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WHITE PAPER

How is color measured?

Calculating Delta E

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Metal Composite Material (MCM) warranties address the color fastness guarantee of the finish. The standard typically states that the color will not fade beyond a Delta E5 for the length of the warranty. But what does this mean?

What is Delta E and why does it matter?

Delta E is the measured change of color from one color sample to another. Color matters. We use color to send a message or create a feeling. For corporations, colors represent a brand, acting as a part of the company identity as important as the name or logo. And when it matters most, close enough doesn't cut it. Because visual perception can vary, color is defined in a 3D color space using a three-point axes. Delta E represents the difference between a given color and a different color. There are two important reasons to measure color difference. First is color matching to ensure paint accuracy before it is applied to an MCM panel. The second is to determine the degree of change over time, often seen as fading, in order to verify the paint performed as expected after panel installation.

Highlights

Delta E (or ΔE) is a calculation of the change in color as measured in the Hunter Lab color space on a three-dimensional axes L a b.

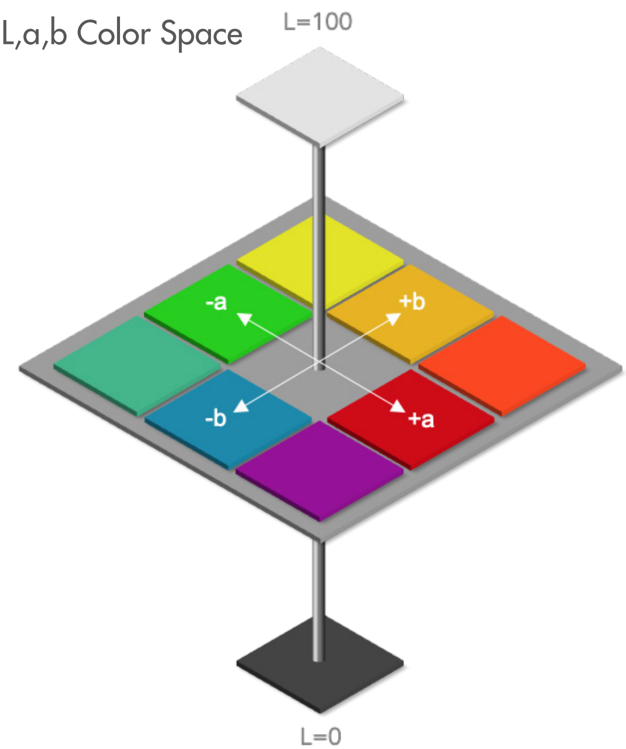
MCM finish warranties guarantee a color change of no more than Delta E5 over the length of the warranty, under defined terms and conditions.

Fluoropolymer paint systems, such as FEVE, provide exceptional color accuracy and resist color fade with warranties for 10, 20 or 30 years.

Let's look at how color is measured.

Color is measured in three dimensions, L, a, and b using the Hunter Lab color scale and measuring with a Spectrophotometer.

L,a,b Color Space



L is light to dark and is illustrated as a vertical measurement. The minimum for L is zero which is black whereas the maximum for L is 100, a perfect reflecting diffuser.

a is green to red and is illustrated in a horizontal axis, left to right measurement. It has no specific numerical limit. Positive is red and negative is green.

b is yellow to blue and is illustrated in a horizontal axis back to front measurement. Positive is blue and negative is yellow.

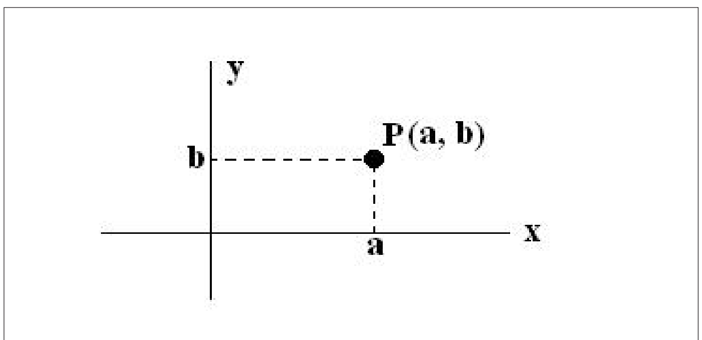
If you think about an ellipse containing all allowable color, any color has a sort of address, determined by the ratio of pairs of opposites. Simplistically, how much red or green it has, how much yellow or blue it has, or how light or dark it is. Colors whose addresses are closer together have a lower Delta E.

When measuring the a axis, it starts with all green at the left. As it moves to the right, one green element of the whole is replaced by one unit of red. Moving farther right, more red is added replacing more green. At the extreme right all red is shown. To illustrate this point, think of a container of drops of color. It begins where all of the drops are green. As it moves right one drop of green is removed and replaced with one drop of red. The farther right it moves more green is removed and replaced with red. The container always holds the same amount of drops but the ratio of the red to green changes.

On a graph we will locate where on this axis your particular a reading is. We can mark it with a line. Similarly, when measuring the b axis, it starts at the back with all yellow and as it moves toward the front one element of blue is substituted for a yellow element. Moving forward more blue is substituted until you reach the very front where only blue is shown.

Again, on a graph we will locate this axis of your particular b reading. When we combine the graphs we have an intersection of a and b.

Now think of a tablet of 100 pages where this intersection is

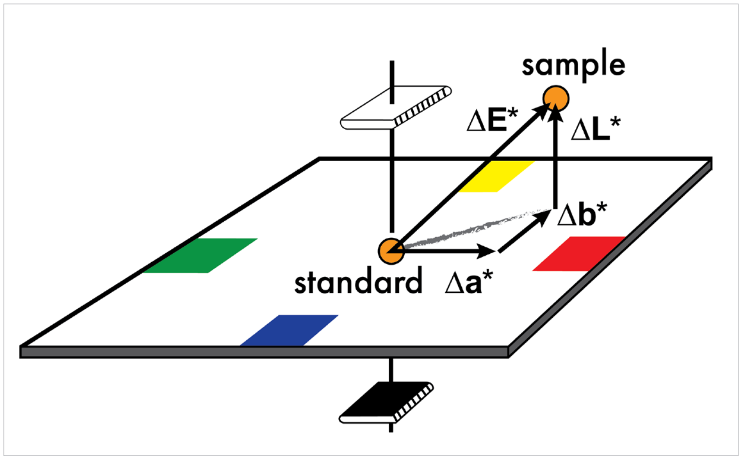


shown as a dot. At the top page it is the top of the L reading, the lightest version of the color. As you move through the pages the color becomes darker. Page 67 is darker that page 50, for example.

When your target color is determined, each of the readings are made, L, a and b, and we end up with your specific color. Consider this the address of the color, much like the address of a high rise at the intersection of a street and avenue and on a particular floor of the high-rise. This is ground ZERO. Now we move to the formulated color and compare its readings to that of the target. Each reading will check the distance on that axis from the target.

To calculate the Delta E variance from the produced color to the target, you square each reading's distance (to ensure a positive number). Then you add all of the squares of those readings and take the square root of that number and this gives you the Delta E variance.

$$\Delta E_H = [(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2]^{1/2}$$



Small differences can have a great impact on the Delta E.

A lower Delta E means there has been less color shift.

A higher Delta E means a more significant color shift.

A Delta E of 1 may be perceptible by some with close inspection.

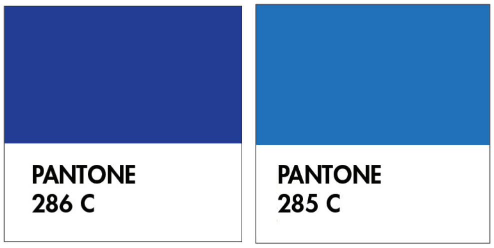
A Delta E of 5 may be noticible at a glance.

In our first example, if the a reading is off by only 1 (square of 1 is 1) and the b reading is off by only 2 (square of 2 is 4) and the L reading is off by only 3 (square of 3 is 9) then the end result is the square root of 1 + 4 + 9 or square root of 14 or 3.74. That means the Delta E would be 3.74.

To make this more visual let's look at a PANTONE (PMS) color chart. PMS is ink on paper rather than paint on metal, but many colors are selected from the Pantone book as the target.

Let's look at two targets and two close numbers next to them.

PMS 286 Target and PMS 285



L = 28.69
a = 4.26
b= -69.28

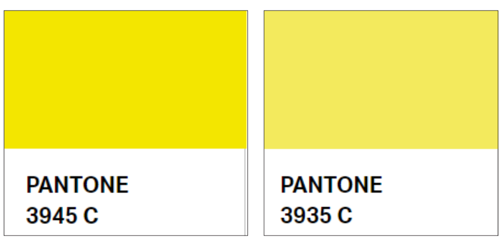
L = 47.87
a = -7.24
b = -50.76

The difference or distance between these addresses are: L = 19.18, a = 2.98, b = -18.52.

Adding the square of each and then taking the square root equals DE 26.83.

The Delta E difference between these two colors is 26.83, still outside of the Delta E 5 that is covered under the warranty Delta E5.

PMS 3945 Target and PMS 3935



L = 82.92
a = -6.05
b = 45.92

L = 84.29
a = -7.43
b = 45.01

Another example would be target PMS 3945 and PMS 3935.

The distance between these addresses are: L = 1.37, a = 1.38, b = 0.91.

Adding the square of each of the above and then taking the square root of that total equals 2.15.

The Delta E difference between these two colors is DE 2.15, which is within the limits of a DE5 warranty.

Invest in a paint system that lasts.

Understand that a small movement in the color reading can greatly impact where the color ends up. Fluoropolymers like FEVE and PVDF do the very best job of holding the original color for the longest time. For a more comprehensive look at the differences between paint systems read our blog comparing polyester and fluoropolymer paints.

Finding the perfect color for your project or corporate identity is important. Keeping that carefully selected color looking it best for decades is also important. You deserve color accuracy and longevity. Your paint system should limit the fading of the color, often caused by UV exposure, toxic atmosphere, proximity to salt water and more.

We use Delta E to make sure our paint matches are accurate and to set limits on how much a color can change over the life of a finish warranty.

The industry standard for producing paint colors within a batch is Delta E 1 for a solid color and Delta E 2.5 for a color with a flake, such as Mica or Metallic.

Typical MCM finish warranties guarantee color changes no greater than Delta E 5 for the duration of the warranted period.

Your choice in paint and the pigment of that paint will determine how long the warranty period will be.

About the Author

Jack Finn, the Eastern North American Specialty Sales Manager for ALPOLIC Materials, has been working in the building sales industry for more than 25 years. With extensive experience in corporate identity program management for the building envelope, he knows how important it is to get the right look and have it last.