ABO PREPARATION

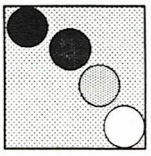
Week

4

Lens Materials & Coatings

Multifocal Designs

4: Lens Materials & Coatings



Lens Parameters

Material	Refractive Index	V-Value	Specific Gravity
Ophthalmic Crown	1.523	59	2..55
Photogrey Extra	1.523	59	2.41
CR–39	1.498	58	1.32
HIGH INDEX PLASTIC	1.6	36	1.36
Dense Flint	1.690	30	4.04
Barium	1.60	42	3.71
1.6 Crown	1.601	41	2.62
Titanium Glass	1.701	31	2.99
Niobium Glass	1.700	40	2.99
Flint 1.8	1.805	25	3.37
Polycarbonate	1.586	30	1.20
Slimline 50	1.700	50	3.30

Highlight

Silor

Hyper Index PLASTIC

Specific Gravity: The weight in grams of one cubic centimeter of any given material. The higher the specific gravity of the material from which a lens is made, the more it will weigh.

V-Value, or Abbe number: A relative measure of the dispersion or color distortion of a lens . Through the optical center of any lens, regardless of material, color distortion is virtually non-existent. As the eye turns behind a powered lens, prism is induced which causes dispersion. Dependent on the v-value, more or less dispersion is induced.

Materials made from dense flint or barium glass are commonly used for the segments in fused glass bifocals. We will be covering bifocal design in the next session.

Although a wide variety of spectacle lens materials are available for use, most lenses sold today are made of either CR-39 plastic, clear crown glass, or photochromic glass.

Glass

Crown Glass:

Most frequently used material when glass is called for in ophthalmic eyewear.

Consists of about 70% sand, 11%-13% calcium oxide or lime and 14% - 16% soda.

Relatively strong provided surface is free from defects such as scratches or pits.

Cleans easily and resists corrosion.

Can be rendered impact resistant through either heat or chemical methods.

Flint Glass:
(Thin Lite)
NO LONGER AVAILABLE

Also known as lead glass. High index of refraction makes it suitable for use in the manufacturing of fused glass multifocals.

Consists of 45% - 65% lead oxide, 25% - 45% sand, and 7% -10% soda.

High specific gravity and low V-value result in heavy weight and increased dispersion.

At one time was used for single vision lenses of reduced thickness which was commercially known as "Thinlite". However these are no longer available due to difficulties in rendering them impact resistant.

Barium Glass:

High index of refraction combined with relatively low amount of chromatic dispersion, make this the material of choice for the fused segment of most glass multifocals manufactured today.

Consists of 25% - 40% barium oxide in addition to sand and other metallic oxides.

Glass

High-Lite Glass: Most frequently used in higher powered minus lenses generally exceeding – 6.00 diopters.

Since it is made with titanium or "titanate" instead of lead, it is relatively light in weight, and has a lower rate of chromatic dispersion while maintaining a 1.70 index of refraction.

Can be chemically treated for impact resistance.

Photochromic Glass: Made with silver halide crystals which respond to ultraviolet light of wavelengths between 300 – 400 nm.

Lenses automatically darken with increased illumination and lighten as illumination decreases.

Has "exposure memory." Lenses will change more readily after initial exposures to light. However, if not used for some period of time, a new "breaking-in" period may be necessary.

Replacing one lens only can be problematic since the new lens may not match the color of the original, even after a "breaking-in" period.

Plastic

CR-39: Most popular lens material used today for a wide variety of single vision and multifocal designs.

Inherently impact resistant: unlike glass, no special treatment of a CR-39 lens is necessary to pass federal standards of impact resistance.

Fragmentation: When a plastic lens breaks the pieces are larger and fewer than with a glass lens. Also, the edges of the broken fragments are not as sharp as glass and there generally is an absence of fine particles.

Plastic

CR-39 (cont):

Fogging: CR-39 responds more favorably to changes in temperature than glass lenses. That is, it is less likely to "fog-up."

Weight: Plastic lenses are approximately 50% lighter than crown glass lenses of comparable size and shape, resulting in significantly greater comfort for the wearer.

Reflections: Internal reflections and surface glare is less with plastic lenses than with glass.

Tinting: Lenses may be tinted virtually any color desired. Even lenses with variable thickness such as those with high minus or plus powers will tint uniformly.

Industrial Applications: In addition to being more impact resistant than glass, plastic lenses are actually more resistant to pitting from certain welding and grinding operations.

Scratching: Since the surface of a plastic lens is softer than its glass counterpart, it does tend to scratch more easily. However, the many excellent scratch resistant coatings available today have generally solved this problem.

Polycarbonate:

A high index of refraction combined with a low specific gravity make lenses made of this material especially thin and light in weight. However, its low V-value means there are significant amounts of chromatic aberration present, especially in higher powers where minimizing the thickness and weight becomes important.

Extremely Impact Resistant: The high degree of impact resistance, make polycarbonate lenses particularly useful for industrial safety applications as well as for use in children's eyewear.

Polycarbonate (cont): Scratching: Although highly impact resistant, the surfaces of polycarbonate lenses are soft and scratch very easily. An excellent scratch resistant coating must always be used with this material. Also, because of its softness, special techniques must be utilized in the fabrication of eyewear made from polycarbonate.

Tintability: Generally, only light tints are available with polycarbonate lenses. In fact, it is the coating which absorbs the color, rather than the material itself. Lens manufacturers are continually working to improve lens coatings in an effort to increase the versatility of this material.

Lens Material Comparisons

	Crown Glass	CR-39	Polycarbonate
Index of Refraction	1.523 Thinner	1.498 Thin	1.585 Thinnest
Specific Gravity	2.55 Heavier	1.32 Lighter	1.20 Lightest
V-Value	59 Least Color Dispersion	58 More Color Dispersion	30 Most Color Dispersion
Impact Resistance	Good (When Treated)	Better	Best
Tintability	Color In Glass *or* Vacuum Coating *or* Photochromic	Virtually Unlimited	Only As Good As SR Coating
Scratch Resistance (Uncoated)	Good	Fair	Poor
Scratch Resistance (Coated)	NA	Good-Excellent	Fair-Good

Lens Tints

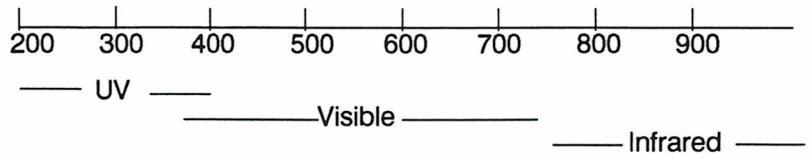
	Light	Medium	Dark	Very Dark
Number	1	2	3	4
Letter	A	B	C	D
% Absorbtion (Approximate)	10%	40%	80%	90%
% Transmission (Approximate)	90%	60%	20%	10%

As shown in the table above, the density of color of ophthalmic lenses may be indicated through the use of numbers, letters, or as a percentage of transmission or absorbtion. For example, a light grey tint may be designated as Grey #1, Grey A, Grey 10% or, less commonly, Grey 90% transmission. Occassionally, colors are described simply as light, medium, or dark.

Most CR-39 plastic lenses are manufactured clear, without any tint. Plastic can be tinted virtually any color and it may be changed or modified with relative ease.

There are several methods of achieving tint in glass lenses. Some are manufactured with the color actually in the material itself. Although this used to be more common, certain colors such as Pink #1 and Grey #3 are still available. With this type of colored glass, however, the density of the tint will change with lens thickness, That is, the thicker the lens the darker will be the color. A Grey #3 tint on a a +3.50 diopter lens, for example, will be significantly darker than the same designated tint on a +1.00 diopter lens. Another method of achieving color in glass is through the use of a metallic oxide applied to the lens in a vacuum. Vacuum coating permits a wide range of color choices and results in a consistent , even density of color throughout the lens regardless of power. Photochromic lenses, described earlier, are commonly available in glass. The most popular photochromic colors are grey and brown.

Polarized Lenses: Polarized lenses are useful for reducing the amount of glare reflected off surfaces such as water, snow, or metallic surfaces. Reflected light is partially polarized with the major direction of vibration being in the horizontal plane. A polarized lens admits only light vibrating in the vertical plane thus reducing the intensity of glare. A polarized lens contains a filter of polyvinyl alchohol which has be layered or "sandwiched" between the glass or plastic lens material.



Ultraviolet

UV 400: A method of specially treating ophthalmic lenses so that most of the ultraviolet wavelengths ranging from approximately 280 - 400 nm will be absorbed by the lens.

In Part 2, *Basic Optical Principles,* we learned that the range of visible light falls between about 390 - 750 nm as indicated above. However, wavelengths which actually reach the retina fall between 380 and 1400 nm, and, if not absorbed by the anterior portion of the eye, we would be able to perceive wavelengths as short as 300 nm.

Certain wavelengths are absorbed selectively by various parts of the eye. For example, wavelengths between 250 - 300 nm are absorbed by the cornea. While wavelengths which fall between 380 - 1900 nm pass through the crystalline lens, the vitreous absorbs all wavelengths longer than 1400 nm thus preventing them from reaching the retina.

Since the cornea absorbs ultraviolet light shorter than 300 nm, overexposure to these wavelengths can result in inflammation of the cornea and conjunctiva. Color changes in the crystalline lens which may contribute to the development of cataracts, may result when the eye is exposed to large quantities of ultraviolet light between 300-400 nm.

Other Coatings

Antireflection Coating : A thin clear film applied to a lens surface which serves to reduce unwanted reflections and at the same time increase the amount of light that passes through the lens to the eye.

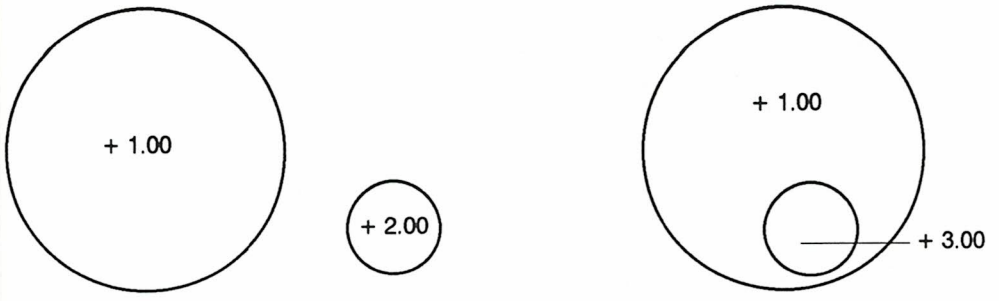
Scratch Resistant Coating: Since a disadvantage of plastic lenses has been their tendency to scratch more readily than glass, lens manufacturers have developed some excellent coatings which significantly increase resistance to scratching.

Edge Coating: A color coating applied to the edge of higher minus lenses which matches the color of the frame. When used properly, it tends to camouflage the thick edge of the lens and at the same time minimizes the concentric circles which can result from reflections off the lens edge.

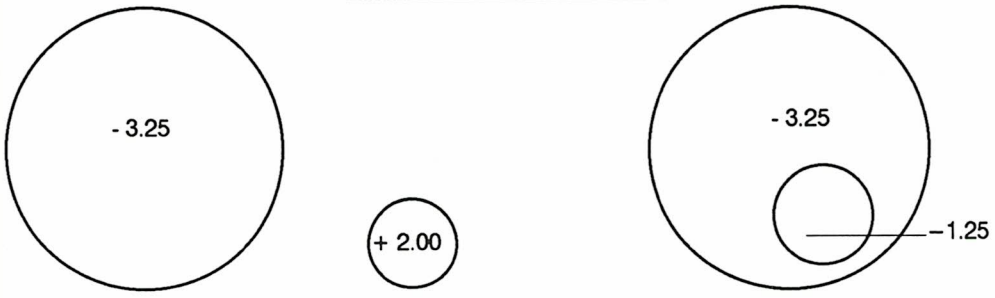
Mirror Coating: A coating applied to the front surface of a lens through a vacuum process which causing the lens to assume properties similar to a two way mirror.

Multifocal Designs

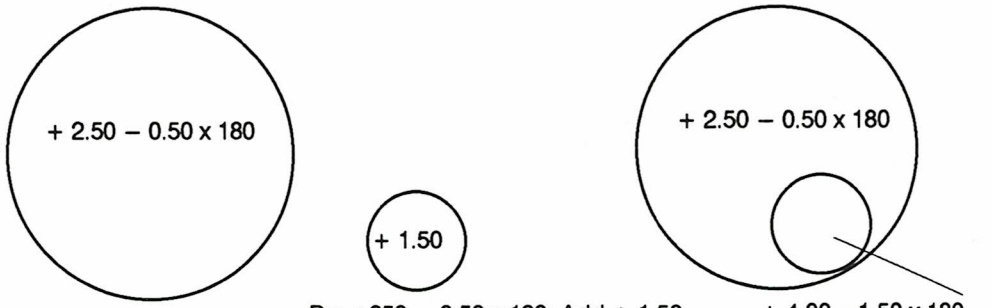
Reading Addition



Rx: +1.00 sph; Add + 2.00



Rx: –3.25 sph; Add + 2.00

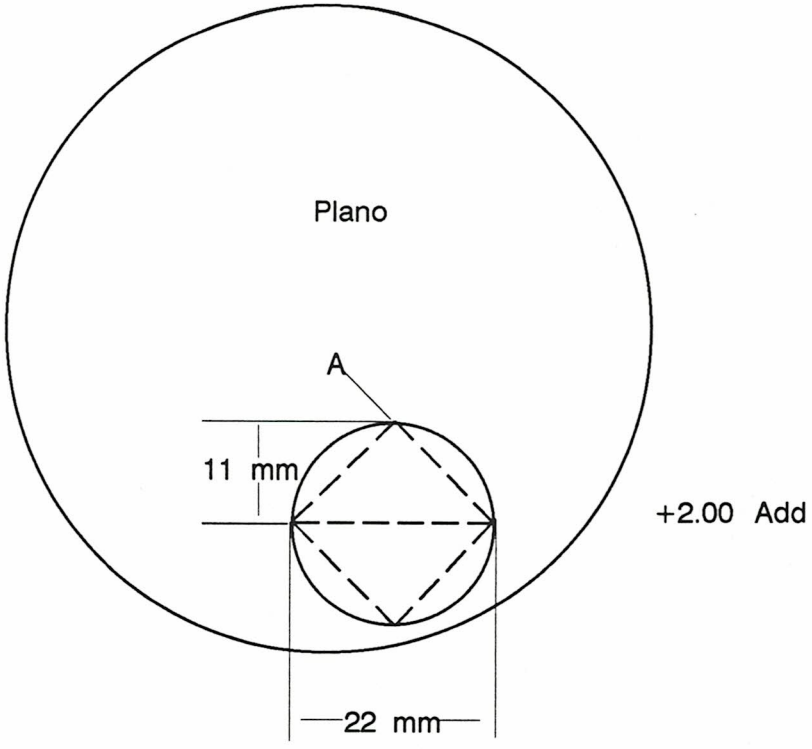


Rx: +250 – 0.50 x 180; Add + 1.50

+ 4.00 –1.50 x 180

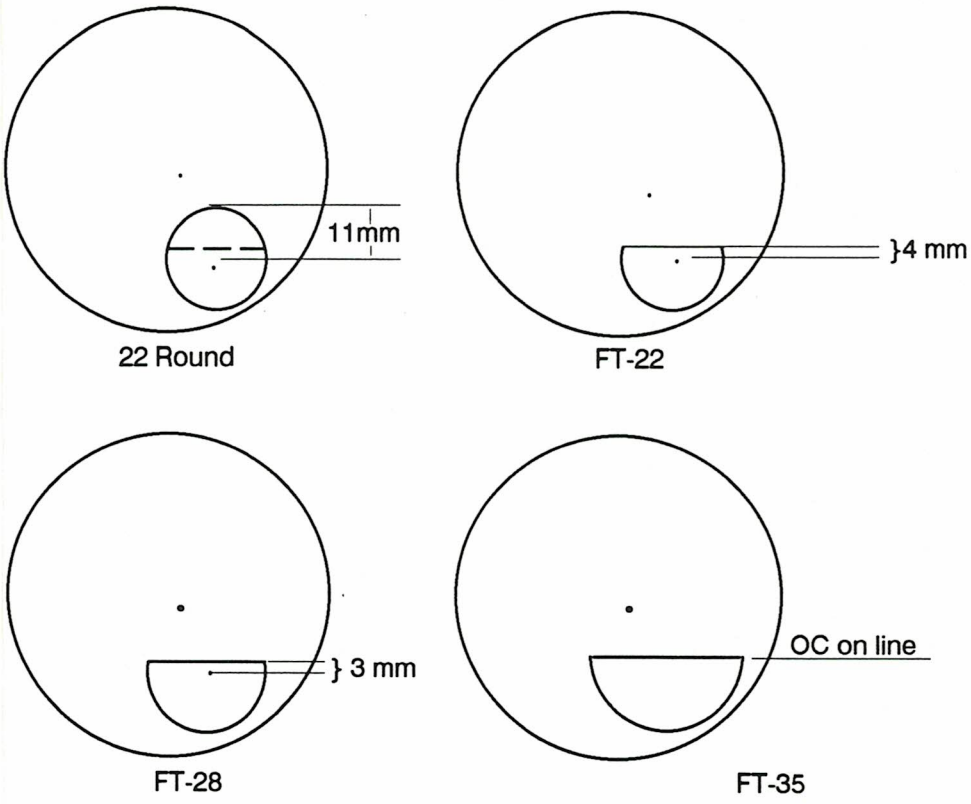
A bifocal lens may be thought of as two lenses combined into one—a larger one sometimes referred to as the *carrier lens* and a smaller one commonly known as the *segment.* The power of the bifocal segment is always plus and is known as the *reading addition.* (Bifocals are used for the correction of presbyopia and are needed to replace plus power which has been lost to the crystalline lens.) To determine the total power through the reading segment, algebraically add the power of the spherical component of the carrier lens to the power of the reading addition. The cylinder and axis remain unchanged.

Image Jump



Since the reading segment may be thought of as a small plus lens which has been added to a larger lens, then we may also think of it as as set of prisms placed base to base. If we consider only those prisms which are vertically oriented, it would look something like the illustration above. The example shows a 22 mm round bifocal segment where the distance from its center to the periphery is exactly 11mm. The instant the eye enters the segment area (point A above) there is some base down prism induced. To determine how much prism we apply Prentice's Rule: $\Delta = F \times dec\ (cm)$; $\Delta = 2.00 \times 1.1 = 2.2\ \Delta$ base down. We know that light is always bent toward the base of a prism and the image is displaced toward the apex. In this case, 2.2 diopters of prism is induced displacing the image upward, toward the apex. This is known as *image jump* since the image appears to "jump" upward the moment the eye enters the segment area. The greater the power of the add and/or the farther the optical center of the segment is from the transition line, the greater the amount of image jump. Since excessive image jump is not desirable, one of the objectives in the development and improvement of multifocal designs has been to minimize image jump.

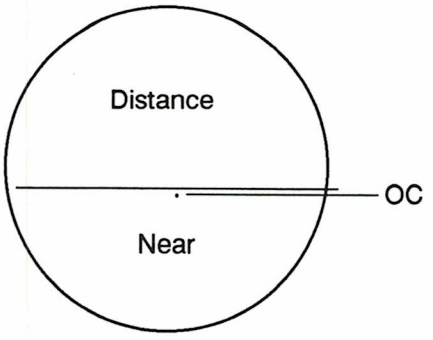
Flat Top Bifocals



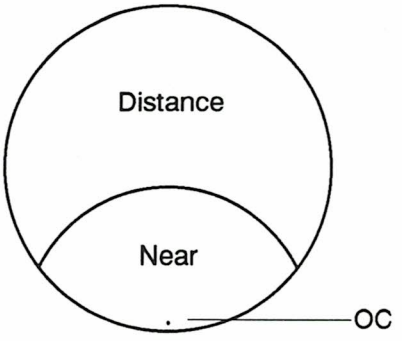
A *flat top* bifocal may be thought of as a round segment with the top cut off. In this design the optical center of the segment is located closer to the transition line, producing less image jump. Flat top segments are also called *straight top* bifocals and are occassionally referred to as *D* segments since they are shaped like the letter D. If the lens on the previous page were a flat top design, the optical center of the segment would be only 4 mm from the transition line rather than 11 mm. The amount of prism produced at that point would only have been 0.8 Δ instead of 2.2Δ—a significant difference.

Flat Top bifocals are available if the following diameters: FT-22; FT-25; FT-28; FT-35; FT-40. The variety of sizes is possible due to the ability to manipulate the position of the optical center of the segment relative to the transition line. Since the optical center of round bifocals are always in the geometric center of the segment, they are commonly available in the relatively small 22mm diameter and are ordered as "22 Round." Although larger diameters are available, more image jump is produced. The patient desiring a larger segment might be well advised to select another style lens.

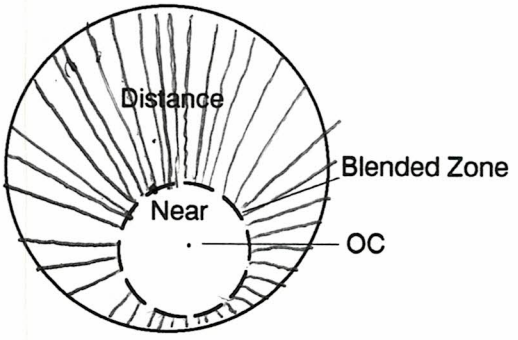
Other Multifocal Styles



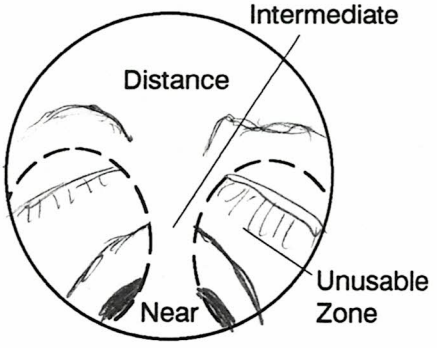
Franklin Style



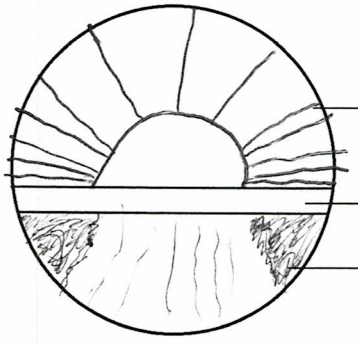
Ultex



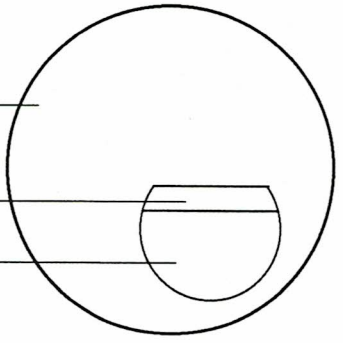
Blended



Progressive



Franklin Style Trifocal



Flat Top Trifocal

Other Multifocal Styles

The ***Franklin Style*** bifocal, also commonly known as the ***Executive*** bifocal, is designed so the reading portion spans the entire diameter of the lens. The optical center of the reading portion is typically located on or near the transition line (which minimizes image jump) and may either be coincident with the geometric center of the lens or slightly decentered in. This style results in somewhat thicker, heavier lenses, so care should be taken not to use it in higher powered prescriptions. As a result, base curve availability is limited.

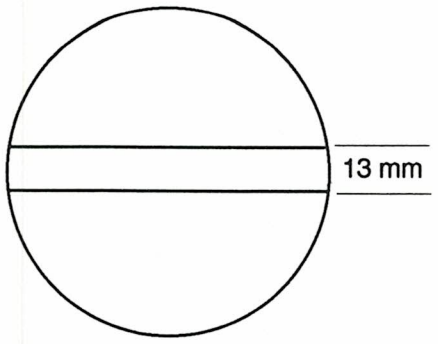
The ***Ultex*** bifocal is rarely used today. Although it offers a potentially large reading area, the optical center of the reading portion is positioned at the bottom of the segment about 18 mm from the transition line which can result in excessive amounts of image jump in higher powered reading additions. This style has largely been eclipsed by improved multifocal designs.

The ***Blended*** bifocal is a round segment, ranging in size from 22-28 mm diameter in which the transition from the carrier lens to the segment has been smoothed making it difficult to see. Although this style is cosmetically appealing for the patient who prefers a lens with no obvious line, the blended transition zone usually consisting of 2-3 mm of unusable area, can sometimes be problematic. Also there can be considerable image jump in larger segment sizes.

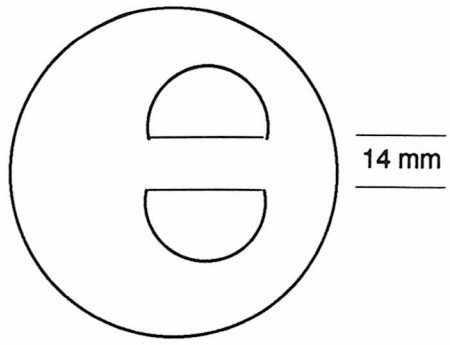
The ***Progressive*** bifocal has achieved tremendous popularity in recent years with virtually every major lens manufacturer now producing their own version of this multifocal style. A progressive lens contains no transition line and no image jump. Instead, there is a gradual or progressive change of power along a "channel" from distance to near. The power of the lens in about the middle of the transition area is approximately equal to the intermediate prescription. The cosmetic advantages of this lens, the smooth transition from distance to near with no image jump, combined with a usable intermediate area have contributed to the popularity of this style. However, the lens is not for every patient. On either side of the channel lies unusable areas of distortion which can be difficult to adapt to. The intermediate zone is relatively small, rendering it impractical the advanced presbyope who depends on a wide field of vision through the intermediate area. The ideal candidate for this lens is the early presbyope since lower add powers result in wider intermediate and near zones and less peripheral distortion. Accurate monocular P.D. and "seg height" measurements are recommeded for successful fitting.

The two trifocal styles shown on the previous page are a franklin style lens and a flat top. If a 28 mm flat top lens also contains an intermediate zone which is 7 mm deep, it is called a 7 x 28 flat top trifocal. Some common flat top trifocal dimensions include: 7 x 25; 7 x 28; 7 x 35; 8 x 35. The intermediate zone of the franklin style trifocal is typically 7-8 mm deep and has fitting limitations similar to the bifocal version of this style. *The power of the intermediate zone is most commonly equal to 50% of the add power.* Although 40%, 60%, and even 70% intermediate zones are occassionally prescribed, they usually need to be specially ordered.

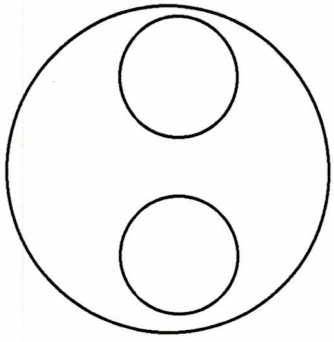
Occupational Lenses



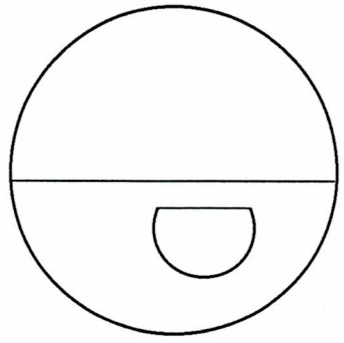
Double E



Double D



Double Round



ED Trifocal

Occupational lenses may be prescribed for any number of specialized occupational or recreational needs. There are a variety of lens styles available to suit numerous needs. The Double D, Double E, and Double Round styles shown above, would typically contain the distance portion of the prescription through the main part of the lens. The bottom segment usually contains the full reading addition while the intermediate prescription will be found through the top segment. However, many combinations of distance, intermediate and near prescriptions through the various sections of the lens are possible depending on the need. Lens blanks are generally restricted to smaller sizes so care should be taken in frame selection. Adjustable nose pads are recommended to allow for some flexibility in manipulating the position of the double segment transition lines after the lenses are mounted in the selected frame. The ED Trifocal Shown above is particularly well suited for the person needing a wide intermediate area in combination with a large distance area and normal reading segment.

Fused & One Piece Designs

Fused	One Piece
Round Flat Top	Ultex Franklin (Executive) Progressive

Glass multifocal lenses may be either of a fused or one piece design. As the name suggests, one piece multifocals are manufactured from one piece of glass where the additional power through the reading zone is achieved through variations in the surface curvature. Fused multifocals are manufactured by *fusing* a higher index material such as barium glass (n= 1.60) to a lower index material such as crown glass (n= 1.523). The result is more plus power through the segment portion of the lens. The table above applies to any size bifocal or trifocal falling in the various categories. For example a fused flat top multifocal applies to any size bifocal, trifocal, or occupational lens previously mentioned.

Hard resin lenses are manufactured through a molding process and typically consist of only one material (CR-39). Therefore they may be considered one piece lenses. The one piece design of resin flat top segments account for the ledge along the transition line separating the carrier lens from the segment which is absent in a fused glass lens of the same style.

Practice Exercises

Determine the power through the reading portion of the following bifocal prescriptions:

1) + 2.00 – 0.50 x 030
+ 1.75 – 0.25 x 010
Add: + 1.50 O.U.

2) + 0.50 – 0.75 x 045
+ 0.25 – 0.25 x 180
Add: + 1.25 O.U.

3) – 2.50 – 1.00 x 090
– 2.75 – 1.50 x 110
Add: + 2.50

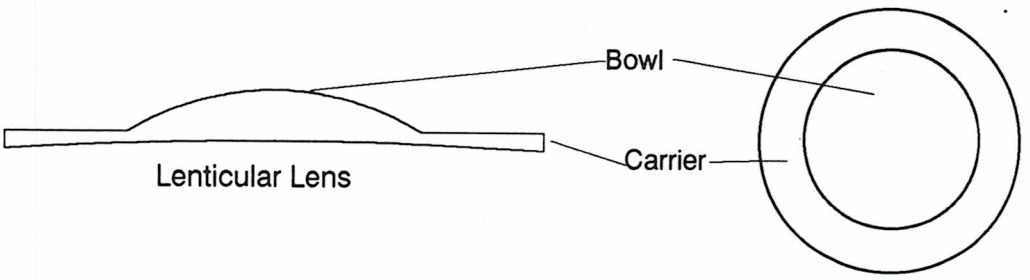
The following prescriptions indicate the distance power and the *full reading addition*.. In each instance you have been requested to make one pair of intermediate powered single vision vocational lenses utilizing 50% of the add power. What lens powers are needed to achieve this purpose?

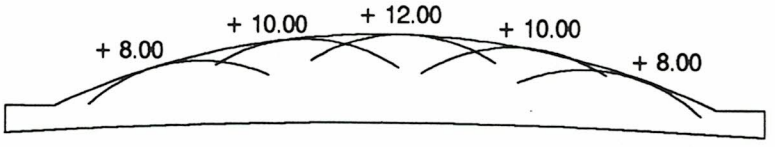
4) + 3.50 – 0.75 x 025
+ 3.75 – 0.50 x 005
Add: + 2.50

5) – 5.00 – 1.75 x 175
– 5.75 – 2.00 x 180
Add: + 2.00

6) + 7.50 + 2.75 x 090
+ 7.75 + 2.50 x 110
Add: + 1.50

Cataract Lenses







There are certain distortions or aberrations inherent in any lens with power. The higher the power, the more pronounced these aberrations become. An *aphakic* spectacle lens (one which is used in post-cataract surgery) can contain as much as eight to twenty or more diopters of plus power, making peripheral distortions a significant problem by reducing the useful area of the lens. One way of minimizing these distortions is through the use of *aspheric* front surfaces. An aspheric surface is one in which the shape is not spherical, but rather emulates the shape of the human cornea which is steeper in the center and gradually gets flatter as it radiates toward the periphery as illustrated above. A *lenticular* design is often used in high plus prescriptions for the purpose of minimizing lens thickness. It consists of a *carrier lens* and a *bowl.* The bowl is the portion containing the prescription. A lenticular lens may be either aspheric or spherical in shape.

Today, post cataract spectacle lenses are being used less frequently than they once were. This is due to improvements in aphakic contact lenses and intraocular lens implants, both of which are optically superior to high powered spectacle lenses.

ABO PREPARATION COURSE

4: Lens Materials & Coatings
Multifocal Designs

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