The American Oil Chemists' Society

Notes and Correspondence

Standardization of Lovibond Glasses

(*Investigation in Co-operation with A. O. C. S.*)

Report for March, 1928

(*Names in parentheses at ends of several sections of the report indicate individuals principally responsible for the work described.*)

I. Continuation of Investigation of the Sixty-five 35-Y Glasses Submitted by A.O.C.S. in August, 1927.

A condensed report giving the final findings on these glasses is nearly ready. This report will give the following data for each of these glasses:

(1) The rigorous equivalent of color quality in terms of yellow and red (both varying from glass to glass).

(2) The practical equivalent in terms of 35-Y x-red.

(3) The sunlight transmission for (a) unidirectional illumination normal to the surface of the glass, and (b) diffuse illumination.

(4) The percentage difference between the transmission for diffuse and unidirectional illumination.

(5) The percentage departure from the sunlight transmission for standard 35-Y.

(6) The percentage departure from the sunlight transmission proper to the yellow numeral assigned to the glass in the present calibration.

The matter of most interest to the chemist using these glasses under present conditions will be the practical equivalent. This states that, in quality of color (hue and saturation), the glass is practically equivalent to standard 35-Y + x-red where x has been determined for each glass from a great number of observations by three different observers. The maximum value of x (i. e. the numeral of the red glass required to be combined with standard 35-Y in order to match the test glass) is only 0.24. In other words, in this collection of sixty-five glasses, the one farthest from correct can be practically matched in hue and saturation by a combination consisting of standard 35-Y and 0.24-R. However, nearly all of these glasses are reddish relative to the standard, the average error being about 0.11-R.

The errors in transmission for sunlight are large enough to be important in only a few cases.

The spectral transmission curves of a number of these glasses are being plotted and compared with the standard. (Priest, Gibson, Judd, Walker, Brown, Riley).

II. Temperature Coefficient of Color of Lovibond Glasses and Cotton Seed Oil.

This investigation, mentioned in the report for February, has been extended.

The determinations on the 35-Y glass alone have been repeated by another observer with results in substantial agreement with the previous determination. Similar determinations have been made on the glass combination 35-Y 7.2-R and on cotton seed oil itself. It is found that the changes in the red and yellow glasses are, to a certain extent, compensating so that the resultant change for the combination is less than for 35-Y alone. A

temperature change of about 20°C would be required to change the color by 0.1-R. Similar (preliminary) determinations on the oil (two samples, about 35-Y 7-R) itself indicate clearly that the changes in quality of color are even smaller than for the glasses. They are quite negligible for a temperature change of 25°C. The transmission of the oil increases very slowly with temperature, but this change (about 2% for temperature change of 25°C) is also entirely negligible in the practice of color grading oil. (Judd).

III. Further Calibration of Bureau of Standards Set of Lovibond Yellow Glasses (B. S. 9940).

Spectral transmission measurements have been made for the following yellow glasses (designated by the makers' marks):

0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90.

The experimental work on these determinations is nearly completed. (Gibson, Brown).

IV. Sensibility to Change in Yellow and Red at 35-Y and at 35-Y 7.6-R on the Lovibond Scale.

In order to check and supplement the estimates of sensibility given in the February report, further observations have been made to obtain estimates of least read and yellow differences perceptible with certainty at 35-Y and at 35-Y 7.6-R. These estimates are as follows:

Experiments have also been made to discover how these sensibilities depend upon brightness. Estimates of sensibility were made at four widely different brightness levels, the highest being very much higher than would ever be used in practical work and the lowest, much lower than would be used. (The respective retinal illuminations were roughly 10,000 photons, 1,000 photons, 100 photons, 10 photons.) The following estimates of least differences perceptible with certainty at 35-Y were made by Judd.

Retinal Illumination	Yellow dif.	Red dif.
10000 photons	1.2	0.05
1000	1.3	.06
100	1.7	.07
10	4.0	.10

It will be noted that the sensibility is nearly constant over a very wide range of ordinary brightness levels such as are commonly used. There is, however, as would be expected, a notable decrease in sensibility at very low brightness. It is probably fair to say that the sensibility is practically constant over a brightness range which the observer would instinctively feel to be satisfactory for such observations. (Judd, Walker, Priest).

V. Approximate Empiric Equivalence of Small Differences in Red and Small Differences in Yellow at 35-Y on the Lovibond Scale.

The approximate empiric equivalence of small differences in red

	Least Differences Perceptible With Certainty			
	At 35-Y		At 35-Y 7-6-R	
	Yel. dif.	Red dif.	Yel. dif.	Red dif.
Estimated by Walker, at moderate brightness, north sky illumination	1.5	0.028	5.6	....
Estimated by Judd, at very high brightness, artificial sunlight	1.2	0.05	1.3	0.068

and yellow at about 35-Y, mentioned in the February report, has been investigated more carefully. The original observation (by Judd) that 0.1-R might be substituted for 5-Y has been substantially verified by two other observers (Priest and Walker). It has also been noted that the basis of this equivalence is equality of dominant wavelengths. It has been shown by computation that the increase in dominant wavelengths due to adding 5-Y is equal to the increase due to adding 0.1 R. The equality of dominant wavelengths appears to be the determining element in the empiric color match. The increase in purity due to adding the yellow is much greater than the increase due to red; but this is of relatively little importance in determining the color match when only small differences are involved. For differences greater than 0.2-R (or 10-Y) this practical equivalence begins to break down. That is, if we have a two-part matched field (at 35-Y) and add yellow to one side and red to the other in the ratio of 50 to 1, the side to which the yellow is added will appear more saturated if the yellow increment is greater than about 10. (Priest, Judd, Walker).

VI. Review and Reduction of Earlier Data on Bureau of Standards Lovibond Red Glasses (B. S. 9940).

The standard red scale adopted by Priest and Gibson in May, 1927, is based fundamentally on the spectral transmission of the glasses determined by Gibson and Harris (years 1923-24) as published in B. S. Sci. Paper 547. Less reliable data for glasses of nominal integral numerals from 3 to 20, inclusive, by Dr. M. Katherine Frehafer (unpublished, but preserved in our files) have been available since 1920. Using these data, the computation analogous to the first step in obtaining the Priest-Gibson numerals has been carried through. This computation is sufficient to show to what extent the numerals are affected by computing them from these entirely independent data on spectral transmission. No weight is to be attached to these earlier results in determining the accurate values of the numerals to be adopted. They are of interest, however, in the following aspects:

(1) They show that approximately the correct numerals are obtained from spectral transmission data much less extensive and precise than the data of Gibson and Harris.

(2) They indicate independently that there are no gross errors in the numerals due to unknown errors in the spectral transmission data of Gibson and Harris.

The following table shows the discrepancies in numerals computed from the two sets of data:

Maker's Numeral	Differences in Computed Numerals (Frehafer Data Minus Gibson-Harris Data)
3.0	+0.02
4.0	— .03
5.0	— .09
6.0	— .11
7.0	— .05
7.6	— .10
8.0	— .02
9.0	+ .04
10.0	— .14
11.0	+ .07
12.0	— .01
13.0	+ .04
14.0	+ .19
15.0	+ .15
16.0	— .22
17.0	+ .29
18.0	+ .10
19.0	+ .11
20.0	— .40

(Gibson, Riley)

VII. Further Data on Bureau of Standards Lovibond Red Glasses (B. S. 9940).

The spectral transmission of red glass marked 1.75 (maker's numeral) in the Bureau of Standards set (B. S. 9940) has been determined.

Three more red glasses in the Bureau of Standards set (B. S. 9940) have been calibrated (by computation from spectral transmission) in terms of the scale of Priest and Gibson. The results are as follows:

Maker's Numeral	Priest-Gibson Numeral
1.75	1.92
1.85	2.10
3.7	3.80

We have now exhausted the possibilities in selection of individual glasses (from this set) to represent exact tenths and exact integers from 1 to 10 on the Priest-Gibson scale as adopted in May, 1927. The final findings are given in the following table:

Desired Exact Numeral	Maker's Numeral on Glass Selected as Closest to Desired Value	Computed Numeral (Priest-Gibson Scale)	Computed Minus Desired
0.100	0.02	0.104	+0.004
.200	.13	.199	— .001
.300	.18	.296	— .004
.400	.28	.365	— .035
.500	.38	.495	— .005
.600	.46	.593	— .007
.700	.56	.711	+ .011
.800	.64	.806	+ .006
.900	.74	.900	.000
1.000	.86	1.003	+ .003
2.00	1.8	1.95	— .05
3.00	2.8	2.99	— .01
4.00	3.9	3.94	— .06
5.00	4.9	5.08	+ .08
6.00	5.6	6.16	+ .16
7.00	6.8	6.85	— .15
8.00	8.2	8.04	+ .04
9.00	9.0	9.17	+ .17
10.00	9.8	10.00	.00

(Gibson, Walker)

VIII. New Equipment for Comparing Lovibond Glasses in Artificial Daylight and for Tests of Color Sense.

Equipment designed to be used with the Martens photometer in comparing Lovibond glasses in artificial sunlight has been constructed and installed. It is now being used in the routine examination of glasses submitted by the A.O.C.S. This new equipment provides a much higher field brightness than has been used heretofore. Comparison of glasses need no longer be delayed because of lack of suitable illumination on dark days. The new equipment, accessory to the Martens photometer, consists essentially of:

(1) A magnesia lined sheet metal lamp inclosure containing two 100-watt gas-filled tungsten lamps. The light used proceeds from the white wall of this inclosure through a hole in one side.

(2) A Davis-Gibson filter which reduces the light to equivalence with noon sunlight.

(3) A biprism and lenses attached to the Martens photometer so as to properly direct the light and give a uniform field of view in the photometer.

A few glasses previously graded in natural north skylight have been regraded with the new apparatus with entirely consistent results.

This apparatus will also serve for tests of color sense such as were made at Memphis by Priest in May, 1927 (See OIL AND FAT INDUSTRIES, March, 1928). It is in fact the same apparatus with the added feature of constant standard artificial sunlight illumination. The variability of natural illumination being eliminated, the results for different observers will be comparable with much less question as to the significance of the comparison. (Priest).

IX. Design of Instrument for Using Lovibond Glasses.

An instrument intended to greatly increase the convenience and accuracy of using the Lovibond glasses in color grading oil has been designed and is now being constructed in the Bureau of Standards instrument shop. The essential features of this instrument are:

(1) Use of the Martens photometer as an observing instrument and as a means of obtaining a brightness match and a measurement of transmission.

(2) Mounting of glasses in wheels as in Bailey's colorimeter.

(3) Use of standard artificial daylight. (Priest).

X. Progress on Routine Calibration of Red Glasses Submitted by A.O.C.S.

Twenty-five red glasses submitted February 17th have been graded, reported, and returned. (Date of report, March 3rd. Date of shipment to Mr. Putland, March 5th.)

Twenty-five red glasses submitted March 5th have been graded, reported and returned. (Date of report, March 10th. Date of shipment to Mr. Pultand, March 14th.)

The grading of twenty-four red glasses submitted March 16th is nearly completed. (One glass received without A.O.C.S. No. in this shipment was returned immediately without being graded.)

Twenty-four red glasses were received March 29th.

Including the glasses received March 16th, the total number of red glasses graded under the present arrangement for routine grading (First lot submitted January 16, 1928) has been 117. (Walker).

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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912.

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State of New York } ss.:
County of New York }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Alan Porter Lee, who, having been duly sworn according to law, deposes and says that he is the Editor of the OIL AND FAT INDUSTRIES, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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ALAN PORTER LEE, Editor.

Sworn to and subscribed before me this 4th day of April, 1928.
(Seal) Johanna E. Schult, Notary Public.
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(My commission expires March 30th, 1930.)