Applications Note

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# What Are Tolerances and How Are They Established?

Tolerances are limits within which a product is considered acceptable. Any product falling outside the tolerances is unacceptable. Product tolerances can be established visually, or instrumentally using any of the color scales and indices available for the instrument. In order to set tolerances, an ideal or close-to-ideal product standard is required, as well as a variety of products that have already been determined to be acceptable or unacceptable. But first, a basic understanding of difference detection is needed.

## Difference Detection Basics

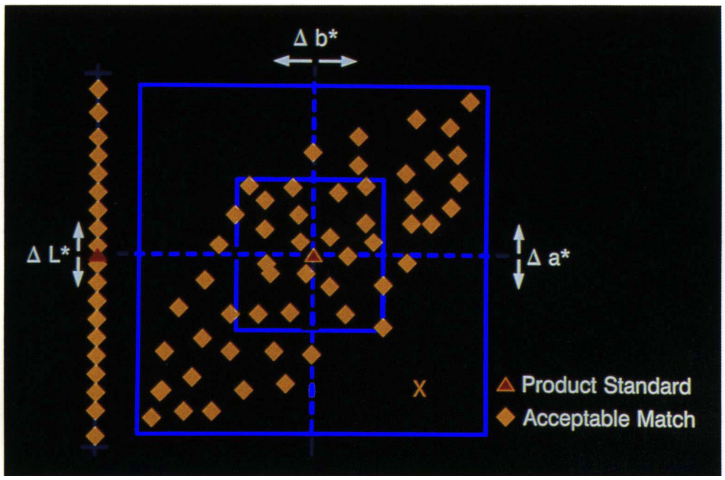
There are two levels of visual color differences that are used to establish color tolerances:

- **Minimum perceptible difference**, which visually defines a just-noticeable difference between standard and sample.
- **Maximum acceptable difference**, which is the largest acceptable difference between standard and sample. Manufacturers are generally concerned about this level of color difference rather than a minimum perceptible difference, and color tolerances are usually based on the maximum acceptable difference. A tolerance based on the maximum acceptable difference is usually larger than one based on a minimum perceptible difference. Any larger difference would cause the sample to be rejected.

When establishing tolerances, it is helpful to remember the following general rules:

- Humans find hue differences the most objectionable.
- Humans will tolerate a little more difference in chroma than in hue.
- Humans will tolerate lightness differences more easily than differences in chroma or hue.

Thus, a graph of visually acceptable tolerances is not square, but football-shaped, as shown below.




## Establishing Tolerances

Sometimes 0.2 CIE L*a*b* units is quoted as an "approximate visual difference limit." In general, however, tolerances should be based on visual assessment using measurements of acceptable and unacceptable samples and an "ideal" product standard. Tolerances should be established for each product color. It is normal to have different tolerances for different colors. It is also typical to find that your tolerances need to be tighter for darker colors and lower-chroma colors.

It is not wise to use ΔE or ΔE* alone as a tolerance. This is because, although the product may be perfectly acceptable when the color difference is spread out over all three dimensions (L, a, and b), if the difference is concentrated on one of the dimensions, it may be obviously unacceptable. For example, if a given tolerance is 1 ΔE (Hunter L, a, b) unit, the difference could be 0.57 for L, 0.57 for a, and 0.57 for b, and would probably be acceptable visually.

$$\Delta E = \sqrt{0.57^2 + 0.57^2 + 0.57^2} = 1$$

However, if the sample is perfect for L and b but off (yet within tolerance) for a, the sample looks very unacceptable.

$$\Delta E = \sqrt{0.0^2 + 1.0^2 + 0.0^2} = 1$$

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