THE SECOND C:
The Sixth Circle of Hell—Heresy, Part 2

By Keith Hoover

Feasible digital color standards, the right illuminants, a concise color palette, DE_{CMC} tolerances —it seems more like Paradise than an Inferno. But then along comes a serpent tempting you to break the digital thread. "Make all your approvals in one quadrant. Match production to the approved lab dip." You think it sounds so reasonable…as you condemn all who follow to a life of shame, want, and nakedness (the origin of fashion?). Oh wait, that's Damnation and this article is about Heresy. In this installment, we will look at two heresies that occur in production, the last stage of the color approval process. We will discover that, while the serpent might offer tainted fruit, the conventional lab dip process is the Original Sin.

THE SINGLE SOURCE OF TRUTH

Every Product Lifecycle Managment (PLM) huckster has led off a sales pitch with that phrase. Nevertheless, it retains a valuable meaning. The color specification selected by a designer should be consistent and unchanging throughout the design to production process. The color of all products in the store should match the designer's inspiration. That is one of the advantages of digitizing an inspiration into spectral data (vetted, of course, for feasibility). A digital standard provides a fixed point of reference.

UNTIL IT ISN'T

Yet many brands specify confused color processes, forfeiting the value of that "single source of truth." They either approve lab dips "by quadrant" or direct the mills to use their approved lab dip as the color standard for production. Both of these methods reflect obsolete practices that pre-date modern digital color management (and the birth date of most of today's brand color managers). The main problems with both these practices are that they 1) change the color standard and 2) break the digital model.

The Quadrant Approval Fallacy

There is a strange conundrum at many apparel brand color offices. Colorists insist that they evaluate everything visually and only use color QC software as a backup. But then they only approve lab dips that fall in certain quadrants of a color difference plot. There are several problems with this approach.

The quadrant approval model assumes two dimensions (a*, red/green and b*, yellow/blue). A requirement for a red shade might be that all approvals must be in the blue (Hue Angle) and bright (Chromaticity) quadrant. But color space is three dimensional. As Ann Laidlaw points out, how does one account for a difference in Lightness (the third dimension in color space) when approving in two dimensional quadrants? Oops. Lightness is a critical factor in achromatic shades, but quadrant approval is silent on it.

Ignoring that logical flaw, limiting approvals to a quadrant creates significant aesthetic, dyehouse, and sustainability [1] issues. Let's look at an example. Brand X specifies that mills must match colors within a tolerance of 1.00 DE_{CMC} under Illuminant X and Illuminant Y. Furthermore, all lab dips will be approved by quadrant. For Ammeye Blue, lab dips will only be approved on the red/bright quadrant (see Plot 1a).

Plot 1a

Quadrant approvals: Plot 1a shows the specified quadrant for all Ammeye Blue approvals. Green dots along the perimeter represent lab dips with the maximum hue and chromaticity difference. The green dot in the center of the quadrant is the "bullseye."

The Aesthetic Problem

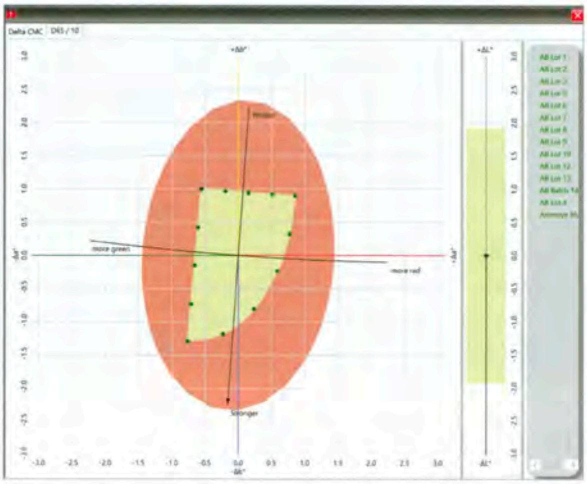
The color manager defends this policy, stating, "We prefer blues on the red side—if they go green, they don't look as nice." This is an argument for color selection, not color replication. In the initial installment of the "Second C" series, we looked at the distinction in purpose between color selection and replication. Once a color designer chooses the desired blue color standard, then subjective hue preferences are moot. The focus changes from aesthetics to a technical process that replicates an objectively defined color standard. The quadrant approval method subverts the will of the designer.

The Dyehouse Problem

Now let's return to the brand's color matching specifications. The color difference tolerance is 1.00 DE_{CMC}. However, that is a spurious specification because only 25% of all possible matches measuring under 1.00 are acceptable because all approvals must fall in a single quadrant. So, color difference numbers are of little use since they might or might not be relevant. This presents a problem for the dye lab in achieving accuracy and precision.

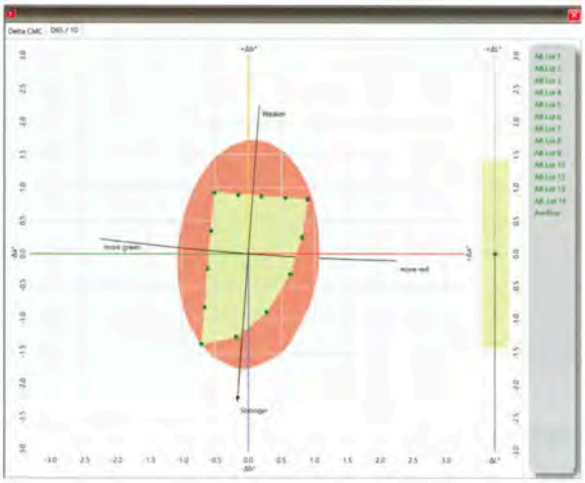
Accuracy describes the quality of the initial color match while precision describes how closely production lots match each other. Dye recipe formulation software is used to create an accurate match and sets the color standard as the center, or bullseye, of a target and then predicts recipes that fall within that target. The size of the target is determined by the magnitude of the DE_{CMC} tolerance. Each predicted recipe includes a best case DE_{CMC}—the lower the predicted color difference, the closer to the bullseye. Various predicted recipes plot in an even distribution *around* the bullseye.

This textile series will share technical insights and wisdom of AATCC members. The "Second C" series will focus on color. If you wish to contribute your own technical insights on topics of interest to AATCC members, contact Communications Director, Maria Thiry; thirym@aatcc.org.



Plot 1b

Quadrant approvals: Plot 1b shows the color difference tolerance of the quadrant vs the CMC ellipse at 1.00.



Plot 1c

Quadrant approvals: Plot 1c shows the CMC ellipse shrunken to 0.74 to reflect the limits of the quadrant. Note however that nearly half of the CMC plot remains "off-limits" for quadrant approvals.

When constrained by quadrant matching, if a recipe predicted to be a perfect match varies even slightly, there is a 75% chance that the resulting lab dip will be in the wrong quadrant and thus unacceptable. So, the dye lab must actually *change the color standard* and select a dye recipe that matches the brand's standard AND falls in the center of the desired quadrant (the new bullseye shown in the middle of the approval quadrant in Plot 1a).

Since the quadrant represents the acceptability tolerance for matching, the actual DE_{CMC} is much smaller than the brand's specification of 1.00 DE_{CMC}. The batches in Plot 1a define the limits of the quadrant. Plot 1b shows the same batches displayed in a color difference plot using the new bullseye target (the center of the quadrant). From this, we can see that 1) there are approved lots in *all four quadrants* (so much for everything being red and bright) and 2) applying a "quadrant tolerance" destroys the usefulness of the CMC model, since many acceptable lots that fall within the ellipsoid are judged unacceptable by the additional quadrant constraint. Plot 1c shows that the nominal tolerance for the quadrant method is less than 0.74 DE_{CMC}, depending on where the batch plots in the ellipse. In many cases, the maximum allowable tolerance is under 0.30 DE_{CMC}.

Which Leads to the Sustainability Problem

Process capability, the amount of color variation between multiple lots of fabric dyed to the same color, was discussed in "The Second C: Leaving Limbo." Lot-to-lot variation can measure up to 0.40 DE_{CMC} over time. The production tolerance required for quadrant approval is irregular and unnecessarily tight. The closer a production tolerance is to a mill's process capability, the higher the risk of out-of-tolerance production lots.

When a tolerance is unpredictable, it has a negative impact on a mill's operational excellence. Lots that would be acceptable for any other customer must be rejected for the quadrant approval brand. Out of tolerance lots must be reworked, dyed to black, or otherwise discarded. Reprocessing lots that are technically out of tolerance but actually usable is a waste of time, material, and resources —unsustainable by definition.

Although the dyehouse in a mill must get color approval from the brand, the true commercial customer is the garment factory. When the mill ships fabric to the factory, the factory inspects the fabric to see if it matches the standard. Which standard?

Since the original brand color standard has been replaced with various mills' working "sub-standard" quadrant approvals, there is no clear color specification against which to judge conformance. So, there are more opportunities for a dispute between the mill and the factory, leading to wasted time, resources, and fabric taking us one step closer to the end of the world.

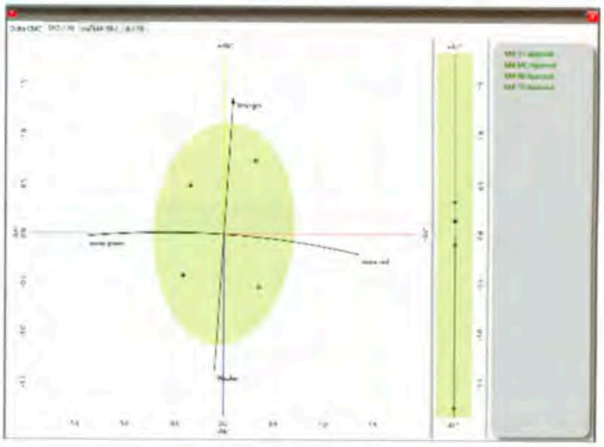
THE LAB DIP-APPROVAL-AS-STANDARD FALLACY

Back in the 20th century, designers working for vertically integrated apparel brands sent "color inspiration" samples (leaves, frozen chicken, etc.) to be matched at the company-owned dyehouse. Once approved, that dyeing became the color standard—and the inspiration was discarded (or fried). In many cases, the color was produced at only one location. If dyed at multiple locations, the approved dyeing was distributed and checked internally.

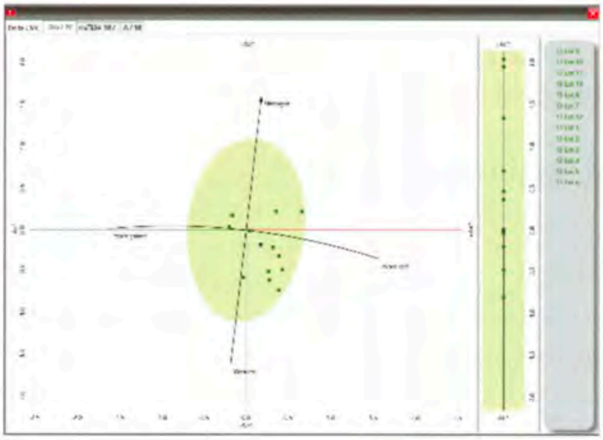
In the intervening half-century, vertically integrated brands have disappeared, replaced by a contract manufacturing model. The integration between design and production has vanished. Many more mills are producing the same colors for a brand, but the technical coordination of vertical integration is gone. Vestiges of the past still remain, however. One such anachronism is replacing the brand color standard with the approved lab dip for production.

It Oughtta Work…

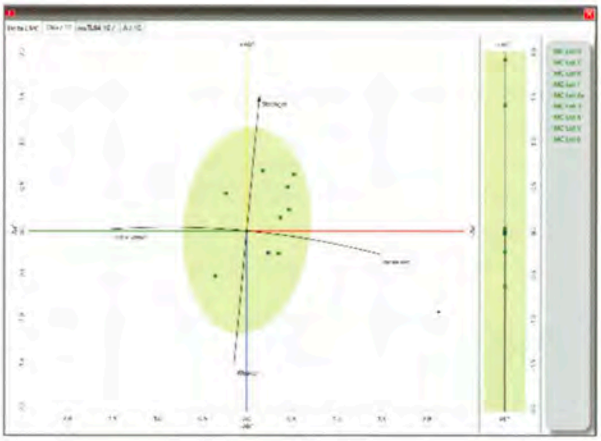
Consider the case of Brand Y who specifies that mills must match lab dips within a tolerance of 1.00 DE_{CMC} under Illuminant X and Illuminant Y. Once approved, all production must match the approved lab dip within a tolerance of 1.00 DE_{CMC}. Let's take a look at what happens when this process is followed at four mills producing Z Z Taupe [2]. Plot 2 shows all four approved lab dips grouped



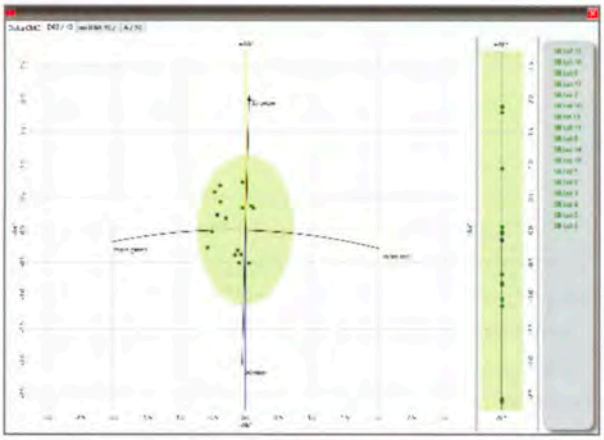
Plot 2: Approved lab dips as standards: Lab dips from four mills were approved under the 1.00 DE_{CMC} tolerance.



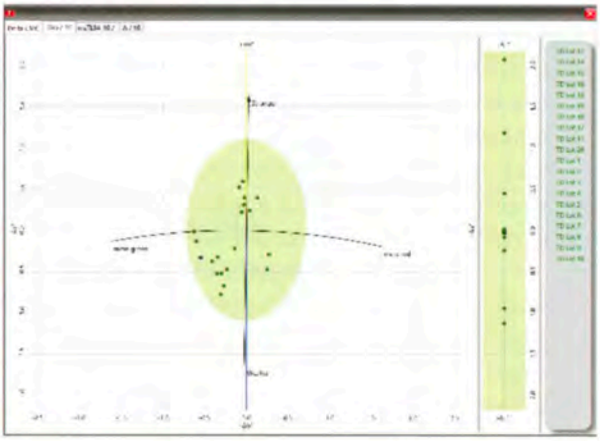
Plot 3a: Mill 13 production. Avg DE_{CMC}=0.66



Plot 3b: Mill MC production. Avg DE_{CMC}=0.68



Plot 3c: Mill SB production. Avg DE_{CMC}=0.72



Plot 3c: Mill TD production. Avg DE_{CMC}=0.59

Approved lab dips as standards: Plot 3a shows four lab dips approved within 1.00 DE_{CMC}. Plots 3b–d show all production lots matched to each mill's lab dip approval. All measure well under 1.00 DE_{CMC}.

together. Plots 3a-d show production plots for each mill using their own approved lab dips as color standards.

So far, everything is fine. Each mill has been able to match the brand's color standard within a tolerance of 1.00 DE_{CMC}. And, each mill has dyed all lots of production within that same tolerance. So, everything should be good, right?

...But it Doesn't

Well, no. Plot 4 shows the production lots from all four mills plotted back to the original brand color standard instead of the approved lab dips. The intention was to produce colors that matched within the industry-accepted DE_{CMC} tolerance. But, since one standard was replaced with four, the maximum color difference across all mills was 1.80 instead of 1.00 DE_{CMC}. The mills were capable of producing lots within 1.00, but the brand color office's bad policy resulted in excess shade variation. And that shade variation was seen by the customer in the store—and perceived as poor quality.

Compounding the Mistake

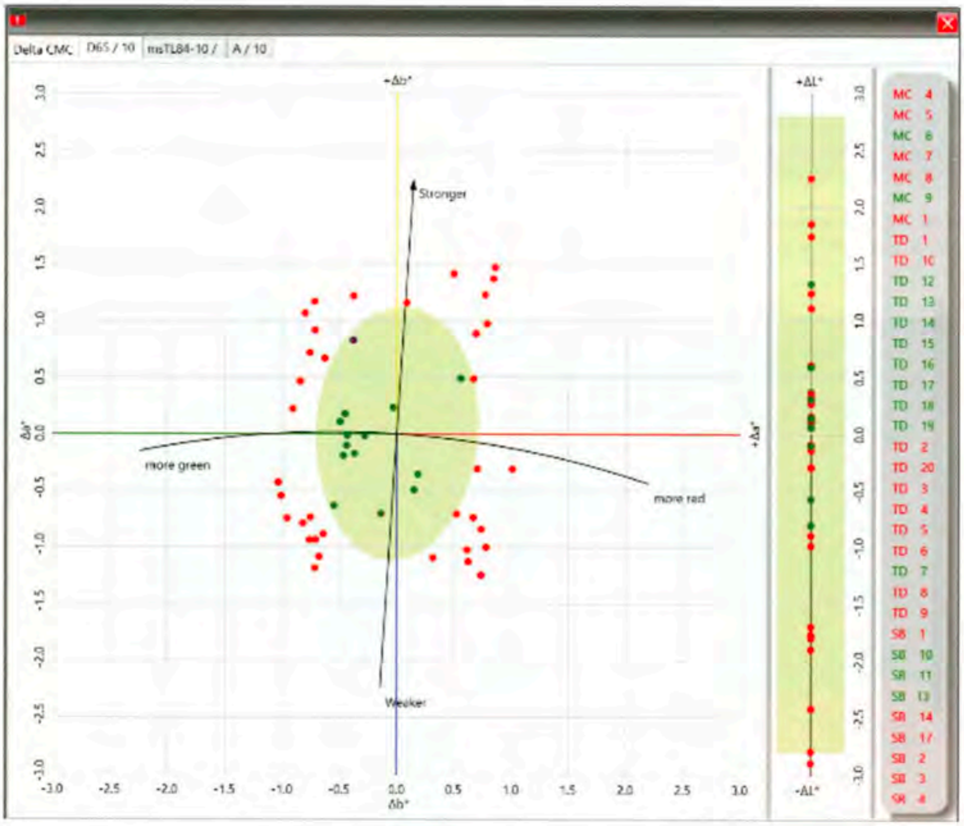
Alas, the brand color manager sees the shading on the selling floor (perhaps at the direction of his or her boss) and improperly concludes that a tolerance of 1.00 DE_{CMC} is too high (even though the bad matches observed may be nearly twice that). Rather than investigate what has actually happened, a hasty decision is made to either 1) lower the tolerance or 2) dare I say it—*approve by quadrants.* In either case, the mills will be punished because of the brand color manager's ignorance. Decisions like this have consequences. They cost the mills because unreasonable tolerances produce excess QC rejections. They cost the brand by 1) imposing a longer color development process, 2) shading on the selling floor, and 3) paying the salaries and budget expenses of a department adding no value.

Color management is a quality process, and any quality process must add demonstrable value at the least cost.

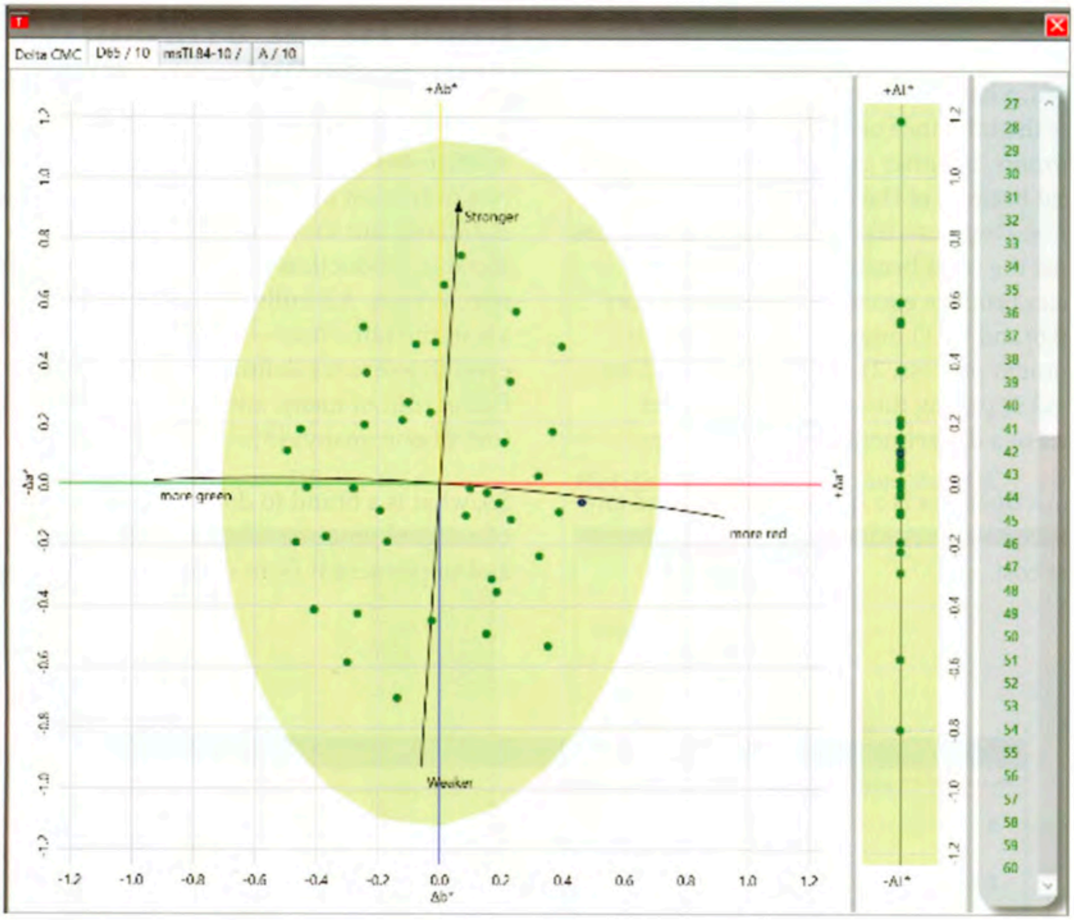
BACK TO THE STRAIGHT AND NARROW

Bad things happen when a brand abandons operational excellence and a single source of truth. Not only must dyehouses deal with multiple color standards, but they must also contend with unpredictable production tolerances resulting in excess rejected lots. All mills dyeing fabric in that color are in the same boat—too many standards and not enough tolerance definition. Instead of *E Pluribus Unum* (out of many, one), we have *E Uno Plurem* (out of one, many) [3].

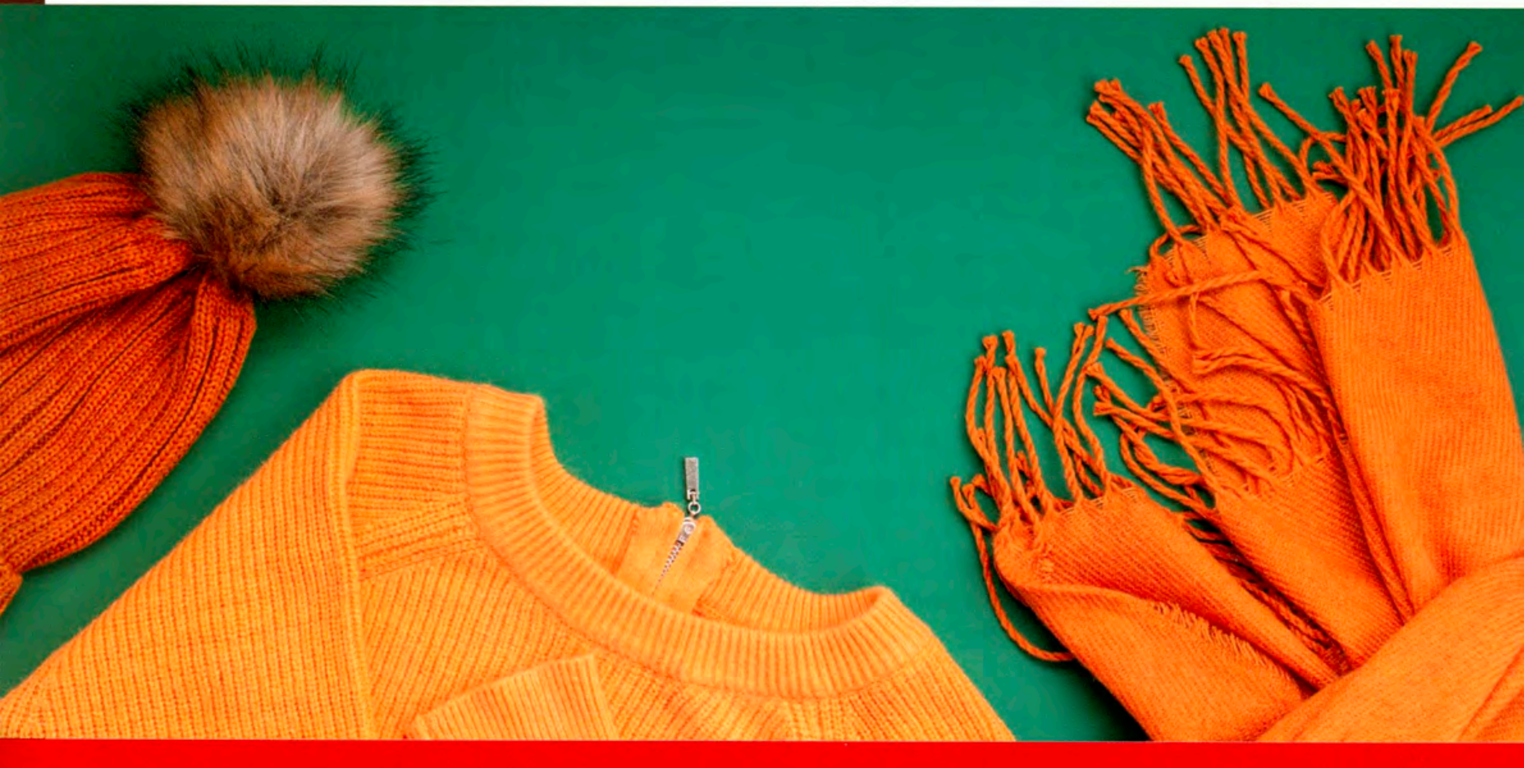
So, what is a brand to do? Leverage the benefits of a digital process. Adopt one color standard and implement it from design to production.



Plot 4: Production to mill approvals: This plot shows all four mills' production compared back to the original standard instead of the individual approved lab dips. The average color difference is 1.21 DE_{CMC} with a max value of 1.80 DE_{CMC}.



Plot 5: Production to the original standard: This plot shows the same number of production lots dyed by four mills all using the same color standard. Note that the good process capability at each mill is reflected in the color quality of the products in the store. The average color difference is 0.49 DE_{CMC}



An approved lab dip represents a single acceptable production lot—not a replacement standard (this is not 1960).

Adopt the right color difference tolerance and make sure it is reflected in production. And that would be 1.00 DE_{CMC}. Plot 5 shows the results of maintaining a single color standard and reasonable tolerance across all mills. A single source of truth drives consistent production.

Exceptions happen, though. If you see bad color in the store, measure it and compare it to the standard. Do not assume anything. The color problems that we see in the store are likely attributable to 1) bad processes like those described here, 2) out of tolerance production that should not have been shipped, or 3) offshade approval exceptions ("Best Can Do's") issued to lab dips or production.

THE ORIGINAL SIN

We have discussed the brand lab dip process—time set aside in the product development calendar to negotiate color acceptability with mills by sending swatches of color on trips around the world—as if it were a legitimate thing. It is not. It is a costly waste of time and resources that delivers little value. Generations after it became obsolete, we are still cursed with its remnants.

In the next installment, we will focus on a better process that applies the advantages of digitalization to assure that all production lots (not just stupid little lab dips) are onshade before the fabric is shipped to the garment factory.

Notes

1. Rather than adopting the typical "It's The End of The World" hype, I define "sustainability" as the outcome of operational excellence, since an optimized process conforms with specifications, conserves resources (such as energy—which costs money), reduces waste (in raw materials and production), avoids unnecessary steps and ingredients, maximizes throughput, and delivers just in time (reducing unmonetized inventory).
2. Naming credit goes to Bob Rich, colorist extraordinaire
3. Translation credit: Andrew Hoover

Keith Hoover, president of Black Swan Textiles, **(www.blackswantextiles.com),** implements manufacturing-centric digital processes for color and fabric development. He has implemented digital color management programs for Ralph Lauren, Target, Lands' End, JCPenney, and Under Armour, ultimately leading to a process that eliminated lab dips altogether. At Under Armour, Hoover championed the UA Lighthouse, driving digitalization and advanced manufacturing processes to explore local-for-local sourcing. He has worked hands-on in mills worldwide and is a frequent AATCC presenter.