TOWARD A COLORIMETRIC SPECIFICATION FOR GAA/SWOP PROOFING AND PRODUCTION INKS - PHASE III

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Abstract

Over the last three years the GAA has been working toward establishing a visually based colorimetric specification for production and proofing ink colors. Phases I and II have been published in the 1988 and 1989 TAGA Proceedings. Phase III of the project, which relates to printing images within the colorimetric parameters determined in Phase II, was recently completed and analyzed. The results are a tentative colorimetric ink specification based on an ink set which can be printed with trap and dot gain consistent with SWOP and produce acceptable image quality. Repeatability and colorimetric tolerances from visual assessments are in the process of being completed.

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Introduction

For the last several years, the Gravure Association of America ("GAA") has been trying to develop a specification for pressproofing and production inks which will provide good agreement between a proof and a production press sheet. Because press run approval is virtually always based on a visual comparison between the press sheet and a visually approved proof, it seemed reasonable that a specification should also be based on visual appearance. However, given the variability in human visual judgments, it was further felt that human variability should be eliminated but that visual colorimetric principles of color matching should be retained. It is known that while densitometry can be appropriate for maintaining a consistent press run, densitometry is not appropriate for assessing critical color reproduction. It was, therefore, decided to evaluate the current CIE systems of color matching and color difference analysis as a basis for the specification of proofing and production inks.

In Phase I[1], press proof inks were evaluated colorimetrically for agreement with the master set of Borden reference inks held by GATF. In Phase II[2], production inks were similarly evaluated and compared to the proofing inks. The effect of different variables on the resultant colorimetric parameters was also included as a basis for possible standardization of methodology so that colorimetric parameters could be validly compared. There were two principal conclusions regarding the inks in these two studies. First, the distribution of proofing inks was greater than the distribution of production inks. Second, the distribution centers of the production inks were significantly different from the Borden reference inks. These comparative data are given in Figures 1-4. Given such differences between the reference inks for proofing and the production inks, it is not surprising that there could be difficulty in matching a production press to proofs. In view of these data, it was decided to make a 4-color press run with an ink set conforming to the Borden reference set and also with a set representing the new "target points", shown in Figures 1–4 as a "+". These press runs have been made, and the press sheet images analyzed colorimetrically and densitometrically. The experimental details follow.

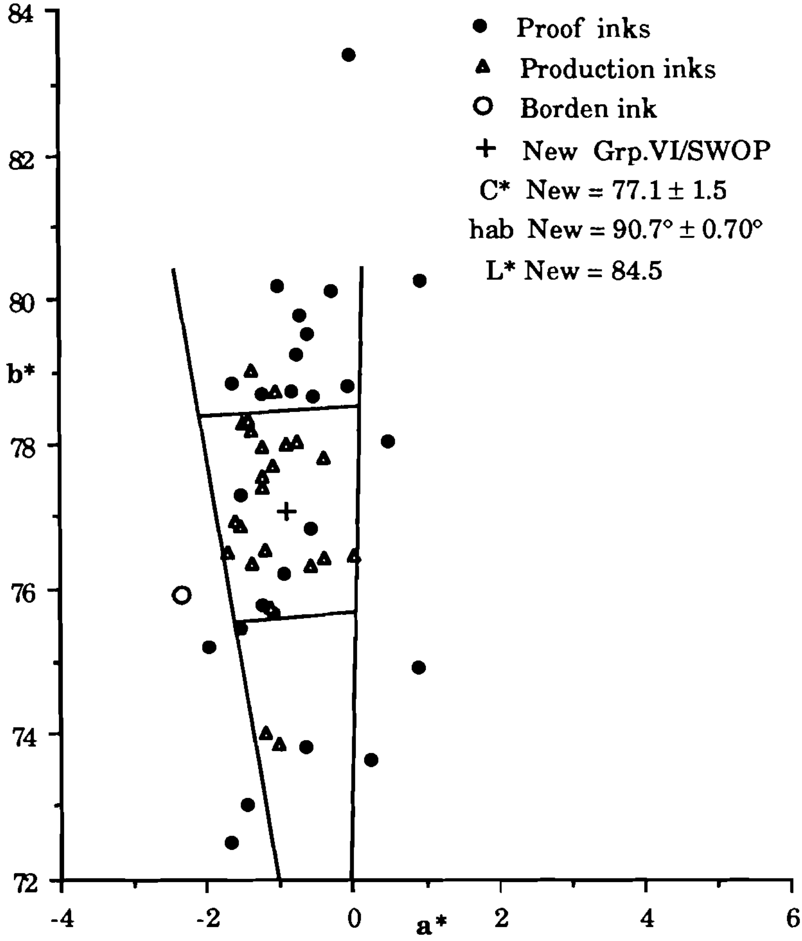

Figure 1. Distribution of proofing and production yellow inks.

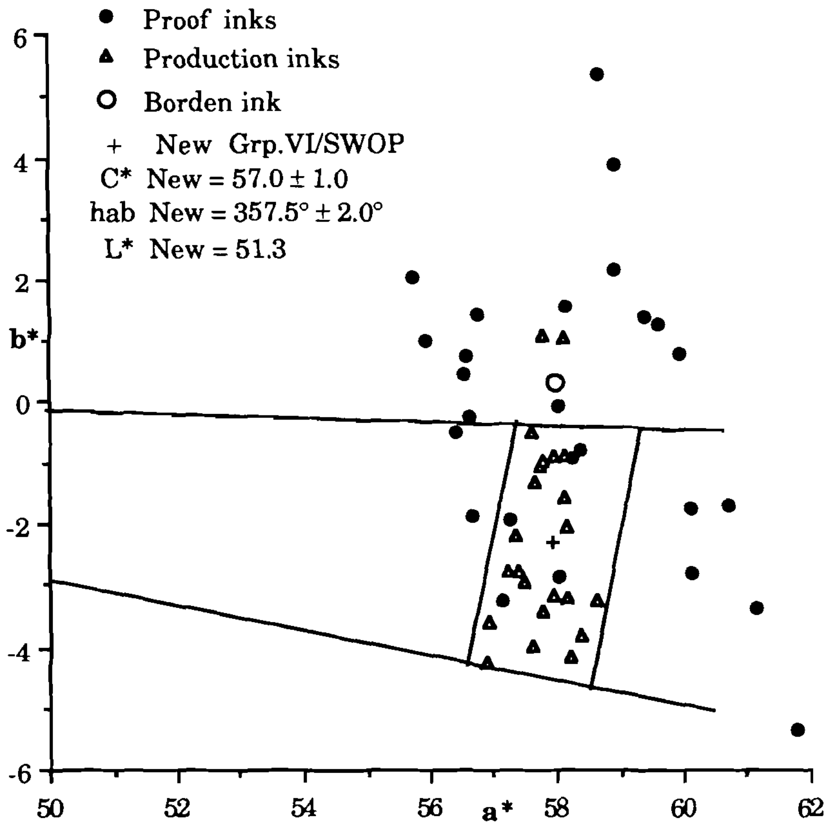

Figure 2. Distribution of proofing and production magenta inks.

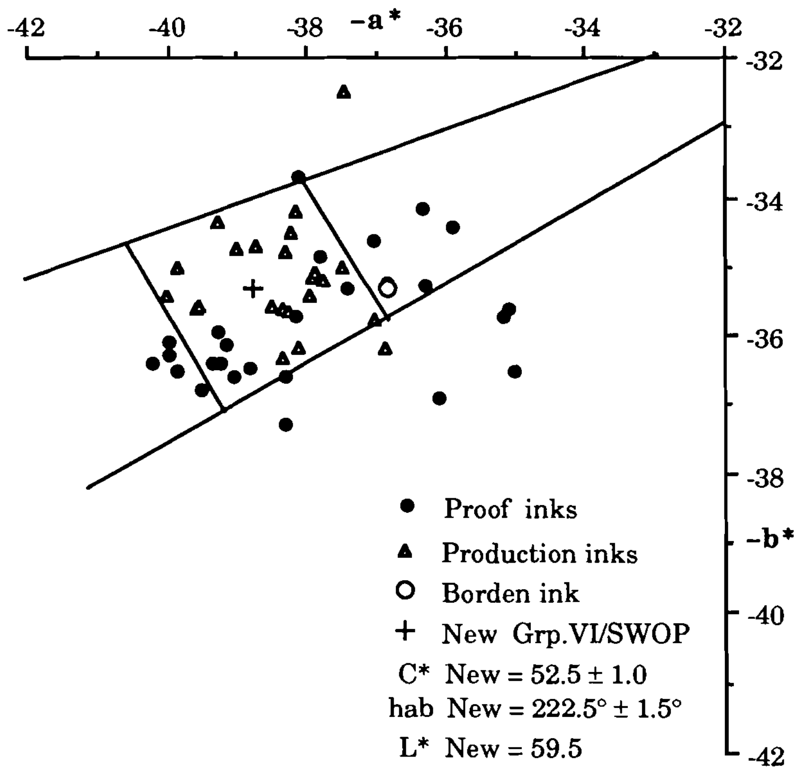

Figure 3. Distribution of proofing and production cyan inks.

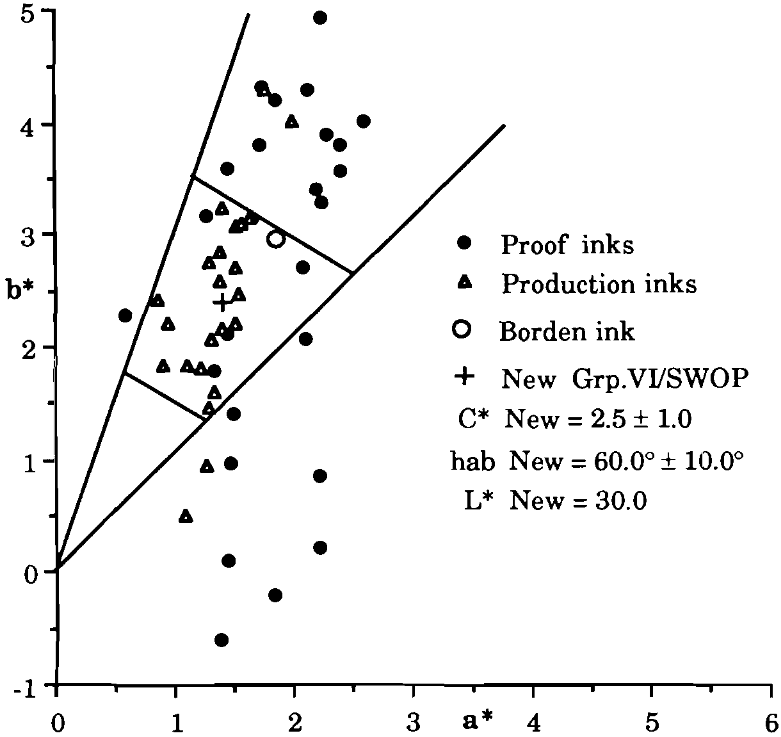

Figure 4. Distribution of proofing and production black inks.

Production Press Runs

The official NAPIM–SWOP reference inks furnished by General Printing Ink ("GPI") are mono-tack formulations ("GPI#1") designed for laboratory color matching and use in the NAPIM–GATF Ink Verification Program. These master formulations are not tack graded for actual printing. SWOP production inks are the same hues as the official NAPIM–SWOP reference set. However, the vehicle systems will likely be altered to achieve the tacks necessary for the ink sequence and operating conditions of the specific printer. The tinctorial strengths may also be adjusted to bring the reflection densities and dot gains within specification. The strengths of the NAPIM–SWOP reference inks date back to the Borden standards established in 1975. At that time, the strengths were considered appropriate for production printing.

In June 1989, GPI supplied two sets of sheetfed inks for press testing at Phototype Color Graphics as part of the color investigation of the GAA/SWOP Color Certification Task Force. The inks were a tack rated version ("GPI#2") of the NAPIM–SWOP reference set (same hues and strengths), and a version ("GPI#3") of GAA recommended shades intended to move closer to the center of the offset industry (the "+" point in Figures 1–4). The black ink was the same for both tests. The printed results were not satisfactory because the dot gain of the cyan and magenta was too high and did not give visual gray balance.

A second production test was conducted in October. Both ink series were further modifications of the formulas run in June and are those designated GPI#2 and GPI#3 in Tables 1, 2, and 3 herein. The strengths were increased, and the tacks fine tuned to the specifications normally applied by Phototype on their Komari Sprint L-425BP press. The ink sequence was black-cyan-magenta-yellow. The prints were within the SWOP density/dot gain specifications and gave a gray balance which was judged visually acceptable.

In January 1990, the GAA Task Force asked GPI to remake the SWOP/Phototype production ink set for further testing. The new batches have been delivered to GATF for verification and distributed to other ink manufacturers for matching. The purpose of this next phase of the study is to establish how well one ink manufacturer can match the established reference inks' colors, and how closely a group of ink manufacturers can reproduce the supplied wet ink samples' characteristics for production printing. All submitted inks will be evaluated under the existing NAPIM–SWOP ink verification test methods. Following this evaluation, a Task Force review of the ink matching and subsequent multi-plant press testing is planned for June.

Press Sheet Analysis

All sheets were measured with a Gretag SPM100 hand-held spectrophotometer which has 45°/0° measurement geometry. The calculated colorimetric parameters are based on the 10° CIE Standard Observer and D50 illuminant for the spectral range of 380 nm to 730 nm in 10 nm intervals. The densities for DIN narrow band ("DIN NB") and ANSI Status T ("Stat T") are computed by the SPM100 from the reflectance spectrum, based on spectral responses for these filtrations in their respective specifications (DIN 16536, Part II, and ANSI 2.18). The average, standard deviation, minimum, and maximum values for each parameter are given in Tables 1 and 2. Table 1 is data derived from measurements of 16 sampled press sheets made with the GPI#2 ink set on Champion Textweb paper. Analogous data for the GPI#3 ink set for 49 sampled sheets also printed on Textweb are given in Table 2.

Because the data in Figures 1-4 were based on integrating sphere (0°/*d*), specular component excluded, reflectance measurements, and the data in Tables 1 and 2 are for 45°/0°, the values of the numbers are NOT validly comparable, as was established in Phase II[2]. Thus, some correlation between the measurement geometries was necessary in order to determine whether the GPI#3 ink set had reached the "+" targets. To estimate a correlation, several (6–7) samples of the GPI#3 press sheet population from Table 2 whose parameters were very close to the average values in Table 2 were again measured in integrating sphere, specular component excluded, geometry on the same instrument as were the samples represented in Figures 1-4. Similar data for these selected sheets are given in Table 3. Integrating sphere values have "I.S." after them. From comparing the average I.S. values with the "target I.S. ("+")" values, it can be seen that the target values were, at best, barely met for cyan and black, but not for yellow and magenta. For the 45°/0° data in Table 3, one can compare the average GPI#2 values with those from a set of IPA SWOP Low and High reference swatches (dated July 1989) to estimate how well the GPI#2 ink set matches the reference ink set (GPI#1). With the exception of slightly too much chroma (C*) for magenta, the GPI#2 ink set was colorimetrically within the SWOP High/Low references.

With regard to conformance to the SWOP reference density ranges, from Table 3, it is seen that the computed Status T density of GPI#2 yellow and black is within the SWOP High/Low references, but the GPI#2 magenta Status T density exceeds the the SWOP High reference, while the GPI#2 cyan Status T density is less than the SWOP Low reference. The principal reason for these results is that while the ink densities were initially set within SWOP, they were adjusted in order to produce and maintain good gray balance throughout as much of the tone reproduction curve as possible without constraint to the SWOP ranges. The guiding principle was to produce the best color reproduction possible and then determine what the specific ink parameters were, rather than to produce less than optimum color reproduction solely for the sake of keeping the ink densities within the SWOP ranges. For example, trap will become increasingly important for three-color gray balance as tone increases so that monitoring ink solid density will be insufficient for ensuring tone reproduction. This approach is simply an empirical way of determining whether the current SWOP High/Low values are appropriate for optimum color reproduction, and whether the SWOP High/Low values should be modified to account for 4-color production conditions, e.g., tack, trap, dot gain, etc.

In Table 3, the Status T densities for integrating sphere geometry are consistently less than the densities from 45°/0° geometry, which is expected and was discussed in Phase II[2]. Phase II[2] also showed that a 45°/0° geometry gives good agreement between spectrophotometric densities and densitometer densities regardless of surface gloss while integrating sphere geometry gives poor agreement with densitometry for the medium gloss and matte surfaces typically occurring in web printing. It is for these reasons that the 45°/0° geometry is preferred and recommended for spectrophotometric measurements in the graphic arts. Based on the results of these phase, the average values of L*, a*, b*, C*, and h_{ab} for the GPI#2 ink set in Table 1 have been tentatively adopted as the target values for a colorimetric specification.

Summary

The results herein are sufficient for establishing tentative colorimetric values for proofing and publication printing applications. However, it is still necessary to establish that these ink characteristics can be produced repeatedly by different ink manufacturers and printers. Also, acceptable tolerances of variation from these tentative values must be determined, and they must be based on visual judgments of acceptability of printed images. These tests will comprise the next phase of this study.

Acknowledgements

The authors wish to make it known that much work by many persons and organizations have been involved in these continuing investigations, and the results reported herein are only a part of the work required for completion. Persons interested in the topics discussed herein or other topics should contact the GAA regarding availability of specific information.

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Literature Cited

1. "The Investigation of a Colorimetric Specification for GAA Group VI/S.W.O.P. Proofing Inks", GAA Task Force for Color Certification, TAGA 1988, pp.549–570.

2. James R. Huntsman, John Souter, "Toward a Colorimetric Specification for GAA Group VI/SWOP Proofing and Production – Phase II", TAGA 1989, pp.95–131.

Table 1

Average Values of Primary and
Overprint Colors Using GPI#2 Inks

Color	L*	a*	b*	C*	h_{ab}(°)	DIN NB	Status T
Av. Y	82.49	-0.90	83.55	83.56	90.61	1.33	1.00
Std. Dev.	0.20	0.12	0.51	0.51	0.08	0.01	0.00
Min.	82.07	-1.16	82.83	82.83	90.48	1.31	0.99
Max.	82.77	-0.71	84.44	84.44	90.79	1.36	1.01
Av. M	45.65	64.76	-2.01	64.79	358.22	1.55	1.48
Std. Dev.	0.23	0.40	0.30	0.39	0.27	0.02	0.02
Min.	45.29	64.00	-2.66	64.06	357.62	1.50	1.44
Max.	46.10	65.73	-1.60	65.75	358.61	1.60	1.53
Av. C	59.78	-42.20	-33.87	54.11	218.75	1.22	1.18
Std. Dev.	0.26	0.25	0.41	0.39	0.30	0.01	0.01
Min.	59.35	-42.56	-34.52	53.10	217.91	1.19	1.15
Max.	60.22	-41.58	-32.63	54.80	219.09	1.23	1.20
Av. K	19.44	0.84	1.89	2.07	66.09	1.54	1.54
Std. Dev.	0.78	0.04	0.14	0.14	1.13	0.03	0.03
Min.	18.06	0.79	1.74	1.91	64.56	1.51	1.51
Max.	20.38	0.91	2.32	2.50	68.51	1.59	1.59

Table 1 (cont.)

Color	L*	a*	b*	C*	h_{ab}(°)
Av. R	44.94	61.14	39.99	73.06	33.19
Std. Dev.	0.28	0.38	0.65	0.57	0.38
Min.	44.14	60.09	38.74	71.64	32.25
Max.	45.40	61.64	41.21	74.07	33.80
Av. G	53.57	-53.19	32.56	62.37	148.53
Std. Dev.	0.28	0.68	0.61	0.70	0.54
Min.	53.16	-54.34	31.21	60.61	147.19
Max.	54.05	-51.96	33.78	63.21	149.28
Av. B	28.09	14.65	-37.18	39.97	291.51
Std. Dev.	0.37	0.77	0.40	0.29	1.17
Min.	27.40	13.74	-37.90	39.45	289.94
Max.	28.67	16.38	-36.52	40.51	294.16
Av. Paper	88.45	-0.48	4.31	4.34	96.37
Std. Dev.	0.32	0.10	0.22	0.22	1.34
Min.	87.84	-0.59	4.08	4.12	93.33
Max.	88.87	-0.24	4.91	4.95	98.10

Table 2

Average Values of Primary and Overprint Colors Using GPI#3 Inks

Color	L*	a*	b*	C*	$h_{ab}(°)$	DIN NB	Status T
Av. Y	82.48	-0.84	80.18	80.18	90.60	1.26	0.96
Std. Dev.	0.21	0.11	0.75	0.75	0.08	0.02	0.01
Min.	81.79	-1.06	77.69	77.69	90.45	1.21	0.95
Max.	82.96	-0.63	81.89	81.89	90.76	1.30	0.97
Av. M	45.88	64.29	-3.40	64.38	356.97	1.54	1.46
Std. Dev.	0.14	0.26	0.25	0.25	0.23	0.01	0.01
Min.	45.63	63.74	-3.92	63.84	356.50	1.51	1.44
Max.	46.24	64.85	-2.57	64.91	357.73	1.56	1.48
Av. C	60.02	-42.25	-33.71	54.05	218.59	1.21	1.18
Std. Dev.	0.17	0.34	0.28	0.39	0.22	0.01	0.01
Min.	59.72	-43.08	-34.59	53.11	218.07	1.18	1.15
Max.	60.47	-41.39	-33.10	55.05	219.21	1.24	1.20
Av. K	19.88	0.70	1.90	2.02	69.54	1.52	1.52
Std. Dev.	0.91	0.04	0.14	0.14	1.41	0.03	0.03
Min.	18.04	0.60	1.55	1.72	64.32	1.45	1.45
Max.	21.94	0.80	2.15	2.27	72.06	1.59	1.59

Table 2 (cont.)

Color	L*	a*	b*	C*	h_{ab}(°)
Av. R	44.78	61.28	37.88	72.04	31.72
Std. Dev.	0.21	0.38	0.47	0.50	0.27
Min.	44.31	59.79	36.76	70.18	31.21
Max.	45.18	62.08	38.73	72.96	32.25
Av. G	54.37	-51.98	32.87	61.51	147.69
Std. Dev.	0.22	0.62	0.47	0.62	0.44
Min.	53.87	-53.07	31.10	58.57	146.83
Max.	54.78	-49.63	33.82	62.32	148.48
Av. B	27.89	17.08	-36.87	40.64	294.85
Std. Dev.	0.37	0.54	0.43	0.38	0.82
Min.	27.01	15.97	-37.77	39.84	293.31
Max.	28.70	18.18	-35.89	41.58	296.64
Av. Paper	88.52	-0.47	4.21	4.24	96.41
Std. Dev.	0.26	0.11	0.15	0.15	1.52
Min.	87.88	-0.62	3.98	3.99	92.90
Max.	88.87	-0.21	4.64	4.66	98.43

Table 3

Average Values of Primary and Overprint Colors Using GPI#3
Inks on Textweb for Integrating Sphere (I.S.) and 45°/0° Data

Sample	L*	a*	b*	C*	hab(°)	DIN NB	Status T
Av. GPI#3 Y, I.S.	83.52	-2.53	68.55	68.59	92.12	1.04	0.79
St. Dev.	0.17	0.07	0.18	0.18	0.06	0.00	0.00
Borden, Mid* Y, I.S.	83.90	-1.27	74.82	74.83	90.97	1.12	0.86
Target, I.S. ("+")	84.50			77.1 ± 1.5	90.7 ± 0.7		
Av. GPI#2 Y, 45°/0°	82.49	-0.90	83.55	83.56	90.61	1.33	1.00
SWOP Y Low, 45°/0°, 7/89	83.00	-1.09	82.20	82.20	90.80	1.26	0.98
SWOP Y High, 45°/0°, 7/89	82.00	0.43	91.50	91.50	89.70	1.49	1.13
Av. GPI#3 M, I.S.	50.01	59.35	1.25	59.36	1.21	1.28	1.23
St. Dev.	0.14	0.24	0.22	0.24	0.22	0.01	0.01
Borden, Mid* M, I.S.	50.28	57.71	4.37	57.87	4.33	1.21	1.18
Target, I.S. ("+")	51.30			57.0 ± 1.0	357.5 ± 2.0		
Av. GPI#2 M, 45°/0°	45.65	64.76	-2.01	64.79	358.22	1.55	1.48
SWOP M Low, 45°/0°, 7/89	47.90	60.60	-2.00	60.60	358.10	1.34	1.30
SWOP M High, 45°/0°, 7/89	46.00	63.10	-0.10	63.10	359.88	1.49	1.43

Table 3 (cont.)

Sample	L*	a*	b*	C*	hab(°)	DIN NB	Status T
Av. GPI#3 C, I.S.	60.46	-35.99	-34.78	50.05	224.02	1.06	1.05
St. Dev.	0.11	0.16	0.17	0.18	0.16	0.01	0.01
Borden, Mid* C, I.S.	56.89	-36.93	-33.97	50.17	222.61	1.14	1.14
Target, I.S. ("+")	59.50			52.5 ± 1.0	222.5 ±1.5		
Av. GPI#2 C, 45°/0°	59.78	-42.20	-33.87	54.11	218.75	1.22	1.18
SWOP C Low, 45°/0°, 7/89	58.20	-42.10	-33.20	53.60	218.30	1.26	1.23
SWOP C High, 45°/0°, 7/89	56.40	-43.90	-34.80	56.00	218.40	1.40	1.35
Av. GPI#3 K, I.S.	29.47	1.74	2.52	3.06	55.45	1.28	1.26
St. Dev.	0.26	0.03	0.03	0.04	0.31	0.01	0.01
Borden, Mid* K, I.S.	30.37	1.82	2.82	3.35	57.20	1.19	1.19
Target, I.S. ("+")	30.00			2.5 ± 1.0	60.0 ± 10.0		
Av. GPI#2 K, 45°/0°	19.44	0.84	1.89	2.07	66.09	1.54	1.54
SWOP K Low, 45°/0°, 7/89	20.30	0.60	1.90	2.00	72.20	1.51	1.51
SWOP K High, 45°/0°, 7/89	18.50	0.70	1.80	1.90	70.20	1.58	1.58

*Borden Mid is for a sample whose density was mid-way between the Borden Low and Borden High.