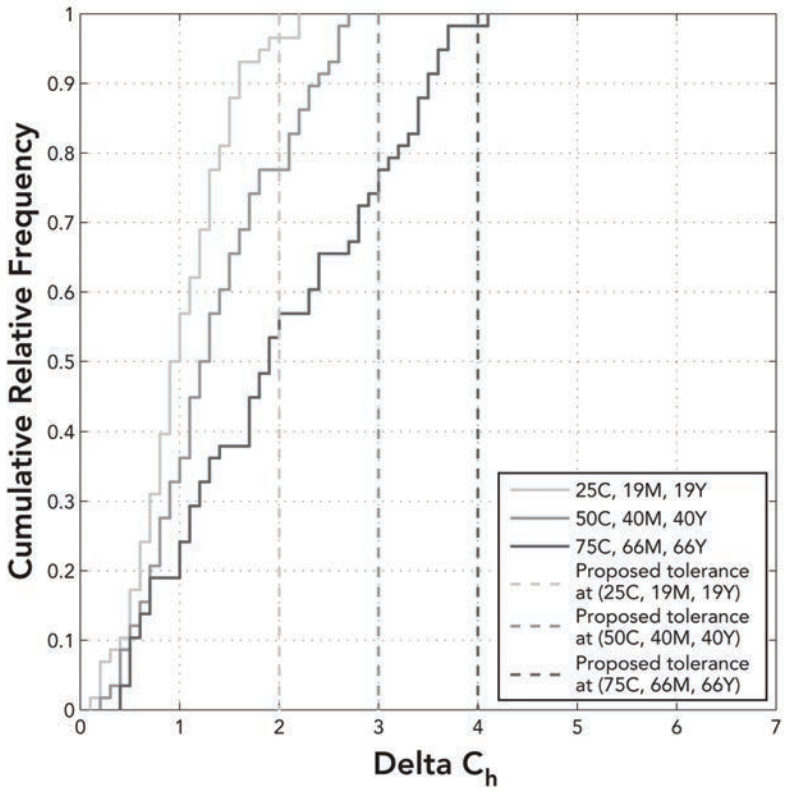

Figure 18. Cumulative distribution of ΔC_h values at quarter-tone, mid-tone, and three-quarter-tone of the 58 passed G7 Master Printer submissions

Table 7 shows the conformance results using the G7 Pass/Fail criteria (average weighted ΔC_h <= 1.5 and max weighted ΔC_h <= 3.0) and the three near-neutral triplet criteria (ΔC_h at quarter-tone <= 2, ΔC_h at mid-tone <= 3, and ΔC_h at three-quarter-tone <= 4). The two criteria produce the same results for 70 of the 85 submissions (82% of the total).

Table 7. Comparison between G7 Pass/Fail and three near-neutral triplet criteria‡

No.	Avg wΔC_h	Max wΔC_h	ΔC_h quarter-tone	ΔC_h mid-tone	ΔC_h three-quarter-tone	Agrees?
1	1.9	3.5	1.2	1.9	4.6	Y
2	1.5	2.7	1.6	2.5	3.5	Y
3	1.4	2.8	1.4	2.2	2.4	Y
4	1.5	3.5	1.8	2.0	2.6	N
5	1.5	2.5	0.5	2.1	2.8	Y
6	0.7	1.5	0.6	1.5	0.7	Y
7	0.9	1.8	1.2	1.4	1.1	Y
8	1.9	4.6	0.8	1.9	4.5	Y
9	1.0	1.8	0.7	1.1	2.8	Y
10	1.4	3.0	1.6	2.2	1.9	Y
11	1.7	3.5	1.5	3.0	5.6	Y
12	1.0	2.2	0.7	1.2	3.1	Y
13	1.0	2.0	1.0	1.5	3.0	Y
14	0.9	1.5	1.3	0.8	1.9	Y
15	1.2	3.2	0.6	1.7	5.1	Y
16	0.7	1.5	1.5	0.7	1.2	Y
17	1.1	3.2	0.1	0.6	2.4	N
18	1.2	2.5	0.9	2.1	2.8	Y
19	1.7	3.5	1.9	1.4	4.8	Y
20	1.2	2.6	1.3	0.8	1.7	Y
21	0.6	1.3	0.8	0.4	1.1	Y
22	0.4	1.0	0.1	0.3	0.5	Y
23	0.9	2.1	0.5	0.6	2.0	Y
24	1.8	4.0	0.7	2.4	6.4	Y
25	1.7	2.9	1.2	2.9	3.4	N
26	1.3	2.6	1.9	2.1	1.3	Y
27	1.2	2.1	0.9	1.3	3.3	Y
28	1.3	2.8	0.6	1.5	4.1	N
29	1.3	3.0	0.9	1.8	3.5	Y
30	1.1	2.4	0.6	0.9	3.4	Y
31	2.2	4.6	2.2	4.2	5.2	Y
32	1.1	2.9	0.5	1.7	3.6	Y
33	1.6	3.2	1.6	3.2	3.5	Y

No.	Avg wΔC_h	Max wΔC_h	ΔC_h quarter-tone	ΔC_h mid-tone	ΔC_h three-quarter-tone	Agrees?
34	0.7	1.4	0.2	1.2	0.4	Y
35	1.6	3.2	1.3	2.4	3.9	N
36	1.4	3.5	0.3	1.3	2.0	N
37	1.1	2.4	0.9	2.3	2.3	Y
38	1.8	3.7	2.2	3.3	2.8	Y
39	1.3	3.1	1.4	3.1	2.4	Y
40	1.9	3.5	1.7	2.9	5.5	Y
41	0.6	1.6	0.3	0.5	0.5	Y
42	1.7	2.9	1.1	2.3	3.8	N
43	0.7	2.1	0.7	0.2	2.0	Y
44	1.0	1.6	1.1	1.6	0.5	Y
45	0.9	1.9	1.0	0.6	1.3	Y
46	1.1	2.8	0.9	1.8	0.5	Y
47	0.9	2.3	1.1	1.0	3.6	Y
48	1.3	2.8	0.9	2.7	1.8	Y
49	1.2	2.3	0.8	1.6	3.7	Y
50	1.9	3.4	1.6	2.8	3.2	N
51	1.5	2.9	1.2	0.8	3.7	Y
52	0.9	2.6	1.5	0.4	2.4	Y
53	1.5	3.7	1.0	1.6	3.3	N
54	0.8	2.0	0.5	0.7	1.7	Y
55	0.9	1.6	1.0	1.1	1.9	Y
56	1.2	3.6	0.8	1.6	2.7	N
57	0.8	1.7	1.0	0.4	0.4	Y
58	1.7	2.7	1.4	2.2	4.1	Y
59	1.4	2.5	1.4	1.1	3.4	Y
60	1.4	2.4	1.5	2.4	1.7	Y
61	0.8	1.6	0.6	1.3	1.1	Y
62	0.6	1.1	0.8	0.8	1.4	Y
63	1.6	3.2	0.7	2.1	2.4	N
64	2.1	3.2	2.1	2.7	4.0	Y
65	0.9	1.5	1.5	1.1	1.0	Y
66	1.3	2.4	2.2	1.1	3.0	N
67	0.8	1.3	1.2	1.2	1.2	Y
68	1.3	2.6	1.2	2.6	0.6	Y
69	1.4	3.2	1.1	1.8	3.4	N
70	1.0	1.8	0.7	1.3	2.9	Y
71	1.3	1.9	1.3	1.7	2.7	Y
72	0.8	2.0	1.8	0.7	0.7	Y

No.	Avg wΔC_h	Max wΔC_h	ΔC_h quarter-tone	ΔC_h mid-tone	ΔC_h three-quarter-tone	Agrees?
73	1.1	2.3	0.8	0.5	2.4	Y
74	1.5	2.5	2.2	2.3	1.8	N
75	0.7	1.3	0.8	1.3	1.0	Y
76	1.0	2.3	0.2	0.9	2.3	Y
77	1.8	3.1	1.7	3.1	4.6	Y
78	1.8	4.1	0.3	1.0	3.4	N
79	0.9	2.1	1.3	1.4	0.7	Y
80	0.8	2.2	0.2	0.9	3.4	Y
81	1.6	3.1	1.9	1.4	5.0	Y
82	1.5	2.6	1.6	2.6	1.7	Y
83	1.0	1.7	1.1	1.7	0.6	Y
84	1.5	2.7	1.3	2.6	3.2	Y
85	0.6	1.1	0.4	1.0	1.0	Y

[‡]Numbers shown in red did not pass.

In conclusion, the three-near-neutral-triplet method shows a high degree of agreement with the calibration pass/fail criteria. This simple method is a good candidate for a grey tolerance metric.

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ISO/TC 130/WG 3 N992 Chung ISO 12647-2 Substrate correction v3a

ISO 12647-1:2004, Graphic technology –– Process control for the production of half-tone colour separations, proof and productions prints –– Part 1: Parameters and measurement methods.

ISO 12647-2:2004, Graphic technology –– Process control for the production of half-tone colour separations, proof and production prints – Part 2: Offset processes.

ISO 12647-2:2004/Amd 1:2007, Graphic technology –– Process control for the production of half-tone colour separations, proof and production prints – Part 2: Offset lithographic processes AMENDMENT 1.

ISO/WD 12647-2:2004, Graphic technology –– Process control for the production of half-tone colour separations, proof and production prints – Part 2: Offset processes.

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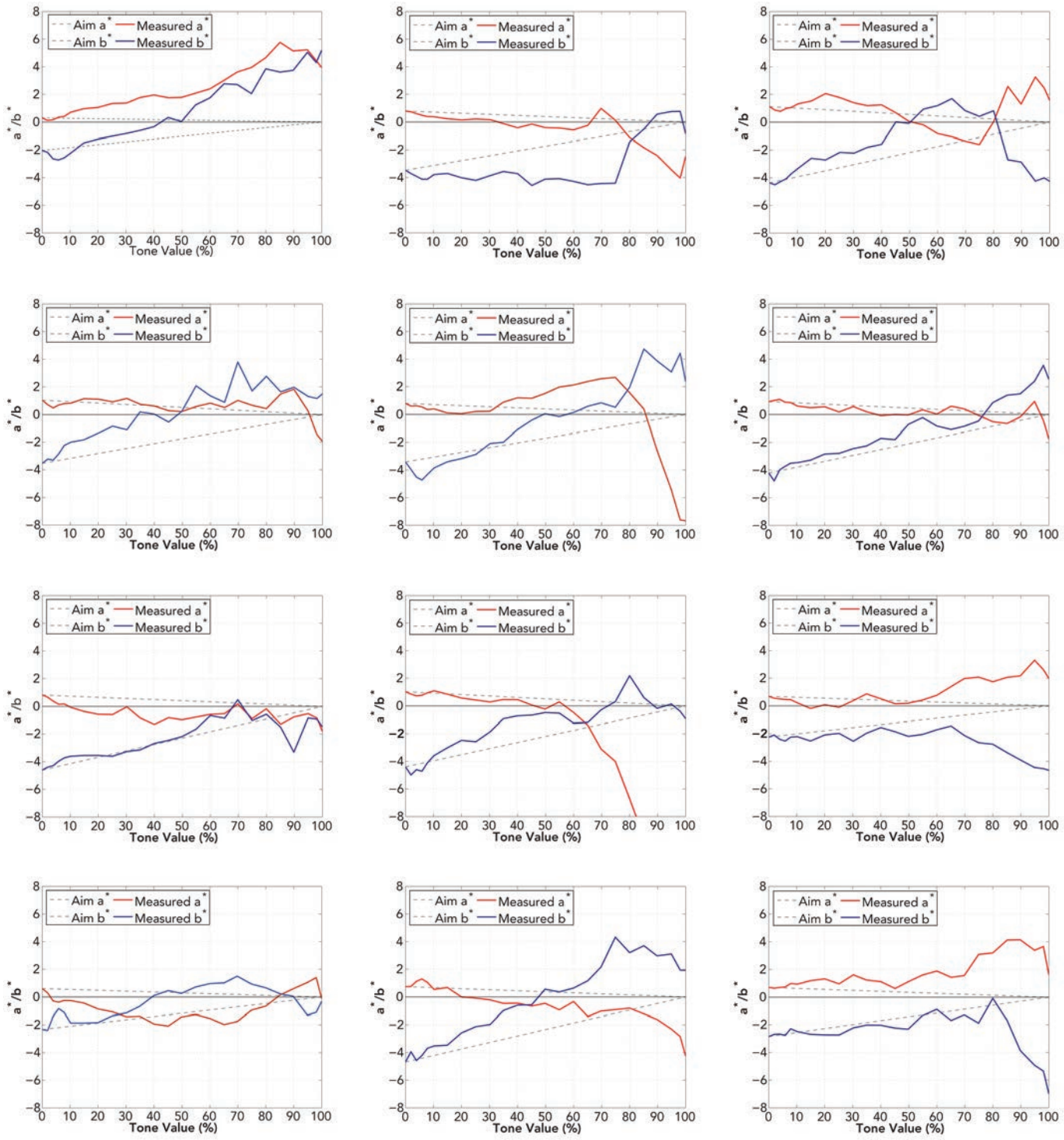
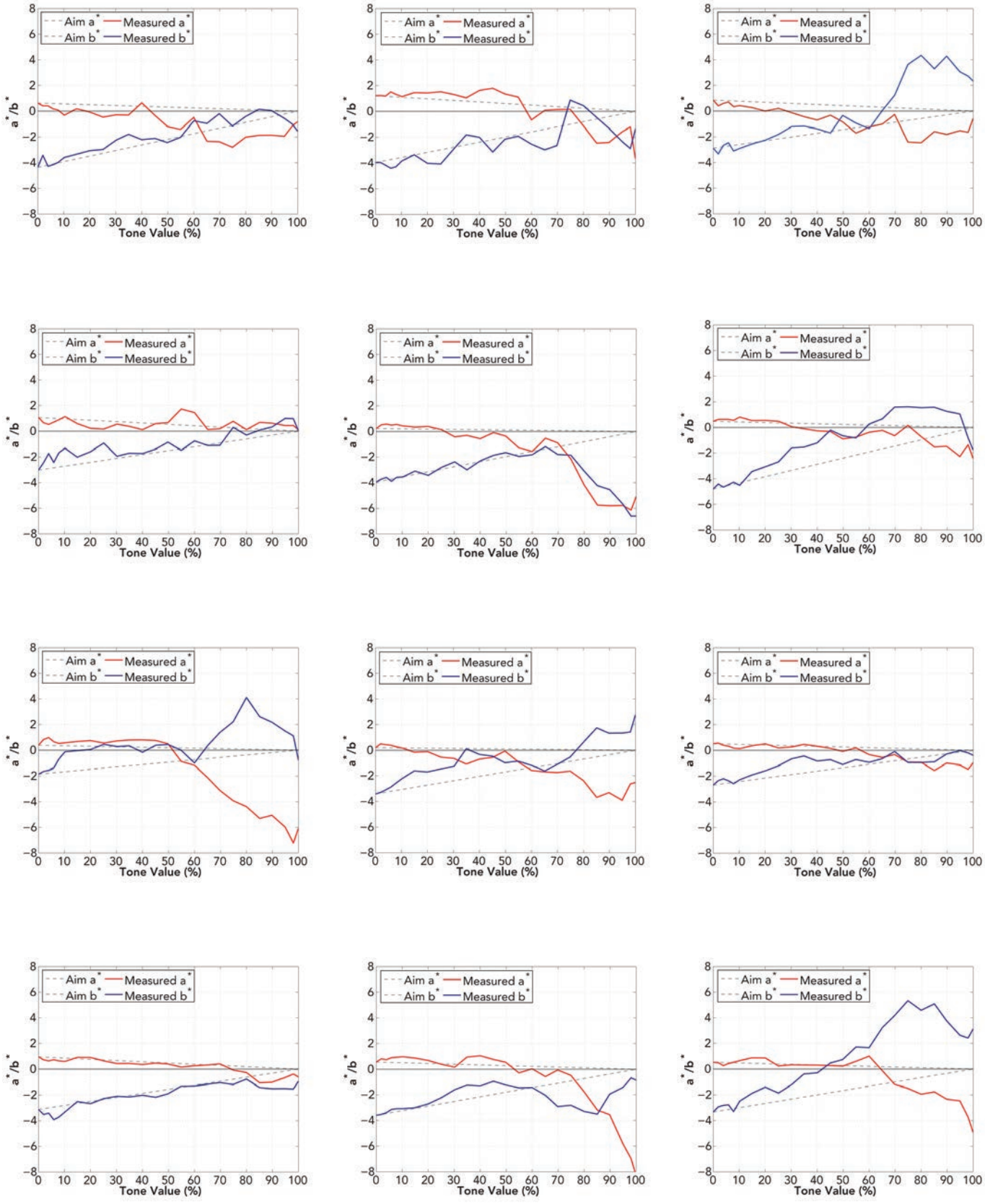
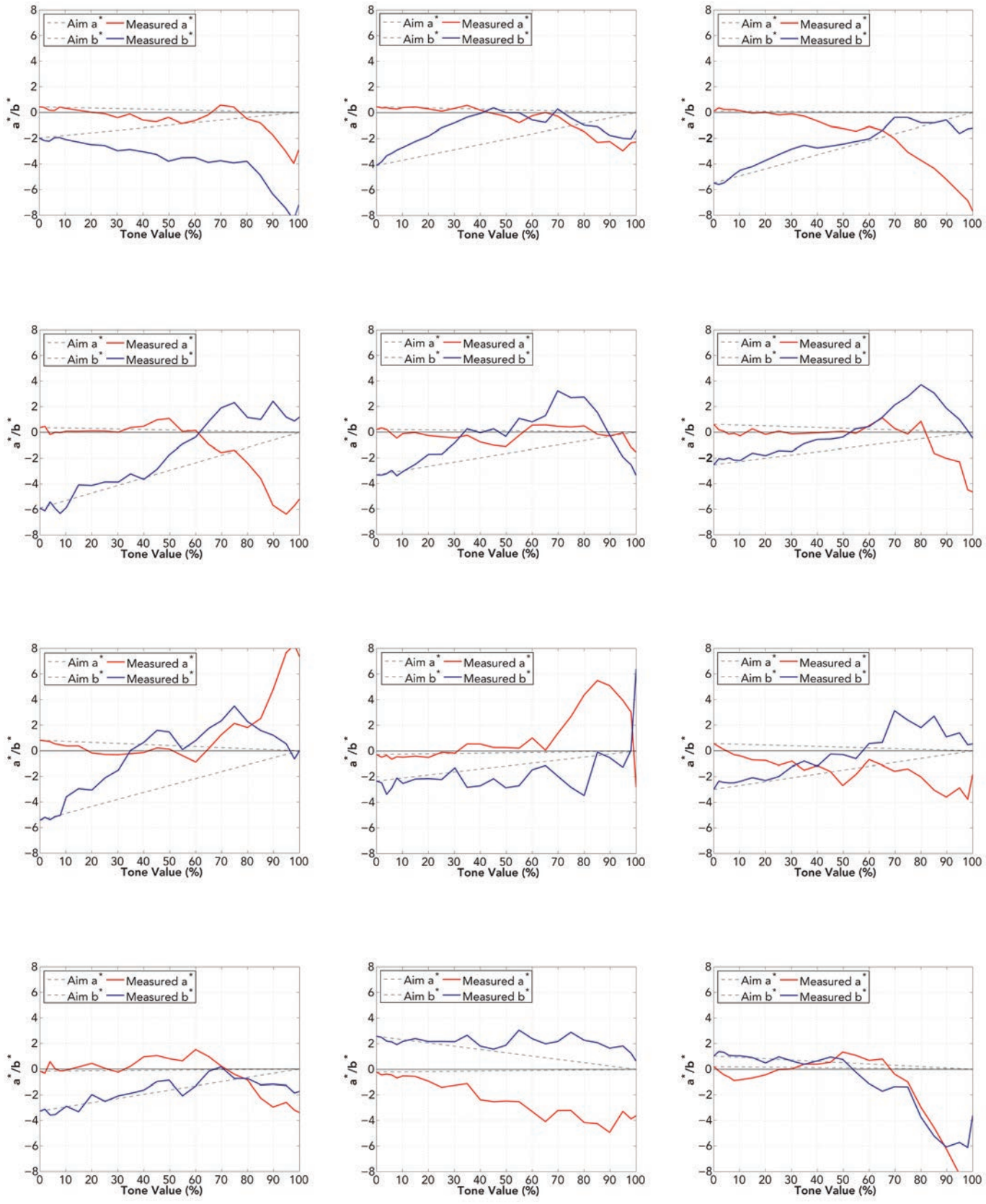
Appendix A. Data Set Grey Ramp Performance

The figures below shows the grey ramp performance of each data set collected from the 85 IDEAlliance G7 Master printer submissions.

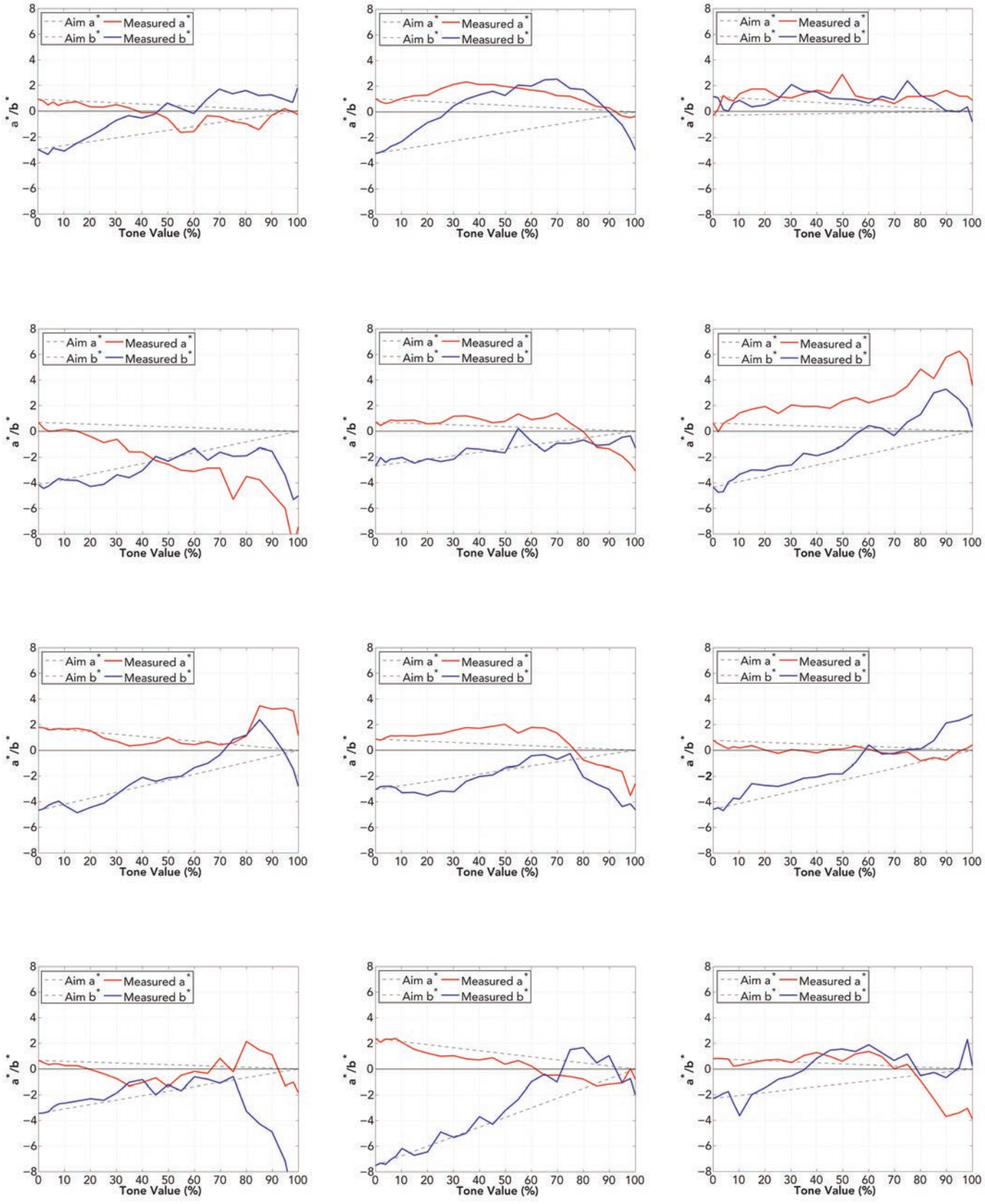


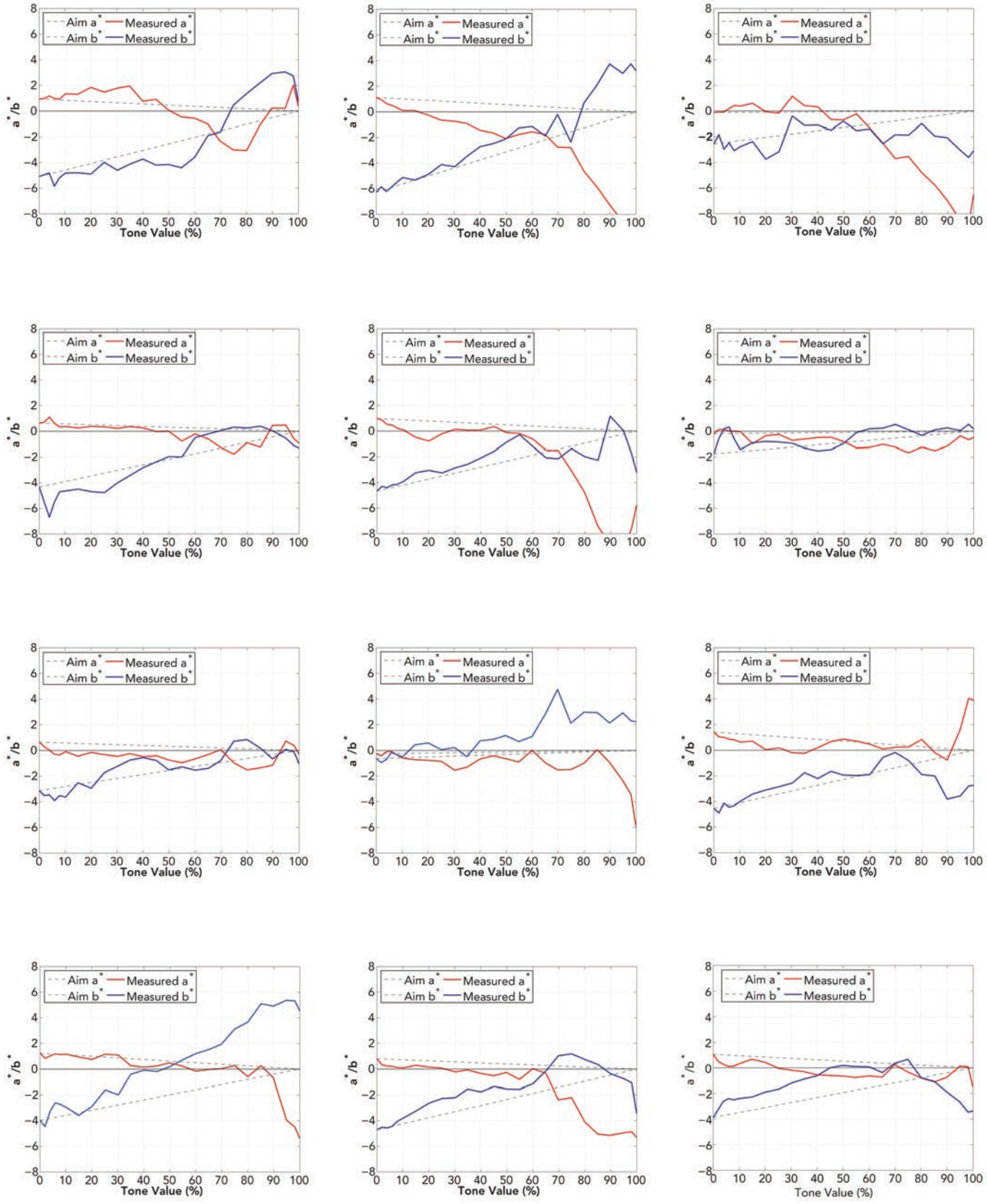
Appendix A: Data Set Grey Ramp Performance



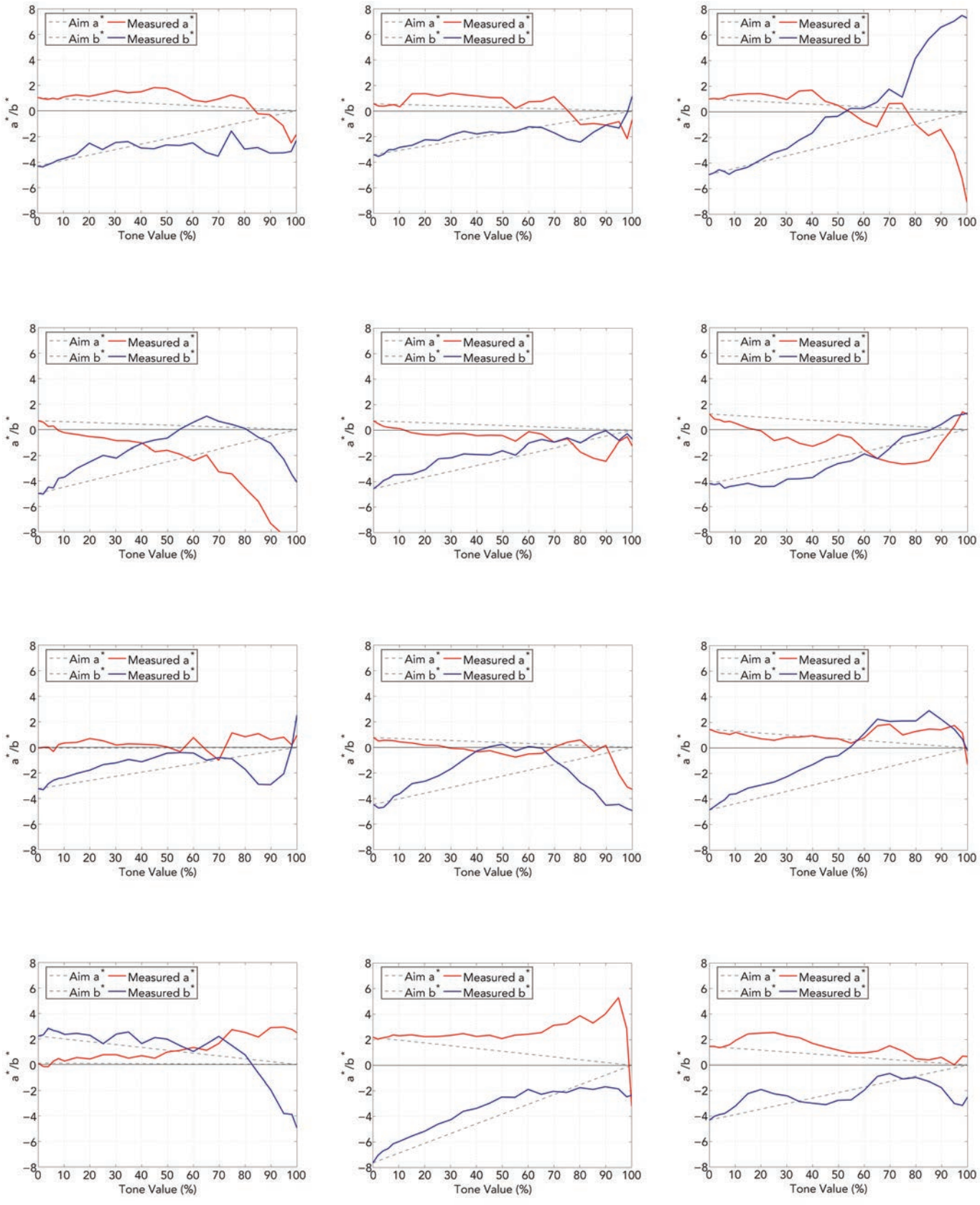

Aim a*
Measured a*
Aim b*
Measured b*
a*/b*
Tone Value (%)

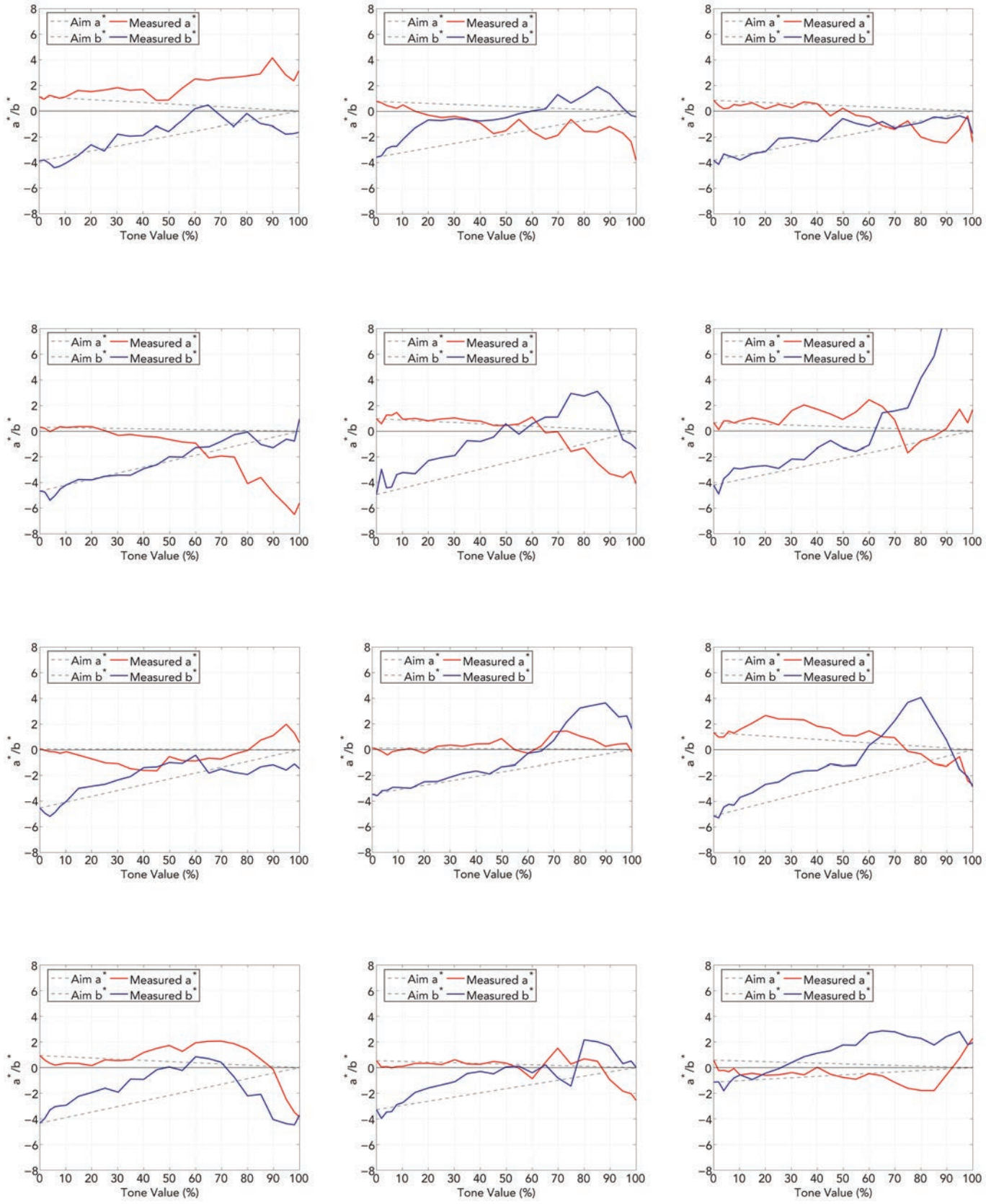
Appendix A: Data Set Grey Ramp Performance



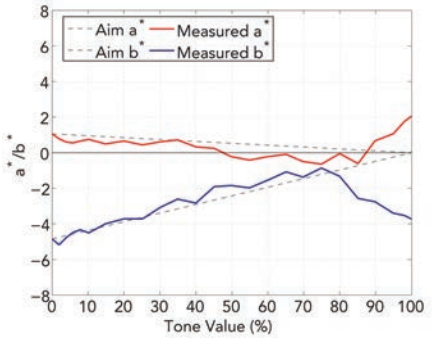

Aim a*
Measured a*
Aim b*
Measured b*
a*/b*
Tone Value (%)

Appendix A: Data Set Grey Ramp Performance




Aim a*
Measured a*
Aim b*
Measured b*
a*/b*
Tone Value (%)

Appendix A: Data Set Grey Ramp Performance



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