ZEISS ClearView Single Vision

Single Vision just got upgraded.

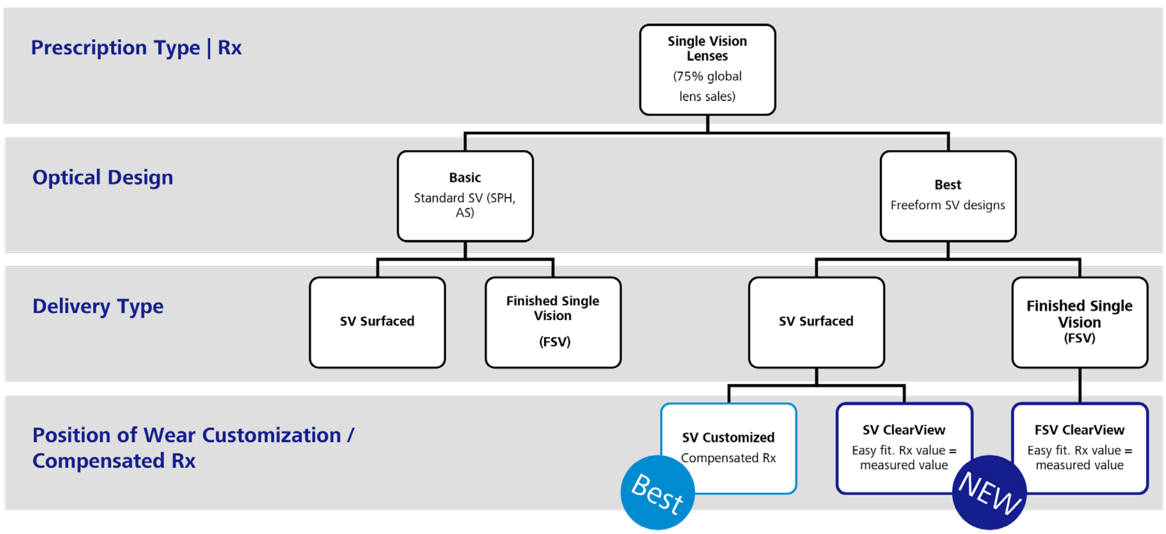
The new standard in single vision at ZEISS.
Thinner and flatter single vision lenses with the highest level of optics, available as finished single vision stock lenses or surfaced single vision lenses.

Seeing beyond

ZEISS ClearView Single Vision

Standard single vision (SV), whether spherical (SPH) or aspherical (AS) are globally the most sold lens type. This lens category is delivered either by stock finished single vision (FSV) with the distinct advantages of a lower cost and fast delivery time, or by SV surfaced. Standard single vision lenses have fallen behind in one of the most important features for every spectacle lens wearer: they typically do not provide great optics away from the lens center. In particular, the demand for flatter and thinner SV lenses has compromised their peripheral optical performance.

Continuing its role as the optical innovation leader, ZEISS has now identified a way to get complex freeform lens designs into both stock FSV lenses and standard SV surfaced lenses. The result is single vision lenses that are both very thin and flat and achieves excellent optics – with clear viewing from the lens center to the periphery. Vision clarity simulations show ZEISS ClearView SV lenses provide on average 3x larger zones of excellent vision clarity when compared to previous aspheric SV lenses.[8] Blind testing demonstrates that single vision lens wearers experience clarity and visual comfort and clearly prefer wearing ZEISS ClearView to ZEISS Aspheric SV lenses. [15,16]



The Standard Single Vision Category

Standard single vision is the most sold ophthalmic lens type, and most of these are stock lenses

Globally, 75%, and in Asia even 83% of spectacle lens wearers who obtain eyeglasses for vision correction are sold single vision lenses. [1] In this segment delivery as an FSV dominates, due to the distinct advantages for the lens retailer and lens wearer of a low cost, and fast delivery time - being in stock ready to edge into the frame. Regardess whether single vision is delivered by FSV or SV surfaced - the vast majority of single vision lenses are in the standard category – typical spherical or aspherical designs – where the measured power on the lens equals the prescribed/Rx value, making them easy to prescribe, easy to order, and easy to fit. A much smaller market segment is the more premium individualized or customized Freeform SV surfaced lenses, that use different levels of individualized position of wear parameters and therefore compensated Rx values. This segment delivers better optics but due to the disadvantages of increased time required with patients, higher cost, longer lead times, and higher fitting complexity mean the majority of single vision wearers simply do not receive their optical benefits. The new ZEISS ClearView single vision lens category delivers many of the benefits of Freeform optics, with the simplicity, speed and cost advantage of the standard single vision category.

Standard single vision lenses do not have great peripheral optics

Typically, standard SV lenses are judged on their material index, anti-reflection coatings, UV or blue light blocking properties or how thin and flat they are. The lens power is measured in the center, but attention is rarely paid to optical performance and vision clarity across the entire lens. Whether the lens is a stock FSV, or a SV surfaced lens - the reality is that standard SV lenses do not provide great peripheral optics. With the constraints of typical SV lens designs, the drive for flatter and thinner lenses even further compromises the optical performance especially in the lens periphery (Figure 1).

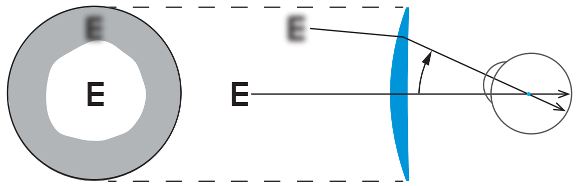


Figure 1. With typical SV lens designs, the drive for flatter and thinner lenses compromises the optical performance especially in the lens periphery (schematic illustration).

When single vision wearers were asked about the importance of different lens features (Figure 2)[2], 100% clearly stated that it was extremely or very important to them that their lenses offer comfortable vision across the entire lens. 90% stated that it was extremely or very important for them to see clearly across the entire lens.

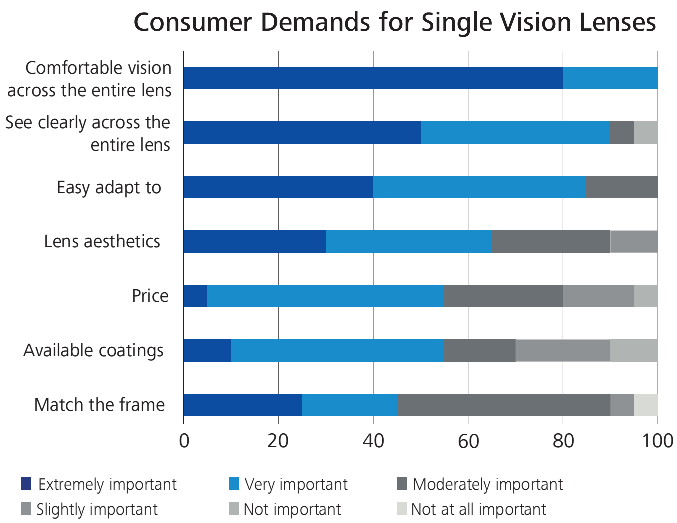


Figure 2. Consumer ratings when asked about the importance of different lens features for single vision lenses.[2]

The assessment of optical performance requires a highly sophisticated simulation

Why do so many SV lenses fall short of expectations in what is one of the most important features for spectacle lens wearers – offering comfortable, excellent, clear vision over a wide field of view? The answer lies in the fact that it's rarely even analyzed, because the assessment of the optical performance across the vision zone requires a highly sophisticated technical simulation that is not straight forward. It cannot simply be measured directly on a lensmeter.

To evaluate the optical performance of an ophthalmic lens or a lens design, the standard technical measures of sphere and cylinder power in the lens center are not enough to understand the visual experience of a spectacle lens wearer looking through many different locations in the given lens. Besides these optical properties, it is important to map the entire lens surface and then take into account the geometric setup including the lens geometry, lens fitting, physiological components (e.g., the center of rotation of the wearer's eye), to allow for a thorough ray-tracing for the wearer in the position of wear. In addition, it is important to factor in how the optical properties of the lens translate into the subjective visual experience perceived by the lens wearer. To this end, particularly the perception of blur is of relevance in this evaluation as it directly impacts visual acuity and can reduce the quality of vision and visual comfort for the wearer.

Image blur in general reduces the perceived resolution of an image, resulting in a relative deterioration of visual acuity and a decrease in visual performance. Image blur is a physiological-optical phenomenon, which can be calculated on the basis of defocus and unwanted astigmatism. The perception of blur by the wearer is also a psychophysical phenomenon, whereby the blur threshold is a more subjective experience which factors in the sensitivity of the observer, the demands and nature of the visual task, the image blur ratio, the contrast of the object, pupil size, ambient lighting, and more. In order to evaluate vision clarity as experienced by a lens wearer, it is therefore essential to establish the limits for the sensitivity and tolerance for the perception of blur. These thresholds can then be applied to predict the optical performance, the peripheral clarity of spectacle lens designs and the areas of clear and undisturbed vision.

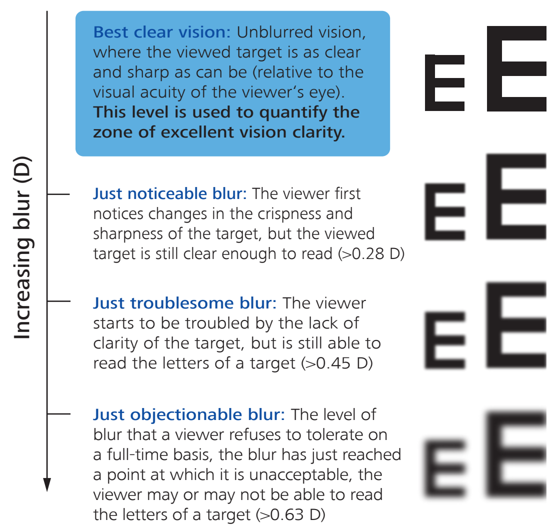


Figure 3. Levels of blur perception and simulated appearance of different sized letter Es based on thresholds at which blur becomes noticeable, troublesome and objectionable for single vision lens wearers based on the study results described by Atchinson and colleagues.[3]

In cooperation with the Queensland University of Technology (QUT) in Brisbane, Australia, ZEISS has conducted a series of studies to define these key parameters [3], [4], [5], which are then applied in a ZEISS Vision Clarity Simulation. Based on the thresholds defined in these studies, blur levels are classified into four distinct levels: the zone of excellent vision clarity providing best clear vision, noticeable blur, troublesome blur and objectionable blur (Figure 3).

ZEISS Vision Clarity Simulation

Building on their extensive knowledge in industrial metrology, ZEISS has developed a methodology that overcomes typical evaluation limitations and allows ZEISS to truly evaluate the optical performance of an ophthalmic lens or a theoretical lens design – the ZEISS Vision Clarity Simulation.

First, the lens surface of the ophthalmic lens is assessed through tactile measurement of the front and back surface using the highly precise and accurate ZEISS Coordinate Measuring Machine (CMM, Figure 4). Secondly, the precise surface geometries are then used in a mathematical simulation, where the lens is simulated in front of the eye of a wearer requiring the exact stated visual correction. In other words, simulating aspects of vision through the ophthalmic lens and computing the paths of particular rays entering the pupil of the eye. The lens reconstruction is calculated using a proprietary software package specifically developed by ZEISS for the design and analysis of ophthalmic lenses using ray tracing. Besides measurements on existing lenses, the ZEISS Vision Clarity Simulation is also used to predict and optimize the optical performance of new lens designs.

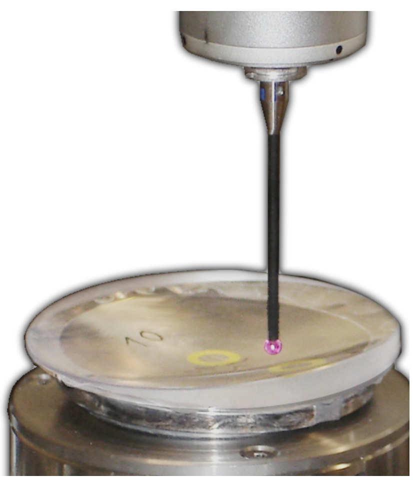


Figure 4. ZEISS' expertise in many fields of optics ensures superior quality. Through tactile measurements with an accuracy of less than 1.5 µm, 3D coordinates are assessed for 1500 points on both the front and back surface of a typical lens by means of a ZEISS coordinate measuring machine (CMM) to precisely assess the lens surface geometries.

The optical properties that are objectively calculated with this mathematical simulation are then evaluated on the basis of the level of blur as subjectively perceived by the wearer. To quantify the blur of the ophthalmic lens or lens design, a single measure of dioptric blur is calculated point by point for a 50 mm diameter viewing area, combining spherical and astigmatic blur occurring due to off- axis viewing into one blur value using the RMS (root mean-square) Power Error. Based on the blur thresholds described earlier, in a last step of the ZEISS Vision Clarity Simulation, the area of excellent vision clarity in the field of view is quantified as the area of the lens for all eye rotations away from the center, in which the level of blur is below the threshold for "just noticeable blur", i.e. the area of completely unblurred vision and hence excellent vision clarity, where the target is as sharp and as clear as can be. This sophisticated mathematical vision clarity simulation allows ZEISS to quantify the size of the field of view that provides excellent and undisturbed clear vision as experienced by the wearer.

The result of the ZEISS Vision Clarity Simulation can be further translated into visual acuity contour plots, which graphically depict the distribution of optical blur over the lens as seen by the wearer and show the deviation from the ideal central correction towards the lens periphery (Figure 5). White areas on the plot thereby indicate the vision zone with excellent vision clarity, offering excellent, uncompromised visual acuity [6] – which even exceeds the minimum requirements for commercial driving in the European Union (EU), to name just one example.

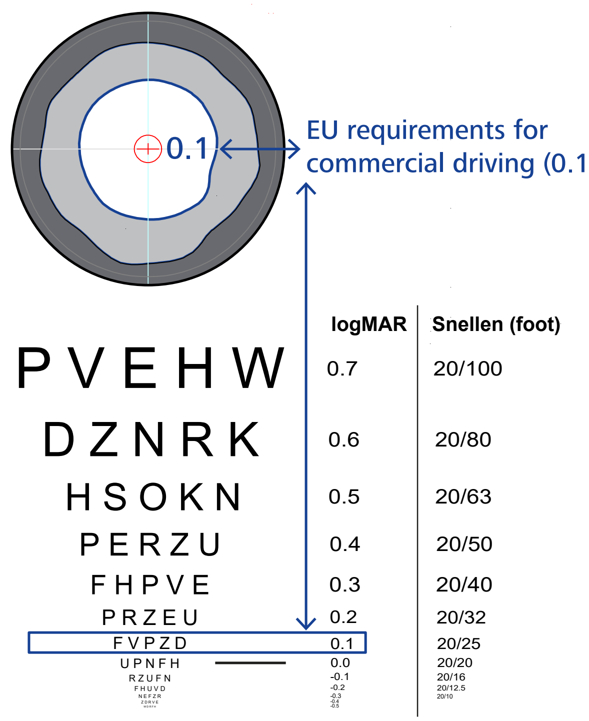


Figure 5. White areas in the visual acuity contour plot indicate the vision zone with excellent vision clarity, which even exceeds the minimum requirements for commercial driving in the European Union (EU).

Benchmarking the vision clarity of typical finished single vision lenses

A detailed assessment of the vision clarity of typical SV lenses based on the ZEISS Vision Clarity Simulation shows most offer less than 50% of the lens area with a zone of excellent vision clarity, and some as low as only 10% (Figure 6).[7] The zone of excellent clear vision is thereby defined as an uninterrupted circular area on the lens providing completely unblurred vision, where a viewed target is as sharp and as clear as can be.

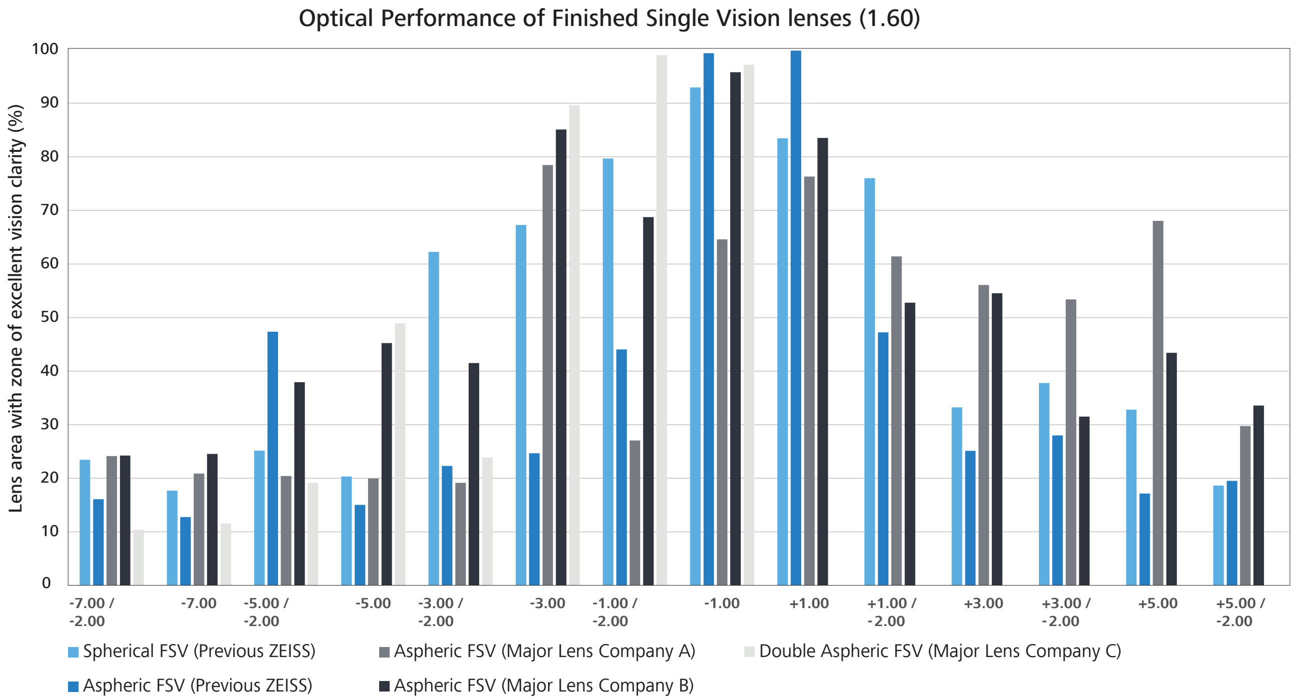


Figure 6. Average percentage share of the total lens area with a zone of excellent vision clarity for typical spherical, aspheric and double aspheric 1.60 finished single vision lenses for minus lenses over a spherical range between -7 and -1 with and without a cylinder of -2 and for plus lenses over a spherical range between +1 and +5 with and without a cylinder of -2 for a lens diameter of 50 mm.

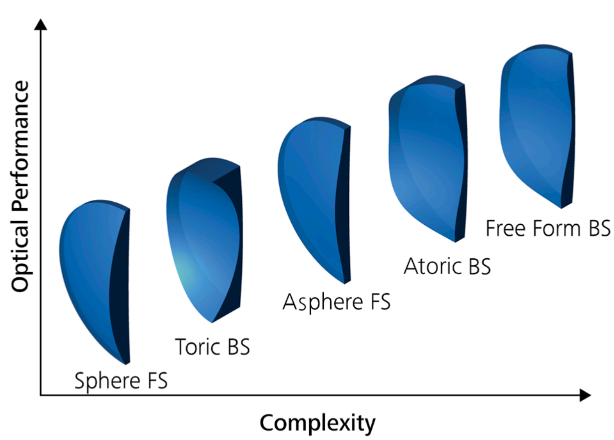
The evolution of single vision lens designs

There are many types of single vision lens designs

But why do many SV lenses perform so poorly with respect to their peripheral optics? The answer lies in the lens design itself. The central power of a lens can be produced by an almost infinite range of lens forms. Lens design choices not only make a big difference in what lens aesthetics and wearing comfort can be achieved, but even more have a significant impact on its optical performance, particularly in the lens periphery. Better optical performance across the entire lens can only be achieved by applying a higher complexity to the lens design optimization (Figure 7).

Spherical (SPH) single vision lenses are typically optimized using only 1 free parameter in the lens center determining the radius of the curvature of the lens surface. This results in optical compromises away from the lens center as peripheral rays are more strongly refracted than rays near the optical axis. The spectacle lens wearer will perceive this aberration as blur, especially when not looking through the optical center of the lens. If using a very high curvature, spherical single vision lenses can also provide good optics for spherical powers but offer poor cosmetics because of their steep profiles (Figure 8).

A flatter lens design must be selected for aesthetic acceptability, but this results in peripheral blur for the wearer. In the end, spherical single vision lenses typically compromise both optics and aesthetics.



Single Vision Lens Design Types	Front Surface Shape	Back Surface Shape	Object Model
Spherical	Sphere	Toric	Single point object model (distance)
Aspheric	Asphere	Toric	Single point object model (distance)
Double Aspheric	Asphere or Sphere	Atoric	Single point object model (distance)
ZEISS ClearView	Very Flat Sphere	Freeform	Single point object model (distance)
ZEISS SmartLife (made to order surfaced SV)	Very Flat Sphere	Freeform using position of wear	3D object model (distance to near)
ZEISS SmartLife Individual (made to order surfaced SV)	Very Flat Sphere	Individualized Freeform using position of wear	3D object model (distance to near)

Figure 7. Overview of relation between complexity and optical performance for typical single vision lens designs (FS, front surface; BS, back surface).

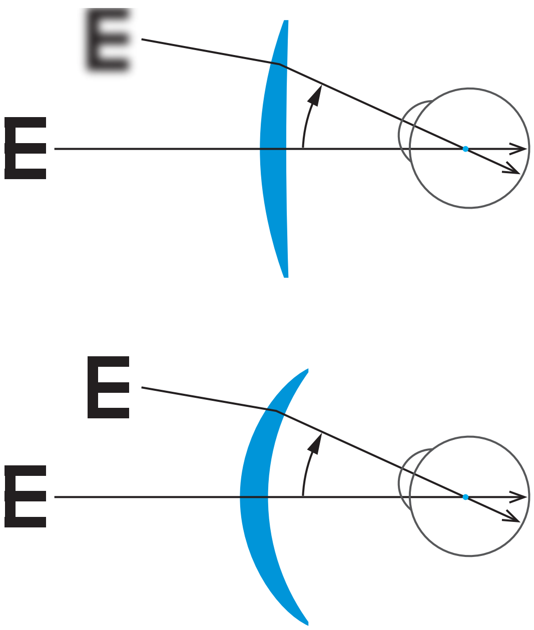


Figure 8. In SPH SV lenses, steeper spherical lens forms are required for sharp peripheral vision, while flatter lens forms produce peripheral blur.

Aspheric (AS) single vision lenses are a more modern design now offered by most lens suppliers and in theory can provide optics as good as spherical single vision lenses, while significantly improving cosmetics. Still being rotationally symmetric, aspherical means that the lens has a more complex shape. One surface, usually the front surface, is non-spherical and typically optimized using 5 free parameters, 1 parameter defining the radius of the curvature in the lens center and 4 aspheric coefficients - but is only optimized in one meridian. In order to eliminate the optical aberrations completely, a unique aspheric lens design would have to be used for each spherical prescription power. Because this is not the case, most sphere powers have unwanted optical aberrations limiting the peripheral vision clarity. Additionally, about 70% of all spectacle lenses incorporate a cylinder correction for astigmatism. In aspheric lenses, the standard toric (two perpendicular spherical shapes) back surface is used for cylinder correction. In this case, the compromise on vision clarity in the lens periphery is even worse, with the front curve selection and aspheric lens designs created for one sphere power only, resulting in an increase in optical aberrations as the cylinder power increases.

Double Aspheric (DAS) single vision lenses - Some lens suppliers now offer double aspheric FSV lenses, whereby the back side of the lens provides cylinder correction using two aspheric shapes perpendicular to each other – often referred to as an atoric surface. The lens is typically optimized using 9 free parameters, 1 defining the radius of the curvature in the center and 4 aspheric coefficients each in of the two perpendicular meridians. The surface between the meridian is typically an arbitrary smooth blend of the one meridian into the other.

Depending on the specific design details, compared to aspheric single vision lenses optimized in only one meridian, double aspheric FSV can be an improvement. However, blending in between the two perpendicular meridians leads to optical errors for peripheral viewing when compared to freeform lens designs where some hundreds of points across the entire lens surface can be specifically optimized.

In conclusion: Spherical, aspheric and double aspheric lens designs do not adequately address the peripheral optics of most prescriptions, especially those with cylinder power.

Freeform (FF) single vision lens designs - More recently, when ZEISS pioneered freeform technology for ophthalmic lenses, freeform single vision surfaced lenses could overcome these problems, using more complex shapes.

Freeform technology means that the lens shape can be perfectly optimized to give the best optics for each individual prescription while delivering very flat and thin lenses - no more compromise. This resulted in a new class of single vision lenses. Depending on the market these products are called Freeform, Digitally surfaced, or HD Single Vision lenses – and have been available only as a made-to-order surfaced lens.

ZEISS SmartLife Single Vision lenses are the most modern and sophisticated example of freeform single vision lenses. The SmartLife SV design incorporates a 3D object model that requires knowledge of factors such as lens orientation and position of wear. The Individual version of the SmartLife design even incorporates the individualized parameters of the actual wearer in the freeform lens design, allowing an extra level of lens optimization. These are variables not possible to account for in single vision lenses that are pre-made without infinite variants held on stock.

ZEISS ClearView Single Vision lenses

ZEISS decided to re-examine industry practices in single vision, challenging why the majority of single vision wearers, namely those who receive standard single vision lenses could not get many of the visual benefits of freeform lens design. ZEISS has now identified a way to get these complex freeform lens designs into standard single vision, whether in FSV or surfaced SV lenses that are easy to fit without compensated Rx values. Whether delivered by FSV or surfaced SV , the advanced freeform lens design in ZEISS ClearView SV uses point-by-point optimization of the lens surface. The lens power is optimized using 700 free parameters across one entire quadrant of the lens, which is then mirrored two times to cover the entire lens surface. Complete optimization of one quadrant is the maximum possible in a pre-made lens design

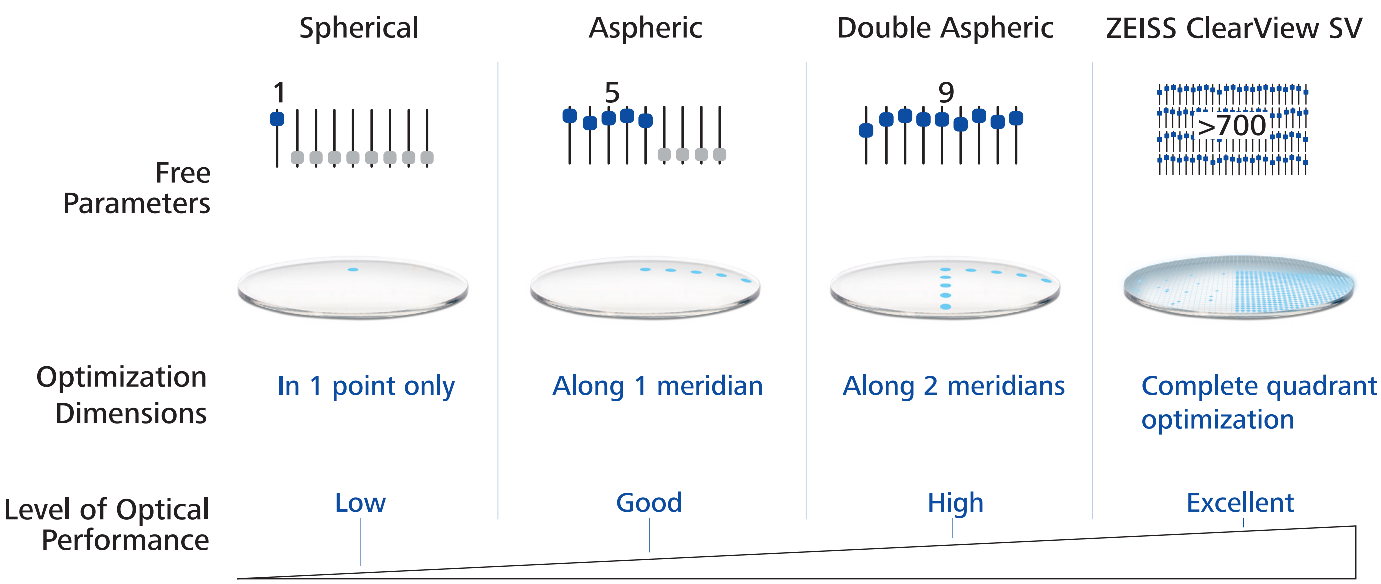


Figure 9. Overview of principles of lens design optimization for SPH, AS, DAS and ZEISS ClearView SV.

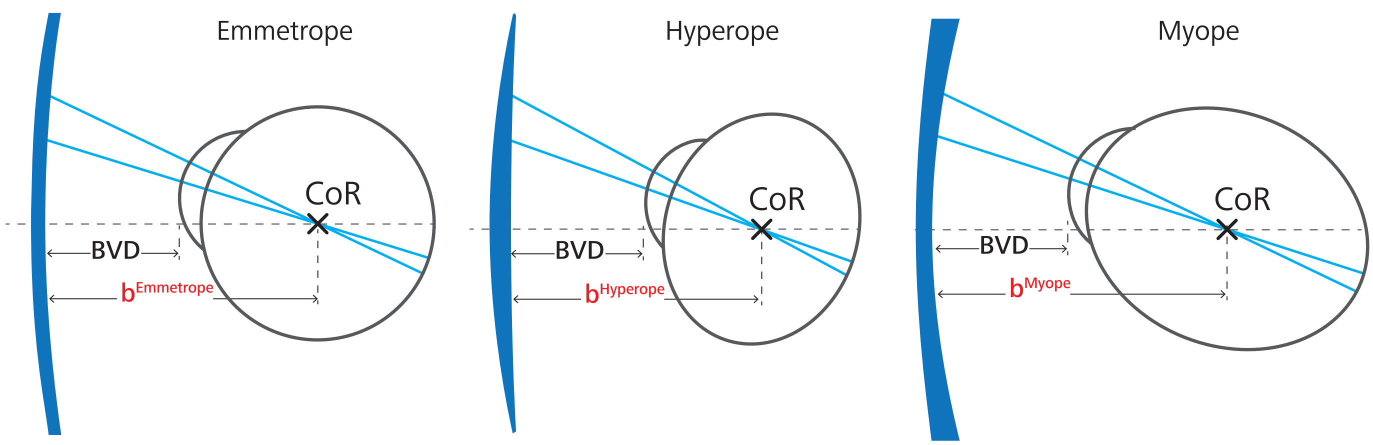


Figure 10. Due to difference in eyeball geometry between emmetropes, hyperopes and myopes, the eye's center of rotation (CoR) varies by prescription. The total distance between the back vertex of the eyeglass lens and the CoR (b') is relevant for the optimization of spectacle lenses.

without knowing the exact orientation for the final fitted lens (Figure 9). The result is a SV lens that is both very flat and thin and achieves excellent optics – with clear viewing from the lens center to the periphery.

CORE technology

The geometry of eyeballs differs from individual to individual. A high myope typically has a 4 mm longer eyeball than someone with perfect vision. Importantly this means that the location of a special point in the eye – its center of rotation (CoR) – also varies by prescription (Figure 10). Using an accurate position of the CoR for the lens design optimization plays a key role for the visual comfort of the wearer – in particular allowing them to see more clearly in the lens periphery.

ZEISS uses its medical and optical expertise to understand how the CoR changes by prescription. It is calculated by prescription using a patented algorithm, generated from more than 300 precise patient measurements. The change in CoR location from high plus through to high minus lenses is taken into account in the lens design with CORE technology.

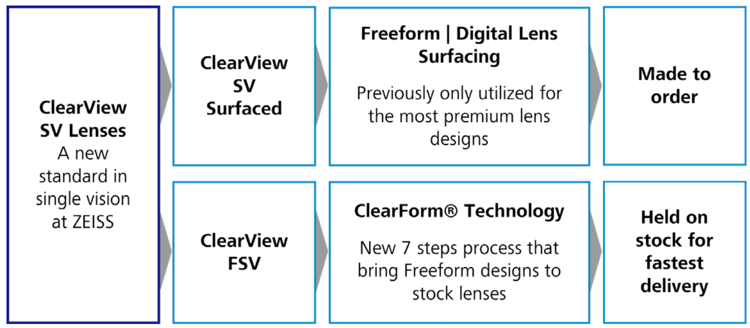
CORE technology is standard in ZEISS premium Rx lens designs. With ZEISS ClearView SV lenses, in both FSV and surfaced SV, CORE technology available for the first time to the standard Single Vision lens category. This complexity is now possible to be fully incorporated into a FSV lens or non-compensated surfaced SV lens due to the use of a freeform lens design with the resulting higher level of surface complexity.

Introducing ClearForm® technology by ZEISS

ZEISS ClearView SV lenses can be delivered by two methods.

I. **Surfaced ClearView SV lenses** are made to order, produced using the latest Freeform Rx lens surfacing equipment, previously used only for the most premium lens categories - now utilized and embraced in the standard single vision category. This equipment is becoming increasingly common in the ophthalmic industry, however it does little good to make a SPH or AS lens design with this equipment, the optical benefit only comes when in combination with a more sophisticated freeform lens design – like ZEISS ClearView.

II. **ClearView FSV lenses** are produced to stock, and held in ZEISS market stocking points, or at customer locations, meaning faster delivery time to customers. The innovation in ZEISS ClearView FSV lenses is perhaps even more remarkable. An innovative production method from ZEISS called ClearForm® technology – is the process which brings a freeform lens design into a finished stock lens. This ClearForm® technology is possible thanks to extensive collaboration between ZEISS global centers of excellence. Lens design and industrial metrology in the ZEISS headquarters in Germany, freeform mold generation in ZEISS's European glass mold making center of excellence, and casting development collaboration between international R&D and manufacturing locations.



ClearForm® technology by ZEISS

ZEISS has developed a special manufacturing method that enables complex Freeform lens designs to be delivered in FSV lenses - ZEISS calls this special advancement ClearForm® technology. This technology is possible thanks to extensive collaboration between ZEISS global centers of excellence. Lens design and industrial metrology in the ZEISS headquarters in Germany, Freeform mold generation in ZEISS's European glass mold making center of excellence, and casting development collaboration between international R&D and manufacturing locations.

The ClearForm® technology can be summarized by seven steps:

1. ClearView "Freeform" lens design (Figure 11) - Optical lens design experts in ZEISS R&D use complex mathematical simulation tools to design the sophisticated freeform optics in ZEISS ClearView lenses. Surface shapes are optimized using >700 free calculation parameters – producing much more complex lens surface shapes than those used in spherical or aspheric single vision designs. The complex ClearView lens surface design is transferred into mold designs required in use in the FSV manufacturing process.

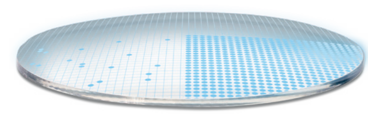


Figure 11 Lens surface shape are optimized with >700 free calculation parameters.

2. Freeform glass mold making (Figure 12) - Computer numerically controlled (CNC) freeform mold generators use special cutting tools that contain millions of diamond particles. These can produce virtually any mold shape in optical glass with a very high degree of accuracy. The worked mold surface is then polished to a very high luster using high-speed rotating polishing spheres, to ensure the final cast lens will be of the highest optical quality.

Figure 12. The highly complex ZEISS ClearView lens design is incorporated into the lens molds using CNC generators using grinding tools containing millions of diamond particles.

3. Mold metrology (Figure 13) - Using ZEISS' industrial metrology expertise, final molds are checked for accuracy and precision with ZEISS coordinate measuring machines (CMM) where over 1500 points on the surface of each mold are analyzed and checked to match the theoretical freeform design.

Figure 13 ZEISS coordinate measuring machines (CMM)

4. Specialized mold pairing & filling (Figure 14)- For each prescription/SKU, front and back molds are paired and assembled together. The molds incorporate 2D Data Matrix Codes (DMC) as part of an industry 4.0 manufacturing process that tracks molds, lenses and quality systematics. The mold assemblies are filled with UVProtect or BlueGuard lens liquid monomers across multiple refractive indicies.

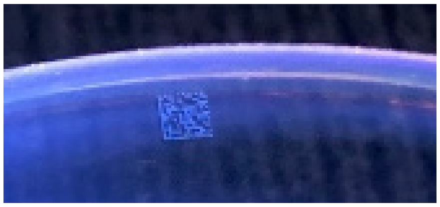


Figure 14. Data Matrix Code (DMC) at the very edge of the final uncut lens.

5. Polymeric thermal cure (Figure 15) - Specially developed thermal "curing" processes are used to turn the liquid monomers into optical grade polymer materials. Controlling precisely the different chemical curing reaction kinetics for each material is critical to ensure the optical shape is perfectly transferred from the mold to the final cast lens without error or distortion. After the curing cycle that takes up to 2 days is complete, the glass molds are removed and the lens shape is now set.

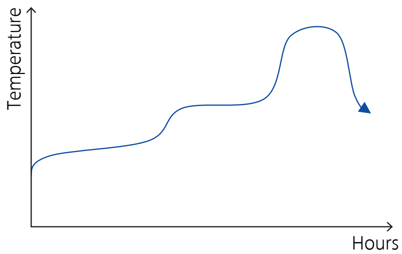


Figure 15. Thermal "curing" process

6. Hard and anti-reflective coatings (Figure 16) - The lenses are coated with a tough and abrasion resistant hard-coating. ZEISS DuraVision anti-reflective coatings are then deposited in vacuum chambers. Ion bombardment is used to deliver densely packed coating layers. This combination of state-of-the-art hard coat and AR technology ensure excellent coating performance and long-lasting durability.

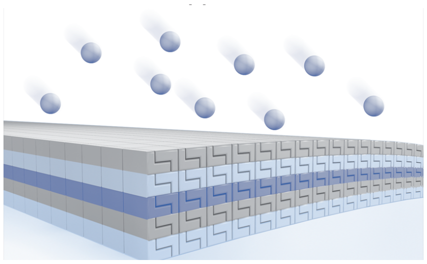


Figure 16. Ion bombardment to deliver densely packed coating layers.

7. Final lens optical check - The precise surface geometries of the finished lens are checked at over 1500 points by ZEISS CMM equipment and then used in optical ray path simulations to ensure the finished lens delivers on the superior optical promise required of ZEISS ClearView FSV lenses.

ZEISS ClearView Finished Single Vision lenses provide a 3x larger zone of excellent vision clarity

The optical performance of ZEISS ClearView FSV lenses was analyzed based on the ZEISS Vision Clarity Simulation to guarantee that the lenses deliver the high optical performance they were designed for.

This analysis comprehensively shows that over a range of minus and plus prescriptions, ZEISS ClearView FSV lenses provide on average a 3 times larger zone of excellent vision clarity when compared to regular ZEISS Aspheric FSV lenses, with a maximum improvement of over 5 times.[8] This means clear vision over a larger area of the lens for all single vision wearers, allowing more comfortable vision and leading to satisfied wearers.

The zone of excellent clear vision is thereby defined as a continuous circular area of unblurred vision on the lens – below the threshold for just noticeable blur. Figure 17 shows two example plots of the simulated vision clarity levels for a 1.60 index ZEISS ClearView FSV lens with and without cylinder, compared to a regular 1.60 Index ZEISS Aspheric FSV. In this example the ZEISS ClearView FSV offer a 3 (with cylinder) to 4 (without cylinder) times larger zone of excellent vision clarity as shown by the white areas on the lens plot.

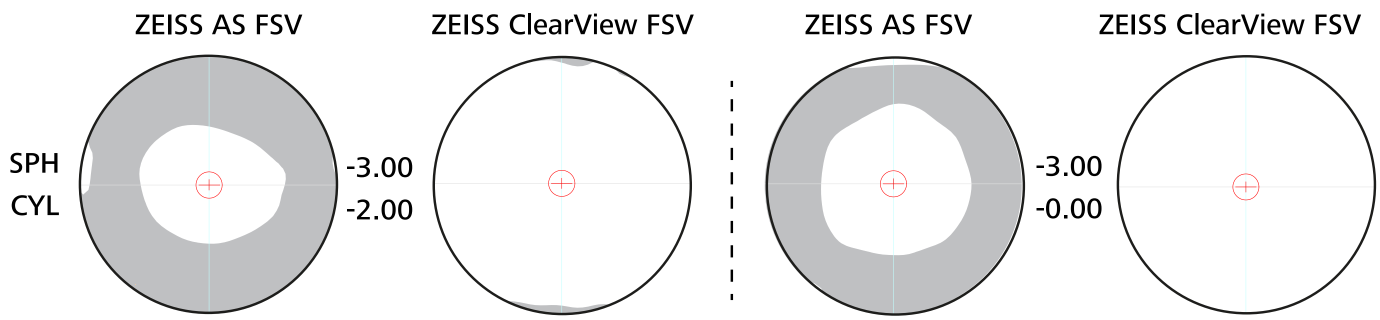


Figure 17. ZEISS ClearView FSV provide on average 3 times larger zones of excellent vision clarity than ZEISS AS FSV as shown by the white areas on the simulated vision clarity lens plot.

On average, ZEISS ClearView FSV lenses offer a 3.1 times larger area with a zone of excellent clear vision when compared to previous ZEISS AS FSV lenses, with up to a 4.0 times larger area for higher myopic prescriptions, and up to a 5.1 times larger area for higher hyperope prescriptions.[8]

% Lens Area with zone of excellent clear vision	ZEISS ClearView 1.6 FSV		ZEISS AS 1.6 FSV		Comparison
	cyl: 0.00 D	cyl: -2.00 D	cyl: 0.00 D	cyl: -2.00 D	
sph: +5.00	94%	93%	17%	20%	5.1 x larger area
sph: +3.00	100%	100%	25%	28%	3.8 x larger area
sph: +1.00	90%	94%	100%	47%	1.3 x larger area
sph: -1.00	99%	94%	99%	44%	1.3 x larger area
sph: -3.00	100%	75%	25%	22%	3.7 x larger area
sph: -5.00	78%	65%	15%	47%	2.3 x larger area
sph: -7.00	59%	56%	13%	16%	4.0 x larger area
Overall Average: ZEISS ClearView 1.6 FSV vs ZEISS AS 1.6 FSV					**3.1 x larger area**

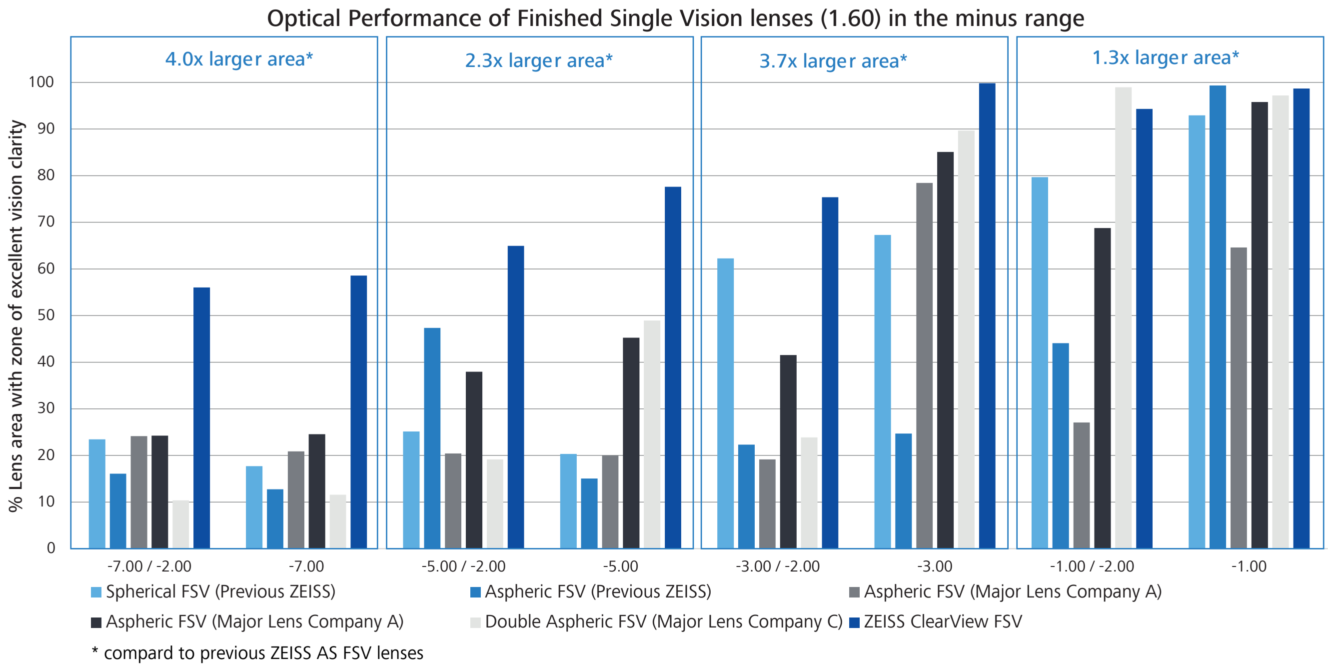


Figure 18. Average percentage share of the total lens area with a zone of excellent vision clarity for ZEISS ClearView FSV and typical spherical, aspheric and double aspheric in 1.60 finished single vision lenses for minus lenses over a spherical range between -7 and -1 with and without a cylinder of -2 for a lens diameter of 50 mm.

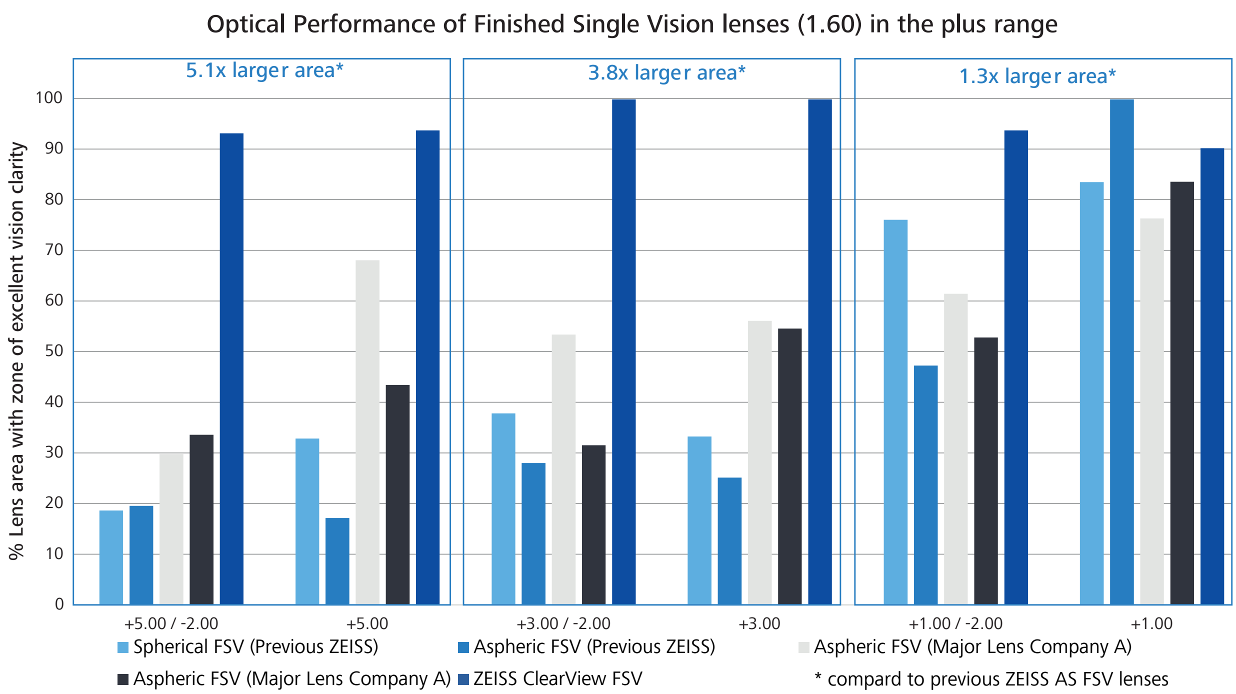


Figure 19. Average percentage share of the total lens area with a zone of excellent vision clarity for ZEISS ClearView FSV and typical SPH, AS and DAS in 1.60 finished single vision lenses for plus lenses over a spherical range between +1D and +5D with and without a cylinder of -2D for a lens diameter of 50 mm.

ZEISS also double checked the performance of ZEISS ClearView FSV lenses compared to FSV lenses from other major branded lens companies. Similar magnitudes of performance improvement can be seen for ZEISS ClearView FSV relative to AS and DAS FSV lenses from other major branded lens companies.[8], [9] Detailed results for minus and plus lenses are shown separately for easy viewing and relevance to Myopes and Hyperopes (Figure 18 and Figure 19).

Reduced Optical Distortion

In addition to less optical blur, ZEISS ClearView SV lens designs also provide reduced peripheral distortion compared to standard SPH or AS single vision lenses. The total magnitude of the distortion effects in the lens design of ZEISS ClearView compared to typical single vision lens designs was summarized by ZEISS lens designers. Based on simulation calculations on different types of distortion typically encountered by spectacle lens wearers, ZEISS ClearView lens designs showed on average over 4% less skew and swim distortion than a regular SPH SV lens and 10% less than a regular AS SV lens.[11]

Thinner Lenses

With ZEISS ClearView SV lenses, wearers can experience excellent vision clarity in a lens that is flatter and thinner than conventional lenses that rely on steeper base curves to provide acceptable optical performance. Freeform SV lens designs with point-by-point optimization provide a thickness reduction at the lens edge for minus lenses.

Across the range of plus lenses, which are thicker in the lens center, 1.60 ZEISS ClearView FSV is on average 8% thinner at the lens center, and up to 13% thinner at the lens center for +5.00 D sphere power, when compared to 1.60 ZEISS SPH FSV (Figure 19).[12]

Flatter Lenses – with no optical compromise

The technology advances in ZEISS ClearView SV also allow for flatter more attractive lenses, by reducing the curvature without compromising vision clarity in the lens periphery. In the FSV form this results in on average 34% flatter lenses across all prescriptions; with up to 49% flatter lenses for the minus range; and up to 25% flatter lenses for the plus range, when compared to ZEISS SPH 1.6 FSV (Figure 20).[13]

In summary, across the entire power range assessed, ZEISS ClearView FSV lenses are 34% flatter and up to 16% thinner compared to typical SPH SV lenses, while delivering the highest level of vision clarity.

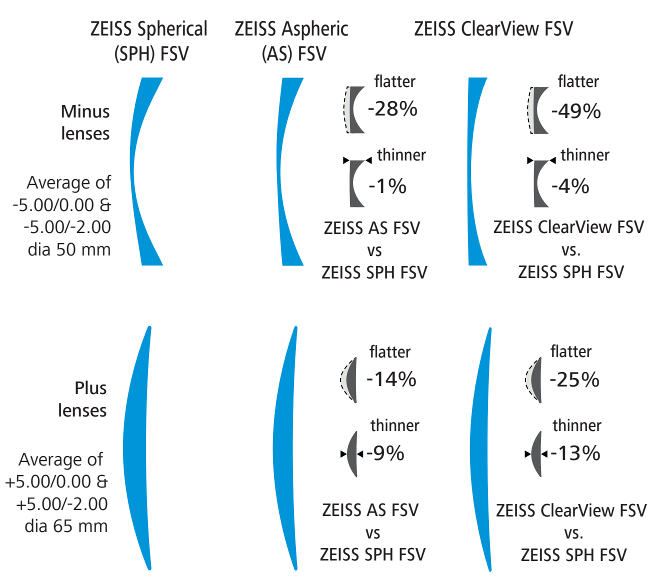


Figure 20. Values for lens flatness and lens thickness of ZEISS ClearView 1.60 FSV and ZEISS AS 1.60 FSV compared to ZEISS SPH 1.60 FSV averaged for -5 D and +5 D with and without cylinder of -2 D.

Single vision lens wearers confirm the difference

Larger zones of excellent clear vision allow higher levels of visual acuity[14] across the entire viewing zone for the wearer, meaning single vision wearers will see more clearly and be more comfortable wearing ZEISS ClearView SV lenses than standard SV lens designs. This was confirmed firstly by a small blind test wearer trial[15], and subsequently by a much larger and independently run double blind wearer trial run by an eye hospital.[16] These wearer trials evaluated the subjective impression of vision clarity, vision comfort, preference and satisfaction.

Wearer Trial 1 - Nineteen single vision lens wearers aged between 30 and 45 were equipped with two pairs of eyeglasses, ZEISS ClearView SV and ZEISS AS FSV lenses. Both pairs of lenses were the same nominal prescription value, fitted in identical frames. Study participants were not aware which lens type was included in which frame in order to collect an unbiased opinion on product performance. They were then asked to rate their experiences both in a laboratory setup with defined viewing scenarios to assess the central and peripheral vision clarity at various viewing distances (near, intermediate, distance) and after 1 week of wearing both lenses in their everyday life.

After 1 week of wear, 78% of study participants preferred the vision performance of ZEISS ClearView compared to ZEISS AS FSV (Figure 21). Moreover, 89% of wearers strongly agreed or agreed that they had experienced all day visual comfort with ZEISS ClearView.

Already immediately after receiving the lenses, by 2 to 1 single vision lens wearers preferred ZEISS ClearView for seeing clearly across the entire lens when compared to wearing ZEISS AS FSV lenses in visual testing scenarios for near, intermediate and distance vision. 89% of study participants rated the immediate impression with ZEISS ClearView as good or very good.

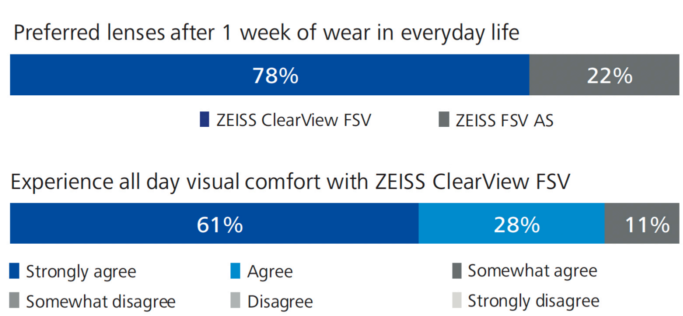


Figure 21. Single Vision lens wearers prefer ZEISS ClearView lenses over ZEISS AS FSV lenses after 1 week of wear in their everyday life.

Independent double blind wearer trial

In a larger double-blind test, externally run by a leading eye hospital, SV wearers were equipped with 2 pairs of eyeglasses – ZEISS ClearView FSV and ZEISS AS FSV in the same frames. Neither participant nor the dispenser knew which pair was which lens design. Across 185 SV wearers, in all of the 19 tested viewing scenarios ClearView was preferred, for clear vision across the lens, comfort, and general preference. As the refractive power of the lens increased, the relative preference for ClearView was even greater. Wearers with prescriptions with:

- Moderate cylinder (1.25 D to 3.00 D) ClearView preferred by 2:1 (67%) to AS FSV
- Moderate sphere power (< -5.00 D) ClearView preferred by almost 2:1 (62%) to AS FSV
- In the group of wearers with both moderate sphere and cylinder power, this preference increased to 87% to AS FSV

Many eye care professionals might find these real preference result surprising for the “simple” single vision category.

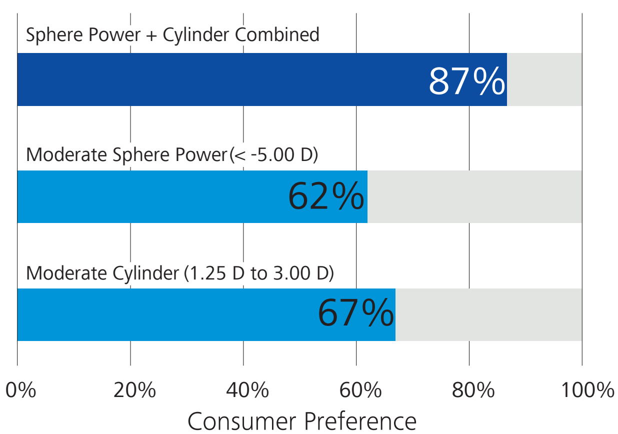


Figure 22. Results of independet double blind wearer trial - ZEISS ClearView FSV and ZEISS AS FSV.

ZEISS ClearView SV - same fitting as for Aspheric Single Vision

For optimal performance, the optical center of the lens needs to be centred on the wearer’s pupil. To this effect, measure the fitting height to the pupil center according to the horizontal viewing line and reduce it by 0.5 mm per degree of pantoscopic tilt.

Key Takeaways

- Standard SV lenses, and in particular FSV lenses are the most sold lens type globally due to their advantages in delivery time and cost. Standard single vision lens designs such as Spherical and Aspheric lenses typically have optical compromises due to design limitations. Typical SV lenses, offer on average < 50% of the lens area with a zone of excellent vision clarity.
- Breaking the compromise between flat lens designs, and great optics. ZEISS ClearView SV deliver on both aesthetics and optics. Whether delivered by FSV or as a surfaced SV, ZEISS ClearView SV lenses are very thin and flat, this is now possible without optical compromise due to the revolutionary Freeform optics included.
- SV lens designs have a long history, spherical, aspherical or double aspheric are typical but have major drawbacks, especially when the lens is made flatter as is demanded by consumer preference.
- ZEISS ClearView SV lenses with freeform optics now available in the standard single vision category, thanks in particular to the optical breakthrough of ClearForm® manufacturing technology.
- 3x larger zone of excellent vision clarity when compared to ZEISS AS FSV lenses.
- 34% flatter and up to 16% thinner compared to ZEISS SPH FSV lenses.
- Blind testing, including that run by an external eye hospital, demonstrates that single vision lens wearers experience clarity, visual comfort, and prefer wearing ZEISS ClearView SV to ZEISS AS SV lenses.
- ZEISS ClearView SV lenses are an easy way for optical retailers to differentiate from their competition, in the most sold ophthalmic lens category of standard SV.

[1] *Strategy with Vision (September 2020). World Lens and Frame Demand Study 2020.*

[2] *Study participants were asked to rate how important different aspects ("price", "to see clearly across the entire lens", "easy to adapt to", "comfortable vision across the entire lens", "aesthetics", "available coatings", "matches the frame") are for them, when choosing new spectacle lenses. Wearer trial comparing 1.60 ZEISS ClearView FSV and 1.60 ZEISS AS FSV in a laboratory setup and in everyday life. N=20 study participants. Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020.*

[3] *D. A. Atchison, S. W. Fisher, C. A. Pedersen and P. G. Ridall, "Noticeable, troublesome and objectionable limits of blur," Vision Research, vol. 45, no. 15, pp. 1967-1974, 2005.*

[4] *D. A. Atchison, H. Guo, W. N. Charman and S. Fisher, "Blur limits for defocus, astigmatism and trefoil," Vision research, vol. 49, no. 19, pp. 2393-2403, 8 2009.*

[5] *H. Guo and D. A. Atchison, "Subjective Blur Limits for Cylinder," Optometry & Vision Science, vol. 87, no. 8, pp. E549-E559, 2010.*

[6] *Excellent visual acuity & visual acuity levels shown in the contour plot are relative to the best corrected visual acuity of the individual wearer. For every person, the achievable visual acuity is determined by inherent anatomical and physiological characteristics of the individual human eye. For reconstruction of plus lenses, a 0.5 D accommodation was taken into consideration as some of the residual optical error can be accommodated by hyperopic wearers.*

[7] *Based on a visual clarity simulation on a 50 mm diameter lens area for 1.60 index typical branded finished single vision lenses. Average of +5 D, +3 D, +1 D, -1 D, -3 D, -5 D, and -7 D with and without a cylinder of -2 D. Quantitative analyses by Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020-2021.*

[8] *Based on a visual clarity simulation on a 50 mm diameter lens area for 1.60 index ZEISS ClearView FSV lenses compared to 1.60 ZEISS AS FSV lenses. Average of +5 D, +3 D, +1 D, -1 D, -3 D, -5 D, and -7 D with and without a cylinder of -2 D. Quantitative analyses by Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020.*

[9] *Based on a visual clarity simulation on a 50 mm diameter lens area for 1.60 index ZEISS ClearView Finished Single Vision lenses and typical branded finished single vision lenses. Average of -1 D, -3 D, -5 D, and -7 D with and without -2 D cyl. Quantitative analyses by Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020..*

[10] *Based on a visual clarity simulation on a 50 mm diameter lens area for 1.60 index ZEISS ClearView Finished Single Vision lenses and typical branded finished single vision lenses. Average of +1 D, +3 D, and +5 D with and without -2 D cyl. Quantitative analyses by Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020.*

[11] *Results based on simulation calculations for distortion parameters in 1.60 index ZEISS ClearView Finished Single Vision lens designs compared to measured ZEISS 1.60 Aspheric Finished Single Vision lenses and ZEISS 1.60 Spherical Finished Single Vision lenses. Average of +6 D, +3 D, 0 D, -3 D, -6 D with and without -2 D cyl. Quantitative analyses by Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020.*

[12] *Measurements of lens thickness on 1.60 ZEISS ClearView FSV lenses compared to ZEISS spherical FSV lenses over a range of prescriptions (-5, -3, -1, +1, +3, +5 D with and without cyl -2 D). Maximum reduction of 16% for center thickness of +5.00/-2.00. Quantitative analyses by Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020.*

[13] *Measurements of lens flatness (base curve) on 1.60 ZEISS ClearView FSV lenses compared to ZEISS Spherical FSV lenses. Average of -5, -3, -1, +1, +3, +5 D with and without cyl -2 D. Maximum reduction of 49% of -5.00 D with and without -2 D cyl for minus lenses. Maximum reduction of 25% of 5.00 D with and without -2 D cyl for plus lenses. Quantitative analyses by Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020.*

[14] *Visual acuity levels are relative to best-corrected visual acuity of the individual wearer.*

[15] *Internal wearer trial comparing 1.60 ZEISS ClearView SV and 1.60 ZEISS AS FSV in a laboratory setup and in everyday life. N=20 study participants aged between 30 and 45 (power range between -7.75 D and +2.50 D with 0D to -2.75 D cyl). Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2020.*

[16] *External wearer trial 2021, comparing 1.60 ZEISS ClearView FSV and 1.60 ZEISS AS FSV by Tianjin Eye Hospital, Tianjin, China, test in laboratory setup and feedback on everyday life use. N=185 study participants aged between 19 and 42 (power range between -8.00 D and +1.25 D with 0D to -3.00 D cyl). 58 wearers with average sphere power < -5.00 D, 33 wearers with average cyl power below -1.25, and 15 wearers with prescriptions below -5.00D sph and -1.25 D cyl. Technology & Innovation, Carl Zeiss Vision GmbH, DE, 2 021.*

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Seeing beyond