Bifocal Centration

Prismatic effect at the near visual points.

When the eye is using the near portion of a bifocal lens it is viewing through an extra-axial zone of the main lens and encounters prismatic effect exerted by both the distance portion and the bifocal segment. The total prismatic effect at the near visual point is the sum of the prismatic effect of the main lens and the prismatic effect, if any, of the segment lens.

The prismatic effect at the NVP of a bifocal lens can be determined by means of the accompanying tables which assume that the NVP lies 8 mm below and 2 mm inwards from the distance optical centre and that the segment drop is 2mm. Table 1 gives the prismatic effect due to the spherical component of the prescription, fractional components of the power can be added to obtain the prismatic effect due to the sphere.

Note that the prismatic effect is given for plus lenses which exert prism base up and out at the near visual points. For minus spherical powers the base directions should be reversed.

Table 2 gives the prismatic effect due to each +1.00 dioptre of cylinder power. For other cylinder powers the value given in the table must be multiplied by the cylinder power. Again, the table gives the base directions for plus cylinder powers. For minus cylinders, the base directions should be reversed, or the prescription should first be transposed into its plus cylinder form when Table 4 will always provide the correct base direction.

Table 5 gives the prismatic effect at a point 6 mm below the segment top and the jump exerted by the segment for each 1.00 dioptre of addition power. For other addition powers the value given in the table should be multiplied by the reading addition.

The tables can be used to determine the prismatic effect at the near visual point on a bifocal lens. Consider the prescription, R +3.50/+1.50 x 45 L -1.75/-1.25 x 165 Add +2.50, segment 30mm round. The prismatic effects, read from the tables, may be summed as follows:

R eye: prism due to sphere = 2.8Δ base up & 0.7Δ base out
prism due to cylinder = 0.75Δ base up & 0.75Δ base out
prism due to segment = 2.25Δ base down
total prism at NVP = 1.3Δ base up & 1.45Δ base out

L eye: prism due to sphere = 1.4Δ base down & 0.35Δ base in
prism due to cylinder = 1.0Δ base down & 0.26Δ base in
prism due to segment = 2.25Δ base down
total prism at NVP = 4.65Δ base down & 0.61Δ base in

The jump exerted by each segment is 3.75Δ base down.

For low power prescriptions, the prismatic effect at the NVP is not great and it is usually ignored provided that the magnitude is the same for each eye. The best type of bifocal for a given situation may then be selected with the vocational requirement for the lens taking prominence. Even with moderate powers, it must be the case that bifocal wearers who have worn a distance correction in the past have become accustomed to the prismatic effect due to the distance portion of their lenses, so that when faced with the selection of a first bifocal design, a sensible guide would be to choose a design whose segment adds little or no prism to that exerted by the main lens.

Table 1
Prismatic effect at the NVP due to PLUS spherical power.
***N.B.* for MINUS powers reverse the base direction.**

sphere power	**Prismatic effect in Δ**	
	vertical	**horizontal**
+0.25	0.2 **base UP**	0.05 **base OUT**
+0.50	0.4	0.1
+0.75	0.6	0.15
+1.00	0.8	0.2
+1.50	1.2	0.3
+2.00	1.6	0.4
+2.50	2.0	0.5
+3.00	2.4	0.6
+3.50	2.8	0.7
+4.00	3.2	0.8
+4.50	3.6	0.9
+5.00	4.0	1.0
+5.50	4.4	1.1
+6.00	4.8	1.2
+6.50	5.2	1.3
+7.00	5.6	1.4
+7.50	6.0	1.5
+8.00	6.4	1.6
+8.50	6.8	1.7
+9.00	7.2	1.8
+9.50	7.6	1.9
+10.00	8.0	2.0
+10.50	8.4	2.1
+11.00	8.8	2.2

0.25 intervals can be found by simple addition:
e.g., +2.75 = +2.50 and +0.25

for +2.50: prism due to sphere = 2.0Δ base UP and 0.50Δ base OUT
for +0.25: prism due to sphere = 0.2Δ base UP and 0.05Δ base OUT

so for +2.75 D sphere prism at NVP = 2.2Δ base UP and 0.55Δ base OUT

Table 2
Prismatic effect at the NVP due to each +1.00 D of cylinder power.
N.B. **for MINUS cylinder powers reverse the base direction.**

Axis direction		**Prismatic effect in Δ**	
R eye	**L eye**	**vertical**	**horizontal**
180	180	0.80 **base UP**	0
5	175	0.81 **base UP**	0.07 **base OUT**
10	170	0.81	0.14
15	165	0.80	0.21
20	160	0.77	0.28
25	155	0.73	0.34
30	150	0.69	0.40
35	145	0.63	0.44
40	140	0.57	0.48
45	135	0.50	0.50
50	130	0.43	0.51
55	125	0.36	0.51
60	120	0.29	0.50
65	115	0.22	0.47
70	110	0.16	0.43
75	105	0.10	0.39
80	100	0.06	0.33
85	95	0.02	0.27
90	90	0	0.20
95	85	0	0.13
100	80	0	0.06
105	75	0	0.01 **base IN**
110	70	0.03 **base UP**	0.08
115	65	0.07	0.14
120	60	0.11	0.20
125	55	0.17	0.24
130	50	0.23	0.28
135	45	0.30	0.30
140	40	0.37	0.31
145	35	0.44	0.31
150	30	0.51	0.30
155	25	0.58	0.27
160	20	0.64	0.23
165	15	0.70	0.19
170	10	0.74	0.13
175	5	0.78	0.07

For other cylinders, multiply the values given in Table 3 by the new cylinder power.

Table 3
Prismatic effect at the NVP and Jump due to each +1.00 D of addition power for various segment designs. The NVP is assumed to lie 6 mm below the segment top.

Segment diameter or size	Prism at NVP in Δ	Jump in Δ
22	0.50 base DOWN	1.1 base DOWN
24	0.60 base DOWN	1.2
25	0.65 base DOWN	1.25
25 x 17	0.15 base UP	0.45
26 x 9	0.15 base UP	0.45
28	0.80 base DOWN	1.4
28 x 19	0.10 base UP	0.5
30	0.90 base DOWN	1.5
30 x 16	0.50 base UP	0.1
30 x 21	0	0.6
30 x 23	0.20 base DOWN	0.8
34 x 22	0.10 base UP	0.5
35 x 22	0.15 base UP	0.45
38	1.30 base DOWN	1.9
40 x 20	0.60 base UP	0
45	1.65 base DOWN	2.25
E-style	0.60 base UP	0

Note that the Jump is always base down (unless its value is zero!).

It can be seen from Table 3 that shaped segments such as the flat (D-shape) and curved-top (C-shape) segments hardly exert any prismatic effect at the centre of the near visual zone and, in general, have proved to be the most popular design. Not only do they not exert much prismatic effect at the NVP, the jump encountered at the dividing line when the eyes transfer their gaze from distance to near, is only about half that which would be exerted by a round segment of the same diameter.

In the case of high power prescriptions, there is much to be said for using the prismatic effect exerted by the segment to counteract the prismatic effect of the main lens. Consider the case of a -8.00 D myope who needs an addition of +2.00 D. From Table 1 the vertical prismatic effect due to the main lens is 6.4Δ base down. If the subject requires a large reading zone then we might consider the use of a large diameter segment. Inspection of Table 3 shows that if we were to dispense a 45 mm downcurve segment then the prism due to the segment would be an additional 3.3Δ base down! The total prismatic effect at the NVP would increase to 9.7Δ base down.

Selection of an E-style segment, on the other hand would result in a reduced prismatic effect at the NVP since this segment design exerts base up prism at the NVP. For the case in hand, the +2.00D addition would provide 1.2Δ base up at the NVP so that, if an E-style bifocal was selected for this power, then the total prismatic effect at the NVP would reduce to 5.2Δ base down, almost 50% less than is obtained with a 45 downcurve segment!

It will be seen in the next section that a knowledge of the prismatic effect at the near visual points of bifocal lenses assumes great importance in cases of anisometropia since no matter what the magnitude of the prismatic effect, differences between the eyes, particularly in the vertical meridian, may prevent comfortable binocular vision.

Prism Controlled bifocals

It is sometimes necessary to be able to alter the prismatic effect at the near visual point, for example, to provide base in prism for the reading portion only, or to balance the vertical prismatic effects at the near visual points. This can be done by using a bifocal design whose method of construction allows independent centration of the reading portion. Such a design is called a

prism-controlled bifocal which is simply a bifocal design whose method of construction is such that prism may be incorporated in the segment which is totally independent of any prism which is included in the main lens.

There are several methods by which prism may be incorporated in the segment only, some leading to designs which may be described as being fully prism-controlled and others which are described as being partially prism-controlled.

A fully prism-controlled design is one whose method of construction permits any amount of prism to be incorporated in the segment and with its base set in any direction. One purpose of this prism is to neutralize all prism at the near visual point which arises from the distance prescription and the reading addition. When all the prism is neutralized the reading portion has its own optical centre coincident with the near visual point. Such designs are often referred to as *centre-controlled* bifocals.

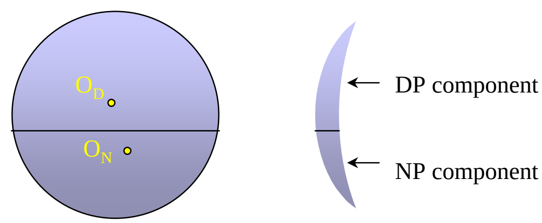

Figure 1. Split bifocal (Franklin design)

Two separate lenses whose powers correspond with the distance and near prescriptions are cut in half, flat-edged along their contact edges and screwed together in a metal frame. They could be bonded together along their contact edges and sprung into a plastics frame. If the optical centre of each component is placed, one at the DVP and one at the NVP, then the design is automatically centre controlled.

Bifocal designs which permit full centre-control include:

Split bifocals (Figure 1) - whose distance and reading portions are formed from two separate lenses which are cut in half and mounted together in the same eye of the frame. (The prism and prescription possibilities with Split bifocals are almost unlimited, since each eye consists of a pair of single vision lenses whose powers and centration may be chosen at will.)

Cemented or bonded bifocals (Figure 2) - where a prism segment is attached to the main lens using Canada Balsam or a more permanent epoxy resin adhesive. Note with this design that the prism base represents the thickest point on the dividing line.

Solid visible (or *semi-visible*) bifocals (Figure 3) - where the segment surface is depressed below the level of the distance portion surface, and being depressed may be angled to provide any amount of prism and hence any amount of prism-control. Note that with this solid prism controlled segment the prism base represents the thinnest point on the dividing line. It can be imagined that the segment surface was first depressed into the back surface of the blank and a small prism dropped into the depression.

The method of construction of these centre-controlled designs also permits unusual prescription requirements to be met such as bifocal designs where a cylinder is required in the distance or reading portion only, or different cylinder powers or cylinder axis directions in the distance and reading portions.

Some prism-controlled bifocal designs are produced with a given amount of prism incorporated

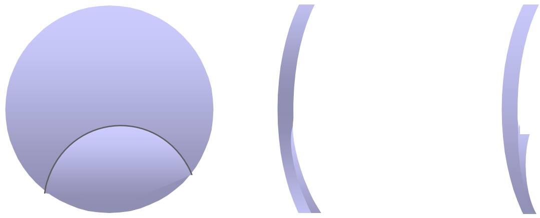

Figure 2. Cemented prism-segment bifocals

The separate segment lens can incorporate any amount of prism with its base set in any direction. Whenever possible, base down prism should be incorporated in the segment to position the maximum depth of ridge at the bottom of the segment.

in the segment by the blank manufacturer. For example, the only solid prism controlled bifocal currently being manufactured in the UK has a 30 mm segment diameter and incorporates prism in ½ Δ steps from ½ Δ up to 4Δ.

Partially prism-controlled designs include:

Solid and fused prism-segment bifocals whose segment is constructed with a fixed range of prisms.

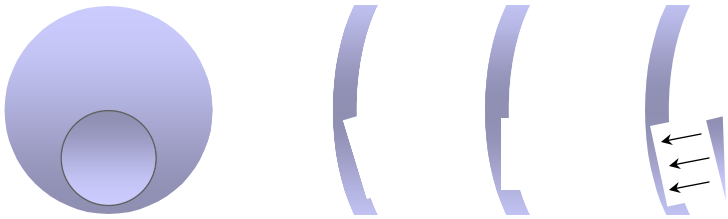

Figure 4. Solid prism-controlled bifocal

In principle, a depression curve is worked on the DP surface and a small prism dropped into this depression.Whenever possible, base up prism should be incorporated in the segment to position the maximum depth of ridge at the bottom of the segment.

Bi-prism bifocals where vertical prism has been added to or removed from the reading portion by means of the slab-off technique.

It has already been seen earlier that some prism-control may be obtained by judicious selection of an appropriate segment diameter. It will be seen, shortly, that partial horizontal prism control may be obtained by additional inset of the segment.

Prism control with invisible segments

A downcurve segment whose optical centre lies below the near visual point exerts base down prism at the NVP, the amount of which depends upon the reading addition over which there is no control once the prescription has been determined, and the segment diameter which can be varied providing that any vocational requirements are met. It is instructive to begin by considering the effect of the segment diameter upon the prismatic effect at the near visual point.

Consider the prescription +2.00/+1.00 x 180 Add +2.00 which has been made up with a 24 mm segment diameter with its top 2 mm below the distance optical centre.

The prismatic effects at a point 8mm below the distance optical can be read from the tables given above.

The NVP lies 8 mm below the optical centre of the main lens whose power along 90 is +3.00. Hence the prism due to the main lens is 0.8 x 3 = 2.4Δ base up.

The NVP also lies 6 mm above the optical centre of the segment element whose power is +2.00 so the prism due to the segment is 0.6 x 2.0 = 1.2Δ base down.

The total prismatic effect at the NVP is the sum of these two components: 2.4Δ base up and 1.2Δ base down which is 1.2Δ base up.

The total vertical prismatic effect at the NVP is, therefore, 1.2Δ base up.

It can be seen that the base down prismatic effect exerted by the segment is counteracting the base up effect of the main lens. This will always be the case when the main lens is positive in power, the base down effect of an invisible segment will reduce the base up prism of the main lens.

It will be realised that if a larger diameter segment is prescribed then the base down prism exerted by the segment would increase, thereby further reducing the base up effect of the main lens. If the prism due to the segment is increased to 2.4Δ base down then it would completely neutralize the base up effect of the main lens and the optical centre of the reading portion would coincide with the NVP, i.e., the design would be centre-controlled. Using the decentration relationship, c = P/F, it is an easy matter to determine what segment diameter is needed to centre-control the reading portion. The necessary decentration of the optical centre of the segment from the NVP is given by:

$$\frac{\text{Prism due to main lens}}{\text{Reading Addition}}$$

or in symbols:

$$P/F = 2.4/2.00 = 1.2 \text{ cm, or, } 12 \text{ mm.}$$

The optical centre of the segment must lie 12 mm below the NVP. Since the NVP lies 6 mm below the segment top, the radius of the segment must be 18 mm and its diameter 36 mm. Hence the use of an invisible round segment of diameter 36 mm would result in a bifocal design whose near optical centre coincides with the NVP.

This control of prismatic effect at the NVP by a suitable choice of segment diameter is also very useful for controlling vertical differential prismatic effect at the NVP's.

In any prescription, if the powers of the lenses differ significantly from one another then the prismatic effects encountered when the eyes look through points away from the optical centres will also differ. Hence, the amounts by which the eyes must rotate in order to obtain binocular vision will also differ.

In general, the eyes have a much larger tolerance to horizontal differential prismatic effects than to vertical differential prismatic effects.

It is generally accepted that the eyes should not be called upon to tolerate more than 1Δ of vertical differential prismatic effect in order to obtain comfortable binocular vision.

Consider the prescription: R -2.00   L -4.00 Add +2.00 for near.

At NVPs situated 8 mm below the distance optical centres the vertical prismatic effect due to the distance portion encountered by the right eye is 1.6Δ base down whereas the vertical prismatic

effect due to the distance portion encountered by the left eye is 3.2Δ base down. The differential prismatic effect is 1.6Δ base down in the left eye.
If the same diameter segment is given to each eye the prism due to the segment would be the same for each eye and the differential prism would remain 1.6Δ base down.
If a larger segment diameter is given to the right eye, it will exert a larger amount of base down prism than the left segment thereby reducing the differential prismatic effect at the NVPs. The difference in segment diameters, d_1 - d_2, which is required to completely eliminate vertical differential prismatic effect at the NVPs can be found from the rule:

$$d_1 - d_2 = \frac{20 \times \text{differential prism}}{\text{Add}}$$

In this example we find:

$$d_1 - d_2 = \frac{20 \times 1.6}{2.00} = 16 \text{ mm.}$$

so, for example, a 38 diameter segment given to the right eye and a 22 mm diameter segment given to the left eye would completely eliminate the vertical differential prismatic effect at the NVPs.
This is easily verified by calculating the prism due to the segment for each lens. Assuming the NVPs to lie 6 mm below the segment tops, the right NVP would lie (19-6) = 13 mm above the segment optical centre whereas the left NVP would lie (11-6) = 5 mm above the segment centre. The prism due to each segment would be:

right eye - 1.3 x 2 = 2.6Δ base down
left eye - 0.5 x 2 = 1.0Δ base down

and it can be seen that the total prismatic effect at each NVP is now 4.2Δ base down. The use of different size segments to provide prism control is usually restricted to the use of 38 and 45 mm segments in conjunction since the difference in these diameters is not too obvious. However, the use of this pair in conjunction restricts the amount of prism control to just 0.35 x Add.

Additional insetting to provide base in prism for near
Bifocal segments are normally inset to bring the near fields of view into coincidence. Additional insetting of the segment beyond this normal extent will create base in prism at the near visual point. Base in prism might be useful to relieve convergence insufficiency or simply to counteract the base out effect which occurs as a matter of course whenever the main lens is positive. It is curious that, in practice, when dispensing prescriptions for near in single vision form, say BE +5.00 DS, the lenses are usually always centred for near, by ordering inward decentration of the near optical centres, to ensure that the subject is not called upon to overcome base out prism at the near visual points. Despite this fact, when dispensing the same prescription in bifocal form the base out prismatic effect of the distance portion at the NVPs is simply ignored. Additional insetting of the segment, if the segment diameter is large enough, will create base in prism to counteract the base out effect of a plus main lens.
The amount of base in prism can be found from the simple decentration relationship, for example, 2 mm of additional insetting, calculated from the geometrical centre of the segment for an addition of +2.50, will introduce 0.5Δ base in. It might occur to the reader that this base in prism could be created by working prism across the entire lens to separate the distance and near centres by an amount which depends upon the powers of the distance and near portions. Suppose we wish to create 1Δ base in for the near portion only, with the prescription, BE +5.00 Add +2.50 for near (Figure 4). This could be achieved by working 3Δ base out across the whole lens, the effect of which will be to displace the distance optical centre outwards by 6 mm, again using the simple decentration relationship, but the near optical centre would move outwards by only 4 mm. Now when the bifocal is decentred 6 mm inwards to restore the distance optical

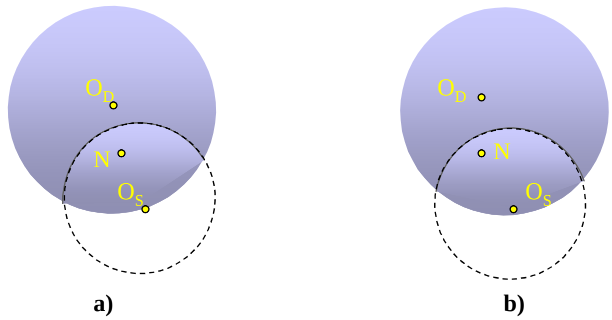

Figure 5. Additional insetting to provide base in prism for near.

Rx R +5.00 Add +2.50 for near with 1△ base in required in the near portion only.

a) The segment has been inset an extra 4mm to create 1△ base in for near.
b) The same effect can be created by working 3△ base out across the DP to move the distance optical centre outwards by 6mm and the near optical centre outwards by 4mm. When the lens is then decentred 6mm inwards to restore the correct position of the distance centre, the segment is effectively inset by an extra 4mm.
This method can be used to provide inset for E-style bifocals.

centre to its rightful position, the near portion will have 1Δ base in at the near visual point, 2 mm inwards from the distance optical centre. It goes without saying that the segment itself will now be inset by a total of 6 mm so the 1Δ base in which has been created could equally have been obtained simply by insetting the segment by an additional 4 mm in the first place. The amount of prism which must be incorporated can be found from the rule:

P = inset (cm) x DP power x RP power / Add

This technique of working prism to split the distance and near centres is useful for providing an inset in the case of E-style bifocals, where, the horizontal inward decentration of the lens to restore the distance optical centre to its correct position does not result in the odd appearance of the segments apparently being in the wrong position in the lens area. Since the dividing line is straight, it is not obvious that the segment has been decentred inwards at all. Needless to say, for other segment designs, not only must the blank be large enough to permit the necessary decentration to be obtained, the segment needs to be of sufficiently large diameter in order to provide the subject with an adequate near vision field. For this reason the technique is usually restricted to large crescent segments, 38 or 45 mm diameter, or to 35 or 40 mm flat-top segment designs.

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Prism controlled bifocals

The examples above illustrate how it is possible to provide partial prism control by careful selection of the segment diameter and/or by additional inset.
Usually, however, it is necessary to control the prismatic effect in the RP by including a prism in the segment of the lens. Some bifocal designs allow any amount of prism to be incorporated in the segment with the prism base set in any direction. These include solid centre-controlled designs and cemented or bonded segments. Such designs can be used to ensure that the optical centre of the near portion coincides with the NVP.
Consider the prescription -4.00/+1.00 x 180 Add +2.00 which is to be produced as a centre-controlled bifocal with the optical centre of the near portion coincident with an NVP which lies 8 mm below and 2 mm inwards from the distance optical centre. The segment specification is 38 x 2 x 2 and the distance optical centre lies 2 mm above the segment top.
The prismatic effect at the NVP can be calculated as shown above assuming, to begin with, that

an invisible segment is used.
From the information given in the specification, the NVP lies 6 mm below the segment top and, therefore, 13 mm above the optical centre of the segment. From the tables:

prism due to main lens = 2.4Δ base down & 0.8Δ base in
prism due to segment = 2.6Δ base down
so the total prism at the NVP = 5.0Δ base down & 0.8 base in

In order to neutralize this prismatic effect the segment must incorporate 5.0Δ base up and 0.8Δ base out, which, when compounded into a single resultant effect, is equivalent to 5.06Δ up at 99. This could be incorporated in a bonded segment of power +2.00 but would result in a thick edge at the top of the segment. A better result would be obtained from a solid design since the minimum depth of ridge would lie near the top of the segment.
These centre-controlled bifocal designs are very useful for prescriptions which include prism in the distance portion only or the reading portion only or different prisms in the distance and reading portions. It is possible in these cases to eliminate any other prism at the NVP due to the distance portion, i.e., to centre-control the design, apart from the prescribed prism at the DVPs or NVPs.
Typical uses for the design include:

- to provide prescribed prism in the DP or NP only, typically to provide prism base in for the near portion only in order to relieve convergence insufficiency
- to counteract the effects of strong oblique cylinders
- to place the optical centre of the NP at the NVP, *i.e.*, to centre-control the NP
- to eliminate vertical differential prismatic effect in cases of anisometropia
- to produce No-Jump bifocals, the amount of prism incorporated in the segment is equal and opposite to the Jump and places the optical centre of the segment on the dividing line at the segment top.

The following examples illustrate some of these possibilities. The NVP is assumed to be 8 mm below and 2 mm inwards from the distance optical centre in each case.
Example i)
DV R +2.50/+1.00 x 180 L +1.00/+1.00 x 180
NV R +4.50/+1.00 x 180 & 2Δ In L +3.00/+1.00 x 180 & 2Δ In
Segment 22 x 2 x 2

This prescription might also be written in the form:-

DV R +2.50/+1.00 x 180 L +1.00/+1.00 x 180
Add +2.00 and 2Δ Base In NP only
Segment 22 x 2 x 2

Needless to say, it is important to be state clearly what prism is required to be incorporated in the DP and what prism is required for the NP and it is for this reason that it is helpful to have the distance and reading prescriptions written out separately and in full.
In this example, prism is required in the reading portion only. The prismatic effects at the NVPs due to the main lens are:

R 2.8Δ base UP and 0.5Δ base OUT
L 1.6Δ base UP and 0.2Δ base OUT

Assuming that the segment drop is 2 mm the prismatic effect due to invisible 22 mm diameter segments is 1.0Δ base d own, so the total prismatic effects at the NVPs before any prism is incorporated in the segments is:

R 1.8Δ base up and 0.5Δ base out

L 0.6Δ base up and 0.2Δ base out

It should be apparent that simply to make a pair of prism segments which incorporate 2Δ base in for each eye would not satisfy the prescription requirement in any way.
We may proceed in one of two different ways:
1) Make a pair of prism segments which incorporate:
R 1.8Δ base down and 2.5Δ base in
L 0.6Δ base down and 2.2Δ base in
This solution offers complete centre-control in that the total prismatic effect remaining at the NVPs is just the prescribed 2Δ base in for each eye, all vertical prismatic effect has been neutralized.
2) Make a pair of prism segments which incorporate:
R 1.2Δ base down and 2.5Δ base in
L 2.2Δ base in
This solution eliminates the vertical differential prismatic effect at the NVPs and provides the prescribed 2Δ base in for each eye at near. It is assumed that bonded prism segments are to be used for this solution. If solid prism segments are employed, a better solution would be:
R 2.5Δ base in
L 1.2Δ base up and 2.2Δ base in
to ensure that the minimum depth of ridge for the left eye is closer to the top of the segment.

Example ii)

DV R +1.00/+4.00 x 60 & 1Δ up   L +1.00/+4.00 x 120 & 1Δ down
NV R +3.00/+4.00 x 60 & 2Δ in   L +3.00/+4.00 x 120 & 2Δ in
Segment 30 x 2 x 2

Strong oblique cylinders give rise to oblique prismatic effects at the NVPs which might prevent comfortable near vision. This is often the case when the resolved horizontal prism is base out, as in this prescription, since it requires an extra effort of convergence by the eyes. This is the likely reason for the base in prism requested for near vision only in this specification. However, the prescription also requires vertical prism in the distance portion only so the segments must also include
R 1Δ base down   L 1Δ base up
in order to neutralize the DP prism in the reading portion.
The prismatic effects at the NVPs due to the main lenses are:
Right eye: prism due to sphere   0.80Δ base up and 0.20Δ base out
prism due to cylinder 1.16Δ base up and 2.00Δ base out
prism in DP Rx   1.00Δ base up
Total prism from main lens   2.96Δ base up and 2.20Δ base out.
Left eye: prism due to sphere   0.80Δ base up and 0.20Δ base out
prism due to cylinder 1.16Δ base up and 2.00Δ base out
prism in DP Rx   1.00Δ base down
Total prism from main lens 0.96Δ base up and 2.20Δ base out

Assuming that the segment drop is 2 mm, the prismatic effect due to invisible 30 mm diameter segments is 1.8Δ base down, so the total prismatic effects at the NVPs, before any prism is incorporated in the segments, is:

R 1.16Δ base up and 2.20Δ base out
L 0.84Δ base down and 2.20Δ base out.

The prism which needs to be added to the segment to provide the prescribed prism of no vertical effect and 2Δ base in is:
R 1.16Δ base down and 4.20Δ base in
L 0.84Δ base up   and 4.20Δ base in
These would be compounded in the usual way to determine the single prismatic effect which

must be incorporated in the segment to achieve the effect:

R 4.36Δ base down at 164.6

L 4.28Δ base up at 168.7

Example iii)

R +2.00 L -2.00 Add +2.50 38 mm segments

No-Jump bifocals

The Jump is simply the prismatic effect at the dividing line due to the segment[1] and is calculated by multiplying the distance from the optical centre of the segment to the dividing line in cm by the reading addition. It is independent of the power of the main lens.

The radius of each segment is 38/2 or 19 mm, so the Jump is:

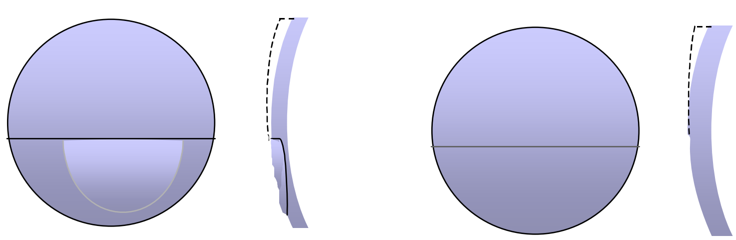
1.9 x 2.5 = 4.75Δ base down

In order to eliminate the Jump, the segment must incorporate 4.75Δ base up, the effect of which will be to shift the optical centre of the segment to the segment top.

Needless to say, a pair of No-Jump bifocals cannot be further compensated for vertical differential prismatic effect at the NVPs. In this example, the 3.2Δ difference is certain to prevent comfortable near vision and it would be usual to equalise the vertical prism in cases of anisometropia rather than to eliminate Jump.

Bi-prism bifocals

Prismatic effect in the reading portion of a bifocal lens can be altered by slabbing-off vertical prism from the lower half of the lens. The slab-off process effects only the vertical prismatic effect at the NVP and results in a horizontal dividing line between the two portions which is in addition to the segment dividing line (Figure 5). For this reason it is customary to restrict the bi-prism technique to bifocal designs which themselves have a straight dividing line between their distance and reading portions. Flat-top, D segments and E-style segments are ideal for this method of providing partial prism control, in the latter case the bi-prism dividing line can be made to coincide exactly with the horizontal dividing line of the segment.



a) **b)**

Figure 5. Bi-prism bifocals

a) Flat-top D-segment bi-prism design
b) E-style bi-prism design

The amount of prism which must be slabbed-off depends, as before, upon the exact prescription requirement.

Suppose it is required to produce a pair of D-segment bifocals with no vertical differential prism at the NVPs for the prescription:

R -2.50/-2.00 x 180 L -1.50/-0.50 x 180

Add +2.00

The vertical prismatic effect at each NVP due to the main lens is:

R 3.6Δ base down   L 1.6Δ base down

so the vertical differential prismatic effect is 2Δ base down in the right eye.

In order to eliminate this differential prism the right eye must incorporate 2Δ base up in the reading portion only or the left eye must incorporate 2Δ base down in the reading portion only.

The slab-off process described above removes base down prism from the lower half of the lens so the right eye would be chosen as the bi-prism design.

It is possible, in the case of plastics bifocals, to incorporate a slab-off on the moulded bifocal surface. When the slab-off is worked in-mould, the cast bifocal surface has base up prism removed from the segment area. If such a design was employed for this example, the left eye of the pair would be the bi-prism design with 2Δ base down added to the reading portion.

Complex prescription requirements

The method of construction of cemented (or bonded) and solid visible bifocals enables complex prescriptions such as cylinders in the distance or near portions only or different cylinders and/or axes in the distance and near portions to be made. The segment elements of these designs could also include different prisms, for example, to centre-control the near portion of the lens.

Consider the bifocal prescription:

DV R +2.00 L +2.00/+1.00 x 90

NV R +4.00/+1.00 x 90 L +4.00

Here a cylinder is required in the distance portion only of the left eye and the near portion only of the right eye. This specification could easily be made as a split bifocal design using the components shown in Figure 6.

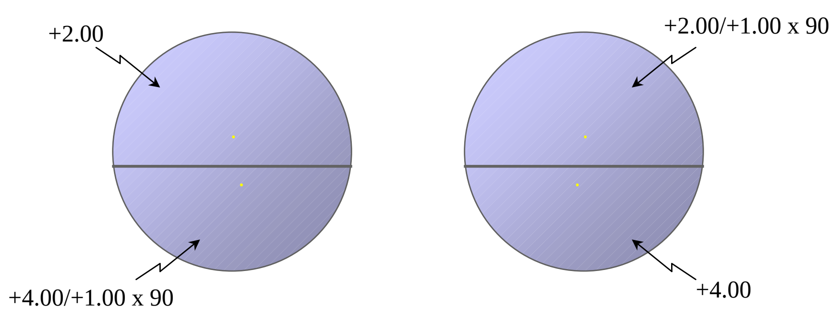


Figure 6. Split bifocals made to specification as follows:

DV R +2.00 L +2.00/+1.00 x 90

NV R +4.00/+1.00 x 90 L +4.00

Four separate lenses are employed and each component may be centred as required.

It could also be made in cemented bifocal form as shown in Figure 7 where a ±5.00D contact surface has been employed.

Or, it could be made as a solid visible design as shown in Figure 8 where a -4.00D spherical RP curve has been employed.

These methods of construction permit more complex astigmatic requirements to be met such as different cylinder powers and/or different cylinder axes to be provided in the distance and near portions.

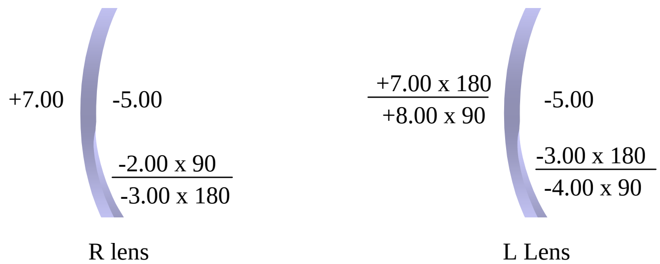


Figure 7. Cemented bifocals made to specification as follows:

DV R +2.00 L +2.00/+1.00* x *90

NV R +4.00/+1.00* x *90 L +4.00

The contact curves are +/-5.00 D

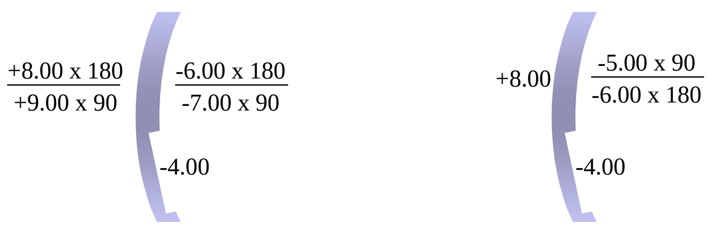


Figure 8. Solid visible bifocals made to specification as follows:

DV R +2.00 L +2.00/+1.00* x *90

NV R +4.00/+1.00* x *90 L +4.00

The segment curves are -4.00 D