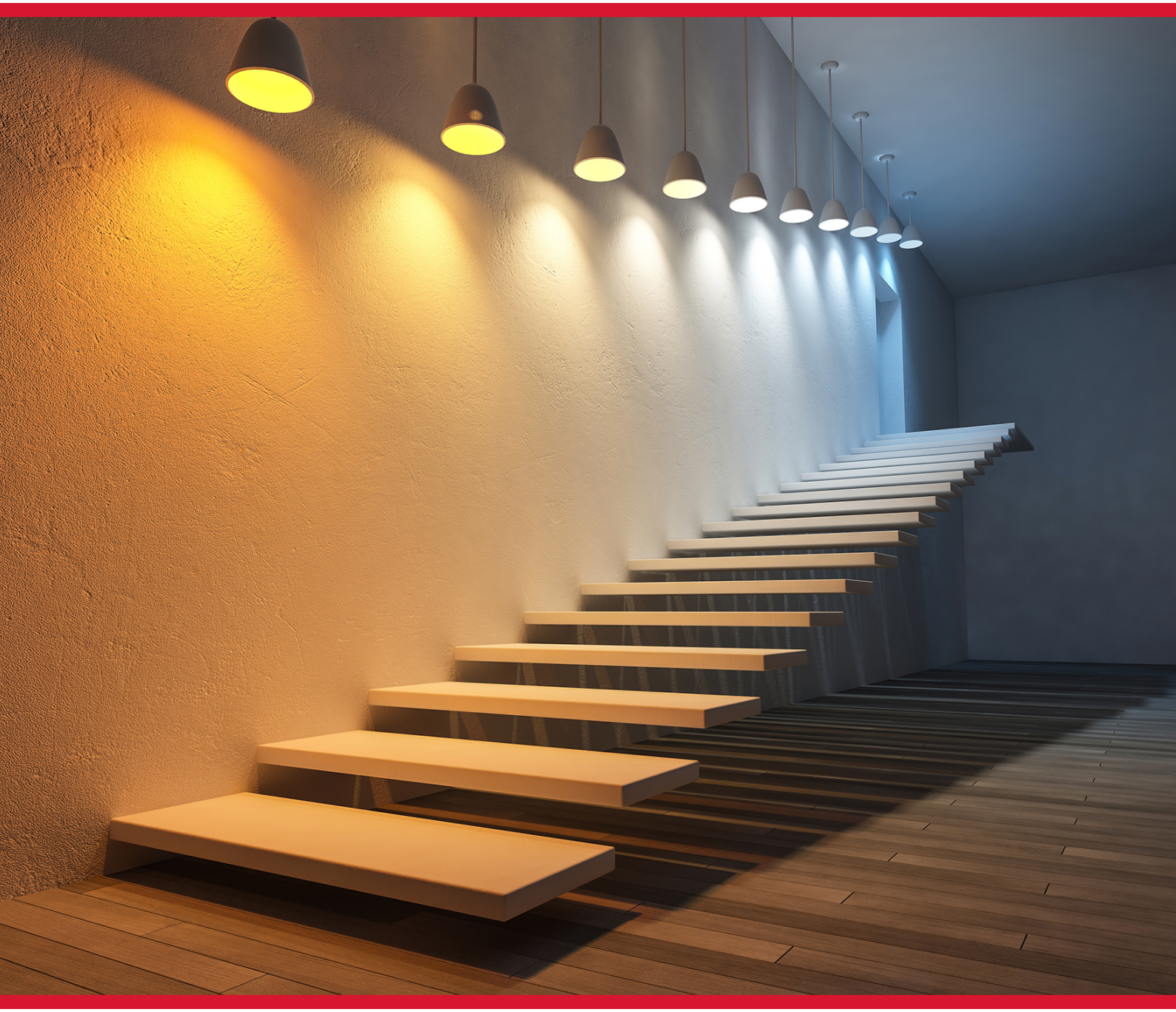
datacolor



METAMERISM

Metamerism is a basic and most important aspect of color technology. Its effects are of concern and importance in many color formulation and production applications. Although light sources and objects that transmit light may exhibit metamerism, this document is concerned with objects reflecting light. Metamerism should be considered within the context of the CIE colorimetric system. This system is based on the premise that the stimulus for color is provided by the proper combination of a source of light, an object, and an observer. The sensation of an object's color is produced by the combination of:

- A light source - illuminating an object.
- An object - reflecting light to an observer.
- An observer - sensing the reflected light.

The combination (light/object/observer) can be expressed as the CIE Tristimulus Values, coordinates of color sensation, computed using the following:

- Light source - CIE standard illuminant data (D65, A, F2, etc.)
- Object - a spectrophotometric measurement.
- Observer - CIE standard observer data (1931 2°, 1964 10°).

Metamerism - Terminology and Definitions

Metamerism always involves a pair of objects. The two objects can be described as "metameric objects", or a "metameric pair". They are sometimes said to be "metameric", "exhibit metamerism", and/or be "metameric matches".

Metameric Objects exhibit the following:

- They have different spectral reflectance factors (spectral curves).
- They match under at least one combination of illuminant and observer.
- They do not match under at least one combination of illuminant and observer.

Metameric Pair - An Example

Reflectance data for a metameric pair of objects can be plotted as spectral curves. These objects are called Metamer Standard and Metamer Batch. Such curve pairs typically cross each other at least 3 times.

Illuminant or Observer Metamerism?

There are two types of metamerism; illuminant and observer. Either one can result in unacceptable colored products.

- Illuminant Metamerism - where metamerism results from changes in illuminants, and where the observer does not change.
- Observer Metamerism - where metamerism results from changes in observers, and where the illuminant does not change.

Illuminant metamerism occurs when a pair of objects match under one light source, but do not match under one or more other light sources. This can result in products that match under production light conditions, but do not match under light sources where they may be sold and/or utilized.

Observer metamerism occurs when a pair of objects match for one observer, but do not match for another. This situation can occur when production matching is done under one of the CIE observers (2° or 10°), and subsequent evaluation done under the other. It also can occur in visual product assessment situations where the color sensitivity functions of those evaluating the match differ from one another.

Reducing the Effects of Metamerism

Metamerism is a potentially important consideration in any color control application involving the color matching of two objects. Its effect can be minimized (or eliminated) in most color production applications by:

1. Utilizing exactly the same colorants in the formulation of the production object that have been used to produce the standard (target).
2. Selecting a production formulation that minimizes metamerism, whenever it is not possible to use the same colorants as were used to make the standard.
3. Substituting "working standards" (made from the production formulation) for the original metameric standard, whenever possible in the control and acceptance processes.
4. Correcting production colors without adding any "new" (different) colorants to the product.

How to Test for Metamerism?

There are two basic tests available that are useful for evaluating whether or not two objects (that match) are metameric.

Visual Test for Metamerism

1. Confirm that the objects match, by viewing (in a light booth) under the reference (primary) light source.
2. Change the light source to a test source that is significantly different from the reference source.
3. If the objects still match, then it is likely that they will match under any source, and are thus probably not metameric. If the objects do not match under the test source, then they are a metameric pair. Repeating this test under a third (different) source (whenever there is a match under the reference and test sources) should be done whenever possible, as there are cases in which the second light does not reveal the mismatch.

Instrumental Test for Metamerism

1. Using a spectrophotometer, measure the objects, and confirm that the objects match under a specific illuminant/observer combination (ΔE=0).
2. Compare their reflectance spectral curves. If the curves differ, and cross each other at least three times, then the objects are metameric.
3. Confirm the metamerism and compute its amount, by calculating color differences (ΔE>0) under different illuminant/observer combinations.

Degree of Illuminant Metamerism - Indices

Even if object metamerism is unavoidable, it may be possible to develop a good commercial match by selecting a production formula resulting in an acceptably low level of illuminant metamerism. The amount of metamerism expected from a candidate formulation can be evaluated using any of the following methods:

- CIE Special Metamerism Index: Change in Illuminant - the color difference (ΔE) between a pair of objects, under a test illuminant, assuming that the objects match (ΔE=0) under the reference (primary) illuminant.
- DIN 6172 Metamerism Index - the color difference (ΔE) between a pair of objects, under a test illuminant, adjusted for an exact match under the reference (primary) illuminant when the objects do not exactly match (ΔE>0) under that illuminant.
- Nimeroff Index of Metamerism - the square root of the sum of the squares of the differences between the spectral curves of a pair of objects that match under the reference (primary) illuminant. This method computes a measure of difference between the object curves over the visible wave length range, without weighting the data.

- Weighted Nimeroff Index - similar to the Nimeroff Index, except that the differences are weighted by CIE color matching functions.
- Root Mean Square - the square root of the sum of the squares of the color differences (ΔE) between a pair of objects, computed under different illuminant/observer combinations. This method is often useful when evaluating candidate color formulations. It yields an indication of how closely the objects will match under (usually 2 or 3) equally weighted different combinations. This method does not require that the objects be truly metameric, as they may not exactly match under any illuminant/observer combination.