# Zeiss Individual™ Progressive Lenses:

## The Optics of Truly Customized Progressive Lenses

**By Darryl Meister, ABOM**

*"Free-form" or "direct surfacing" technology holds the potential to free eyeglass wearers from the optical compromises of traditional, mass-produced progressive lenses. Carl Zeiss Vision—one of the earliest pioneers in this exciting technology—offers the first progressive lens to integrate an extensively customized lens design with an exclusive fabrication process. Using a sophisticated online calculation engine and patented free-form technology, Zeiss Individual takes personalization to the highest level by precisely personalizing every lens for each wearer's exact prescription requirements, fitting geometry, and frame size.*

## Limitations of Traditional Progressive Lenses

Carl Zeiss Vision offers some of the most advanced progressive lens designs available today. The superior optical performance of ZEISS's acclaimed progressive lenses is achieved through a sophisticated approach to optical design that relies on first managing the global geometry of the lens design to ensure excellent ergonomic utility for the wearer, and then precisely refining the optics of the lens design on a point-by-point basis to deliver the widest, clearest fields of vision possible.

No matter how sophisticated in design, however, traditional progressive lenses cannot account for the visual requirements of individual wearers. Traditional progressive lenses are produced from *semi-finished* lens blanks that are factory-molded in mass quantity. Each lens design is typically available in twelve addition powers per eye, in up to a dozen lens materials, resulting in hundreds of lens blanks for each base curve offered. A second, "short-corridor" version of the lens doubles the total number of lens blanks needed. Hence, traditional, semi-finished progressive lenses necessitate massive product development and inventory costs.

Consequently, changes to the basic lens design of these progressive lenses are limited to subtle variations in optical design across a handful of base curves that must work sufficiently well over the relatively broad prescription ranges associated with each. Traditional progressive lenses are therefore designed for a few "average" prescription powers, using "average" fitting parameters, for either "standard" or "small" frame sizes. This results in optical compromises for many wearers, preventing them from enjoying the best possible vision. Additionally, these compromises impose limits on the adaptation rates of traditional progressive lenses.

No single progressive lens design will deliver optimum performance for every possible combination of prescription, fitting, and frame size values. Each prescription requires a unique optical design to fully eliminate *lens aberrations*, which represent departures from the desired prescription. Factors such as the position of the fitted lens can introduce additional power errors. Moreover, unless the corridor length of the lens design matches the ideal length associated with a given frame, visual utility is further compromised.

Although certain wearers may enjoy the intended optical performance in traditional progressive lenses, many wearers must tolerate reduced performance (Figure 1). Performance and wearer satisfaction can be maximized, however, if the optics of the progressive lens design are suitably tailored to the unique visual requirements of the individual wearer. Zeiss Individual delivers this ideal progressive lens performance for each wearer by employing the full potential of free-form manufacturing with proprietary design and processing technologies.

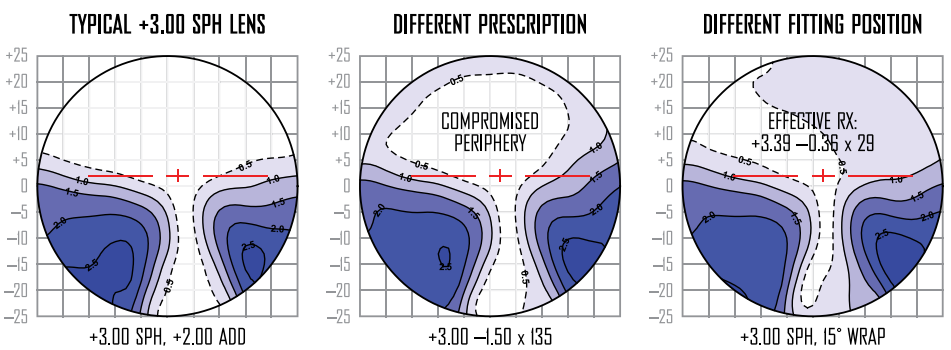



*Figure 1. Plots of ray-traced astigmatism demonstrate that the optical performance of progressive lenses is sensitive to the prescription and position of the fitted lens.*

ZEISS

# "Real-Time" Optical Design

» Zeiss Individual lenses integrate free-form technology with "real-time" optical design.

The advent of "free-form" surfacing technology has freed lens designers at Carl Zeiss Vision from the constraints of traditional mass lens production by enabling optical laboratories to deliver progressive lenses that have been designed and produced "on demand" for a specific wearer. Unlike traditional lens manufacturing, free-form surfacing allows complicated lens designs to be surfaced directly onto a lens blank using an extremely accurate, computer-controlled multi-axis generating and polishing system. When this technology is utilized in conjunction with optical design software capable of designing progressive lenses on the fly, it becomes possible to match the optics of each progressive lens exactly to the visual requirements of the individual wearer just prior to fabrication.

Zeiss Individual represents a revolutionary breakthrough in the integration of these advanced technologies. Zeiss Individual is uniquely designed for each wearer using Carl Zeiss Vision's proprietary optical design engine and patented free-form technology.[1,2] Using parameters supplied by the eye care professional, including the wearer's prescription, fitting geometry, and frame information, this powerful optical design engine performs complex calculations online in a centralized server computer. Each lens design is dynamically manipulated in "real time" by this powerful optical design engine using data specific to the wearer in order to create a truly unique and fully customized progressive lens design. The final lens calculations are then transmitted to state-of-the-art free-form surfacing equipment for fabrication using Carl Zeiss Vision's exclusive Precise-Form™ technology (Figure 2).

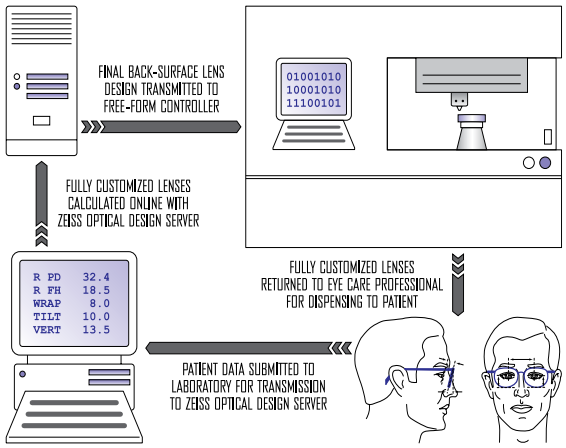



*Figure 2. Carl Zeiss Vision's patented free-form technology incorporates a powerful optical design engine that custom-designs each progressive lens online in real time, before transmitting the final lens calculations to a precision free-form generator.*

This online optical design process begins by managing the global geometry of the lens design. The ideal corridor length for the wearer's chosen frame style and fitting height is calculated in order to maximize the utility of the central viewing zones while maintaining smooth transitions in power and astigmatism. This avoids rapid changes in power and astigmatism, which would otherwise result in excessive image swim as well as greater levels of certain *high-order* wavefront aberrations, including *coma* and *trefoil*. The inset of the progressive corridor and near zone is also precisely calculated using the wearer's interpupillary distances, prescription, reading distance, and even the position of each lens.

Next, the optical performance of the lens design is carefully refined during a sophisticated optical optimization process. Using computer ray tracing, the *low-order* wavefront aberrations produced by the wearer's specific prescription values and fitting parameters are calculated, including unwanted *astigmatism* and *defocus* caused by incorrect addition power. The initial optical performance of the calculated lens is then compared against the performance of the ideal or "target" lens, while the optics of the actual lens design are optimized on a point-by-point basis, using complex asphérization algorithms, until the final lens reproduces the desired optical performance of the target lens as closely as possible (Figure 3).

The real-time optical optimization and management utilized for Zeiss Individual lenses ensures that every wearer enjoys the best vision possible. By customizing each lens design for the wearer's exact prescription, fitting, and frame data, every lens will faithfully preserve the intended optical performance. Therefore, wearers will no longer have to tolerate the various optical compromises that are characteristic of traditional, mass-produced progressive lenses.

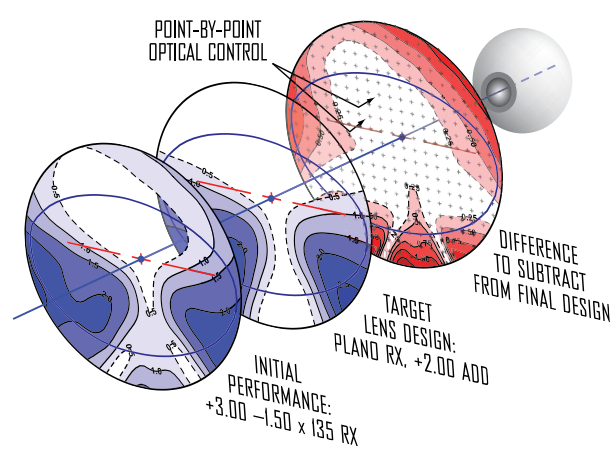



*Figure 3. Using the wearer's exact prescription and fitting requirements, a powerful optical design engine manipulates the optics of each Zeiss Individual lens design by applying complex asphérization algorithms on a point-by-point basis.*

# Total Aberration Control for Any Wearer

» Reduced high-order and low-order wavefront aberrations

Lens designers at Carl Zeiss Vision have long understood the importance of minimizing the progressive surface characteristics associated with both low-order and high-order wavefront aberrations. Carl Zeiss Vision's powerful optical design engine offers total control of the most visually detrimental aberrations by carefully defining the global geometry of the lens design and then precisely fine-tuning the optics of the design on a point-by-point basis across the entire lens. This allows every wearer to enjoy the clearest, most comfortable vision possible (Figure 4).

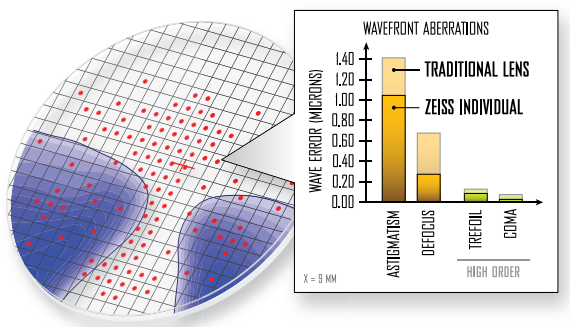



*Figure 4. Wavefront aberrations are minimized with every Zeiss Individual lens by precisely fine-tuning the optics at numerous points across the entire lens.*

Zeiss Individual has been designed with exceptionally smooth transitions in power and astigmatism, which serve to minimize high-order aberrations across the lens. Smooth transitions in power and astigmatism also minimize distortion and image swim. Moreover, Zeiss Individual employs a variable corridor length to ensure that these power transitions are never any greater than necessary for a given frame size. In fact, the average error produced by high-order aberrations over the new Zeiss Individual lens is actually smaller than the average error produced by a recently introduced, so-called "wavefront-enhanced" progressive lens (Figure 5).*

Furthermore, Carl Zeiss Vision's optical design engine places an even greater emphasis on minimizing the low-order aberrations produced by the wearer's prescription and fitting geometry, including astigmatism and defocus. These low-order aberrations are generally more detrimental to vision quality in progressive lenses.[3] Because Zeiss Individual is fully customized for each wearer, these low-order aberrations are minimized in every lens, regardless of the wearer's prescription or fitting geometry (Figure 6).

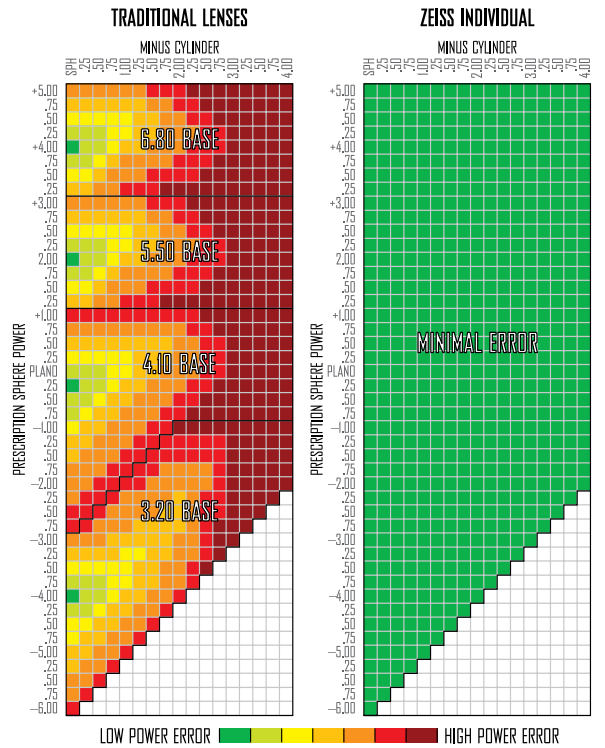
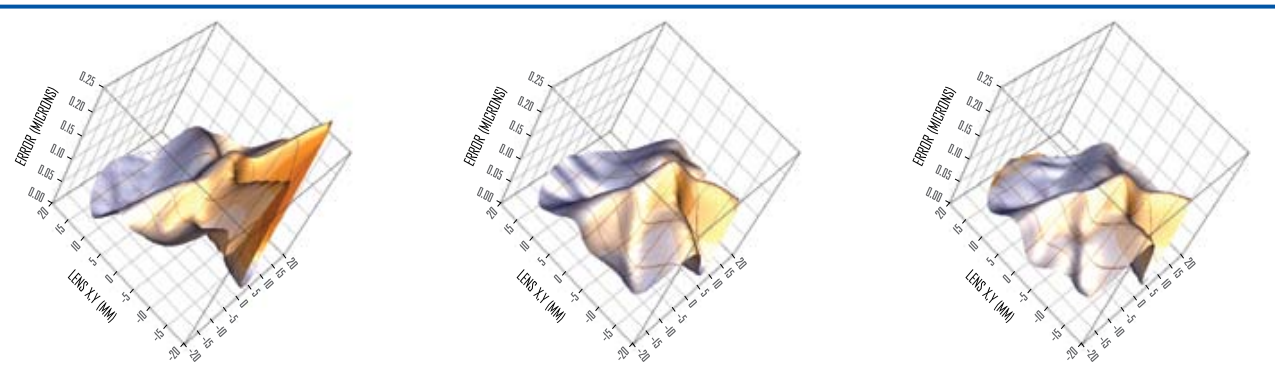



*Figure 6. Unlike traditional progressive lenses, the optical performance of Zeiss Individual is not limited by the availability of factory-molded base curves, so every wearer enjoys the best optics possible with minimal lens aberrations.*




**CONVENTIONAL PROGRESSIVE LENS**
Average High-Order Wavefront Error = 0.099 μm

**"WAVEFRONT-ENHANCED" LENS**
Average High-Order Wavefront Error = 0.075 μm

**ZEISS INDIVIDUAL™**
Average High-Order Wavefront Error = 0.067 μm

*Figure 5. The unique global management and optical optimization of Zeiss Individual results in exceptionally low levels of high-order wavefront aberrations.**

# Fully Customized for the Wearer's Prescription

» Optimized optics deliver up to 50% wider fields of clear vision

When a wearer looks obliquely through the peripheral regions of a spectacle lens, aberrations occur that result in errors from the desired focus of the lens. Lens aberrations such as *oblique astigmatism* create unwanted sphere power and cylinder power errors in the periphery. These unwanted powers errors produce blur, which degrades image quality and narrows the field of clear vision for the wearer (Figure 7).

According to the principles of optical lens design, each prescription combination ideally requires a unique base curve or optical design in order to eliminate these lens aberrations completely. Traditional semi-finished lenses, however, are only available in a limited number of base curves. Typically, each base curve will deliver optimum optical performance only for sphere powers located near the center of the prescription range associated with each base curve. Other prescription powers will suffer from residual aberrations because of this compromise. Moreover, when the prescription contains cylinder power, no conventional base curve or aspheric design can eliminate the aberrations produced simultaneously by both the sphere and cylinder powers of the lens.

The optical effects of lens aberrations are further exacerbated with progressive lenses. Oblique astigmatism interacts optically with the surface astigmatism of the progressive lens design, causing the zones of clear vision to shrink. Lens aberrations can also cause the viewing zones of a progressive to become distorted and shifted from their ideal location as certain regions of unwanted astigmatism become more blurred while other regions of astigmatism actually become clearer. This distortion of the shape and location of the central viewing zones disrupts binocular vision through the lenses.

Fortunately, Zeiss Individual is fully customized to the unique prescription requirements of each wearer. Each Zeiss Individual lens is optically optimized online by Carl Zeiss Vision's optical design engine using the wearer's exact prescription requirements (Figure 8). By fine-tuning the optical design of the lens for the exact prescription, residual lens aberrations are virtually eliminated, resulting in up to 50% wider fields of clear vision. Thus, wearers will enjoy the widest fields of vision possible, regardless of prescription. Furthermore, unwanted changes to the location and shape of the viewing zones are also eliminated, preserving the binocular utility of the lenses with wide, symmetrical fields of view (Figure 9).

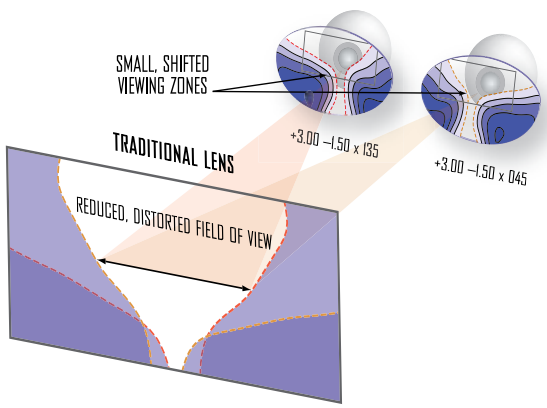



*Figure 7. For many prescriptions, the field of clear vision may be significantly reduced and distorted in shape by uncorrected lens aberrations.*

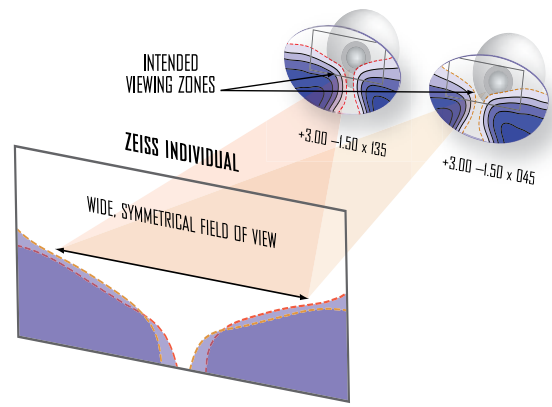
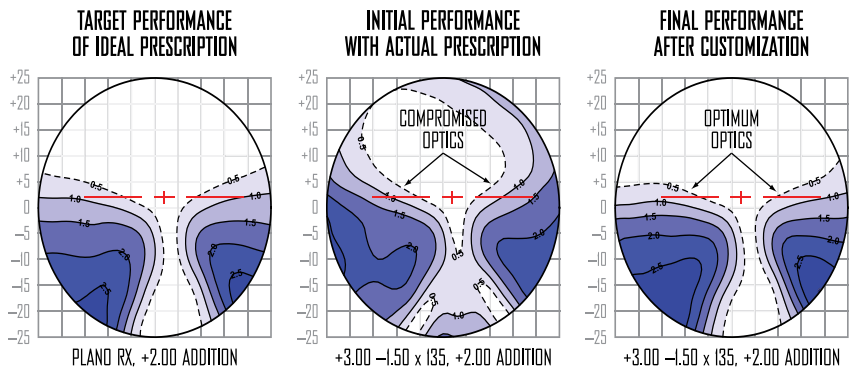



*Figure 9. Zeiss Individual is precisely customized for the wearer's exact prescription requirements, which ensures wide, symmetrical fields of clear vision.*

*Figure 8. Ray-traced optical astigmatism comparison: Because each Zeiss Individual progressive lens is designed in real time, the optics of the lens design can be optically optimized to the exact prescription requirements of the wearer, ensuring that every lens performs exactly as intended, with no residual optical aberrations that could otherwise reduce and distort the clear fields of vision.*



## Fully Customized for the Wearer's Fitting Parameters

» Position of wear customization ensures maximum acuity and symmetric viewing zones

The *position of wear* represents the position of the fitted lens relative to the actual wearer, including the pantoscopic tilt, face-form wrap, and vertex distance of the lens. Spectacle prescriptions are typically determined using refractor-head or trial-frame lenses that are positioned perpendicular to the wearer's lines of sight. Once fitted to the wearer's face, however, eyeglass frames generally leave spectacle lenses tilted with respect to the lines of sight. Unfortunately, tilting a lens introduces oblique astigmatism, which results in unwanted power changes across the lens. Therefore, the position of wear can have a significant impact upon the optical performance of a progressive lens, particularly the quality of vision through the central viewing zones (Figure 10).

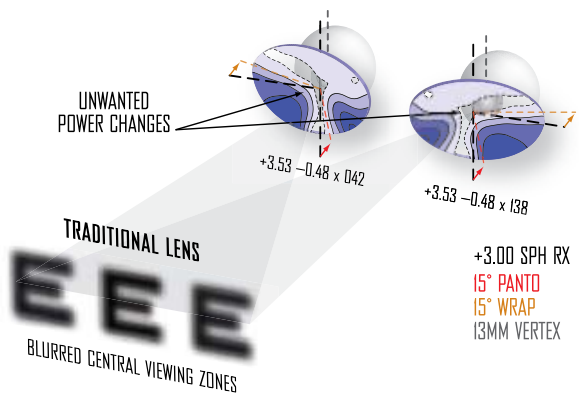



*Figure 10. Vision may be significantly degraded by the position of the fitted lens.*

During the real-time optical design process used for Zeiss Individual, the position of wear of the fitted lens is modeled using ray tracing in order to apply the necessary optical corrections across the lens surface. If the wearer's pantoscopic tilt, face-form wrap, and vertex distance are supplied, the optics of each Zeiss Individual lens design will be precisely customized for this exact position of wear (Figure 11). Wearers will therefore enjoy the best optical performance possible, regardless of their unique fitting requirements (Figure 12).

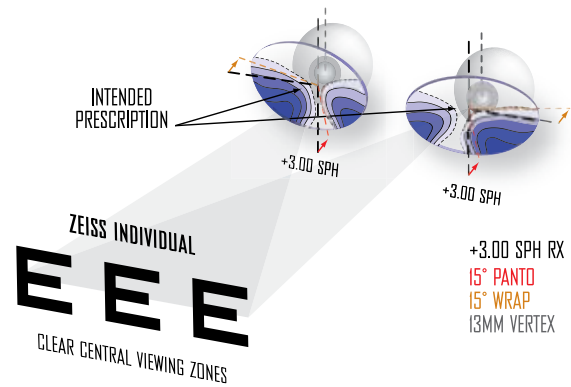



*Figure 12. Zeiss Individual is precisely customized for the wearer's exact fitting parameters, which ensures clear vision through the central viewing zones.*

Traditional progressive lenses are often designed to exhibit the specified optical performance only when measured using a *focimeter*, such as a lensometer (Figure 13). Because Zeiss Individual is designed to provide the *wearer* with the prescribed optical performance once the lens in the actual position of wear, however, small differences from the original prescription are required at the distance and near verification points of the lens. These power adjustments are supplied as a *compensated prescription*, which represents the correct lens powers to verify with focimeters.

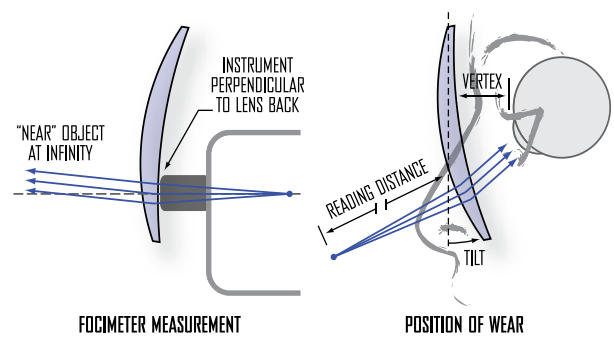
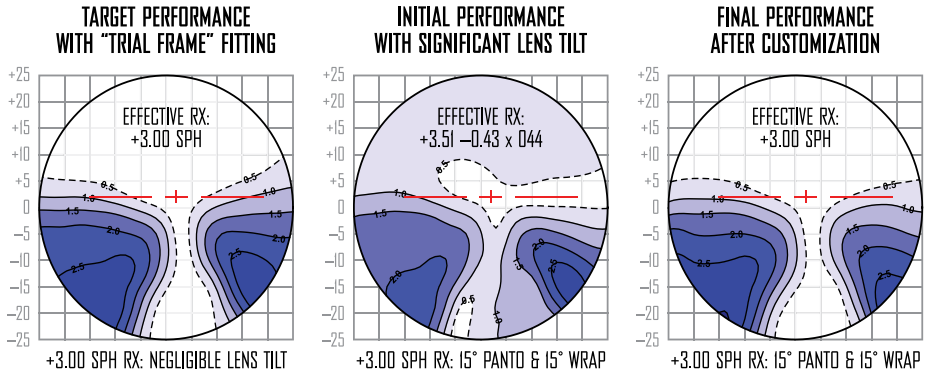



*Figure 13. Although traditional progressive lenses are often designed to exhibit the specified optical powers only when measured using a focimeter, Zeiss Individual is designed to provide the specified optical powers in the actual position of wear.*

*Figure 11. Ray-traced optical astigmatism comparison: Because each Zeiss Individual progressive lens is designed in real time, the optics of the lens design can also be precisely tailored to the exact fitting requirements of the wearer, ensuring that every lens performs exactly as intended, with no unwanted prescription changes that could otherwise degrade vision quality through the central viewing zones.*



## Fully Customized for the Wearer's Frame Choice

» Continuously variable corridor length with fitting heights from 13 to 35 mm, in 0.1 mm increments

The *corridor length* of a progressive lens, or the vertical distance to the near zone, is a critical feature that significantly influences optical performance and wearer satisfaction. If the corridor length is too long for a given frame size, reading utility is greatly reduced, since the near zone is essentially cut away. If the corridor is too short, on the other hand, the optics of the lens design must be essentially "compressed." Due to the mathematical constraints of progressive lens surfaces, the rate of change in unwanted astigmatism across a progressive lens design must increase as the corridor length decreases, resulting in narrower central viewing zones, reduced intermediate utility, and higher levels of unwanted peripheral astigmatism.

Because the corridor length of a progressive lens design should be no shorter than necessary, within the limits of physiologically comfortable vision at least, "standard" progressive lenses have generally been designed to work well in conservative frame styles with a sufficiently large "B" (or vertical) dimension. The fashion trends of the industry continue to favor "minimalist" frame styles, however, with small vertical dimensions that often necessitate relatively short fitting heights. Unfortunately, "standard" progressive lens designs often do not offer sufficient reading utility in these frame styles, since much of the near zone is cut away.

At the other extreme, various "short-corridor" progressive lens designs are also available today. These progressive lenses are often designed to work in extremely small frame styles, resulting in significantly reduced comfort and utility compared to "standard" lens designs. Consequently, unless the corridor length of the lens design happens to coincide with the optimal length required by the size of the frame, the wearer must tolerate unnecessary optical compromises and suboptimal performance (Figure 14).

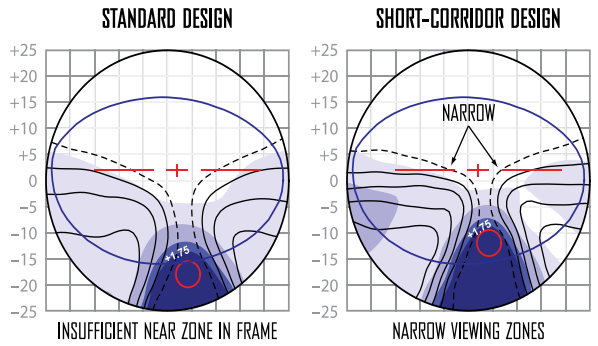



*Figure 14. Unless the corridor length of the lens design coincides with the optimal length required for a given frame size, the wearer must tolerate insufficient reading utility or smaller viewing zone sizes and higher levels of peripheral astigmatism.*

» Matching the optics of the lens design to the wearer's frame size takes full advantage of the available lens area

The corridor length of the Zeiss Individual lens design, on the other hand, is precisely customized in real time in order to match exactly the corridor length of the lens design to the fitting height required by the wearer's chosen frame style, in 0.1 mm increments. By matching the optics of the progressive lens design to the wearer's frame size, the lens design can take full advantage of the available lens area. This maximizes the utility of the central viewing zones without unnecessarily compromising optical performance in other regions of the lens (Figure 15).

The corridor length of Zeiss Individual to 85% of the addition power varies continuously from 10 to 16 mm. Vision research at Carl Zeiss Vision has demonstrated that 16 mm represents the maximum length suitable for physiologically comfortable vision. Because the optics of the Zeiss Individual lens design are perfectly matched to virtually any frame style, with fitting heights from 13 to 35 mm, each and every Zeiss Individual lens will deliver sufficient reading utility while providing the largest viewing zones possible.

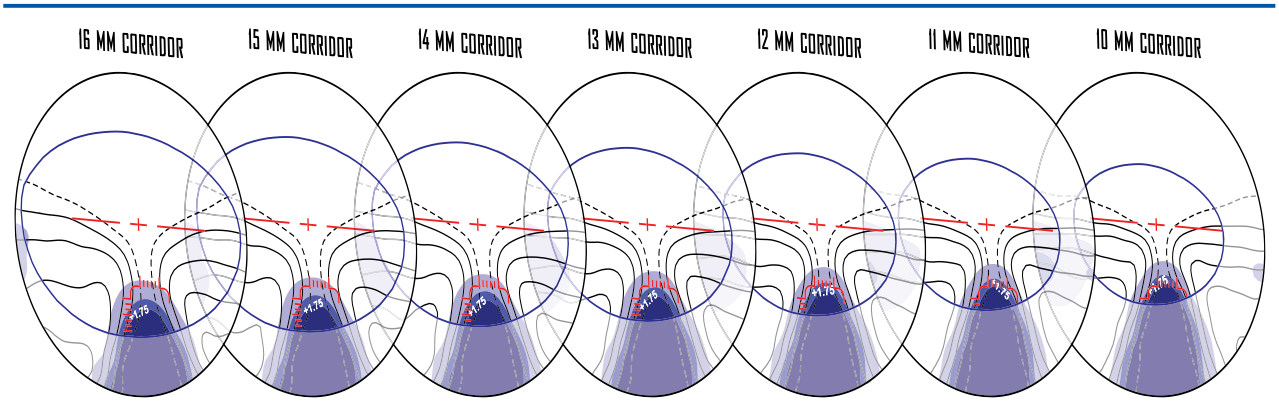



*Figure 15. Using "real-time" optical design to manage the global geometry of the progressive lens design, the corridor length of Zeiss Individual varies continuously from 10 to 16 mm—in 0.1-mm increments—in order to precisely match the optics of the progressive lens design to the size and fitting height of the wearer's chosen frame style.*

## Precise-Form™ Technology

Although a "free-form" or "digital" surfacing process can theoretically cut surfaces with incredibly high precision—to 0.01 diopters—delivering accurate lens surfaces of consistent quality relies on meticulous process engineering and ongoing quality control. Due to the dynamics of the soft lap polishing process used with free-form generators to polish complex shapes, such as progressive lens designs, dozens of polishing parameters must be carefully adjusted in order to ensure uniform polishing over the entire surface. Otherwise, errors from the desired surface shape may result, including unwanted waves.

» Meticulous production

As one of the earliest pioneers in free-form lens technology, Carl Zeiss Vision has comprehensive experience and expertise in free-form lens production. Precise-Form™ technology by ZEISS integrates patented free-form technology with extensive process control. Engineers at Carl Zeiss Vision manufacture and evaluate thousands of lenses, while fine-tuning dozens of process parameters, in order to ensure that each lens consistently delivers unsurpassed surface quality and optical performance, regardless of prescription, lens design, or material (Figure 16).

Moreover, progressive lenses produced by free-form surfacing must be frequently validated against the target designs by "mapping" the optics over the entire lens (Figure 17). Failure to validate the production quality of a free-form surfacing process on a regular basis can lead to inferior quality compared to traditional lens molding, if the process begins to "drift" from best practice. Free-form progressive lenses from Carl Zeiss Vision must meet stringent quality guidelines and optical design specifications. This extensive process engineering ensures that every progressive lens delivers the precise optical powers that the wearer requires.


*Figure 17. Engineers at Carl Zeiss Vision, a world leader in free-form lens production, rely on sophisticated tools to ensure superior quality and optics.*

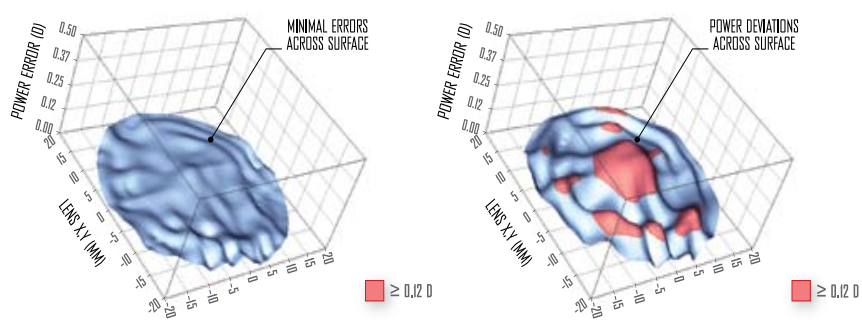
» Single-surface accuracy

Some so-called free-form progressive lenses rely on lens blanks with some or all of the progressive optics placed on the front surface using traditional lens molding techniques. Using Precise-Form technology, Zeiss Individual lens design is directly surfaced onto the lens blank. This ensures extremely accurate replication of the progressive lens design. Placing all of the progressive optics on a single surface eliminates the potential for misalignment between the optics of the front surface and the prescription back surface, which can result in reduced optical performance.

» Back-side optics

Placing the progressive optics on the back surface of the lens also maximizes the fields of clear vision by locating the viewing zones closer to the eyes while minimizing unwanted magnification effects. *Skew distortion*, which is an aberration that causes objects to appear sheared or "bowed" through the periphery of progressive lenses because of magnification differences across the lens, is due both to magnification created by differences in curvature across the *front* surface and to magnification as a result of the unwanted cylinder produced by these differences in curvature. Placing the progressive optics on the *back* surface of the lens, however, eliminates the contribution of the front surface to these magnification effects.[4]

*Figure 16. Precise-Form technology integrates patented free-form technology with rigorous process engineering that involves carefully adjusting and testing dozens of free-form surfacing and polishing parameters—including the speed, duration, and pattern of movement—for each lens material and surface design in order to ensure pristine lens surfaces with incredibly accurate optical powers.*



# Superior Performance Through True Customization

» Proven performance in large scale wearer trials

Extensive wearer trials have confirmed the exceptional performance of Zeiss Individual. In a masked comparison between Zeiss Individual and two leading traditional progressive lenses, wearers showed a statistically significant preference for Zeiss Individual. Moreover, when the perceived field of near vision during a critical viewing task was assessed, these wearers indicated up to 50% more reading area compared with the traditional progressive lenses. Additionally, in acceptance testing of over 700 wearers who had purchased Zeiss Individual, over 90% of these wearers rated it among the top two levels of performance.[5] Finally, in a masked comparison between Zeiss Individual and three leading free-form progressive lenses, wearers showed a clear preference for Zeiss Individual in all attributes of performance. Clearly, when it comes to proven performance, Zeiss Individual is in a class of its own.

The seemingly endless variety of "free-form" or "digitally surfaced" progressive lenses available today may seem daunting to many eye care professionals. Unfortunately, many of these free-form lenses are marketed with vague or poorly supported claims regarding the actual visual benefits to the wearer, if any. Because these new lens designs are often positioned as "premium" products to eyeglass wearers, it behooves eye care professionals to consider carefully the features and benefits offered by the various lens designs available from this new—and often confusing—category of lenses.

The inherent visual benefit of producing progressive lenses using free-form surfacing is minimal without the application of some form of customization for the wearer. The full potential of free-form technology will only be realized when utilized in conjunction with powerful software tools capable of "real-time" optical design using input specific to the individual wearer. It is possible, for instance, to use free-form surfacing technology to deliver traditional-type progressive lenses on demand, often by mathematically combining a fixed, predefined progressive lens design (or "points" file) with the prescription curves normally applied to the back of the lens blank. Free-form progressive lenses of this type essentially replicate the performance of traditional, semi-finished progressive lenses.

Furthermore, free-form technology will not substantially improve a fundamentally poor lens design. If a given lens design offers only mediocre performance and wearer satisfaction, a free-form customized version of that same design will only ensure that this mediocre performance is delivered consistently to all wearers. Lens designers at Carl Zeiss Vision rely on real technology with demonstrable benefits applied to proven lens designs. For over fifteen years, ZEISS lens designers have been utilizing free-form technology to enhance the visual performance of progressive lenses through the customization of award-winning lens designs. Zeiss Individual, a product of the same lens design platform that earned GT2™ by ZEISS the OLA's prestigious *Award of Excellence in Lens Design*, represents the most technologically advanced customized lens solution by ZEISS. Zeiss Individual is the first progressive lens that can be fully personalized to each wearer's prescription, frame size and position of wear—integrated with a precise and patented fabrication process. Only by ZEISS.

| Zeiss Individual: Most Advanced Features | Competitor Free-Form Lenses: Features Often Limited |
|---|---|
| Starts with a proven base lens design with award-winning heritage | May utilize a base lens design that provides substandard optical performance |
| Designed in "real time" for each wearer using advanced software created | May utilize a fixed lens design or points file to deliver essentially a "digital semi-finished" progressive |
| Fully customized for the wearer's prescription using precise optical optimization | May utilize a lens design with little or no optimization for the specific prescription |
| Fully compensated prescription for prescribed optics in the position of wear | May utilize prescription powers for focimeters that compromise performance |
| Fully customized for the wearer's specific fitting geometry (panto, wrap, vertex) | May not be compensated for these important personal factors that can compromise performance |
| Fully customized variable corridor length in 0.1 mm steps with fitting heights from 13 to 35 mm | May utilize only one or two corridor lengths for every possible frame size |
| Back-side progressive optics using Precise-Form™ fabrication and patented technology | May utilize a molded front-surface progressive or a dual-surface lens design |
| Precise production using extensive process engineering by free-form experts | May utilize a "plug-n-play" free-form production system with less consistent quality |


1. Hof A. and Hanssen A. "Spectacle Lens with Spherical Front Side and Multifocal Back Side and Process for Its Production." US Patent 6,089,713; 2000.
2. Haidl M., Mertin M., and Zaiser M. "Process and an Apparatus for Making Plastic Material Spectacle Lenses." US Patent 7,083,279; 2005.
3. Villegas E. and Artal P. "Spatially Resolved Wavefront Aberrations of Progressive-Powered Lenses in Normal Viewing Conditions." *Optom Vis Sci*, 2003; Vol. 80, No. 2. pp 109-112.
4. Meister D. and Fisher S. "Progress in the spectacle correction of presbyopia. Part 2: Modern progressive lens technologies." *Clin Exp Optom*, 2008; Vol. 91, No 3. pp 251–264.
5. Guth O. and Winter C. "Improvement of Wearing Properties by Taking Each Wearer's Personal Data Into Account in Lens Production." *Deutsche Optikerzeitung*, 2000; Vol. 10. pp 1-11.



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