ZEISS PhotoFusion X

Performance perfected.

ZEISS PhotoFusion X lenses, the latest generation of photochromic lenses from ZEISS.

Seeing beyond

ZEISS PhotoFusion X

Launched in 2022, PhotoFusion® X is the latest generation of photochromic lenses from ZEISS. In addition to improved speed and darkness when compared to previous PhotoFusion photochromic lenses, these lenses are perfectly clear indoors and dark outdoors. Plus they provide sunglass-level UV protection and excellent blue light protection, making PhotoFusion X the best possible choice for photochromic eyewear.

Most people have seen eyeglasses that maintain a lingering tint indoors. This slow speed-to-clear is a common pain point for photochromic lenses and new potential buyers.[1] PhotoFusion X lenses are faster to clear than previous PhotoFusion lenses and other photochromic brands.

Beside providing sunglass level UV protection already in the clear state, ZEISS PhotoFusion X lenses now also provide built-in blue light protection. This unique feature is achieved by using ZEISS BlueGuard lens material as foundation for the additional PhotoFusion X treatment.

Compared to other photochromic brands, PhotoFusion X lenses provide a higher level of blue light blocking - up to 50% when inside and the lens is clear, and up to 95% when activated outdoors.[2] This is important because many consumers are demanding blue light protection around digital screens and artificial light in indoor settings.

Key Benefits

Outdoors, ZEISS PhotoFusion X lenses are performance-optimized photochromic lenses that provide glare, blue light and UV protection.

Sunglass-level (Cat 3) darkness outside;

- UV Protection to 400 nm
- Excellent blue light blocking properties
- New and improved color hues
- Up to 26% darker Grey and up to 18% darker Extra Grey than previous generation[29]

Indoors, PhotoFusion X provides excellent clarity while blocking up to 50% of potentially harmful blue light.

Photofusion X provides ground-breaking transition speed.

- Speed-to-clear – up to 4.5 times faster than the most common photochromic brand´s latest generation.[3],[4]
- Speed-to-dark – up to 75%[30] faster than previous PhotoFusion lenses, achieving over 70% absorption in as little as 15 seconds and full sunglass-level (cat 3) darkness in 27 seconds.[5]

ZEISS PhotoFusion X lenses are available in seven colors including a classic sunglass grey, a very fast pro grey, a very dark extra grey, a warm sunglass brown, a very fast pro brown, the pioneer grey-green and a vibrant blue.

Speed to Clear

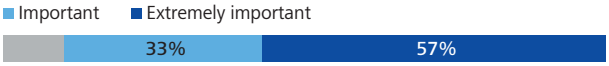
Consumer Expectations

Consumers often buy a variety of prescription lenses: clear, sunglasses, and more recently, blue light protection lenses. But multiple prescription eyeglasses are expensive and not always easy to manage.

Offering a two-in-one solution, photochromic lenses have long doubled as sunglasses and clear eyewear – but never quite perfectly. Early generations were not dark enough or were slow to clear when coming indoors. Slow fade-back speed is a visual inconvenience, as it's difficult to see indoors with dark lenses, and in social situations they may appear out of place.

Studies from ZEISS and others confirm fast transition is important to consumers.

- For many consumers, quick clearing indoors is the most important feature in photochromic lenses.[1]
- Slow change from dark to light is the most common pain point for photochromic lens wearers.



The speed which they change from dark to light when you go inside*

**Quantitative survey with N=232 consumers (photochromic lens wearers) in UK, in April 2021.*

- "too slow to go clear" was the most cited technical performance reason for not purchasing photochromic lenses.[20]
- In the same study, 100% of experienced photochromic lens wearers noted "clearing up fast inside" is an important characteristic, even more so than darkness or indoor clarity.

These results indicate a significant gap between the speed of common photochromic lenses and the expectations from both experienced photochromic wearers and potential new customers.

** In this document PhotoFusion X Grey and Extra Grey represent the products that in the USA are commercially identified as ZEISS PhotoFusion Grey and Extra Grey in ordering systems, but labelled as ZEISS PhotoFusion Grey Black and Extra Grey B respectively on FSV and SF product labels.*

Light is Essential but it Challenges Vision

Managing Changing Lighting Conditions

Light is essential to our life – to be able to see clearly – and to perform in life's activities to our very best. But light also presents challenges and risks for our eyes, and for our visual comfort. Eyeglass wearers have different needs depending on their environmental light conditions. When people are indoors, they typically want their lenses to be clear.[1] When stepping outdoors, their eyes perceive glare and they want sunglasses that provide comfortable glare and UV protection.

Exposure to the solar spectrum has a positive impact on well-being and mood[6], [7], making it vital to spend time outside. During vacation, for example, people spend five to six hours more time outside per day.[8]

However, illumination levels can vary from 100,000 lux in direct sunlight to less than 10 lux in a dimly lit room. Lighting engineers typically recommend no more than 1,000 lux of uniform illumination for comfortable vision. Compared to direct sunlight, this generates a 100:1 dynamic range.

When moving outdoors from a comfortably-illuminated indoor environment, eyes must adapt to illumination up to 100 times higher. This sudden increase in illumination is perceived as glare.

Glare can be divided into disability glare and discomfort glare. Disability glare is caused by losing luminance contrast from scattered light.[9] Discomfort glare is the subjective pain and/or annoyance people experience when exposed to bright light.[10], [11]

The most obvious trait in discomfort glare is illuminance (i.e. intensity of the light from the glare source at the observer's eye).[12], [13] However, there may be other factors, such as the spectral distribution of the light source. Shorter wavelengths (blue light) generate more discomfort glare.[14], [15]

Sunlight and digital devices, such as computer screens, tablets or mobile phones, tend to produce more short-wavelength light.[16] Whether glare is caused by changes in light intensity, or intense artificial blue light, discomfort glare is omnipresent in our modern world.

Artificial Blue Light – a Modern Challenge

Modern artificial light sources and the usage of digital devices are increasing the eyes' exposure to artificial blue light. While longer wavelength blue light can help us stay alert and awake, shorter wavelengths can generate visual irritation and potentially harm the eyes.

In addition, blue light is thought to contribute to digital eye strain, causing symptoms like blurry vision and visual discomfort.[17]

Both the eye care industry and scientific community have become increasingly concerned about artificial blue light exposure. This has resulted in growing consumer demand for protective eyewear.

Consumer interest is driving rapid sales growth in blue light lens sales and eyeglass wearers increasingly searching for "blue light glasses" online.

Online search data shows that patients are increasingly interested in blue light glasses. Google searches for blue light glasses have increased five-fold in two years (Figure 1).[18] In 2020, this term (blue light glasses) outpaced photochromic lenses searches.

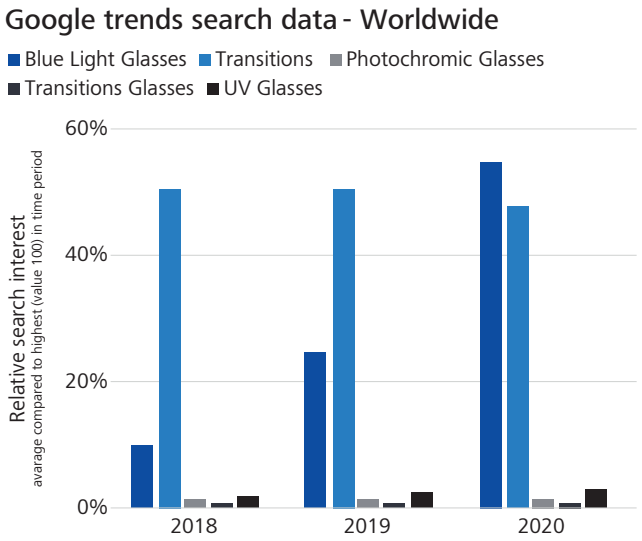


Figure 1. Google trend search data shows growing consumer interest in blue light glasses.

In addition to scientifically based blue light concerns (discomfort glare and potential harm), this search data indicates how important it is to consumers to provide a solution with a high level of blue light protection both indoors (artificial light sources, digital display) and outdoors (solar light conditions).

Previous generations of photochromic lenses came with limited blue light protection, particularly indoors when lenses are clear.

Because photochromic lenses are used all day and in all environments, they should offer a higher level of protection. Wearers want to protect their eyes and vision no matter if they are exposed to artificial blue light indoors or solar radiation while spending time outdoors.

UV Radiation

UV radiation is not visible to the human eye but poses potential risks to eye health. Shorter wavelength UV (below 380 nm) does not penetrate deeply, posing only a small chance of causing retinal damage.

However, without protection, UV radiation can damage anterior ocular structures and the skin around the eyes.

Beyond acute temporary damage, such as sunburn, chronic ultraviolet radiation exposure can cause irreversible long-term ocular tissue damage. Because electromagnetic radiation energy increases as the wavelength decreases, UV radiations with wavelengths shorter than 400 nm have a greater capacity to disrupt cellular structures and functions than visible light between 400 and 780 nm.

UVC radiation (below 280 nm) is absorbed by the atmosphere. But ocular tissue is exposed to the UVB (280 to 315 nm) and UVA radiation (315 to 400 nm) in sunlight which can damage various structures:

Eyelids and periorbital skin: UV induced eyelid damage is common. Experts recommend sunscreen on the eyelids to prevent damage, but people often do not take this safety measure to avoid eye irritation.
UV radiation can cause several chronic skin conditions:

- Eyelid photoaging, which makes the skin thicker and generates prominent wrinkles;
- Sebaceous gland damage;
- Skin cancer on the eyelid.

Lens: As the eye ages, protective pigments in the lens are converted into pigments that react to UVR, further damaging lens proteins and the lens's outer layer. When damage accumulates, the lens can develop a cataract, severely compromising vision.

Iris: Melanoma tumors are the most common cancer of the eye, and evidence suggests that UVR is one of its leading causes.[19]

Retina: In young people, some longer UVR wavelengths may reach the retina and cause photochemical damage.
Because UV poses such significant ocular risks, customers expect their eyewear to provide full protection – especially from photochromic and other lenses targeted for outdoor use.
In order to provide high performance, ZEISS has focused on speed, sunglass level glare protection, excellent blue light and UV protection and high clarity in its newest photochromic lenses.

ZEISS PhotoFusion X

The New Benchmark for Photochromic Lenses

ZEISS PhotoFusion X is a complete photochromic lens portfolio uniquely designed to satisfy consumers' need for speed-to-clear, blue light and UV protection.

ZEISS has re-engineered its photochromic system to deliver ground-breaking transition speeds, improved darkness, superior protection and attractive colors – all with the world's leading optical expertise built into every ZEISS lens.

Thanks to ZEISS BlueGuard which is used as the base lens material, ZEISS PhotoFusion X provide excellent blue light protection in any environment.

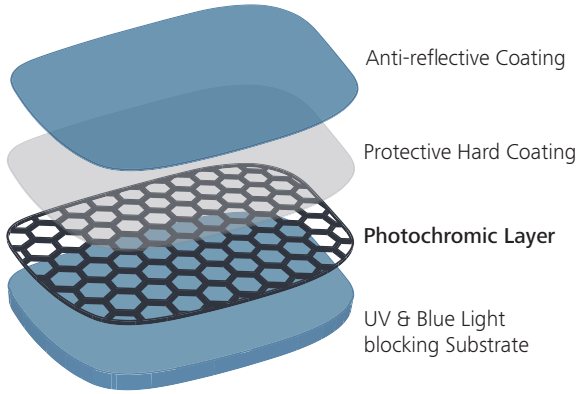


Figure 2. The photochromic layer is embedded on a UV & Blue Light blocking Substrate protected by a Hard Coat and an Anti-reflective Coating.

A Completely New Photochromic System

ZEISS PhotoFusion X continues the ZEISS PhotoFusion tradition of delivering market-leading activation and fade-back kinetics, without compromising indoor clarity or sunglass-level activation. PhotoFusion X has a completely new photochromic system, using faster dyes in a robust and more open carrier matrix.

ZEISS employs a new generation of specially developed and patented dyes. These ultra-low enthalpy, photokinetic dye compounds react incredibly fast, making them clearer indoors, dark outdoors and faster to react than previous generations.

Each ZEISS PhotoFusion X lens contains billions of dye compounds, each less than 0.3 nm across, that change shape and orientation based on lighting conditions. The supramolecular polymeric matrix provides a robust framework to deliver toughness and durability, while allowing for intra-matrix space giving the dyes maximum performance.

Energy from UV radiation is absorbed by the photochromic dyes causing the dye compounds to open-up. In this open form, the

dyes can absorb visible light which results in a sunglass level tinted lens (Figure 3).

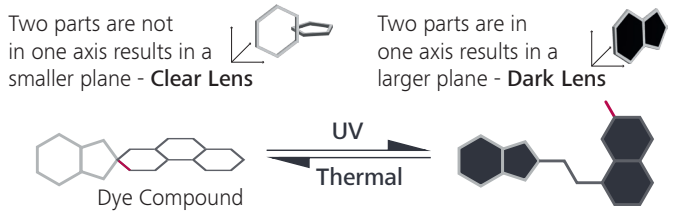


Figure 3. Reaction of a photochromic molecule and its changing structure based on UV / thermal impacts.

The more intense the UV radiation, the darker the lens becomes. Even moderately intense UV will darken them to sunglass level. Without UV exposure, the ambient temperature makes the dyes close rapidly, allowing the lens to revert to perfect clarity.

Sunglass-Level Darkness

The ocular system adapts to higher illumination in 30 to 60 seconds.[20] ZEISS PhotoFusion X lenses support pupillary system and retina adaptation. When exposed to sunlight, PhotoFusion X lenses reach 70% light absorption in just 15 seconds and full sunglass level (Figure 4) (cat 3) in as little as 27 seconds.

Tint description	Luminous transmittance category	Visible spectral range in T%
Clear or very light	0	80-100
Light tint	1	43-80
Medium tint	2	18-43
Dark tint	3	8-18

ISO 8980-3 based categories for luminous transmittance (T%)

Figure 4. Sunglass protection level per DIN EN ISO 8980-3.

Activated State – Darkness (23°C)

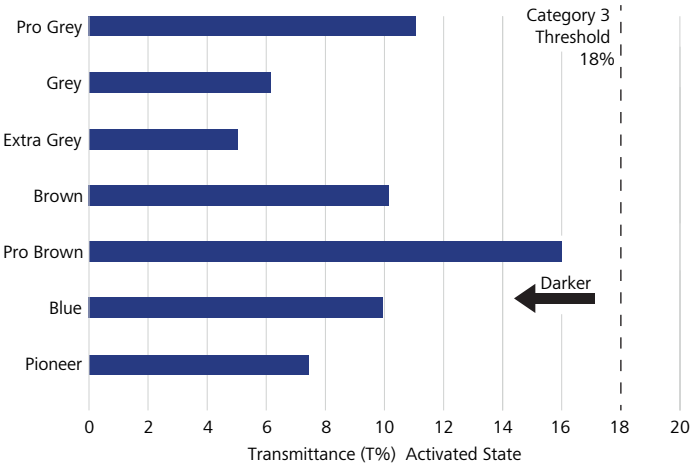


Figure 5. Transmittance (T%) of PhotoFusion X colors with activation at 23°C (Polycarbonate HC only).

ZEISS PhotoFusion X Grey is up to 26% darker than the previous PhotoFusion Grey (Figure 6), and up to 11% darker than a the most common photochromic brand's latest generation grey.[21]

Activated State – Darkness (23°C)

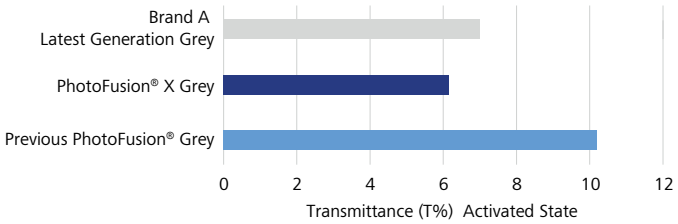
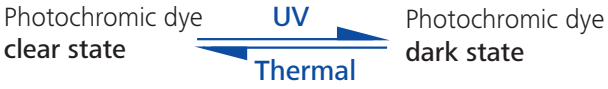


Figure 6. Transmittance (T%) of PhotoFusion X Grey and previous generation of PhotoFusion Grey with activation at 23°C (Polycarbonate HC only).

PhotoFusion Brown was upgraded to be over 30% darker than the earlier generation brown, and PhotoFusion X Brown maintains this level of improved darkness while delivering improved fade-back speed compared to this upgrade.

ZEISS PhotoFusion X Extra Grey is up to 18% darker than the previous generation Extra Grey, and up to 4% darker than the most common photochromic brand's latest generation extra dark grey.[33]



Darkness at High Temperatures

Compared to the previous generation, PhotoFusion X photokinetic dye compounds have equal or improved activation performance when temperatures rise. The clarity/darkness of photochromic dyes are determined by the equilibrium between UV radiation and temperature. UV transforms the dyes into their activated state, while heat deactivates them. In other words, the higher the temperature, the lighter the tint, which is true of all photochromic lenses. In the original generation of PhotoFusion only the Extra Grey and Pioneer colors were designed with sunglass level darkness at hotter temperatures. In PhotoFusion X the regular Grey and the regular Brown colors also remain dark at these higher temperatures.

Activated State – Darkness (35°C)

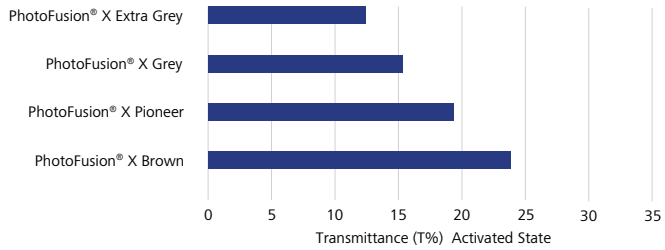


Figure 7. Transmittance (T%) of PhotoFusion X colors with activation at 35°C (Polycarbonate HC only).

Perhaps most notable is the increase in darkness in PhotoFusion X Grey compared to the previous generation of grey. At 23°C it is up to 26% darker, and even at 35°C it is over 29% darker.[31]

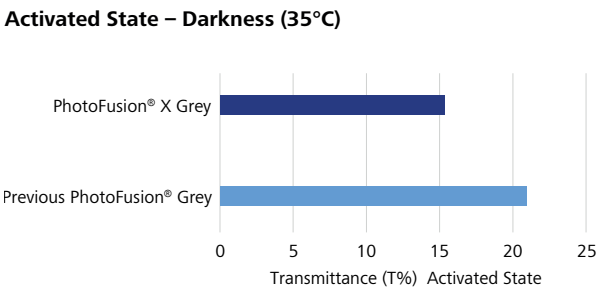


Figure 8. Transmittance (T%) of PhotoFusion X Grey and previous generation of PhotoFusion Grey with activation at 35°C (Polycarbonate HC only).

Groundbreaking Transition Speeds

Once again, ZEISS PhotoFusion X sets the industry standard for photochromic performance and transition speeds. PhotoFusion X is fast-to-clear and fast-to-dark.

Depending on color, material and environmental conditions, PhotoFusion X is faster to clear than the latest generation of today's most common photochromic brand, and even significantly faster than previous PhotoFusion lenses. The chemistry of photochromic dyes means activation is always faster than deactivation. In other words, time-to-dark is rarely an issue. Time-to-clear is the primary performance gap.

There are many ways to measure photochromic speed, and different manufacturers choose varied metrics to report performance of their latest products.

ZEISS sets a high standard when measuring speed to clear using a metric that is considered most important to eyeglass wearers. ZEISS's primary fade-back assessment measures the time it takes a lens to fade-back to a perfectly clear level – 80% transmittance (80%T). Other brands use lower transmittance levels as the threshold, such as 70% (70%T), which helps them claim to be fast but isn't truly clear.

80%T matches the ISO 8980-3 definition for a clear lens (category 0). The 10% distinction may seem negligible, but it significantly impacts speed results, due to the shape of the fade-back transmittance curve (%T).

The curve shows the clearing speed decreases while transmittance increases. For many photochromic lenses, it can take a long time to fade-back from 70%T to 80%T, making the higher threshold the more appropriate measure when judging these lenses.

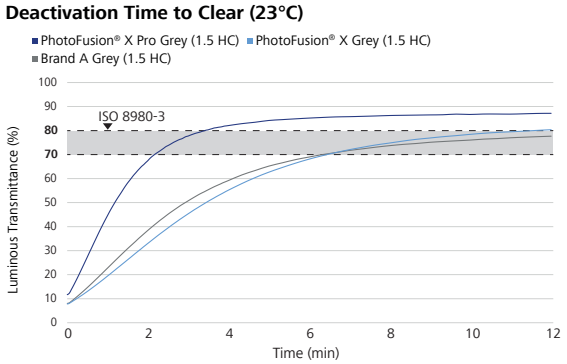


Figure 9. Transmittance (T%) depending on deactivation time at 23°C.

Speed Results - ZEISS Photochromic Testing

ZEISS's photochromic measurements comply with ISO 8980-3, and report fade-back speeds based on the 80%T threshold at 23°C.

PhotoFusion X Pro Grey reaches 70% Transmittance in 2-3 minutes of fade back and is perfectly clear (80%T) in 3.5 - 5 minutes (depending on index) which is up to 4.5 times faster to clear than a well-known photochromic brand's latest generation grey.[22]

PhotoFusion X Pro Brown reaches 70% Transmittance in 2 minutes of fade back and is perfectly clear (80%T) in 4 minutes (depending on index) which is up to 3.7 times faster to clear than a well-known photochromic brand's latest generation brown.[23]

PhotoFusion X Grey is up to 1.5 times faster to clear than the same common brand's latest generation grey, while being 11% darker when activated.

PhotoFusion X Brown is up to 2 times faster to clear than a common brand's latest generation brown[23] while it is up to 10% faster than the recent upgrade of PhotoFusion Brown with a similar warm color hue.

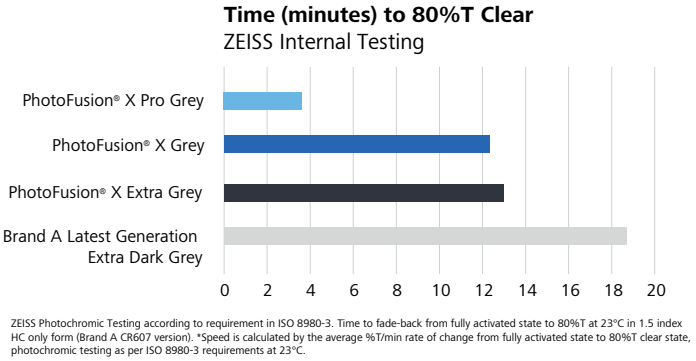
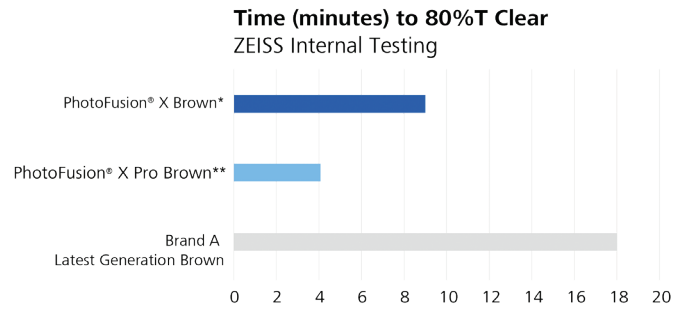


Figure 10. Time to fade-back to 80%T from full transmittance ZEISS internal testing of ZEISS PhotoFusion X Grey, Pro Grey and Brand A Grey.

Speed Results - Independent Testing

Customers often ask for photochromic test results from independent laboratories. To answer these queries, ZEISS



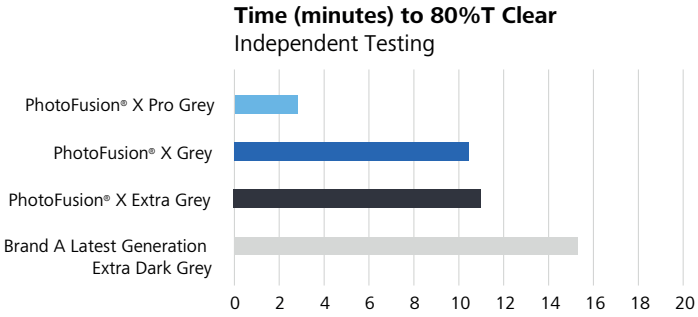
ZEISS Photochromic Testing according to requirement in ISO 8980-3. Time to fade-back from fully activated state to 80%T at 23°C in 1.5 index*, Polycarbonate** HC only form (Brand A CR607 version). *Speed is calculated by the average %T/min rate of change from fully activated state to 80%T clear state, photochromic testing as per ISO 8980-3 requirements at 23°C.

Figure 11. Time to 80% transmittance ZEISS internal testing of ZEISS PhotoFusion X Brown, Pro Brown and Brand A Brown.

collaborated with Colts Laboratories, an independent ophthalmic lens testing company in the USA, to measure the photochromic properties of PhotoFusion X lenses and compare them to the latest lenses from other brands.

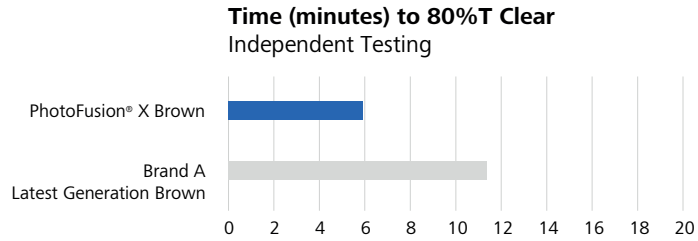
Colt's independent test results lead to similar conclusions. PhotoFusion X Pro Grey measures up to 4.5 times faster than a well-known photochromic brand's latest generation grey, comparing average fade-back speed to an interpolated time to 80%T.

PhotoFusion X Extra Grey is up to 30% faster to clear than the same most common brand's new generation extra dark grey, while being up to 4% darker when activated.[33]



Testing by independent testing laboratory in USA according to requirement in ISO 8980-3. Based on the average speed (%T/min) of fade-back from fully activated state to 80%T at 23°C in 1.5 index HC only form (Brand A CR607 version).

Figure 12. Time to 80% transmittance independent testing of ZEISS PhotoFusion X, Grey and Brand A Grey.



Testing by independent testing laboratory in USA according to requirement in ISO 8980-3. Based on the average speed (%T/min) of fade-back from fully activated state to 80%T at 23°C in 1.5 index HC only form (Brand A CR607 version).

Figure 13. Time to 80% transmittance independent testing of ZEISS PhotoFusion X Brown and Brand A Brown.

PhotoFusion X Brown was twice as fast as the same brand's latest brown.

Testing by ZEISS and Colts are both ISO 8980-3- compliant. Minor testing procedure differences, allowable under ISO 8980-3, account for small differences.

Indoor Clarity

In addition to increasing indoor blue light protection, speed and darkness, ZEISS PhotoFusion X lenses provide excellent indoor clarity, with up to 95% transmittance when combined with DuraVision® AR coatings (Figure 14).[25]

Often, lenses that block blue light show reduced indoor clarity because the added grey/blue color additives impact overall transmittance. However, ZEISS BlueGuard lens materials provide excellent clarity, especially when combined with advanced photochromic dye compounds.

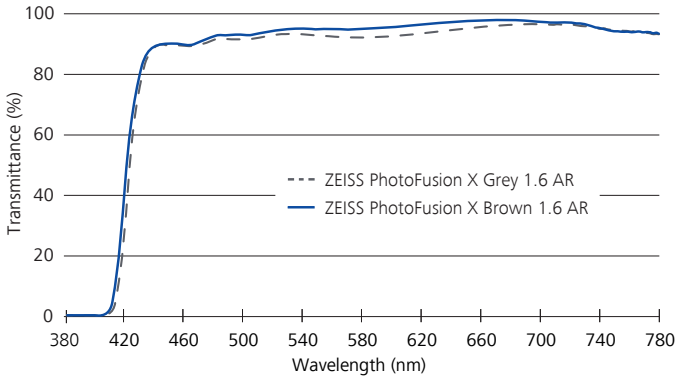


Figure 14. Clear state transmittance ZEISS PhotoFusion X Grey and Brown 1.6 index AR.

A Unique Level of Blue Light Protection

ZEISS PhotoFusion X blocks 30% more potentially harmful blue light indoors compared to a well-known photochromic brand's latest generation. This is due to the use of blue light bocking BlueGuard® base material.[26]

ZEISS BlueGuard® lens materials block up to 40% of potentially harmful blue light. In combination with the PhotoFusion X photochromic coating, the blue light blocking properties of the clear lens rise up to 50% in the clear state.[26]

The sun emits UV and blue light, especially in the high-energy visible light (HEV) range. ZEISS PhotoFusion X provides its highest blue light protection when outdoors and fully activated. When fully activated outdoors, the lens blocks up to 95% of blue light.[27]

Other photochromic brands typically apply their photochromic layer on base materials that often do not block blue light or even

UV up to 400 nm. This becomes evident when measuring the blue light blocking properties indoors of PhotoFusion X compared to a well-known brand's latest generation.

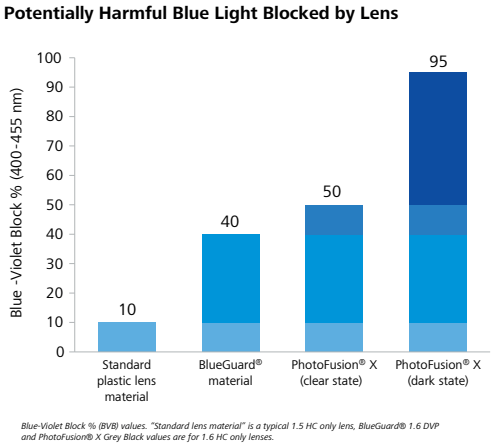


Figure 15. Blue light blocking properties based on Blue-Violet Block metric.

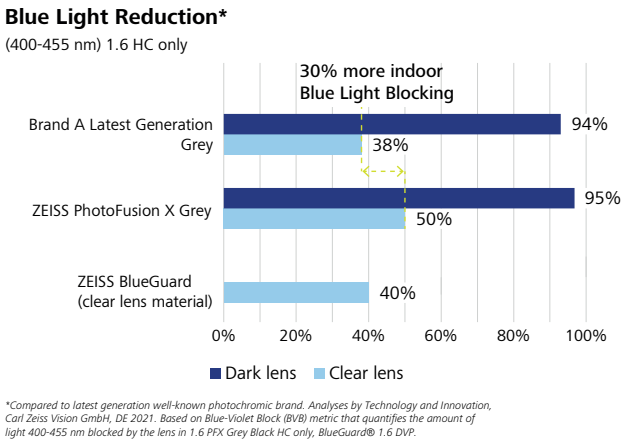


Figure 16. ZEISS PhotoFusion X lenses have 30% more indoor Blue Light Blocking compared to well known photochromic brand's latest generation.

Many eyeglass wearers want blue light protection indoors when photochromic lenses are not activated, but previous photochromic lenses had less blue light protection.

Digital devices are often used indoors. Therefore, blue light protection should be also maximized when lenses are clear.

ZEISS researchers found a way to close this protection gap, providing blue light protection in any environment and situation, indoors or outdoors.

A consumer acceptance survey for BlueGuard® lens materials, found wearers feel a comfort advantage when wearing these lenses and using digital devices.[23]

- 95% agree they experience less general visual discomfort;
- 95% agree they experience less discomfort glare;
- 94% feel less irritated by artificial blue light.

ZEISS PhotoFusion X lenses offer the best level of blue light protection in the ZEISS portfolio in lenses that are not permanently tinted.[27]

ZEISS Blue-Violet Block

ZEISS 's quantifies the level of blue light blocking by blue-violet block (BVB), which measures the percentage of the potentially harmful blue-violet light, between 400 and 455 nm, not transmitted by the lens.

$$Blue\ Violet\ Block = 100\% - \frac{\int_{400}^{455} T(\lambda)d(\lambda)}{\int_{400}^{455} d(\lambda)}$$

T = spectral transmittance of the lens (%) at each single nm

Shorter blue light wavelengths have higher energy levels, and these photons can interact with biological tissue on a molecular level. The latest ISO blue light report (ISO/ TR20772:2018) notes blue light up to 455 nm delivers the greatest phototoxic risk to retinal pigment epithelium. The report also suggests minimizing blue light exposure up to 455 nm and maximizing longer wavelengths to avoid interfering with circadian rhythm and other important functions.

This is precisely how ZEISS PhotoFusion X on BlueGuard® lenses are designed.

Sunglass Level UV Protection to 400 nm

ZEISS PhotoFusion X lenses provide sunglass-level UV protection, blocking UV radiation up to 400 nm in both the clear and activated states. This protection is built into ZEISS BlueGuard materials. This means PhotoFusion X lenses provide the same UV blocking properties as premium sunglasses.

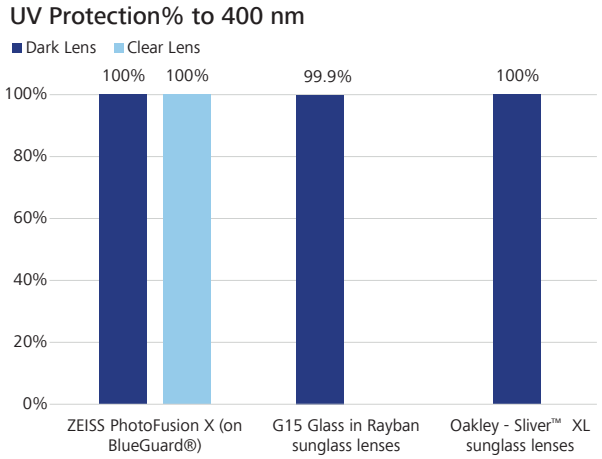


Figure 17. UV Protection% measures the amount of UV radiation blocked by the lens between 280 – 400 nm, based on a transmittance calculation defined by the Australia Standard for sunglass and fashion spectacles (AS1067.2:2016). ZEISS PhotoFusion X Grey result for 1.6 index.

Premium sunglasses typically offer full UV protection to 400 nm; however, people may not own a pair or wear them on cloudy days. A Vision Council of America survey found only 21.2% always wear sunglasses when outdoors.[28]

Because PhotoFusion X are everyday lenses, for use indoors and outdoors, wearers have them on all the time, providing more reliable and consistent protection. As a result, PhotoFusion X lenses can provide the average wearer better protection over time from UV radiation than sunglasses.

Better Looks with New Hues

The photochromic dyes in PhotoFusion X lenses have been developed with improved hues, closely matching consumer preferences in the sunglass industry. Through its sunlens division, ZEISS supplies non-prescription sunglass lenses to many of the leading sunglass brands, giving ZEISS unique insights into sunglasses fashions and color choices.

Specific improvements by color:

PhotoFusion X Grey has a more neutral grey-black color hue when activated and maintains this tone during activation and fade-back. Compared to previous generation PhotoFusion Grey these lenses up to 26% darker at 23°C, and even at high temperatures (35°C) are over 29% darker.

PhotoFusion X Extra Grey also has a more neutral grey-black color hue when activated and maintains this tone during activation and fade-back. Compared to the previous generation PhotoFusion Extra Grey these lenses are up to 18% darker at 23°C, and even at high temperatures (35°C), they are over 9% darker.[34]

PhotoFusion X Brown has a warm brown tone, with similar darkness but slightly faster than the recently upgraded PhotoFusion Brown.

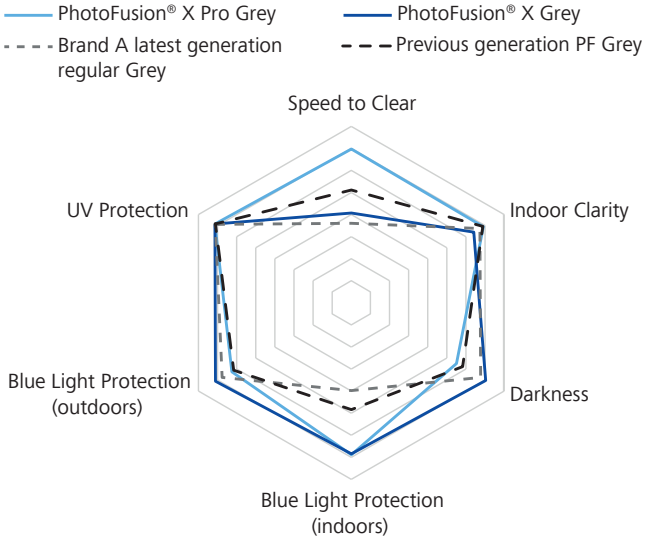
PhotoFusion X Pro Grey and **Pro Brown** are a breakthrough in speed - developed to be extremely fast to clear. The darkness of the PhotoFusion X Pro Grey is similar to that of the previous generation PhotoFusion Grey.

PhotoFusion X Blue received great feedback in the previous generation, so ZEISS retained this color hue and improved photochromic reaction speed.

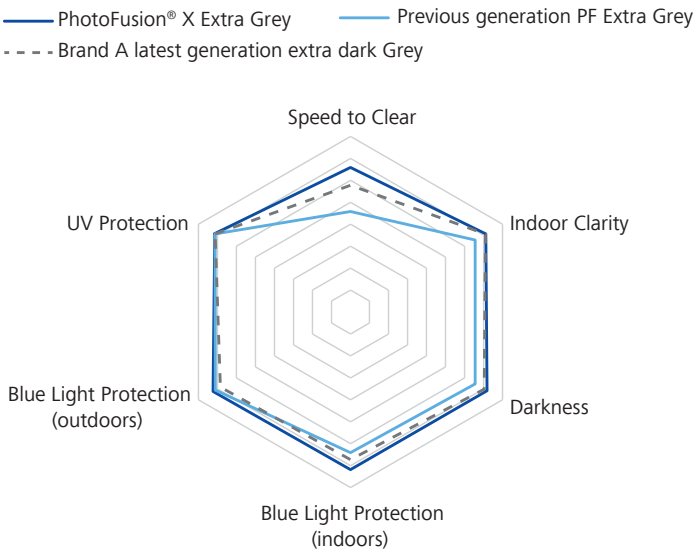
PhotoFusion X Pioneer is also faster and retains the same grey-green hue, which closely matches the popular grey-green sunglass color.

The Best Overall Photochromic Lens Technology

There are many photochromic lens choices available to eye care professionals - including new generations from multiple brands. Amongst this crowded field of products; ZEISS PhotoFusion X provides the best overall package of performance and protection when viewed across the variables that eyeglass wearers value most: Faster fade-back to clear, excellent clarity indoors, sunglass level darkness outdoors, high indoor and outdoor blue light protection and full UV protection.

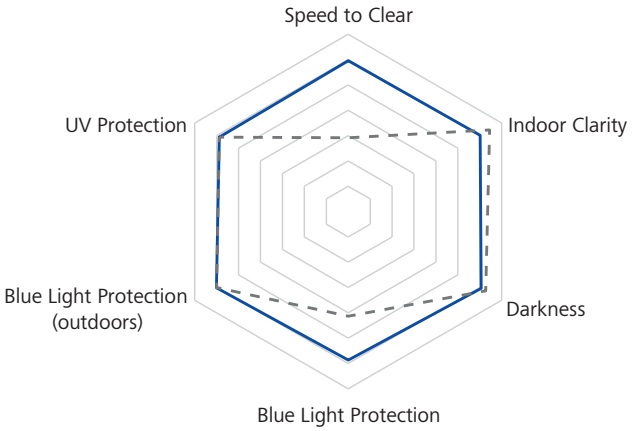


ZEISS PhotoFusion X Extra Grey performance comparison*



ZEISS PhotoFusion X Brown performance comparison*

PhotoFusion® X Brown - - - - Brand A latest generation Brown



**Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, DE, 2021. All photochromic measurements at 23°C and in accordance to ISO 8980-3. Speed to Clear is %T/min average rate of fade back from activated state to 80%T for 1.5 HC (CR607 version for Brand A). All other Measurements for Poly HC. Indoor Clarity is T% deactivated. Darkness is 100%- T% in activated state. Blue light protection is quantified by the Blue Violet Block (BVB) metric. UV Protection by UVProtection% that is 100% minus the UV transmittance calculation defined by the Australia Standard® for Sunglasses and fashion spectacles (AS1067.2:2016).*

ZEISS PhotoFusion X (results vary slightly by material)	**Brown**	**Pro Brown****	**Grey**	**Extra Grey******	**Pro Grey**	**Pioneer**	**Blue**
Activated Darkness (23°C)	11%T (89% absorption)	16%T (84% absorption)	7%T (93% absorption)	5%T (95% absorption)	11%T (89% absorption)	8%T (92% absorption)	11%T (89% absorption)
Activated Darkness (35°C)	25%T (75% absorption)	31%T (69% absorption)	17%T (83% absorption)	12%T (88% absorption)	25%T (75% absorption)	19%T (81% absorption)	27%T (73% absorption)
Indoor Clarity (T%)	95%T with AR* (86%T HC only)	94%T with AR** (86%T HC only)**	93%T with AR* (85%T HC only)	92%T with AR* (84%T HC only)	94%T with AR** (86%T HC only)**	92%T with AR (84%T HC only)	92%T with AR (83%T HC only)
Time to Perfectly Clear (to 80%T)	8.5 min	4.1 min	12 min	15 min	3.8 min	12.3 min	8.3 min
Time to Clear (to 70%T)	4.5 min	2.0 min	6.6 min	8.2 min	2.2 min	5.7 min	2.6 min
Time to Dark (to 18%T – Cat 3 sunglass level)	48 sec	60 sec	27 sec	24 sec	27 sec	33 sec	33 sec
Blue Violet Block ** - Clear State	48%	53%	50%	52%	50%	50%	51%
Blue Violet Block ** – Dark State	96%	93%	96%	96%	90%	96%	75%
UV Protection% to 400 nm	100%	100%	100%	100%	100%	100%	100%

*Table Values: Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, DE, 2021. All measures 1.5 HC 23oC unless indicated; - *on 1.60,*

***on Polycarbonate; All photochromic measurements in accordance to ISO 8980-3. Absorption is defined as 100% minus transmittance. Blue Violet Block (BVB) metric quantifies the amount of light 400-455 nm blocked by the lens. UV Protection% to 400nm is 100% minus the UV transmittance calculation defined by the Australia Standard® for Sunglasses and fashion spectacles (AS1067.2:2016) Photochromic performance is influenced by temperature, UV exposure, and lens material.*

****In this document PhotoFusion X Grey and Extra Grey represent the products that in the USA are commercially identified as ZEISS PhotoFusion Grey and Extra Grey in ordering systems, but labelled as ZEISS PhotoFusion Grey Black and Extra Grey B on FSV and SF product labels.*

***** In moderate to cold weather, darkness can achieve values beyond Category 3, e.g. outdoors in cold, but sunny weather.*

NOTES

References

[1] *Photochromic Lens Wearer Study in the UK (n=232) in 2021 external institute).*

[2] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, DE, 2021, based on Blue Violet Block (BVB) metric that quantifies the amount of light 400-455 nm blocked by the lens, for PFX Grey 1.6 HC only lenses.*

[3] *Testing by independent testing laboratory in USA in 2021-22 according to requirement in ISO 8980-3. Based on the average speed (%T/min) of fadeback from fully activated state to the interpolated time to 80%T at 23C in 1.50 index HC only form (CR607 version of comparison brand).*

[4] *Testing by independent laboratory in USA according to requirement in ISO 8980-3. Based on the average speed (%T/min) of fadeback from fully activated state to 80%T at 23°C in grey 1.6 index and grey Polycarbonate HC only form.*

[5] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, DE, 2021, in accordance to ISO 8980-3. Time to darkness levels based on 1.6 HC Grey and Extra Grey. And average speed (%T/min) of activation from clear state to 30%T at 23°C in grey 1.6 index and polycarbonate in HC only.*

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[18] *Google trends weekly result for country selection Worldwide from 1/1/2018 to 12/31/2020 for the terms "blue light glasses", "photochromic glasses", "transitions", "Transitions glasses" and "uv glasses", Data analysis as of July 2021.*

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[21] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, Aus 2021 in accordance to ISO 8980-3. Based on activate state T% at 23C in 1.5 HC only form. Testing by independent testing laboratory in USA in 2021-22 according to requirement in ISO 8980-3. Based on activate state T% at 23C in Poly HC only form.*

[22] *Testing by independent testing laboratory in USA in 2021-22 according to requirement in ISO 8980-3. Based on the average speed (%T/min) of fadeback from fully activated state to the interpolated time to 80%T at 23C in 1.50 index HC only form (CR607 version of comparison brand)..*

[23] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, Aus 2021. Based on the average speed (%T/min) of fadback from fully activated state to 80%T at 23C in 1.50 index HC only form, comparison brand CR607 version.*

[24] *Testing by independent testing laboratory in USA according to requirement in ISO 8980-3. Based on the average speed (%T/min) of fade-back from fully activated state to interpolated time to 80%T at 23°C in 1.5 index HR only form (Brand A CR607 version).*

[25] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, DE 2021. For 1.6 PFX Brown with DuraVision Platinum AR coating. Measurements on Perkim Elmer.1.6 PFX Brown with DVP: 95%1.6 PFX Grey with DVP: 93%.*

[26] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, DE 2021. Based on Blue Violet Block (BVB) metric that quantifies the amount of light 400-455 nm blocked by the lens in 1.6 HC only.*

[27] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, DE 2021. Based on Blue Violet Block (BVB) metric that quantifies the amount of light 400-455 nm blocked by the lens in PFX 1.60 HC only*

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[29] *Testing by independent testing laboratory in USA in 2022 according to requirement in ISO 8980-3. Based on activate state T% at 23C in Poly HC only form.*

[30] *Testing by independent laboratory in USA in 2021-22 according to requirement in ISO 8980-3. Based on the average speed (%T/min) of activation from clear state to an interpolated time to 30%T at 23C in grey polycarbonate HC only form.*

[31] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, Aus 2021 in accordance to ISO 8980-3. Based on activate state T% at 35C in 1.50, 1.60, and Poly HC only form.*

[32] *Analyses by Technology and Innovation, Carl Zeiss Vision GmbH, Aus 2021. Based on Blue Violet Block (BVB) metric that quantifies the amount of light 400-455nm blocked by the lens in 1.6 grey and brown HC only. BVB indoor calculation for 1.60 Grey = 50%; BVB outdoors PFX Brown is 96% - 94% PFX Grey is 94% or more.*

[33] *Testing by independent testing laboratory in USA according to requirement in ISO 8980-3. Based on activated state Transmittance , at 23C in Polycarbonate HC form.*

[34] *Testing by independent testing laboratory in USA according to requirement in ISO 8980-3. Based on activated state Transmittance , at 35C in Polycarbonate HC form.*

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