





Complete course in dispensing

Part 6 - Lens selection

After last month's article (November 14, 2008) discussing the basic properties of materials used for the manufacture of spectacle lenses, **Andrew Keirl** and **Richard Payne** give an overview of the vast selection of lens types and designs available for the 'normal' power range. **Module C10361, two general CET points**

ith the prevalence of online information available for consumers today, many lens manufacturers have seen the need to enhance their product ranges with marketable brands, employing household names and retail marketing tactics to ensure their lens ranges are more appealing. With such an extensive range of options now available, it is vital that practitioners can see past the ever increasing lists of brand names and marketing terminology used to properly consider the true attributes of any given lens design and use the appropriate 'tool' for the appropriate 'job'. Future articles will discuss lens coatings and 'complex' lenses. It is of course impossible to consider every product available in an article of this nature.

Spectacle lenses

In very simple terms, a spectacle lens is an optical device with the purpose of altering the vergence of pencils of light transmitted from the lens to the eye. Physically, a lens is an optical medium bounded by two polished surfaces, one of which must be curved. The curvature employed may be spherical, cylindrical, toroidal, aspherical or free-form (surfaces that cannot be defined using a single mathematic equation). The usual function of a spectacle lens is the correction of a refractive error. However, spectacle lenses are also used to correct binocular vision anomalies, reducing the amount of light that reaches the eye (a tinted lens) or to provide mechanical protection (a safety lens).

Best-form lenses and spectacle lens design

What is a best form lens? Put simply, it is 'a lens designed to minimise the effects of certain stated defects or aberrations in its image-forming properties'. Aberrations can occur with lenses that are free from manufacturing defects and manufactured using the best materials and can









Figure 2 Categories of lens form

from being a perfect copy of the object. Aberrations that afflict spectacle lenses can be broadly divided into two types, image deforming aberrations and image degrading aberrations. In addition, some aberrations occur with monochromatic light, the monochromatic aberrations (1-5 in the list below); other aberrations occur with light that contains at least two

SERIES MODULES

- Practice development, marketing and communication
- Prescription interpretation
- Frame design
- Spectacle lenses
- Tints and coatings
- Dispensing
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wavelengths. These are the chromatic aberrations (6) which were addressed in article 5 of this series. The six aberrations are:

- 1 Spherical aberration
- 2 Coma
- 3 Oblique astigmatism
- 4 Curvature of field
- 5 Distortion
- 6 Chromatic aberration (TCA)

A best form spectacle lens is a lens designed to minimise the effects of oblique astigmatism and therefore provide the best possible vision in oblique gaze. Secondary considerations are distortion and transverse chromatic aberration.

In recent years, the analysis of lens form has been revolutionised by the use of the personal computer. The possibility of rapid analysis of lens performance is now a reality. Calculations, which took hours to do in the past, can now be done in seconds. This allows us to examine lens performance by examining the results of exact ray tracing in the oblique gaze positions. Eye care practitioners should understand these effects and whenever possible should dispense spectacles with best form theory in mind. There are occasions when the dispenser should specify the form required and not leave it to the manufacturer. There are also numerous examples of when the practitioner should understand the advantages of one design compared to another, for example, spherics verses aspherics. In summary, lens designers must consider:

• Off-axis performance (oblique astigmatism, distortion and transverse chromatic aberration)

- Appearance
- Spectacle magnification
- Thickness.

The main aberration of interest is oblique astigmatism. Put simply, oblique astigmatism causes a spherical lens to behave like an astigmatic lens and can occur when an eye views through off axis points on a lens. It occurs because of the asymmetry in the refraction of rays

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TABLE 1

Lens 1 BVP = +5.00DS, F ₂ = -1.00 D, t = 6.53mm					
Ocular rotation(°)	Oblique rower (D)	Distortion (%)	TCA (Δ)		
0	+5.00 DS	0.00	0.00		
5	+5.02DS/-0.02DC	0.16	0.02		
10	+5.10DS/-0.08DC	0.65	0.05		
15	+5.22DS/-0.19DC	1.50	0.07		
20	+5.40DS/-0.35DC	2.78	0.10		
25	+5.63DS/-0.57DC	4.57	0.13		
30	+5.94DS/-0.86DC	7.02	0.17		

Lens 2

$BVP = +5.0005$, $P_2 = -5.000$, $I = 0.0511111$					
Ocular rotation(°)	Oblique power (D)	Distortion (%)	ΤርΑ (Δ)		
0	+5.00DS	0.00	0.00		
5	+5.01DS/-0.01DC	0.14	0.02		
10	+5.04DS/-0.04DC	0.56	0.05		
15	+5.08DS/-0.10DC	1.28	0.08		
20	+5.14DS/-0.18DC	2.36	0.10		
25	+5.21DS/-0.27DC	3.83	0.13		
30	+5.29DS/-0.39DC	5.80	0.17		

Lens 3

BVP = +5.00DS, F₂ = -6.00 D, t = 7.00mm

Ocular rotation(°)	Oblique power (D)	Distortion (%)	TCA (Δ)
0	+5.00DS	0.00	0.00
5	+4.99DS/0.00DC	2.99	0.03
10	+4.97DS/0.00DC	1.85	0.05
15	+4.94DS/-0.01DC	1.02	0.08
20	+4.89DS/-0.01DC	1.85	0.11
25	+4.82DS/-0.01DC	2.99	0.14
30	+4.72DS/0.00DC	4.47	0.17

in two mutually perpendicular planes called the tangential and sagittal planes. The visual effect of oblique astigmatism can be better appreciated by considering the off-axis performance of the following three +5.00 DS lenses. Lens 1 is made in a flat form using a back surface power of -1.00 D. Lens 3 is made in a much steeper form using a -6.00 D back surface power. The ocular rotation is in relation to the principal axis of the lens.

Table 1 shows that:

• The best off-axis performance (an oblique power closest to +5.00 DS) is obtained with the lens with the steeper form

• Steeper forms give better control of distortion

- The lens form makes little difference to the amount of TCA produced.
- Remember that all three lenses will

give the same back vertex power (+5.00 DS) when measured using a focimeter! It is important to note that all the lenses in the above example employ spherical surfaces.

In summary, lenses with steeper (spherical) curves:

- Provide good off-axis vision
- Control distortion
- Are more bulbous
- Are thicker

• Produce more spectacle magnification.

- Lenses with flatter (spherical) curves:
 Produce poor off-axis vision
- Produce poor off-axis visit
 Produce more distortion
- Are less bulbous
- Are less build
- Are thinner

• Produce less spectacle magnification. Sphero-cylindrical and toric lenses have properties that remind us of oblique astigmatism. Oblique astigmatism is an off-axis aberration caused by asymmetrical refraction at a spherical surface. Sphero-cylindrical and toric lenses have axial astigmatism. While oblique astigmatism is a nuisance, axial astigmatism is often induced on purpose, eg in the correction of astigmatic ametropia.

Lens form

To describe the overall form of a lens we can divide them into several groups as shown in Figure 2. Flat form lenses though rarely used today consist of equi-convex, equi-concave, bi-convex, b-concave, plano-convex and planoconcave forms. Lenses where one surface is spherical and the second surface plano-cylindrical can also be term 'flat'. Curved-form or meniscus lenses differ from flat form lenses in that one surface is convex and the other concave. Figures 1 and 2 illustrate several lens form comparisons.

Astigmatic lenses are usually manufacture in curved or meniscus form to provide improved oblique performance. These lenses are referred to as toric lenses which consist of one spherical surface and one toroidal surface.

Base curves

Eye care practitioners and lens manufacturers use the term 'base curve' in different ways. The eye care practitioner is usually interested in the finished lens as opposed to the semi-finished lens. With regard to finished spherical lenses, the base curve is the lower of the two surface powers. As far as finished toric lenses are concerned, the base curve is the lowest numerical power found on the toroidal surface.

In the mass production of stock lenses and semi-finished cast moulded bifocal and multifocal lenses it has become commonplace for manufacturers to categorise lenses by their base curve. They also tend to restrict the number of base curves available to certain power ranges that provide 'best form' performance across as wider range of powers as possible. For the purposes of manufacture, the base curve of a lens is defined as the spherical surface of a semi-finished uncut lens which, in most cases, is the front surface of the lens. So eye care practitioners and manufacturers define the base curve in different ways. This difference is important when we are faced with suspected lens form intolerance. It is always wise to contact the manufacturer to clarify exactly what their definition of base curve is, before placing an order for a specific base curve.

Aspheric lenses

So far we have seen that the lens form

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TABLE 2

Ocular rotation(°)	Oblique power (D)	Distortion (%)	TCA (Δ)
0	+5.00DS	0.00	0.00
5	+5.00DS	0.13	0.02
10	+4.98.DS/-0.01DC	0.51	0.05
15	+4.95DS/-0.01DC	1.17	0.07
20	+4.91DS/-0.02DC	2.16	0.10
25	+4.85DS/-0.02DC	3.52	0.13
30	+4.76DS/-0.02DC	5.35	0.16

introduces surface astigmatism in order to neutralise the aberrational astigmatism associated with flat form lenses. Aspherical surfaces are derived from a family of curves called conicoids, as shown in Figure 3.

An aspherical surface is actually astigmatic, the negative surface astigmatism increasing progressively as we move away from the vertex of the aspherical surface. This negative astigmatism is used to counteract the positive oblique astigmatism arising from off-axis gaze. This is how aspheric lenses work! An aspherical surface can have its asphericity (p-value) chosen to counteract the oblique astigmatism for any chosen form. If a flatter form than the traditional spherical form is chosen, the sag of the necessary asphere will be less than that of a spherical surface of the same radius. Hence, a thinner, lighter, less bulbous lens is produced with less magnification of the eye and surround.

The reduction in the thickness and weight of an aspheric lens is the result of a two-stage process. Firstly the lens is flattened (which makes it thinner) and then the off-axis performance of the flatter form is restored to that of a steeper spherical design by aspherising the surface, as a result of which the final lens form is thinner still.

If lens 1 in the previous examples (Table 1) is made in aspheric form with a convex hyperbolic surface (p-value of -2.00) the off-axis performance is as shown in Table 2.

It will be noted that the optical performance of this aspheric lens is very similar to the steep lens with a -6.00D back surface. However, it has the cosmetic appearance of the fat lens. Hyperbolic surfaces are commonly employed in aspheric lenses for the normal power range.

Today we encounter aspherical surfaces in many of the lenses we dispense and although there are numerous minus-powered aspherical lenses the real impact has been on plus-powered lenses. To summarise, the advantages of aspheric lenses for the normal power range are:

- Good off-axis performance
- Some control of distortion
- Less spectacle magnification
- Reduced sensitivity to fitting distanceThinner and lighter lens

• Noticeably flatter lens form provides improved cosmesis.

In recent years computer aided design has allowed lens manufacturers to integrate aspheric surface technology into a growing number of more complex forms. Elliptico-toroidal or atoroidal surfaces combine different oblate elliptical cross sections along each principle meridian providing a different degree of asphericity for each meridian with much improved oblique performance in higher cylindrical corrections.

The integration of aspherical surfaces into lenticular lens forms has greatly improved their optical performance and appearance. More recently, the introduction higher base curve lens forms for use in wraparound-style sunglass frames has only been possible with the use of specially designed aspherical surfaces.

Individual free-form surfaces

The latest innovation and possibly ultimate breakthrough for lens designers has been the development of free-form surfacing technology. Free-form surface creation involves the use of precision point by point (CNC) grinding and polishing processes to create a complex, irregular, asymmetric aspherical surface. Wavefront computer modelling systems are used to design each lens surface, taking optics-influencing variables and the wearer's physiological viewing habits way beyond the usual elements of just the optical prescription. This process can eliminate even the smallest aberrations and because there are no constraints with free-form surfacing, lens designers have the freedom to create totally unique lens surfaces and integrate a wider range of individual parameters into the lens design that are unique to the final wearer.

Figure 3 The conicoids

(and the lens material) can influence the quality of vision provided by a spectacle lens. The visual performance of a lens has to be considered when the patient looks through points on the lens close to the principal axis and also when the patient views through off-axis points on the lens. An ideal best-form lens is one whose off-axis performance is essentially the same as its back vertex power. The aberration oblique astigmatism causes a spherical lens to behave like an astigmatic lens when a patient looks away from the principal axis. Oblique astigmatism is a consequence of the form of the lens. Generally speaking, when restricted to spherical surfaces, flatter lens forms produce higher levels of unwanted oblique astigmatism. Oblique astigmatism may be controlled if the lens is made in a more curved form.

However, curved lenses tend to be thicker and more bulbous than a lens of the same power but made using flatter curves. One of the features of current single vision spectacle lenses is the large number of designs made in aspheric form. Originally, aspheric lenses were only used for the high powered positive range. However, it was Jalie who pointed out the cosmetic advantages of using lenses with an aspherical surface for low powers so that nearly flat forms could be used which at the same time give acceptable off-axis performance. Jalie suggested that the front surface of positive lenses and the rear surface of negative lenses should be in aspherical form, the other surface being spherical or toroidal depending on the prescription. Unlike Jalie's patent, minus aspheric lenses tend to be made with a front aspherical surface, presumably because the ophthalmic industry is equipped mostly for the manufacture of concave toroidal surfaces only. As previously mentioned, any flattening of the lens form can introduce unwanted aberrational astigmatism and also distortion. This can be largely overcome by the use of an aspherical surface, which



As eye care professionals it is vital that we keep up to date with this emerging technology and more importantly, become familiar with the additional information required by many lens manufacturers when ordering a freeform surfaced, individual lens.

So far we have considered the basic concepts of the best-form lens and the recent innovations that have brought the optical profession closer to this goal. We must also consider the vast range of different lens types available, their uses and common features.

Before deciding on the optimum lens for a given prescription the following points should be considered:

- Lens form
- Material
- Field of view
- Centre thickness
- Weight
- Reflections
- Availability of surface processes.

Single-vision lenses

Single-vision lenses can be broadly divided into the following groups:

• *Meniscus*. A spherical lens with two spherical surfaces, one convex and one concave

• *Toric*. A meniscus lens incorporating a toroidal surface for the correction of astigmatism, the other surface being spherical in form. The majority of toric lenses incorporate a concave toroidal surface. Bi-toric lens are occasional encountered in practice

• *Aspheric*. One aspherical surface combined with either a spherical or toroidal surface

• *Double aspheric*. A lens that employs two aspherical surfaces

• *Atoric*. A lens that employs an atoroidal surface for the correction of astigmatism

• *Free-form*. A free-form lens is a lens that is manufactured without a predetermined surface. A free-form surface is a surface that cannot be defined with a single mathematical equation.

Single-vision lens availability extends right across the range of powers and materials with plastics lenses being available in refractive indices from 1.498 to 1.74 and glass lenses from 1.523 to 1.90.

Single-vision dispensing example 1 Client 1 is a male in his early 20s and has been wearing spectacles since his early teens. His prescription details are:

Right -3.00/-1.25 x 170 6/5

Left -3.50/-1.00 x 10 6/5

Monocular distance centration distances were 32mm in both eyes.

This example gives the practitioner the opportunity to explore various material



Figure 4 The Hoyalog system

and design options to provide the patient with the best cosmetic appearance without compromising visual performance. To illustrate the above options, we will use plastics lens materials from the Hoya catalogue, as listed in Table 3.

Inspection of the above prescription will reveal that the principal meridians of the lens are roughly vertical and horizontal. The principal powers are -3.00D along 170 and -4.25 along 80 in the right eye and -3.50D along 10 and -4.50D along 100 in the left eye.

TABLE 3 Plastics	lens materials	offered b	y Hoya
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Product	Refractive index (n _e)	V-value (V _e)	Density (g/cm ³)	
Plastics materials				
CR39	1.50	58	1.32	
PNX (Trivex)	1.53	43	1.11	
Eyas	1.60	41	1.32	
Eynoa	1.67	31	1.37	
Eyry	1.70	36	1.41	

Because of the orientation of the principal meridians, an ideal frame will be one that has its shortest dimension along the vertical meridian. This of course is the case with most modern designs. If the principal powers were reversed, a little more thought would need to be given to the selection of an appropriate frame. In order to equalise the nasal and temporal edge thicknesses the frame should have a box centre distance that is close to 64mm (BCD = DCD). The frame chosen for this example had a BCD of 65mm resulting in only 0.5mm of inwards decentration in both eyes. Excessive inward decentration will cause an increase in the temporal edge substance. Practitioners play a very important role in helping clients select frames that are cosmetically pleasing and appropriate for a client's facial features. However, practitioners must also help clients to select frames that are suitable for the given prescription. It is therefore important that optometrists and dispensing opticians can visualise the mechanical appearance of the finished lens. Table 4 gives the edge and

TABLE 4 Edge and centre thicknesses for the lenses used in example 1

Product	Centre thickness	Max edge thickness	Min edge thickness
Hilux 1.5 (spherical)	R 2mm L 2mm	R 4.2mm L 4.5mm	R 2.7mm L 2.7mm
Nulux 1.5 (aspherical	R 1.8mm L 1.8mm	R 3.8mm L 4.0mm	R 2.5mm L 2.5mm
Hilux Eyas 1.6 (spherical)	R 1.4mm L 1.4mm	R 3.2mm L 3.5mm	R 2.0mm L 2.0mm
Nulux Eyas 1.6 (aspherical)	R 1.1mm L 1.1mm	R 2.8mm L 3.0mm	R 1.7mm L 1.7mm
Hilux Eynoa 1.67 (spherical)	R 1.0mm L 1.0mm	R 2.6mm L 2.8mm	R 1.5mm L 1.5mm
Nulux Eynoa 1.67 (aspherical)	R 1.0mm L 1.0mm	R 2.5mm L 2.7mm	R 1.5mm L 1.5mm
Nulux Eyry 1.70 (aspherical)	R 1.0mm L 1.0mm	R 2.4mm L 2.6mm	R 1.5mm L 1.5mm

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centre thicknesses for appropriate Hoya products for this prescription.

The lens of choice, both mechanically and optically, is the Nulux Eyry. The Nulux Eynoa produces almost the same edge thickness but this material has a lower V-value (31 compared to 36) which may result in reduced offaxis performance. When comparing the spherical and aspherical options, the use of an aspherical surface results in a reduction in lens substance in all cases. The aspherical surface will also produce an improvement in off-axis performance.

Single-vision dispensing example 2

Client 2 is female and in her mid 30s, who is generally dissatisfied with her last pair of distance spectacles. A stable refraction of right +5.50 DS and left +4.75 DS was found. Visual acuities were 6/6 in both eyes. Discussion with the client revealed that she finds her current lenses to be far thicker and heavier than a previous pair despite having paid an additional fee to 'upgrade' them. Poor vision in oblique gaze was also an issue, with her feeling unsteady when using stairs. Inspection of the lenses suggested that a higher refractive index lens had been dispensed with a distance centration distance of 62mm and a frame box centre distance of 74mm resulting in 6mm of inward lens decentration. Points for consideration are:

 Control of the lens substance by considering frame size and decentration
 Lens material, form and surfacing.

In this case, the client had previously worn spherical CR39 lenses in a frame with a box centre distance that was much closer to the required centration distance resulting in less decentration. The newer, larger frame and subsequent 6mm decentration had resulted in a greater lens substance despite the use of a higher refractive index material.

On this occasion a new, smaller frame with swept out lugs was chosen to avoid decentration and reduce the lens substance. The frame BCD was 64mm. To illustrate the above options, we will again use Hoya lenses. If we continue to use a high refractive index material, possible lens options available are:

1 Stock lenses, spherical surfaces (maximum refractive index 1.67)

2 Minimum edge thickness surfaced, spherical surfaces (maximum refractive index 1.67)

3 Minimum edge thickness surfaced, aspheric lens (1.70 refractive index).

Option 1: Stock lenses, spherical surfaces

From a cosmetic, mechanical and optical point of view, this is not a good choice. The material used was Hoya's Eynoa

TABLE 5	Lens	details:	Stock	Eynoa	Hilux
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	Centre thickness	Max edge thickness	Min edge thickness
Right	5.3mm	4.6mm	3.0mm
Left	4.7mm	4.1mm	2.7mm

material which has a refractive index of 1.67. Table 5 has the details.

Option 2: Minimum edge thickness surfaced, spherical surfaces

Again the material used was Eynoa with a refractive index of 1.67. The use of minimum edge thickness surfacing techniques produces an appreciable improvement in weight, thickness and cosmesis. Table 6 has the details.

Option 3: Minimum edge thickness surfaced, aspheric lens

The refractive index of the chosen lens material was 1.70 (Eyry). The use of an aspherical surface (along with a slightly higher refractive index) has produced a further reduction in lens substance and will ensure good off-axis performance. Table 7 has the details.

The lens of choice is therefore option 3. A further option would be to use a bi-aspheric (Eyry Nulux EP). This lens, using free-form technology, offers a wide visual field with clear and stable vision in oblique gaze and reduced spectacle magnification. Hoya's Hoyalog system (Figure 4) was used to determine lens thickness in the above examples.

Bifocal and trifocal lenses

Along with separate single-vision corrections, bifocal lenses provide the presbyope with the traditional solution of combining distance and near vision corrections in a single lens with the reading addition incorporated into a specific section of the lens. For vocational purposes the distance or near portions of the bifocal can be

TABLE 6 Lens details: Surfaced Eynoa Hilux

	Centre thickness	Max edge thickness	Min edge thickness
Right	3.3mm	2.6mm	1.0mm
Left	3.0mm	2.4mm	1.0mm

TABLE 7	Lens details:	Surfaced	Eyry Nulux	
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	Centre thickness	Max edge thickness	Min edge thickness
Right	3.0mm	2.4mm	0.9mm
Left	2.8mm	2.3mm	1.0mm

specified with an intermediate addition or a trifocal lens can be specified. Trifocal lenses (Figure 5) contain an intermediate portion usually located between the distance and near portions. Examples of bifocal and trifocal availability are given in Tables 8 and 9.

Due to a decline in demand, bifocals and especially trifocals are not available in as wider range of lens types and materials as was once the case. Lenses are available in spherical, toroidal, aspheric and reduced-aperture lens forms. Although the range of available indices is generally smaller, 1.74 spherical and atoroidal curve-top bifocal lenses have been recently introduced.

Most bifocal and trifocal plastics lenses are cast moulded as front-surface segment lenses. Glass bifocal lenses are either solid or fused. Examples of current bifocal and trifocal lenses are given in Tables 8 and 9.

Specialist bifocal and trifocal lenses will be covered later in this series. Although bifocal lenses are not extensively used, particularly for first-time presbyopic clients, they still provide a simple and sometimes more appropriate form of correction for presbyopes. As a general rule, if the distance prescription is minus, flat-top bifocal segments provide better control of centration for near as the base-up prism produced by the segment will neutralise some of the base-down prism generated by the main lens. However, if the distance prescription is positive, round down-curve segments provide better control of centration at near.





Figure 5 Schematic of a trifocal lens



Progressive power lenses

For the modern presbyope and many eye care professionals alike the progressive power lens or varifocal has become the lens of choice. Progressive power lenses (or PPLs) are designed to provide clear vision across a range of distances. In addition, wearers of PPLs experience no image jump between the different zones.

The basic progressive lens

In very simple terms, a PPL can be thought of as having two spherical surfaces, one for distance and one for near, connected by an aspherical surface. The change in power within the progression corridor is achieved by continuously altering the radii of curvature between the distance and near zones. This change in power is brought about by the use of an aspherical surface. The process of changing the surface power creates unwanted aberrational surface astigmatism either side the progression corridor, resulting in image blur and restricting the usable width of the intermediate and near portions of the lens to a central 'corridor' (Figure 6).

The second consequence of a progressive surface is that of skew distortion (Figure 7) which occurs because a change in power is accompanied by a change in magnification. Skew distortion is responsible for the 'swimming effect' reported by new wearers of PPLs. Early PPL designs like the original Varilux, introduced by Essel in 1959, had a cast-moulded front surface progression with a fairly hard boundary between the usable and unusable zones.

Despite early limitations, technological improvements in both lens design and manufacturing techniques have led to a rapid growth in PPL availability and performance. Modern progressives have a far wider progression corridor, with the boundaries between the zones on the lens being far softer. This has allowed a far greater number of clients with a much wider variety of optical corrections to successfully adapt to PPLs. The advantages and some disadvantages for the presbyopic wearer over the more traditional forms of lens are:

Advantages of PPLs

• No visible segment

• Lens appears to be a single vision thus offering improved cosmesis

• No image jump as there is no abrupt change in power

• Provides a good range of clear vision at all distances

• More natural use of available accommodation.

• Peripheral surface astigmatism results in a narrower near and intermediate field of view when compared to a bifocal or trifocal lens

• Adaptation can be unpredictable and can take a few days or even weeks

• Intolerances are more common place.

PPL markings

To assist practitioners in the identification of a particular lens, a universal marking system is used for all progressive lenses (Figure 8). With reference to Figure 8, A is the distance power checking point, B is the near power checking point, C is the nasal reference point, D the temporal reference point, E the fitting cross and F the prism checking point. The nasal and temporal reference points are usually two engraved circles 34mm apart. The reading addition is engraved under the temporal reference point with the manufacturer's identifying mark under the nasal reference point.



is applied to most PPLs in order to improve cosmesis, particularly the lens thickness at the upper edge of the lens. Approximately 0.6Δ base-up prism is removed for each dioptre of reading addition, effectively adding equal base down prism in both lenses equivalent to 2/3 of the reading addition. This thinning prism should always be taken into account when neutralising a progressive lens at the prism checking point.

A process known as prism thinning

TABLE 8 Bifocal lens types					
Segment type	Abbreviation	Range of sizes	Characteristics		
Flat-top	S seg	25mm-45mm	Good field of view at near Reduced image jump Improved centration at near with minus Ienses More obvious visible segment design Used in aspheric lens forms		
Curve-top	C seg	25mm-40mm	Good field of view at near Reduced image jump Improved centration at near with minus Ienses Less obvious segment design Used in aspheric lens forms		
Round	R seg	15mm-45mm	Poorer field of view at near More image jump Improved centration at near with plus lenses 'Invisible' segment		
Executive	E style		Widest field of view at near No image jump The most obvious segment design Very small range of indices available		

TABLE 9 Trifocal lens types

Segment type	Intermediate seg depth	Available sizes	Intermediate/near ratio
Flat-top	7mm	28mm	50% of full reading add
Flat-top	8mm	35mm	50% of full reading add
Flat-top	14mm	35mm	60% of full reading add
Curve-top	8mm	28mm	50% of full reading add
Round	Concentric 7 & 8mm	Various	50% of full reading add
E style	7mm		50% of full reading add
Double D	Segs top & bottom	28mm	60% or same as full reading add

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Flat-top bifocal

Figure 7 Skew distortion

Different PPL designs

To compare the often subtle differences between various PPL designs we can study isocylinder charts that plot the points on the progressive surface that have the same amount of surface aberrational astigmatism. Available from most manufacturers, they provide us with an illustration of the width and characteristics of the progression corridor for any given lens. Generic examples of isocylinder plots are shown in Figure 9.

Withsomanybrand names and marketing terms in use today, a general appreciation of the variety of different PPL designs can help avoid the risk of intolerance caused when switching lens brands, especially if neither the practitioner nor the client expected a problem.

As with single-vision surfacing, progressive lenses have benefited greatly

Progressive power lens

from modern design and manufacturing technologies. Many lens designs now feature back surface and bi-surface progressions, anti-fatigue lenses incorporate smaller reading additions beneficial to the early and pre-presbyopic wearer requiring accommodative relief, and with individual lens designs, wearers can benefit from greater fields of view, improved visual comfort and quicker adaptation.

PPL dispensing example

The client is a male in his late 40s who flies helicopters for a living. With his presbyopia increasing he is finding it more difficult to cope with his current tinted PPLs especially when viewing the wide instrument panels in front of him. He also needs to be able to view the ground through lower quarter-light



Figure 8 Universal marking system for varifocals

panels by his feet when landing and finds the increased head movement required tiring by the end of the day. His current lenses are older in design. Areas for consideration are:

- Design of PPL
- Working distances
- Sun protection.

Further discussion with the client reveals that he rarely needs to read at 40cm, with his instruments being about 90cm in front of him and he only needs to use the lower quarter panels to view the ground when it is about a meter away.

He is dispensed with a free-form surfaced individual progressive design to provide a wide field of view. For improved safety and sun protection, a polycarbonate photochromic lens with a reflection-free coating is specified. The reading addition is also reduced to



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Figure 10 The differing types of vocational degressive and progressive lenses

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increase working distances in the near and intermediate zones of the lens.

Vocational and degressive lenses The traditional idea of a progressive lens incorporating correction for just distance, intermediate and near vision has been challenged in recent years by a new breed of lens that offers practitioners the opportunity to select, from various lens designs, a far more tailored solution for specific vocational tasks. The degressive, or enhanced near vision lens, has at a stroke revolutionised the prescribing of lenses for intermediate and near corrections, and provides practitioners with a valuable new tool for occupational and vocational dispensing (Figure 10).

Through careful investigation at the point of dispensing, often in the form of a visual task analysis, practitioners can now select from a wide range of vocational progressive and degressive lens designs that truly meet the demands of a modern workplace. Examples of occupational and degressive lenses are the Essilor Interview, Essilor Computer 2V and 3V, Rodenstock Nexyma, Zeiss Gradal RD and the Hoya Hoyalux Workstyle.

Summary

This article has only provided a very brief overview of the many lens designs and materials available. As eye care professionals, a good working knowledge of the available lens types, designs and their characteristics is an essential part of our role. Not only must we remain familiar with the more traditional lens designs and materials available but we must also keep up to date with the ever changing range of new products and technologies that make our profession so diverse and so interesting to work in.

Further reading

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MULTIPLE-CHOICE QUESTIONS - take part at opticianonline.net

- Which of the following aberrations is of most concern in spectacle lens design?
- A Coma
- A Coma D Obligue actigm
- B Oblique astigmatism C Distortion
- **D** Transverse chromatic aberration

Which of the following statements is most correct?

- A Spherical lenses with flatter surfaces give better control of oblique astigmatism
- **B** Spherical lenses with flatter surfaces give better control of distortion
- **C** The form of a spectacle lens has a significant effect on transverse chromatic aberration
- **D** The form of a spectacle lens has an insignificant effect on transverse chromatic aberration

Which of following lenses cannot be

- described as a flat lens?
- **A** F1 = +4.00D, F2 = -1.00D
- **B** F1 = +2.00D, F2 = +2.00D
- **C** F1 = +4.00D, F2 = plano
- **D** F1 = +4.00D, F2 = +1.00D

4 Which of the following statements is correct?

- **A** The base curve of a finished toric lens is the lower of the two powers worked on the toroidal surface
- **B** The base curve of a finished toric lens is the higher of the two powers worked on the toroidal surface
- **C** The base curve of a finished toric lens is taken to be the curve worked on the spherical surface
- **D** The base curve of a finished meniscus lens is the higher of the two surface powers

Which of following is not an advantage of

- a low-powered aspheric lens?
- A Good off-axis performance
- **B** Reduced surface reflections **C** Less spectacle magnification

D Reduced sensitivity to fitting distance

6 Which of the following surfaces is commonly employed in a low-powered aspheric lens?

- A Parabola
- **B** Hyperbola
- **C** Oblate ellipse
- D Prolate ellipse

Which of the following bifocal segments will produce most image jump?

- A A flat-top S28 segment
- **B** A flat-top S35 segment
- **C** A round 38mm downcurve segment

D A round 28mm downcurve segment

- Which of the following bifocal options will provide the best control of centration for near?
- **A** Distance prescription -4.00D, round 38mm downcurve segment
- **B** Distance prescription -4.00D, flat-top S28mm segment
- **C** Distance prescription +4.00D, flat-top S28mm segment
- **D** Distance prescription -4.00D, round 28mm downcurve segment

Which of the following statements regarding progressive power lenses is most correct?

- A Modern PPLs are usually 'hard' in design
- **B** All new wearers of PPLs adapt to their lenses within 10 days
- **C** PPLs display no image jump
- D Peripheral surface astigmatism results in a wider near and intermediate field of view when compared to a bifocal or trifocal lens

10Which of the following statements regarding PPLs is most correct?

- A Skew distortion is a result of surface aberrational astigmatism
- **B** Lens wearers often describe surface aberrational astigmatism as a 'swimming effect'
- **C** Skew distortion is also troublesome in bifocal lenses
- **D** Skew distortion occurs because a change in power is accompanied by a change in magnification

1 Which of the following statements regarding PPLs is most correct?

- **A** The distance between the engraved circles on a PPL is different for every brand
- **B** The reading addition is engraved under the temporal reference point
- **C** The manufacturer's identifying mark is engraved under the temporal reference point
- **D** Prism thinning is always beneficial

1 Which of the following lenses is best described as an enhanced reading lens as opposed to an occupational or workstation lens? A Hoyalux Workstyle B Zeiss Gradal RD

- C Rodenstock Nexyma 80
- **D** Essilor Interview

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The deadline for responses is January 8 2008



