QUALITY TESTING & COMPARISONS

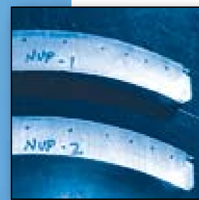
HARD RESIN POLARIZED LENSES

by Younger Optics

NuPolar®
polarized lenses

GENERAL INTRODUCTION

As polarized lenses gain in popularity and are being offered by an increasing number of lens manufacturers, it is easy to begin to think that all of these lenses are manufactured the same, and are of equal quality and similar performance. This is certainly not true, and this report attempts to show how NuPolar® hard resin polarized products consistently out-perform other products in the marketplace.

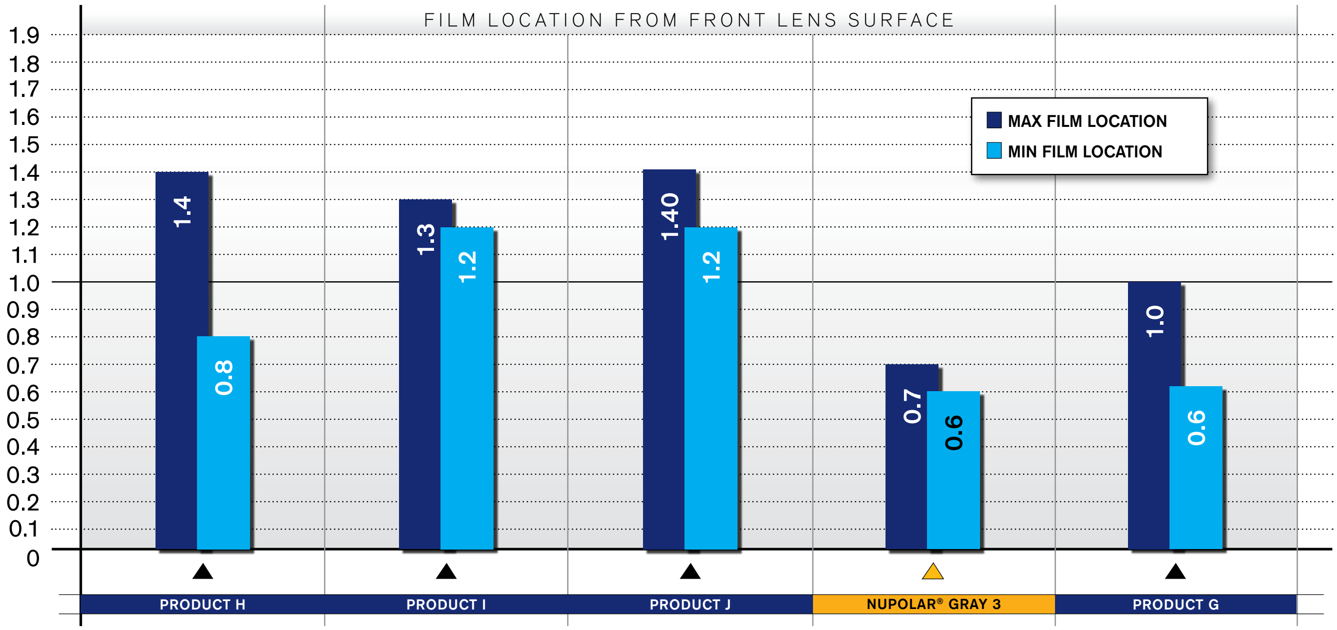


Many of the tests described here have never been published before, and much can be learned about what makes a good versus a poor polarized lens. It is our hope that not only the test results, but also the description of the tests and the conclusions written help you, the users of polarized lenses, to make more informed and better decisions when you decide which polarized lenses you choose.

POLARIZING FILM LOCATION

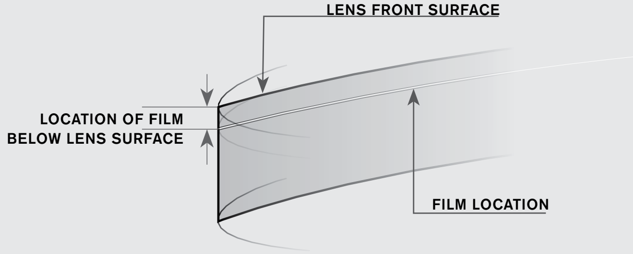
COMMENTARY

Precisely locating the polarizing film from the front surface of the lens is one of the most difficult tasks in lens casting. The goal is to position the film within a narrow tolerance; ideally between .4mm and .8mm. Notice that NuPolar's average minimum film distance of 0.6 mm is significantly better than the other tested lenses which range from 0.6 mm for Product G all the way to 1.2 mm for Product J.



TEST DESCRIPTION

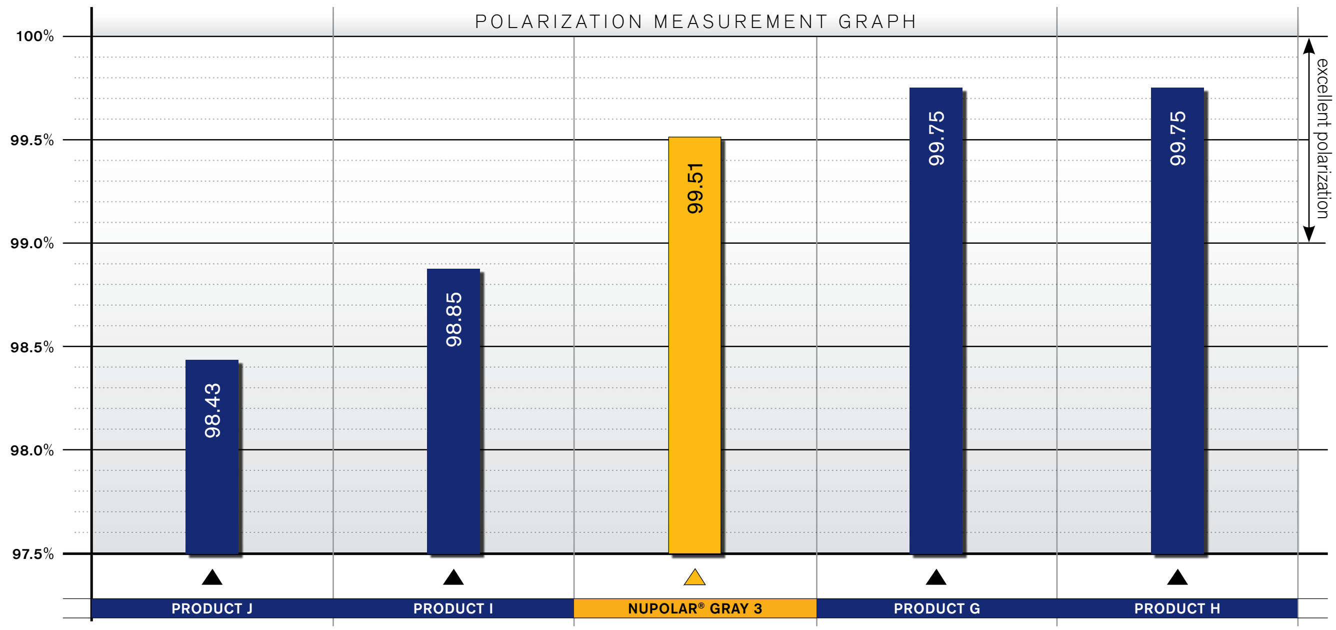
It is important for lens processing that the polarizing film is reproducibly positioned near the front surface of the lens. To confirm this, cross-sections are sliced from lenses, and the distance of the polarizer from the front surface is measured at multiple locations across the width of the lens by using a calibrated scale and optical magnification.



POLARIZATION COEFFICIENT

COMMENTARY

Most darker colored polarized lenses provide excellent polarization, with a coefficient above 99%, as this graph shows. Polarization Efficiency is particularly a problem when polarized lenses are produced in much lighter colors such as light blue, green or yellow. These lenses often have polarized efficiency so low that they cannot really be considered polarized lenses. Looking at a glare demonstrator through less efficient polarized lenses you can see that virtually none of the glare is cut out.



TEST DESCRIPTION

For polarized lenses, one wants to know how efficient the polarizer is, or conversely, how much polarized light is blocked. Therefore, the transmittance of a polarizer (how much light gets through the polarizer) is measured using a spectrophotometer.

For more accurate assessment of the polarizing properties of the lens, transmittance (T) is recorded at discrete wavelengths (designated T_λ) across the entire visible spectrum (400–700 nm). In fact, two sets of measurements are made, with two different lighting conditions: all the light hitting the lens in the same plane as the polarizer's absorption axis ($T_\perp$, light blocked), and all the light hitting the lens in the other plane ($T_\parallel$, light aligned to pass through polarizer). These measurements are then used in the following equation to calculate the polarization quality. This value is the Polarization Coefficient. On a scale of 0-100%, 99+ % is a very good polarized lens.

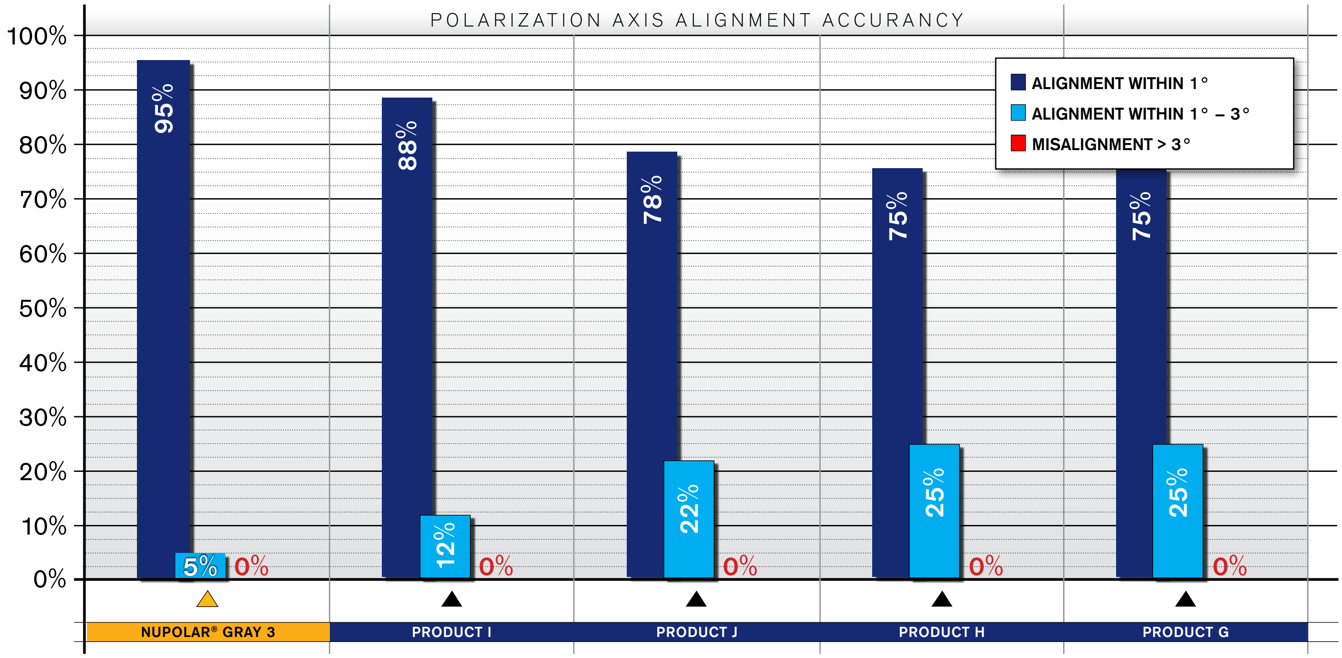
$$\text{Polarization Coefficient (0-100\%)} = \frac{\sum_{\lambda=1}^{n}\left[100\times\sqrt{\frac{T_{\lambda,\parallel}-T_{\lambda,\perp}}{T_{\lambda,\parallel}+T_{\lambda,\perp}}}\right]}{n}$$

POLARIZING AXIS ALIGNMENT

COMMENTARY

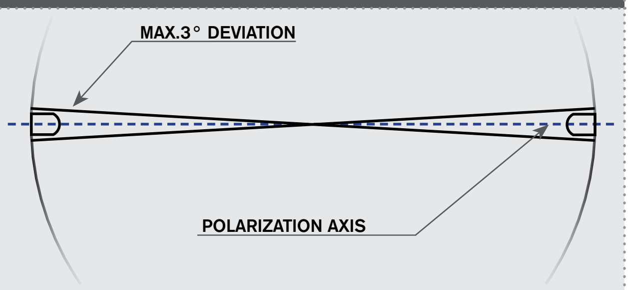
Industry standards allow a 3° degree tolerance for axis alignment. Beyond that the wearer may experience visual discomfort. This chart shows that all products tested fall within the industry tolerance. However, if we look closer we can see that NuPolar® typically does a much better job of alignment than any of its competitors. Fully 95% of all NuPolar® tested product falls within 1° degree of perfect alignment. Some of the competitive tested product have only 75% of their lenses within the 1° range.

While it should once again be stated that ALL competitive product fell within industry standard, this is just another example where NuPolar® does a better job of one aspect of polarized lens manufacturing.



TEST DESCRIPTION

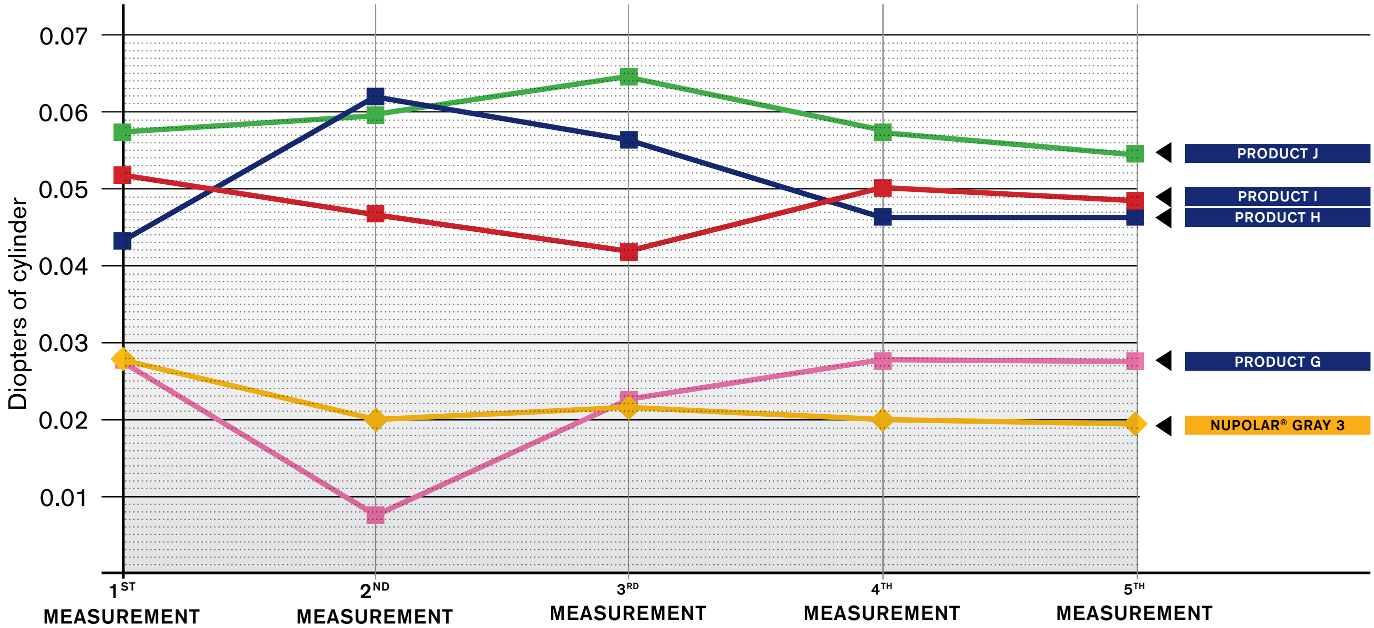
For most effective blocking of glare, the polarizing absorption axis should be aligned as closely to horizontal as possible. Lenses are typically marked with this alignment axis to assist proper positioning in the frame. Misalignment of the axis by more than 3° may be noticeable to the wearer, and ISO 8980-3 requires that the marks and the axis differ by no more than +/- 3°.



UNWANTED CYLINDER

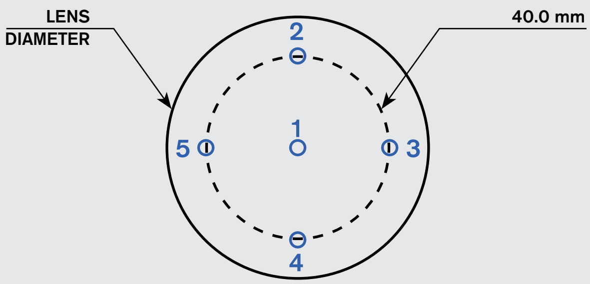
COMMENTARY

During the casting process of any hard resin lens, enormous thermal-chemical forces are at work. For example, during the casting process, hard resin materials shrink about 11%. This creates tremendous stresses and strains on every plastic lens produced. With a hard resin polarized plastic lens these forces become even more significant. Not only do you have a thin film stuck within this thermal-chemical reaction, you also have a much thinner layer of hard resin in front of the film than behind it. In addition, the film itself is created by "stretching" a polyvinyl alcohol sheet to line up the iodine crystal and make the film polarized. This stretching process creates additional stresses and strains which all interact in the complex casting process. How well this entire polarized casting process is controlled and monitored often shows up on the front surface as cylinder. NuPolar's cylinder is consistently low at every test point, and never exceeds more that 0.03 Diopter. While Product G also does a fairly good job of controlling cylinder, Products H, I, and J do not. Product J, with nearly 0.07 Diopters of cylinder, would not be acceptable in Younger's testing.



TEST DESCRIPTION

If the front lens surface is warped from its designed spherical or aspheric surface, optical measurements of the uncut lens blank will show unwanted cylinder. This excess cylinder can compound optical errors in the finished lens, and therefore should be kept to a minimum. Lenses were checked for unwanted surface cylinder by measuring reflected light (using a Focovision instrument) at five locations distributed across the area of the lens.

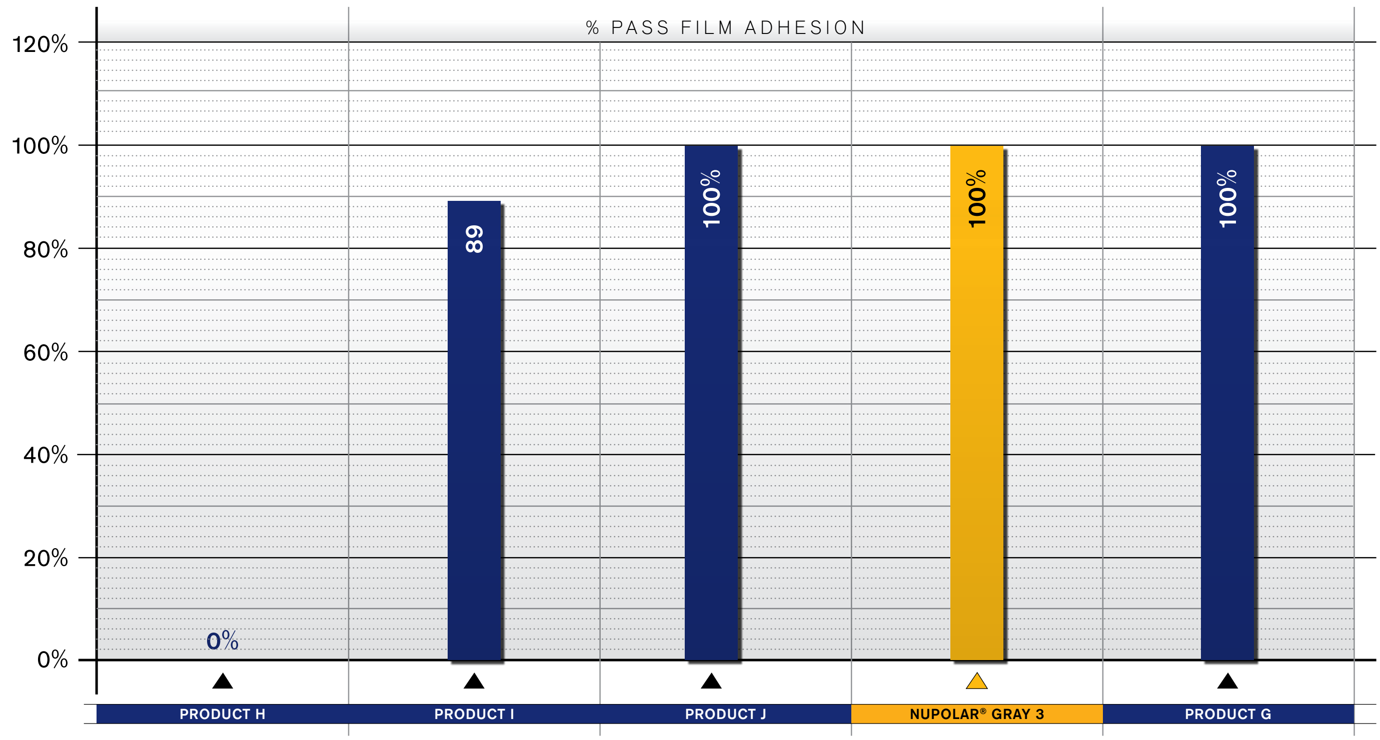


POLARIZING FILM ADHESION

COMMENTARY

Years ago, the biggest complaint about polarized lenses were that they separated or delaminated. When this failure occurs, it is really due to the fact that the film did not completely chemically "bond" itself to the hard resin material. Theoretically, the stronger this bond, the less likely a delamination is to occur. While most lenses have greatly improved their adhesion in the past few years, this is not universally true.

Notice on the graph that while NuPolar, Product J, and Product G all pass the Film Adhesion test without failure, Product I had 11% of its tested lenses fail, and ALL of Product H's samples failed. Clearly, according to Younger's performance criteria, Product H and Product I are not acceptable products. The main message here is that while most products do pass the Film Adhesion test, not all do.



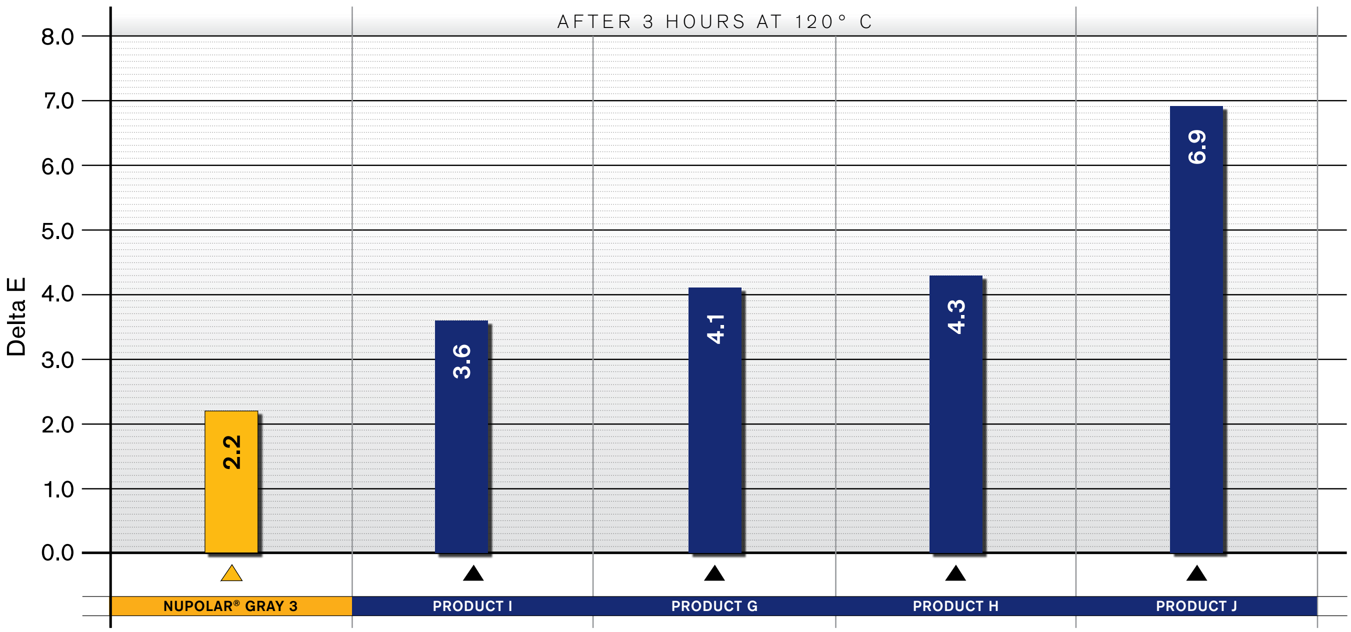
TEST DESCRIPTION

Younger has a proprietary method for testing Film Adhesion. Passing this test insures that the lens will be able to survive through subsequent laboratory and finishing processes.

OVERALL COLOR SHIFT: DELTA E

COMMENTARY

This test clearly shows that NuPolar's color is much more stable when subjected to elevated temperatures. NuPolar's Delta E of 2.2 after 3 hours is far better than any of its competitors. This low Delta E goes a long way towards insuring that NuPolar® will not shift color when exposed to the higher temperatures often required in AR Coatings, Hard Coatings, and even during lens processing. Delta E is really the summation of shifts in both color and in color hue.



TEST DESCRIPTION

The ΔE calculation includes three dimensions to characterize the visual change when lenses are subjected to test conditions. Lens color is characterized by the Hunter **a** (Red-Green) and **b** (Blue-Yellow) values, while the saturation of the color is given by the Hunter L value. The equation given below gives a good overall comparative value of how different the object will appear after testing. In this example, the lenses were measured for L, a, b values before and after testing under the severe conditions of 3 hours in a 120°C oven.

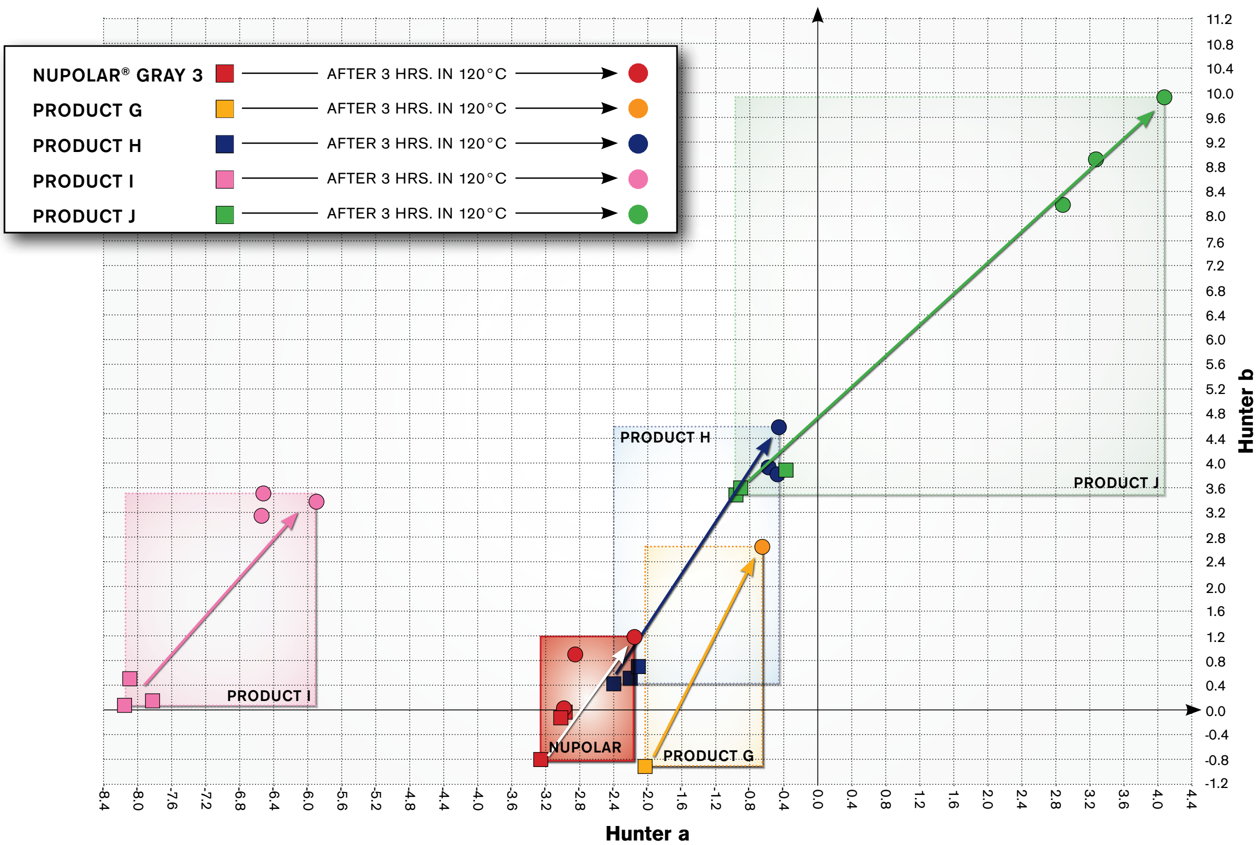
$$\text{Del E} = [\,(\text{L original} - \text{L final})^2 + (\text{a original} - \text{a final})^2 + (\text{b original} - \text{b final})^2\,]^{1/2}$$

WITH HEAT

CHANGE IN HUE: **a**, **b**, COORDINATES

COMMENTARY

On a Hunter **ab** color chart, the greater the distance a sample "shifts" after being subject to elevated temperatures, the more that color will "shift" from its original color. On this chart you can see clearly that the shifting of the NuPolar® lens is confined within a much smaller "box" than any of the other tested lenses. In examining the results one can see that all the samples are shifting up and to the right (more yellow and more red) but, this shift is dramatically less on NuPolar versus other products. Some products such as Product J are dramatically shifted, others, less so. But clearly NuPolar is the most stable product in this test.



TEST DESCRIPTION

When a lens is subjected to heat, it may change color due to thermal degradation. Measuring the color of a lens before and after a heat test (such as 3 hours in a 120°C oven) tells us how much the color has shifted. One way to look at the color change is by using Hunter **a**, **b** values. The "Hunter **b**" scale indicates changes from blue (low **b** values) to yellow (high **b** values), while the "Hunter **a**" scale shows shifts from green (low **a** values) toward red (high **a** values). In the plot, arrows indicate before and after color values for competitive samples. Smaller amounts of change between before and after values mean less visible color shift and a smaller color box. Note that the NuPolar® lenses change very little, and both before and after values are contained in the smallest "color box".

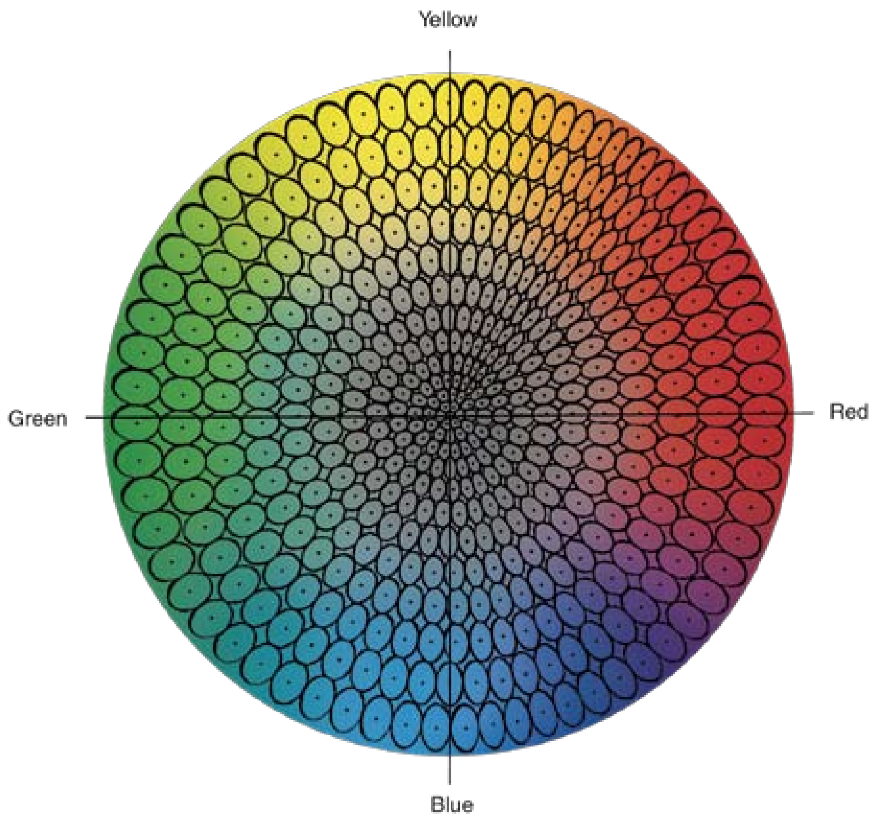
COLOR CYCLE TOLERANCE

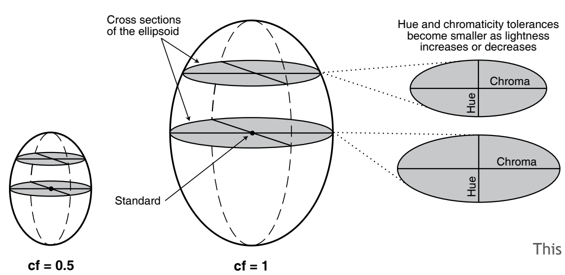
DESCRIPTION

Millions of years of evolution have turned the eye into a magnificent color comparison instrument. While colorimeters and other color computers can remember and store color values better than the human eye, the eye is exceptional at comparing two samples side by side and detecting very subtle color differences. Unfortunately, this is exactly the position we find ourselves in when we use two separate polarized lenses and put them side by side PERMANENTLY in an eyeglass frame.

Interestingly, the eye does not perceive all color differences equally. The color diagram below shows the eye's tolerance "ellipsoid" for differences in color. Notice that the ellipsoids are exceedingly small in the center (pure gray area), and increase in size outward. In practical terms, this means that the eye is much more able to see even small color differences between lenses when their color is a pure gray versus lenses which tend towards a less pure gray, such as a green/gray as found with a Green-15 colored lens.

The main point to remember here is that the closer two lenses are to a pure gray, the more discriminating the eye will be in picking up very subtle differences that would be missed entirely if the lens were an off gray!





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TEST CONCLUSION

Excellent quality hard resin polarized lenses are the most difficult lenses in the world to cast. Lower quality polarized lenses are not nearly as difficult. When polarizing efficiency, heat stability, color stability, axis placement, optics, film location and adhesion are considered, it becomes easier to understand the differences. While several other polarizing hard resin lenses may match Younger in some areas, no other hard resin polarizing lens on the market comes close to NuPolar® lenses in overall performance.

HARD RESIN COMPETITOR SUMMARY

	POLARIZING FILM LOCATION	POLARIZATION COEFFICIENT	POLARIZING AXIS ALIGNMENT	UNWANTED CYLINDER	POLARIZING FILM ADHESION	COLOR CHANGE WITH HEAT	
						OVERALL COLOR SHIFT: DELTA E	CHANGE IN HUE: a, b, COORDINATES
NuPolar® Gray 3	●●●●●	●●●●●	●●●●●	●●●●●	●●●●●	●●●●●	
Product J	●●●	●●●●	●●●●	●●	●●●●●	●	
Product I	●●●	●●●	●●●●●	●●●	●●●●	●●●●	
Product G	●●●●	●●●●●	●●●●	●●●●●	●●●●●	●●●	
Product H	●●	●●●●●	●●●●	●●●	○	●●●	

Notes on Tests:

All of these comparative evaluations were conducted using 6 Base Single Vision lenses only. All test groups contained equivalent number of samples for Younger and the competitive products. The data contained in this comparison was obtained using the following instruments: Hunter Lab UltraScan XE Spectrophotometer, Focovision CX V 2.1.6 (by reflection), High powered microscopy, Polarization alignment plates and some equipment proprietary to Younger Optics.

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