G. James is glass

TECHNICAL BRIEF

Understanding Colour

Colour is an extremely difficult parameter to quantify and understand. This brief will attempt to give an overview as to the methodology behind colour analysis and why it is necessary to accurately define colour.

Colour as we all know is what you see when you look at or through an object. The colour we see is the result of physical modifications to the light that has passed through or has been reflected off an object.

Due to the inherent differences between peoples eyes and the way each persons brain interprets the signals sent to it (from the eyes) we all perceive colour differently. Even very similarly colored objects may appear noticeably different to many people. Try placing two closely coloured objects in a group of people and ask them to describe what are the differences between the colour of the two objects. It will be quickly become obvious as to why colour is so difficult to define. Then bring the same group back at a different time of day (different lighting condition) and you may receive an entirely different set of answers. This apparent discrepancy in colour definition was a challenge for science to define.

To describe the colour of an object 3 things are required:

- a light source
- an object
- an observer

If the colour is measured in an accepted method, using both a standard light source and a standard observer. The object itself, being analysed, will then become the only variable in any analysis. This is important but very difficult to achieve in practice due to natural variation between lighting systems and the population's sight.

Over the years numerous evaluations of the population's perception of colour under many differences in lighting conditions have been performed. The International Commission on Illumination (CIE) was engaged to provide a universally accepted consensus from these analyses. The CIE developed and released a list of defined standard observers and illuminants, while also implementing a standardised methodology by which a colour analysis should be performed. Such a consistent approach to procedures and standards by the CIE allowed colour to measured and defined universally for the first time.

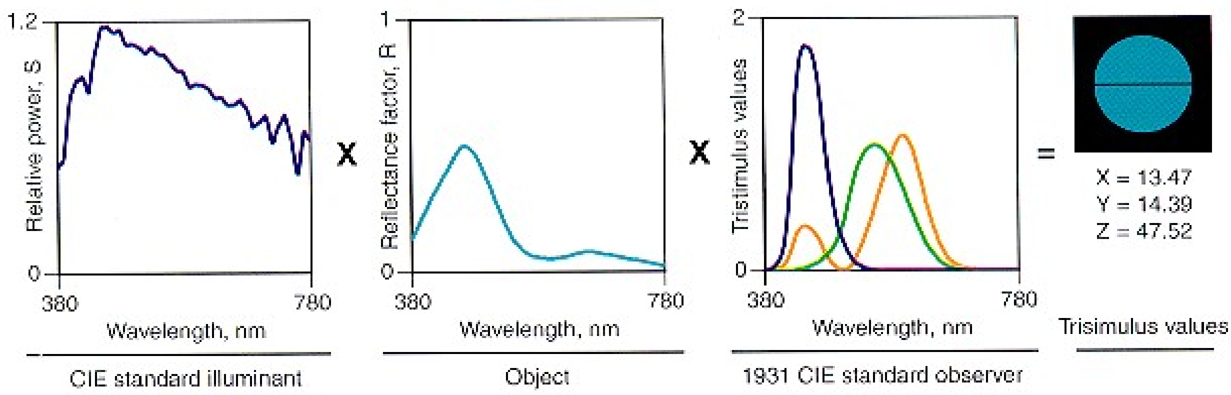
MORE DETAIL REGARDING THE ANALYSIS AND CALCULATION

In order to gain a further understanding of how the colour of an object is defined we shall step through the basics of the measurement and derivation procedure used to define the colour of an object.

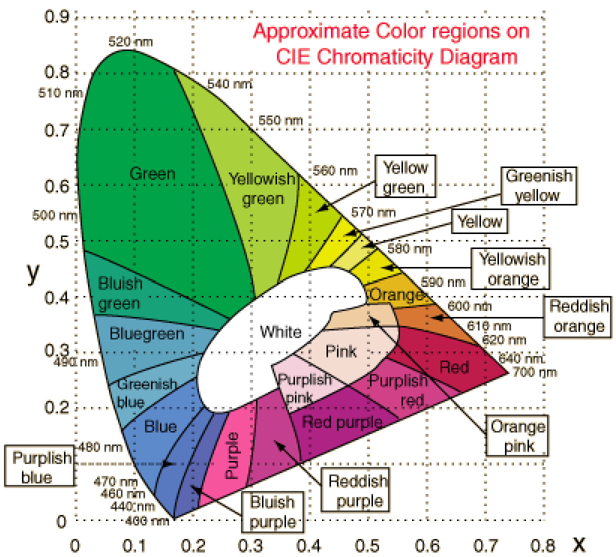
As described earlier, to define the colour of an object 3 things are required: an observer, an object and a light source (illuminant). The CIE developed a range of standard observers and standard illuminants. The standard observers are a statistical average of the response of the populations' eye to red, green and blue light. The standard illuminants are the spectral power distribution emitted from specific light sources at held at designated temperatures.

The amount and distribution of light either passing through or being reflected off an object, known as its spectral distribution. The spectral distribution of an object is measured with a device known as a spectrophotometer. A spectrophotometer is detection system, which is able to determine how much light of a specific wavelength, is either passing through or being reflected by an object. By measuring this response over wavelengths that together make up visible light (380- 780 nanometers). The spectrophotometer can determine precisely how the object has physically modified the light either passing through of reflected off its surface. The modification of the incoming light is generally referred to as the transmitted or reflected spectral response (or spectrum) of the object.

The colour of the object as defined by the CIE is result of the standard illuminant multiplied by the spectrum of object multiplied by the standard observer. This calculation is represented graphically below



The results of the calculation are 3 separate values known as the tristimulus values. The tristimulus values form a 3 dimensional colour space consisting of a red, a blue and a green axis. These values can be mathematically transformed into a 2 dimensional plot known as a Chromaticity Diagram (shown below).



However, the disadvantage of the tristimulus values and chromaticity diagram is that it is difficult to accurately compare differences in colour due to the non-linearity of the results it generates. This non-linearity is the result of the human eye being more sensitive to observing green than it is to detecting blue and red colours.

This limitation was overcome by the development of more uniform colour systems, all of which are based on mathematical transformations of the tristimulus results. While there have been many different colour systems developed over the years, the most common system for determining differences between relatively similarly coloured objects is the CIELAB Colour System.

The CIELAB System is a mathematical transformation of the tristimulus values with the advantage being that it uses an opposed axis of similar magnitudes to define colour. This means that the colour difference between two objects can be easily and accurately evaluated. Essentially this system transforms the tristimulus colour space into a two dimensional graph where the colour of the object is independent of the transmitted or reflected percentage of the light passing through or striking an object.

The CIELAB System and its precursor the 'Hunter Lab' Colour System are the two most common colour systems utilized in the glass industry.

Two representations of the CIELAB Colour System: