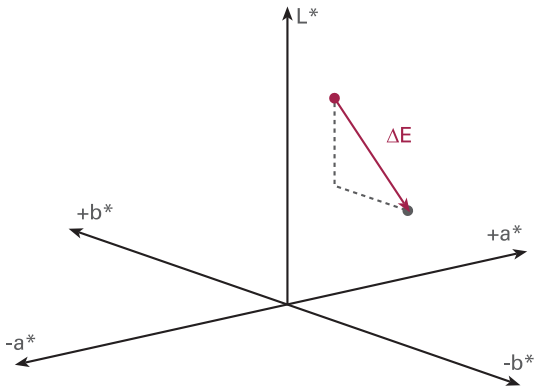
DELTA E, DELTA H, DELTA T: WHAT DOES IT MEAN?

Delta E (ΔE)

Delta E is defined as the difference between two colors in an L*a*b* color space. As the values determined are based on a mathematical formula, it is important that the type of color formula is taken into account when comparing the values. In Color Verifier alone, there are three different formulas to choose from, each producing different results.

The CIE L*a*b* formula used in the proofing market calculates the Euclidian distance, i.e. purely the distance between two points in a three-dimensional color space. The actual position of the points themselves is irrelevant.

Delta E



However, the human eye is more sensitive to some areas of color and less sensitive to others, a fact that the formula does not take into account.

To compensate for the inadequacies of the human eye, further color formulas have been developed. Colors in a highly saturated area are assigned less importance during the evaluation than colors along the gray axis, which is where the human eye is most sensitive.

To say that a delta E value of 1 is visible to the untrained eye is, therefore, true for the gray axis but does not apply for the highly saturated area.

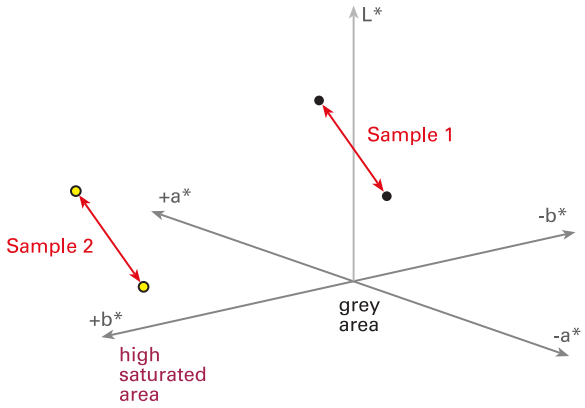
Nevertheless, the CIE L*a*b* color formula is still used by the proofing market. However, it is perfectly acceptable to use, for example, CMC or CIE 94 in the production market (Fiery) if you just want to check the stability of the output device.

The following delta E values are valid universally:

Delta E value	Meaning
0 - 1	A normally invisible difference
1 - 2	Very small difference, only obvious to a trained eye
2 - 3.5	Medium difference, also obvious to an untrained eye
3.5 - 5	An obvious difference
> 6	A very obvious difference

Color samples in different areas of the CIE L*a*b* color space that were evaluated using different color formulas have shown very different results.

Delta E sample comparison



Sample 1		Sample 2	
CIE L*a*b*	6.78	CIE L*a*b*	16.78
CMC	9.95	CMC	5.63

Colors along the gray axis were usually viewed more critically in CMC, while the highly saturated areas were judged more moderately. The formulas below have been specially adapted to the human eye:

Tolerance method	% Agreement with visual
CIE L*a*b*	75%
CMC	95%
CIE 94	95%

Delta H (ΔH)

The difference between two colors in the three-dimensional L*a*b* color space is known as delta E. However, this distance is only partly suitable for evaluating measured gray balance. The current ISO 12647-7 norm includes the hue difference delta H for primary colors and grayscales. To satisfy this proofing norm, a maximum tolerance of 1.5 is permitted in gray areas and 2.5 in the primary colors.

The formula necessary to calculate delta E (CIE L*a*b*) for contract proofs determines the Euclidean difference, i.e. the direct difference between two points in a three-dimensional space.

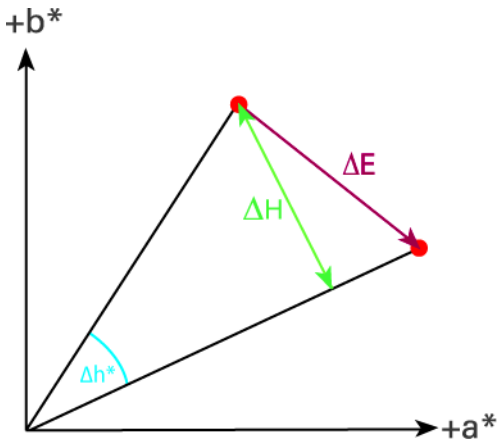
The human eye is more sensitive to some areas of color and less sensitive to others. Colors in highly saturated areas are assessed less strongly than colors along the gray axis, where the human eye is particularly sensitive. This fact is not sufficiently taken into account when calculating ΔE.

Experience has shown that color differences calculated according to the CIE L*a*b* formula are assessed much too strongly in more highly saturated colors and too weakly in gray areas.

For color samples in saturated areas, a delta E of 1 is not normally visible to an untrained eye. However, the color cast can be detected between two colors close to the gray axis.

The absolute color difference between two samples is known as the hue difference (delta h*). This measured value is used to calculate the fractional value of delta E, which evolves from the hue difference between two color samples alone. Differences in brightness are ignored during the calculation of delta H.

Delta E, delta H and delta h*



It is important not to confuse delta H with the value for the difference in hue angle delta h*. The hue error describes a Euclidean difference between two color samples; in contrast, Δh* is a value from the polar system.

The ΔE color difference of the following pairs of colors is approximately identical. The respective differences in hue only become evident as a result of the ΔH value.

	Reference L*	a*	b*	Measured L*	a*	b*	ΔE	ΔH
Sample 1	54.77	-36.86	-49.80	49.34	-29.29	-53.42	10.00	8.33
Sample 2	68.99	-0.16	-1.97	58.77	-0.26	0	10.40	0.98

Delta T (ΔT)

Delta T describes the colorimetrically calculated dot gain defined by ISO 12647-7. It is pre-defined for primary colors with a tolerance of +/- 5% tone value difference.

Delta T stands for the tone differences between the reference and the result. These tolerances can only be measured for the primary colors, e.g. 100% cyan. It is not possible to calculate delta T values for colors composed of a mixture of cyan, magenta, yellow and black.

You can see a visual description of delta T if you create a protocol of the measurements with Color Verifier. On the last page there are four diagrams (gradation curves) with a blue (reference) and a red (measurement) curve describing the input and output values (tone) of Cyan, Magenta, Yellow and Black.

For example: If you have a reference output of 40% cyan and a measurement of nearly 50%, your delta T result for this patch is around 10%. This corresponds to a dot gain of around 10% and you will be able to recognize corresponding variations in the gradation curves.

Protocol in Color Verifier