Applications Note

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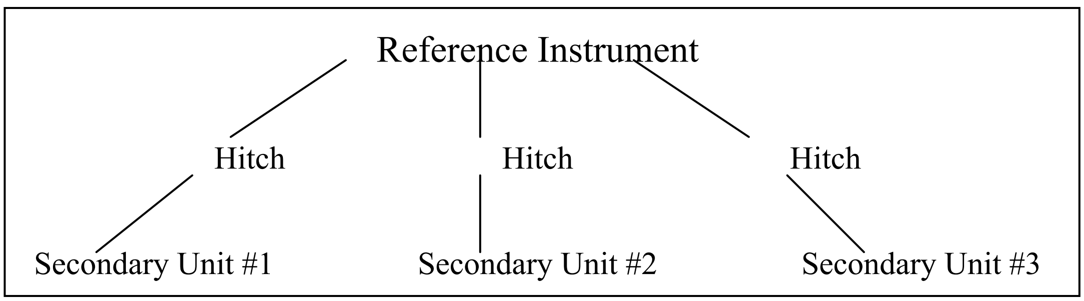
HunterLab's Guide to Hitch Standardization

Hitch standardization, also known as transfer standardization, is a process by which two instruments of similar design can be made to read the "same" values on a group of specimens. The process involves assigning one instrument to be the reference, or master, unit and mathematically adjusting the secondary, or slave, unit(s) to read the "same" values. In this way, two or more instruments can be hitched together.



Here's a simple example: A MiniScan XE Plus was used to read a green standard and a green sample. It was then hitched to the green standard values read on another instrument and the green sample was read again. The values read on the MiniScan XE Plus are shown below.

D65/10°	**L***	**a***	**b***
Green Standard (Unhitched)	51.13	-26.43	13.21
Green Standard (Hitched)	51.22	-26.70	12.60
Green Sample (Unhitched)	53.64	-24.49	13.57
Green Sample (Hitched)	53.70	-24.72	12.94

On the reference instrument, the Green Sample read L* = 53.77, a* = -24.81, b* = 12.86. As you can see from the table, the hitched green sample values on the MiniScan XE Plus are closer to this reading than the unhitched green sample values.

Choosing the Best Instrumentation

The best hitch results are obtained when the instrument set contains units of similar geometry. This means that hitched instruments should all have either diffuse illumination and 8° viewing or 45° illumination and 0° viewing. The two geometries should not be combined in a hitch.

When using a combination of colorimeters and spectrophotometers (sometimes referred to as spectrocolorimeters) in the hitch network, it is recommended that a spectrophotometer (such as a ColorQuest, LabScan, or UltraScan), rather than a colorimeter (ColorTrend HT or D25), serve as the reference unit. This makes the most of the spectrophotometer's ability to measure across the entire visual spectrum and takes advantage of the tightness in readings that can be achieved within a population of spectrophotometers. In the case where all spectrophotometers or all colorimeters are being used for the hitch, the reference unit can be selected at random. It is recommended that the reference unit be placed in a central laboratory where performance can be monitored on a regular basis.

Other instrument capabilities, such as varying port sizes, UV filters, and light sources, should be well-defined and as standardized as possible for all the instruments. Similarities between the instruments should be maximized for the best results.

The Basic Technique

Hitching a secondary unit to a reference instrument requires that a specimen be read on both units and the values compared and adjusted accordingly. This specimen, known as the hitch standard, is first read on the reference instrument and its values recorded as spectral data or colorimetric (tristrimulus) data. The hitch standard is then physically moved to the secondary instrument where it is reread and the values from the reference unit are input into the secondary instrument's processor. Through the software, the secondary unit is then "biased" to the reference unit using either an additive or a ratio calculation, as shown below.

Hitch Calculations

BIAS (Additive) Calculation:

Hitched Sample Value = Unhitched Sample Value + Hitch Bias

Hitch Bias = Assigned Standard Value – Measured Standard Value.

RATIO (Scalar) Calculation:

Hitched Sample Value = Unhitched Sample Value * Hitch Ratio

$$\text{Hitch Ratio} = \frac{\text{Assigned Standard Value}}{\text{Measured Standard Value}}$$

For the MiniScan XE Plus example cited above, the following BIAS calculations apply:

L*: 53.70 = 53.64 + Hitch Bias; Hitch Bias = 0.06
Hitch Bias = 51.22 - 51.13 = 0.09

a*: -24.72 = -24.49 + Hitch Bias; Hitch Bias = 0.23
Hitch Bias = -26.70 - (-26.43) = 0.27

b*: 12.94 = 13.57 + Hitch Bias; Hitch Bias = -0.63
Hitch Bias = 12.60 - 13.21 = -0.61

For measurements made on a D25-9, the following RATIO calculations apply:

L*: 53.69 = 53.59 * Hitch Ratio; Hitch Ratio = 1.00
Hitch Ratio = 51.02/50.96 = 1.00

a*: -26.63 = -27.69 * Hitch Ratio; Hitch Ratio = 0.96
Hitch Ratio = -28.56/-29.64 = 0.96

b*: 11.58 = 13.86 * Hitch Ratio; Hitch Ratio = 0.84
Hitch Ratio = 11.42/13.51 = 0.85

Small differences in the hitch calculations are due to rounding of the final results.

In general, the bias type of hitch is preferable for dark colors and when the samples to be measured are very close in color to the hitch standard. Bias hitches are convenient because once the instrument is hitched, it rarely needs to be rehitched. On the other hand, ratio hitches are acceptable for a wider range of colors (including colors less similar to the hitch standard), but, at least with the HunterLab D25-9, must be re-established each time you standardize the instrument.

When the hitch has been implemented, the values obtained on a hitched instrument would ideally be the same as those obtained on the reference unit. The unhitched values represent data read relative to the secondary instrument's white tile. The hitched values represent data read relative to the reference instrument's white tile.

The capability of establishing a hitch standardization varies among HunterLab products. Most of the instruments which offer hitch standardization offer the ability to hitch on tristimulus data. Some of the spectrocolorimeters have the additional ability to perform a hitch based on each point of spectral data, which means you can then view the hitched data under any color scale, and observer. Tristimulus hitches limit your data viewing capabilities to the illuminant and observer conditions under which the hitch was created. For a general overview of instrument and software capabilities, refer to the chart below. For specific instrument operation instructions, refer to your instrument user's manual.

Hitch Standardization Capabilities - Instruments

HunterLab Instrument	Hitch Calculation Method	Instrument Geometry	Hitch Basis Available
ColorFlex	Depends on Software	Diffuse/8° or 45°/0°	Depends on Software
ColorQuest Sphere/ColorQuest II/ColorQuest XE/ColorQuest XT	Depends on Software	Diffuse/8°	Depends on Software
ColorQuest 45/0	Depends on Software	45°/0°	Depends on Software
ColorTrend HT	Bias	0°/35°-45°	Tristimulus
D25 (A, L, and M)	Depends on Processor	45°/0°	Tristimulus
D25LT	Bias	45°/0°	Tristimulus
LabScan/LabScan XE	Depends on Software	0°/45°	Depends on Software
MiniScan/MiniScan XE/MiniScan XE	Depends on Software	Diffuse/8° or 45°/0°, LAV and SAV	Tristimulus only for MS, MS/B and MS/T,

HunterLab Instrument	Hitch Calculation Method	Instrument Geometry	Hitch Basis Available
Plus		models available	Spectral also available for all other models with Universal, EasyMatch QC, EasyMatch Coatings, or EasyMatch Textiles software
SpectraProbe/ SpectraProbe XE/SpectraProbe S/8	Bias	45°/0°, 0°/45°, or Diffuse	Tristimulus
UltraScan/UltraScan XE/UltraScan PRO/UltraScan VIS	Depends on Software	Diffuse/8°	Depends on Software

Hitch Standardization Capabilities – Software/Processors

Software/Processor	Hitch Calculation Method	Hitch Basis Available
-9 Processor Firmware (D25-9)	Ratio	Tristimulus
ColorFlex Firmware	Bias	Tristimulus
ColorTrend HT Hand-Held Terminal/Utility Software	Bias	Tristimulus
DP-9000 Firmware	Bias	Tristimulus
EasyMatch OL	Bias	Tristimulus
EasyMatch QC	Bias, Ratio	Spectral, Tristimulus
EasyMatch Textiles/EasyMatch Textiles QC	Bias	Spectral
MiniScan Firmware	Bias	Tristimulus
MultiSensor Software/MultiSensor XE	Bias	Tristimulus
Universal Software/EasyMatch Coatings	Bias	Spectral, Tristimulus

Selection of a Primary Hitch Standard

Due to the visual non-uniformity of the color scales, it is recommended that each distinct color be assigned a separate hitch standard. This will improve the reproducibility of the measurements between the reference and secondary units. Ideally, hitch standards should be made of the same material and colorants as the samples to be analyzed and should differ by no more than about 5 ΔE units from the usual samples to be measured. The use of hitch standards that are spectrally different than the product can result in increased differences in the secondary units as compared to the reference. Each secondary unit requires a set of hitch standards and reference instrument values for initial setup.

There are many cases where multiple copies of the hitch standard are unavailable or the stability of the specimen is in question. For these cases, a material of the same color with the following characteristics would be ideal:

- Readily-available quantity
- Uniform surface
- Stable over time
- Non-metameric to the sample
- Non-photochromic
- Non-thermochromic.

A good example of a commonly-used and stable hitch standard is a ceramic tile. This type of standard can easily be sent to the various locations of the secondary instruments after being read on the reference unit.

Preparation of a Secondary Hitch Standard

In the case where the hitch standard's color will change over time, care must be taken to ensure optimum shipping conditions and quick use of the hitch standard. Once the hitch standard is read on the secondary instrument to establish the initial hitch, a secondary standard should be chosen for use in routine product evaluation. This secondary standard should be a more stable material that can be used to re-establish the hitch as needed.

The secondary hitch standard procedure is used, for example, in the determination of United States Department of Agriculture (USDA) grade color for tomato products. The instrument network is composed of 45°/0° colorimeters that are hitched together to the reference instrument at USDA via an actual tomato paste sample. This "soft" standard is prepared and read on each secondary instrument, and the assigned values from the reference unit are entered into each unit. Since the standard is biodegradable, its shelf-life in an open container is relatively short. Therefore, the next step is to read a red ceramic tile, the "tomato tile," relative to this hitch.

When the tomato tile is read on each secondary instrument with the soft standard hitch in place, the values obtained become the "new assigned" values from the reference instrument. The secondary instrument can then be rehitched using the tomato tile in the future rather than the soft standard. The tomato tile becomes the secondary hitch standard. It is checked periodically against a new soft standard.

Instrument Performance and Hitch Standardization

Each instrument should be standardized prior to working with a hitch standard to ensure robustness of the data. Periodic restandardization should be done per the individual instrument recommendations. Each hitch standard or product standard should be reread and compared to itself as a sample on a routine basis to ensure confidence in the hitch calculations.

In addition, a checking program should be implemented for evaluating the performance of the hitch standardization on each secondary unit for each color relative to the reference instrument. A set of stable specimens that could be read on each instrument and compared would serve as a check on the program.

Changes in the hardware on any reference or secondary unit will affect the assignment of hitch factors. It is recommended that routine diagnostics be performed on each unit in the network to ensure proper maintenance. Refer to specific diagnostic routines described in your User's Manual. Maintenance of the instruments (i.e., replacement of the lamp or preventative maintenance work by a service technician), followed by rereading of the instrument standards and the hitch standards are recommended on a scheduled basis.

Summary of the Hitch Standardization Procedure

1. Choose the reference instrument and the specimens to be used as hitch standards. Each color should have its own hitch standard for best results. Each secondary unit should have its own set of hitch standards.
2. Label each standard for easy identification.
3. Standardize the reference unit using its calibrated instrument tiles. Read each hitch standard on the reference unit and record the data. If tristimulus data is being obtained, record the standard observer and illuminant. Note that use of a colorimeter as a reference or secondary unit will require the use of Illuminant C and the 2° standard observer.

   Example of Recorded Hitch Data

   Model: LabScan 11/01
   Serial Number: 13502

   Colorimetric Data (C/2°):

L*	56.45
a*	-10.12
b*	1.02

   If spectral data is being used, write down or print the 10 nm data for the entire measurement range of the instrument.
4. Forward the hitch standards and the recorded hitch data to each secondary unit location.
5. Read the instructions for hitch standardization in the User's Manual for the secondary instrument. Set up this instrument to read the same color scale, illuminant, standard observer, etc. as the hitch data from the reference instrument. Standardize the secondary instrument using its own calibrated tiles.
6. Following the specific instrument procedures, read the hitch standard on the secondary unit. When prompted, input the values from the reference unit. The computer or processor will then determine the hitch offset, and the instrument is ready for sample analysis.
7. If you plan to use a secondary hitch standard, read the secondary standard as a sample. Record the values read for this standard with the hitch implemented. These values will now serve as the assigned values from the reference instrument. The instrument can now be rehitched using this secondary standard.
8. Implement a check program to evaluate the hitch for each secondary unit relative to the reference instrument.

For further reading, refer to:

ASTM E1455, "Standard Practice for Obtaining Colorimetric Data from a Visual Display Unit Using Tristimulus Colorimeters."

Berns, Roy S., *Billmeyer and Saltzman's Principles of Color Technology*, New York: John Wiley & Sons, 2000.

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