10. Varilux Multi Design, the first step to a personalized design

The background

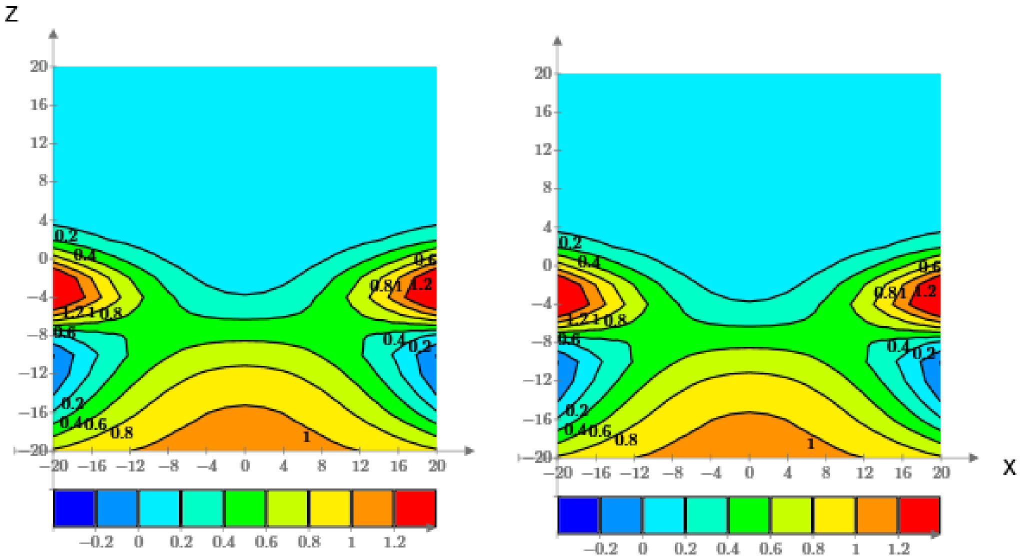
Following the invention of Varilux, Essilor tested and launched until 1990 a series of new designs in order to offer the functional and aesthetic advantages of progressive surfaces to all spectacle wearers. Varilux Omega for people having passed cataract surgery, Varilux Pilot for overhead work, Data Comfort for presbyopic computer screen users and Alpha as entry correction for the emmetropic presbyope were the brand names of these special purpose lenses [1], [2]. The broad scope of this research work and particularly the feedback from all kinds of wearer segments provided a deep insight into the relation between visual perception and design features. One major conclusion was, that there is no single specific design which is optimum for all add powers. Logically the next development step after Varilux 2 was a progressive lens which had one particular design for each add power, so that the whole product range from add 0.75 to add 3.50 consisted of 12 different designs. The Essilor VMD (Varilux Multi Design, called Varilux Infinity in the USA) was launched in 1988.
The inventor of the coresponding patent US 4 838 674 is Maurice Dufour, a close collaborator of Bernard Maitenaz in the Varilux development (see also " Progressive Memories").

10.1 The Mono-Design lenses

In chapter 6 we had chosen for the curvature of the main meridian the function

$$K(z0) = \frac{1}{87.5} + \frac{A \cdot 0.0011}{4 \cdot 0.525} \cdot \left(1 + 3 \cdot \left(1 + e^{0.29 \cdot (z0+3)}\right)^{-3} - \left(1 + e^{-0.20 \cdot (z0+28)}\right)^{-30}\right)$$

with the curvature of the far vision zone 1/87.5 mm^{-1} and the add power A. Thus the power increase from the FV to the NV region is proportional to A. Calculations using the formalism in chapter 6 show, that also the power increase from FV to NV in the periphery as well as the surface astigmatism are proportional to the add power. This is illustrated in Fig 1 and Fig 2 showing the normalized plots for the power increase and the surface astigmatism for add 1 and add 3.
For this type of lenses the plots of power increase and surface astigmatism for the different addition powers are homothetic, i.e. their contour plots, if divided by the corresponding addition power, are identical. These lenses are characterized by only one typical design for all adds and were called by Essilor Mono-Design lenses.

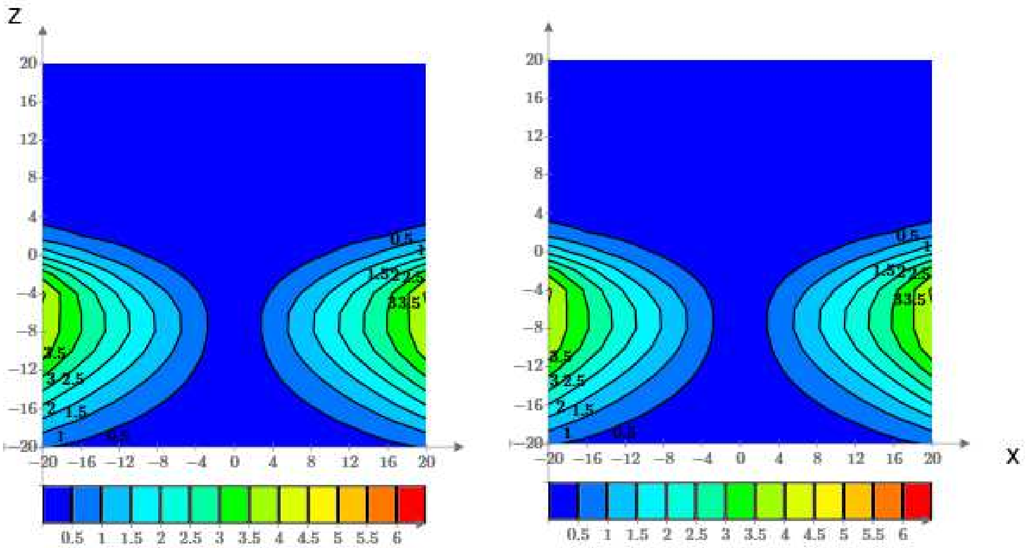


Add 1.00

Add 3.00

3

Fig 1:Mono-Design, power increase (normalized)



Add 1.00

Add 3.00

3

Fig 2: Mono-Design, surface astigmatism (normalized)

10.2 The Multi-Design patent

Exceptionally here, for the Essilor VMD, a special paragraph is dedicated to the patent. The whole story around the Multi Design concept is told in [3] (unfortunately, today only the German version exists, but in the following months I will add a translation into English).

Fig 3 shows a front view of the progressive surface S with the denominations needed for the description of the invention.The curve C1 separates the far vision zone VL from the intermediate vision VI, C2 is the separation line between the intermediate vision VI and the near vision zone VP (quantitative definition see paragraph 10.3). According to the patent A1 and A2 are the points on the main meridian where the progression of previously developed designs starts and ends. For the new surface the power increase begins at A3, situated at a distance d1 below A1, and continues until the point A4 situated at a distance d2 below A2. The addition power is assumed in point A2 and ΔC is the curvature increase between A2 and A4.

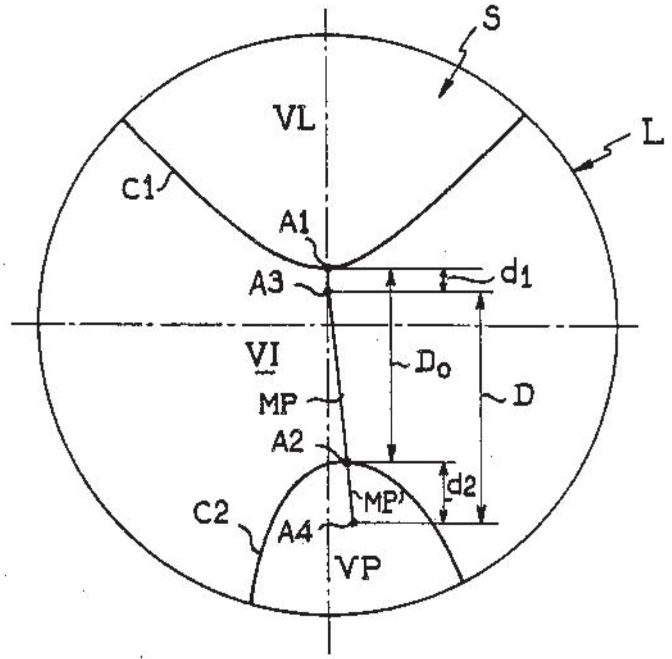


Fig 3

Fig 4 shows the graphs of the patent document quanitfying d1, d2 and ΔC.

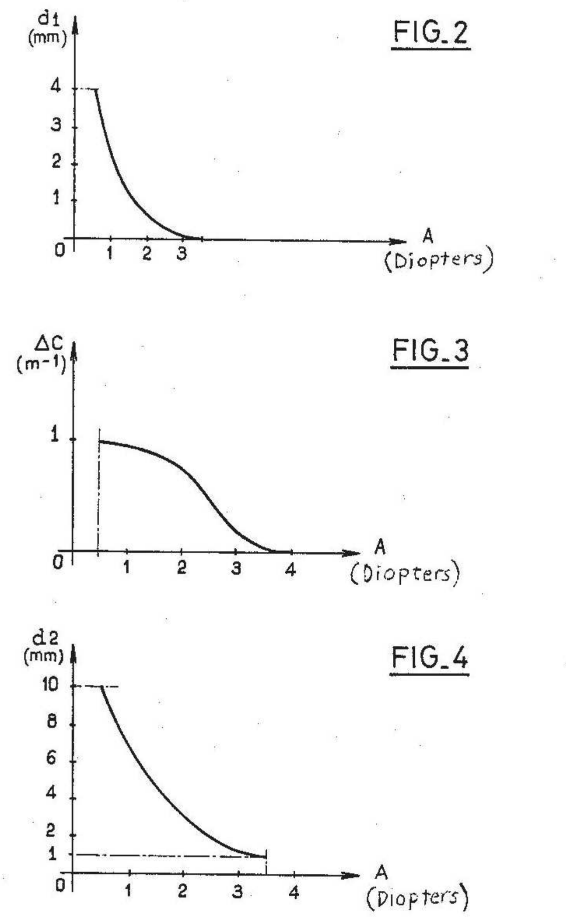


Fig 4

10.3 Calculating a Multi Design model surface

The patent defines the position and the power progression of the main meridian, but does not specify the geometry of the orthogonal sections. So for our model calculations of a Multi-Design lens according to the patent we choose a surface type discussed in chapter 9, because there the principal meridian as well as the orthogonal sections are described by analytical functions and we can thus adapt them rather easily.

So the equations and the results below do not represent the Essilor VMD (Varilux Infinity) as it was launched on the market, but illustrate the Multi-Design concept as it is described in patent US 4 838 674.

The points A1 and A2 shall have the z coordinates +2 and -16 mm, giving a distance A1A2 (or D0 how its is called in the patent) of 18 mm. The curve C1 is a curve of constant average power (Df+0.12) D and C2 represents a constant average power of (Dn-0.12) D, Df, Dn designating the FV-, respectively the NV- surface power.
In order to demonstrate the characteristics of the Multi-Design concept of the patent we consider the two add powers 1.00 and 3.00.

Mono-Design Add 1.00

$$K(z) = \frac{1}{8} + \frac{0.01}{0.525}\left(1 - \left(1 + e^{-2.29 \cdot (z \cdot 0.65 + 2.19)}\right)^{-30}\right)$$

is the equation of the meridian curvature of a Mono-Design with far vision (surface) power 6.56 D and add 1.00 D. In compliance with the definitions above the progression starts at 2 mm and stabilizes at -16 mm

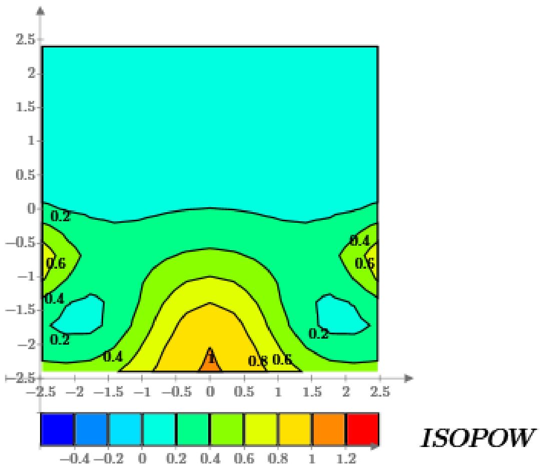


Fig 5a

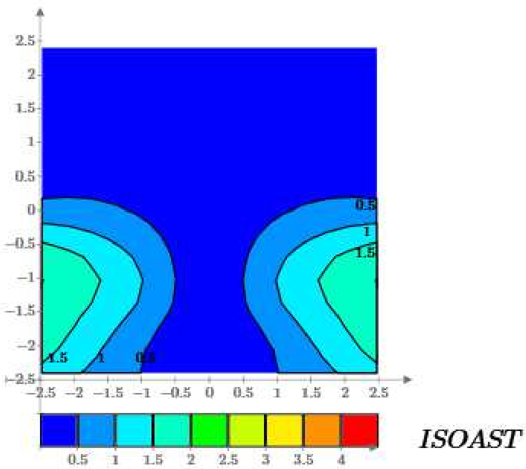


Fig 5b

Fig 5a shows, that an effective progression length of 18 mm is rather long. As designed, the power increase of 0.88 D is obtained at -16 mm, but due to the slow asymptotic progression the add power 1.00 D is reached only for z values below -20 mm.

Measuring the distance in Fig 5b between the 1 D isoastigmatism lines, the near vision zone has a width of about 25 mm at -15 mm. (I am well aware, that this kind of defining the extension of a visual field, is simplified , but experience shows that the interpretation of isoplots is very useful for first assessments and particularly for the comparison of different designs.)

Multi-Design Add 1.00

For the meridian

$$K(z) := \frac{1}{8} + \frac{0.015}{0.525}\left(1-\left(1+e^{-2.29\cdot(z\cdot 0.68+2.6)}\right)^{-30}\right)$$

the progression starts 2.5 mm lower than for the Mono-Design and the effective progression length is 4 mm longer, including the additional power increase of 0.5 D in the lower NV part. These figures have been taken from the graphs of Fig 4. Calculating the Multi-Design surface with the formalism of chapter 9 we obtain Fig 6a and 6b.

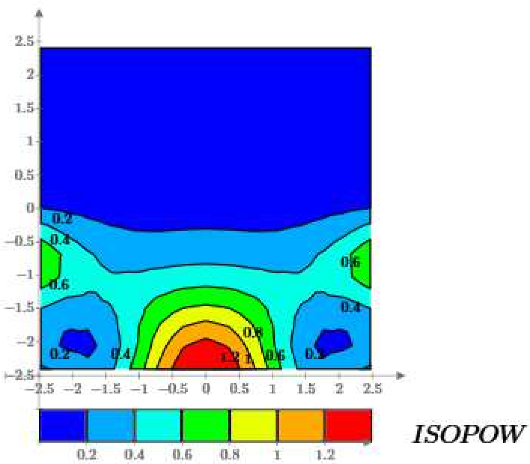


Fig 6a

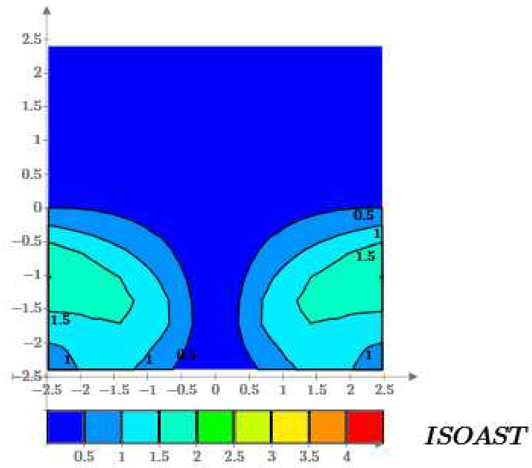


Fig 6b

Both plots show a smooth, wide transition from a perfect FV part into the progression zone. At about -16 mm, as in the case before, the add power reaches 0.88 D. Because of the extra power ΔC the full add is reached higher than for the Mono-Design. The width of the NV zone measured at -15 mm is neatly smaller than for the Mono Design, but is still large with 15 mm.
The low positioned, wide transition channel into the intermediate zone is much appreciated by the young presbyope, particularly if he has never worn spectacles before.

Multi Design Add 3.00

From Fig 4 we see, that the parameters characterizing the Multi- Design of the patent are decreasing with increasing add power and are almost zero for Add 3.00. Thus

$$K(z) := \frac{1}{8} + \frac{0.03}{0.525} \left(1 - \left(1 + e^{-2.29 \cdot (z \cdot 1.05 + 2.65)}\right)^{-30}\right)$$

describes the progression for Add 3.00 between 2 mm and -16 mm with extra power ΔC zero

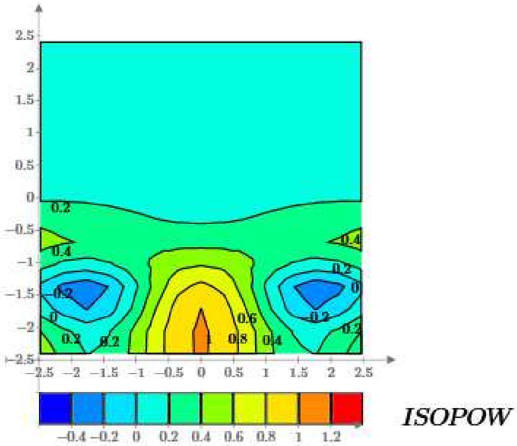


Fig 7a

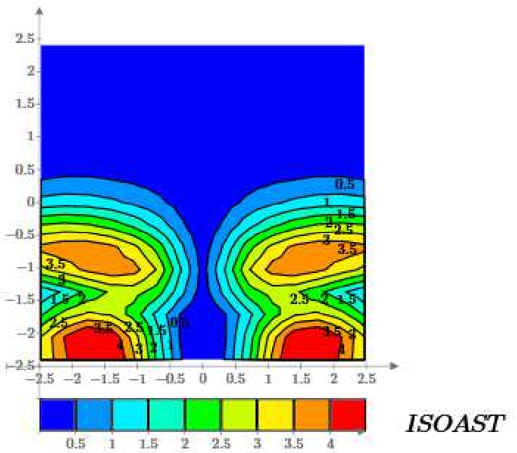


Fig 7b

Fig 7a shows the power plot, which is normalized in order to clarify the differences to the add 1.00 design. Along the main meridian, now, the (normalized) curvature increase is steeper and the full add power is reached earlier. In the periphery of the NV region the power drop is somewhat more rapid than for the add 1.00 geometry. In Fig 7b (not normalized) the astigmatism extends higher in the FV part periphery than for add 1.00 and the NV zone has a width of 12 mm, which is good for the high add power.
The focus on a high positioned, broad near vision part in the add 3.00 design represents an sensible benefit for the older presbyope.

10.4 Vertical optical modulation

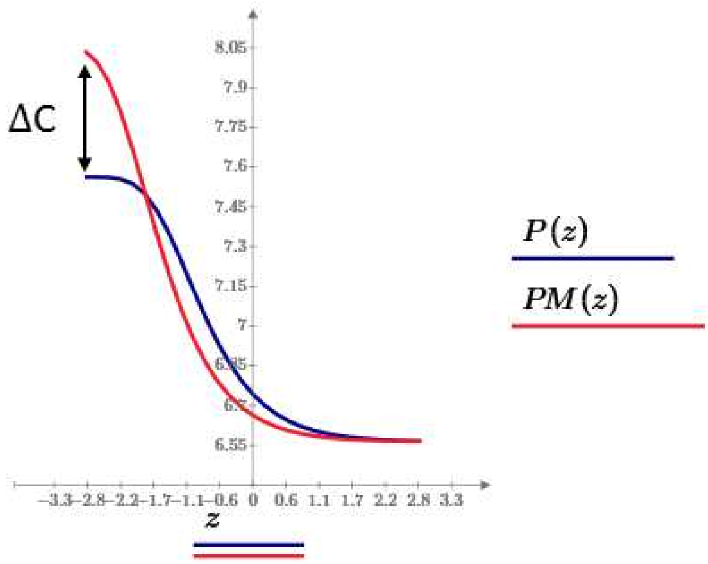


Fig 8

Fig 8 compares the progression P(z) and PM(z) respectively for the Mono- Design and the Multi-Design for the add 1.00. For this case the extra power in the lower NV part is 0.5 D and decreases with increasing add power and reaches 0 for ADD 3.50. According to Fig 4, in the same way also the parameters d1 and d2 diminish going to higher adds. Above we have analyzed two extreme cases, the specific designs for add 1.00 and 3.00. The construction principle to obtain the designs for the intermediate adds was the systematic variation of the parameters d1, d2 and ΔC according to the graphs in Fig 4, which Essilor called vertical optical modulation.

10.5 Analysis of designs and calculations

Essilor VMD was the first progressive lens developed under the Multi-Design concept, which means the concept, that one specific design cannot offer maximum visual comfort to all segments of spectacle wearers.
In the years after Essilor VMD, the development of future Varilux lens generations systematically took into account the Multi-Design philosophy. So it was also one of the success features of Varilux Comfort, which followed Essilor VMD in 1993.

The segmentation chosen for the Essilor VMD was the physiological age of the spectacle wearer, i.e. for each add power a special geometry had been developed. In the years after 1988 all the big market players launched Multi-Design lenses, using also other criteria for typing the wearers, for example the kind of ametropia, the cultural and ethnic roots, special working and leisure activities,..... . With the arrival of the CNC production and the improvement of its efficiency, today the spectacle lens industry enables the opticians to offer the ultimate solution to the wearer , i.e. the personalized progressive lens. Thanks to this sophisticated technology the design takes into account not only the individual visual correction, but also the characteristics of the frame, the morphology of the wearer's face, and the visual strategy of the person.

References

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