# *Whiteness Index and the Assessment of the NAILM Testpiece*

## "The Color 'White'"

The color 'white' is associated with purity, freshness, and cleanliness. 'White' is important to the institutional textile industry for the aesthetic value and for utilitarian purposes. In most institutions, white is the preferred color for sheets, towels and many other products. White linens are psychologically associated with purity for the hospital and freshness for the hospitality industry. 'White' is also an indication of cleanliness. In the institutional environment, a consistent and high degree of 'white' is an indication of a quality facility. Maintaining the level of white is the responsibility of the laundry manager.

The Testpiece Service is a 'tool' used for quality control, which enables the subscriber to monitor their ability to maintain white linens. The 'Whiteness Index' is a scale by which the testpiece is evaluated to determine how well it meets the preferred white. A system that can measure the Whiteness Index and provide the subscriber a result that is an indication of the level of 'white' represented by the products in their institution is the goal of the Textile Testing Lab when providing the NAILM Testpiece Service.

The purpose of this article is to discuss 'white' as a color of products in the institutional linen industry and to increase your understanding of the results of the Testpiece Service.

### The NAILM Testpiece

The testpiece is a 100% cotton percale sheeting fabric that has been subjected to a routine finishing process of scouring, bleaching and calendering. If you are a subscriber to the Testpiece Service, you may have observed the off-white color of the original testpiece. The color is due to the fact that cotton in its natural state is off-white or yellowish.

### What is the preferred 'White'?

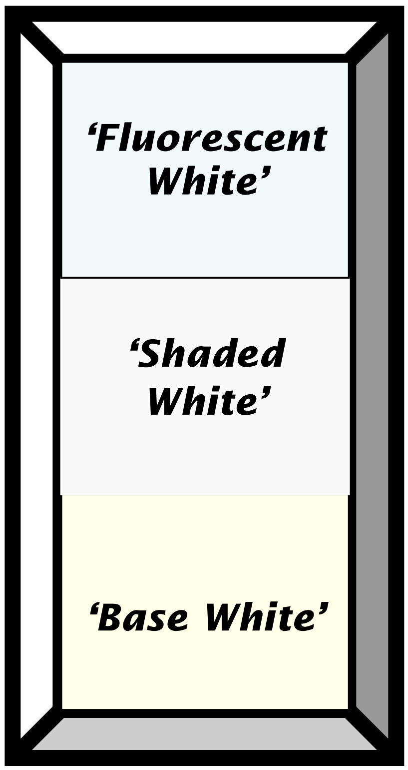
In physical terms, a white object is one that reflects all the light impinging on it without any loss of intensity, for example, clouds in the sky or fresh fallen snow on a bright sunny day. The 'best white' or 'ideal white' is considered to be a matter of personal taste and varies with cultural background. In the literature, it has been reported that the Far East prefers a reddish white, Europeans prefer a neutral white, while Americans prefer a bluish white.

In general, 100% cotton or cotton blends will be perceived as whiter by making them less yellow. And to make them less yellow we automatically make the color of the product appear bluer. Visually blue and yellow are opposites and an increase in blue results in a decrease in yellow. This is the basic theory behind the processes of achieving a whiter linen product.

Visually we associate yellowness with soiling or the lack of cleanliness and an attribute that should be removed during the laundering process. The traditional method for removing the yellow discoloration is through bleaching. Chemical bleaching (oxygen and/or chlorine compounds) removes some degree of yellowing by chemically destroying the colorant that caused the discoloration.

Bleach alone may not achieve the level of whiteness that industry and consumers expect from a white linen product. Even with extensive bleaching most cotton textiles are, at best, an off-white color with a light yellow tint. Historically, to correct for the yellowness that bleaching has not removed, bluing was added to the washing chemicals. Bluing is a blue dye that masks the natural yellowing of cottons and increases the visual whiteness because the product appears bluer. Bluing may still be used, but today most institutions add fluorescent whitening agents or optical brighteners to white textiles.

The perception of whiteness of a testpiece or any other ‘white’ product consists of three components of the color ‘white’.




**Fluorescent white:** is the addition of optical brighteners on white, resulting in an increase in blue reflectance.

**Shaded white:** is the amount of whiteness increase due to the compensation of yellowness by the addition of a product such as bluing.

**Base white:** is the contribution to the whiteness by the fabric itself. It is a pure reflectance of a cotton fabric that absorbs some of the blue light and thus produces a yellow tint. The whiteness of the base fabric is a very important component of whiteness because it determines the extent by which the yellowness can be compensated by physical means, i.e. bleaching and/or optical brighteners.

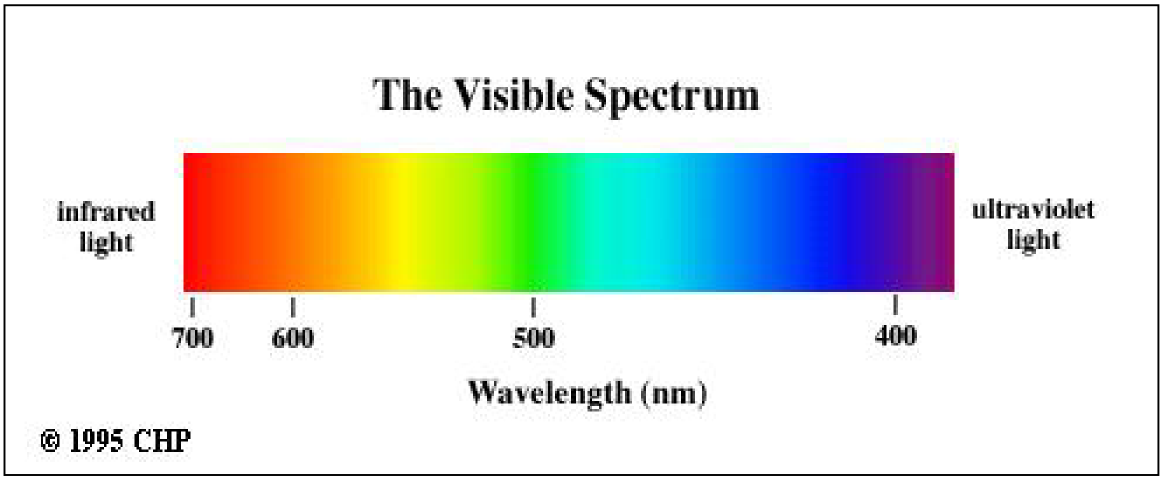
The human eye cannot distinguish between the three components. When light reflects from a white object, what the eye sees is the whiteness of the object as a whole. Depending on the light source, the visual assessment will recognize the product as bright white, white or off-white.

The light source significantly affects the perception of white. The sun is considered the fundamental source of light and lamps or light bulbs are artificial light sources. Daylight is the standard light source used to visually examine all white linens. Changing the light source may affect the apparent whiteness. For example, incandescent lamps produce a warm, yellow glow and fluorescent lamps produce a greenish-white.

If you have questioned the results of your Whiteness Index from a testpiece report as not being representative of products in your institution is may be due to a difference in light source. Another reason for the discrepancy may be the use of fluorescent whitening agents or optical brighteners.

**What are Fluorescent Whitening Agents?**

Fluorescent Whitening Agents (FWAs) are additives to laundry processing chemicals that are specifically designed to increase the perceived whiteness of linens. The fibers, yarns and fabric absorb FWAs thus gaining fluorescence and a whiter appearance. FWAs are not stable compounds and are affected by heat, pH and light. The main reason for adding FWAs to detergents is to restore the original optical brightness of linens that may have been lost due to abrasion, light exposure, bleaching or just wash-out.




FWAs make a fabric appear 'whiter' by absorbing light in the near-ultra-violet portion of the spectrum (typically 340-360nm) and re-emitting that energy in the blue region of the spectrum, from 420 to 460 nm. Fluorescence is blue light that is added to a (normally yellow) substrate thus increasing the perceived whiteness by making the object appear brighter and less 'yellow'.

Fluorescent whitening agents are extremely effective in compensating for the yellowness occurring in cottons. They are water-soluble compounds that have an affinity for cotton materials. In simplistic terms FWAs are similar to dyes applied in the textile industry and they are applied using the same techniques during processing.

If you have observed that linens in your facility appear whiter than the testpiece, this may be due to the use of optical brighteners. When you receive the NAILM Testpiece it does not contain optical brighteners. But when the testpiece is subjected to 5 or 20 washings where optical brighteners are added, the whiteness of the testpiece that you see in your institution is influenced by the effect of the optical brighteners. The FWAs function the same for the testpiece as they do for other linens, by absorbing the near UV light and emitting it in the blue region adding extra brightness and perceived whiteness to the FWA treated testpiece.

## Instrumental Measurement of White

The color 'white' is defined in colorimetric terms as a color with the highest luminosity, no hue and no saturation. Instruments measure the color of 'white' as a property of reflecting light at all wavelengths, that is, the reflectance of the whole visible spectrum of 100%. This defines the 'ideal white'; a condition rarely found in nature.

'Whiteness' is the attribute of color perception by which an object is compared to approach the preferred white. The 'Whiteness Index' is a number, computed by an instrument that indicates the level of whiteness. In the testpiece report, the higher the Whiteness Index value, the greater the whiteness of the measured testpiece. If the preferred white fabric has a high reflectance, then the ideal Whiteness Index for textile materials should approach 100. This is the characteristic used when establishing the criteria for evaluating the results of the Whiteness Index of NAILM's Testpiece Service.

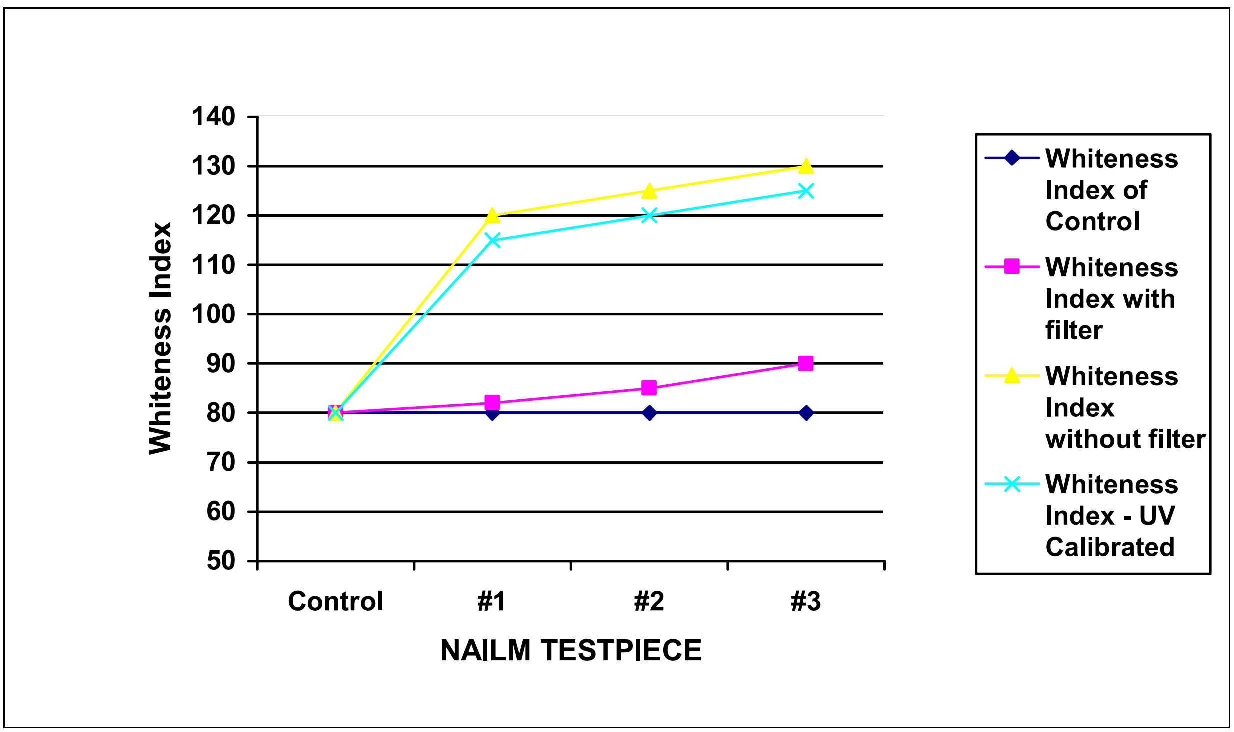
In June, 2002, the Textile Testing Lab at the University of Kentucky purchased a new instrument for measuring whiteness, a Hunterlab LabScan XE. The light source of the new instrument is a Xenon Flash, which is a light source that contains a high amount of UV energy. Therefore, the instrument is equipped with a UV absorbing filter. As the filter is moved in and out of the path of the light source, the amount of UV energy illuminating the sample is controlled. Utilizing a filter to eliminate the UV portion of the instrument's light source, does not account for the improvement of 'white' due to the use of optical brighteners.

For both the new and old instruments the lab has always filtered out the effect of optical brighteners and reported the Whiteness Index of the testpiece fabric. That is, the Whiteness Index of a control testpiece is a measure of the base white of the original fabric. When the washed testpiece is returned for evaluation, the degree of whiteness or Whiteness Index is also a measure of the base white. During the 5 or 20 washings of the testpiece, detergents and bleach can reduce the yellow discoloration of the testpiece and the value of the Whiteness Index should increase.

Over the past year, subscribers to the NAILM Testpiece Service have expressed concern that the reported results of the Whiteness Index is lower and does not correlate with what they see in their facility. By conducting a thorough review of reports and instrumental comparisons, we have reached the conclusion that the new instrument has a more efficient filter. This enables the system to eliminate all of the effect of optical brighteners. Therefore, the Whiteness Index reported as the results of the test piece excludes the effect of FWAs and reports the true whiteness of the base fabric.

To illustrate, the Whiteness Index of three testpieces were measured on the Hunter LabScan XE. The measurements are recorded with and without the filter. The results are illustrated in the following figure.

**Figure: Whiteness Index of NAILM Testpiece**




The Whiteness Index of a control testpiece (an unwashed sample, retained by the Textile Lab) was 80. The Whiteness Index of three testpieces was measured with the filter inserted, illustrating the method currently used for the NAILM Testpiece.

The use of FWAs can make the sample measurements difficult. If the Whiteness Index of flourescent samples is measured without a filter, the resulting Whiteness Index value will consist of both reflected and fluorescing light. The resulting value would provide an indication of the effect of FWAs, but is also influenced by the amount of UV in the light source of the instrument itself. The resulting Whiteness Index may exceed 100 as illustrated by Whiteness Index values of 120-130.
The resulting Whiteness Index is not a true measure because the human eye cannot detect the UV value of this measurement.

Ignoring the effect FWAs have on the visual evaluation of the Whiteness Index increases the possibility that the instrumental evaluation of the testpiece will not agree with the visual determination that the subscriber sees. An alternative to including all of the fluorescence is to calibrate the instrument to include a portion of the fluorescence. The Hunter LabScan instrument is equipped with a standard fluorescent tile that can be used for performing a UV calibration procedure. The position of the UV filter is adjusted while measuring the standard tile until a known whiteness value is achieved, resulting in the 'UV' calibration of the instrument. If a sample containing FWAs is then measured, the resulting amount of fluorescence effect of the FWAs should be included in the Whiteness Index. The Whiteness Index reported in the graph as UV Calibrated illustrates the effect of measuring a testpiece with the calibrated procedure.

The Textile Testing Lab is in the process of changing the method used to measure Whiteness, which will include the apparent effect of optical brighteners. This change will enable the resulting Whiteness Index to more closely replicate the visual assessment of your test piece. However, the change depends on the development of a standard procedure for measuring the Whiteness Index of material containing FWA's. This will enable labs to measure the whiteness of textile materials that have been optically enhanced at a level that is closer to what the eye can visually detect.

We will continue to work with both the textile industry and the instrument manufacturers to produce a standard procedure for measuring the Whiteness Index and include the effect of optical brighteners.