Quality learning note 1

Giving full power to the wearer in lens design

Improving performance, enhancing business

Céline Torracinta - Cyril Guilloux

There is no question that digital surfacing is opening new horizons in lens design giving crystal-clear benefits to wearers, the full scope of which is not even imagined yet. For the first time ever, lens designers feel capable of giving full power to the wearer.

The long-standing expertise of ophthalmic leaders in Vision Sciences had historically been limited by the technological difficulties that had to be taken into account, at manufacturing level. The reason for this was that with non-digital manufacturing, we were limited by only a sphere or torus for the back surface of lenses. As a sphere has only its radius as a variable parameter, the back surface of the lens was used to adjust optical power for distance vision point only.

The front surface role was therefore more complex to manage for lens designers. This meant that before the advent of digital surfacing the lens designers had always been limited by the inability to take fully into account basic parameters to manage the direction of gaze in relation to the lenses. So first order parameters in visual comfort like those induced by the rotation of the eye around its centre (CRE for centre of rotation of the eye) were not respected. Such parameters are manifold, such as eye movements, variability of pupil diameter, actual length of the eye, frame parameters however trendy they may be, behavioural characteristics, whether they be ametropia-induced or not…

It is now possible to optimize visual performance using digital surfacing, provided the lens designer closely sticks to what is the wearer's actual perception of power in real life conditions, i.e. wearing with actual spectacles. If the designer knows the function of the visual system for each individual, then yes, it is possible to stretch the boundaries and work to the physical limits of the ophthalmic lens (any lens which has 2 surfaces and is made from a given material).

No question, really. Wearers will see better and better in the decades to come and we are just at the dawn of an era to create ophthalmic top performance products. It is expected by marketing experts that the growth in value of the high end segment will be at least 4 times more than that of the entry segment, in almost all wealthy countries.

This will however have a price that the complexity of optical surfaces will have to pay.

Though checking lens power may remain a relevant procedure from the standpoint of quality assurance, the numerical output of such measurement may in many cases be a bit far from the expected wearer's prescription.

As will be explained in detail hereafter, this misleading discrepancy lies in the sound difference between the relative positioning of the lens vis-à-vis the axis of the focimeter, compared to that of a mounted lens in front of the eye. Remember that the dream of lens designers is to adapt the measured prescription to the wearer's direction of gaze everywhere on the lens surfaces…

This is why leaders in the ophthalmic industry such as Essilor or Zeiss have already started printing on the stickers of their top-class lenses both the wearer's prescription and the focimeter's expected values at standard measuring positions. The trend is not likely to fade away… It is thus key not to get confused by dual power labeling, and above all to fully understand what the lens check actually measures. We hope this paper will help.

Summary

The aim of the lens designer is to provide to the wearer the lens which delivers the prescription as measured by the ECP.

The "wearer power" is the power seen by the wearer when looking through the lenses fitted into the frame.

Focimeters are control instruments that have been originally designed to measure powers of single vision lenses at the optical centre.

Mainly because path of optical rays are different, focimeters do not measure the power seen by a wearer.

If the lens power is calculated to match the focimeter measurement, then the wearer power will deviate from the prescription when the lens will be fitted in front of the eye.

In order to provide a progressive lens fully matching the prescription in as-worn conditions for all gaze directions, it has to be individually optimized and must be machined with Digital Surfacing.

As a consequence, two sets of powers values are printed on the progressive lens sticker, one for the wearer prescription, the other for the focimeter check.

Wearer power calculation combined with digital surfacing is the best way to fulfil wearers' true expectations.

1 WEARER'S PRESCRIPTION SETS THE TARGET OF EACH DIRECTION OF GAZE

Eye examinations measure prescription in certain conditions *(figure 1a)*. The wearer's direction of gaze is perpendicular to the trial lens, and sets the target for lens designers. Estimating, or knowing, the relative position of the eye vis-à-vis the mounted lens, the lens designer will build optical surfaces which will recreate the optimum conditions determined by the eye exam for each direction of gaze. In fact, one point of the surface will strictly correspond to one direction of gaze, in given conditions (distance between the eye and the lens fitted in the frame *(figure 1b)*.

As a consequence, the geometry of a "worn-lens" is quite different from that of the trial lens.

> Eye exam conditions

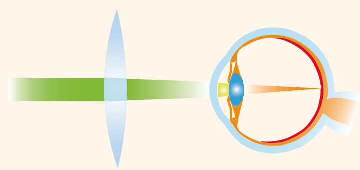


Figure 1a
- Trial lens
- Surfaces : sphero-torical
- Orientation : no tilt
- On-axis : aligned with eye axis

> Real life (spectacles)

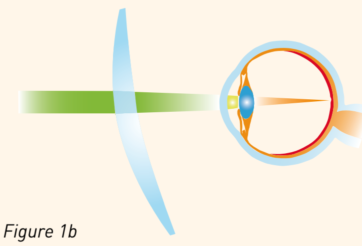


Figure 1b
- Fitted lens
- Surfaces : at least one aspherical surface
- Orientation : horizontal and/or vertical tilt
- Off-axis : lens decentred

> Main assumptions generally used by lens designers are :

- a CRE (Centre of Rotation of the Eye) positioned at 25.5mm from the lens (CRE is important because the eye rotates around it to explore the object space),
- a vertical lens tilt of about 12° (because of this and due to lens geometry, incidences on the lens of rays entering into the eye are obviously not perpendicular to the surface of the lens…).
- for advanced lenses, an estimation of pupil size as a function of the direction of gaze and the distance to the object looked at by the eye, as pupil size is fundamental to optimize ophthalmic performance,
- also, an estimation of object distances as a function of the direction of gaze.

2 CHECKING LENSES WITH FOCIMETERS

Focimeters are control instruments used to check power, astigmatism and prism at one point (i.e. on a small area of the lens).

Conditions of use are very specific *(figure 3)* :
- focimeter support is perpendicular to one surface of the lens,
- lens is placed against a dedicated support,
- pupil diameter of the instrument is fixed,
- rays come from infinity.

Historically, focimeters have been designed to measure powers of single vision lenses at the optical center, where there is no prism and where the focimeter is thus aligned with the optical axis of the eye. In this configuration, ray paths are obviously quite similar to the wearer's. This situation is also met when the lens optical center shift compensates the lens vertical tilt T *(figure 4)*.

For lenses with complex surfaces, or prism, this is obviously another story.

> Position of a lens on a focimeter

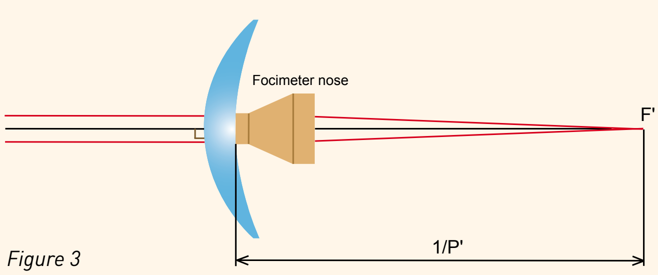


Figure 3

> Checking single vision lenses

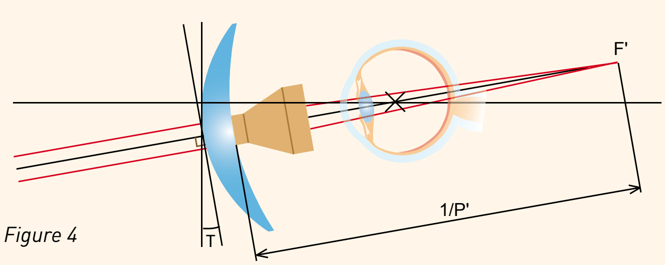


Figure 4

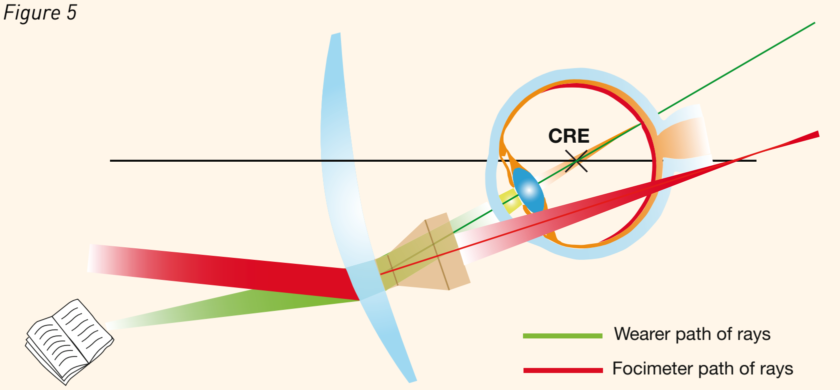
3 FOCIMETERS DO NOT MEASURE WEARER POWER

Figure 5 represents the difference between the ray paths in focimeters and the ray paths for wearers with spectacles. Differences in values may be very significant.

As can be seen, focimeter's and wearer's paths of rays are quite different.

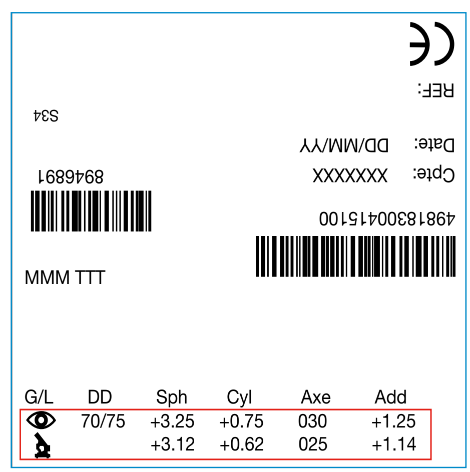
Refer to the Expert's Corner section for an example of calculation of the differences in obtained values.

Figure 5



4 NECESSITY FOR DUAL LABELLING ON TOP RANGE DIGITALLY SURFACED PROGRESSIVE LENSES

Though actual differences between wearers' prescription and focimeters' values can already be found in the market, they are generally not yet too big, so that dual labelling is often skipped by manufacturers. However, taking advantage of all the possibilities that digital surfacing offers nowadays will induce differences which will be much more significant than today's average, so that dual labelling is more and more becoming a necessity on the high-end segments.
On the sticker here-attached (red box), the first line gives wearer / prescribed power, while the second one provides focimeter power.



REF:
S34
Date: DD/MM/YY
Cpte: XXXXXXX
894689
4981830041510
MMM TTT

G/L	DD	Sph	Cyl	Axe	Add
	70/75	+3.25	+0.75	030	+1.25
		+3.12	+0.62	025	+1.14

IN CONCLUSION, and as depicted in this article, new digital surfacing technologies now allow lenses to be designed from both a wearer's and a wearing perspective. This is a first. Today lens designers have access to a world of improvements in visual comfort, the horizon of which cannot even be imagined. An undisputable new world for business growth too.

think blue

THE EXPERT'S CORNER SESSION

Focimeter value versus wearer power, an example of calculation

Figure 7. Let's consider a +4D. SV lens prescribed for far vision. This lens was calculated for the wearer, taking into account a pantoscopic tilt of 15°. It means that, in the conditions depicted on the attached figure, the wearer power is exactly +4D.

Figure 8. If the focimeter was aligned on the eye's optical axis, it would be consistent between focimeter and wearer, but this situation does not represent the way the lens is measured with a focimeter, because the support is not fully in contact with the lens.

Figure 9. The attached figure depicts the real focimeter measurement conditions, that is for which the lens is fully in contact with the lens. The path of rays is perpendicular to the lens, as if the focimeter rotated 15° from the previous situation.

Due to the pantoscopic tilt, the focimeter path of rays is different from the wearer's one, and so the focimeter measurement will not be +4D. The focimeter measurement for a +4D. single vision lens, tilted 15° and calculated for the wearer, will be +3.64 (+0.27, 90°).

We can do the same experiment for different tilt values, the lens being always recalculated for the wearer taking into account the tilt angle. For the same +4D wearer power calculated lens, the focimeter measurement will change, depending on the initial tilt of the lens.

The following table gives the focimeter measurements according to the tilt, from 0° to 15°.

This experiment can be reproduced with a focimeter, tilting the lens in front of the support.

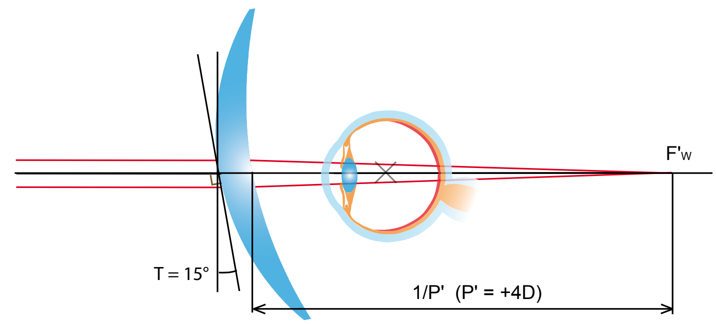


Figure 7

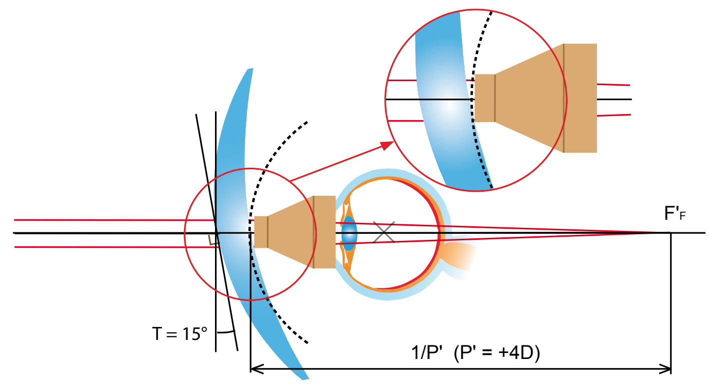


Figure 8

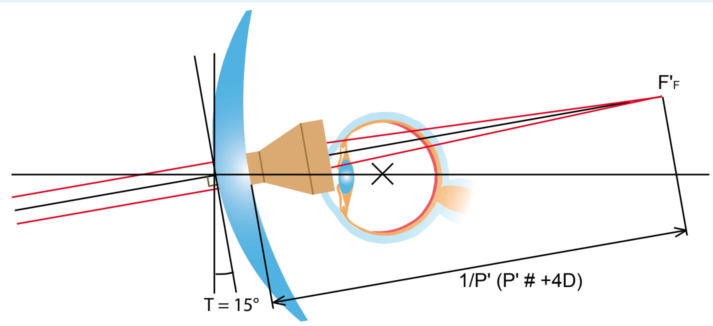


Figure 9

ANGLE (°)	SPHERE (D.)	CYLINDER (D.)	AXIS (°)
0	4.00	0.00	-
3	3.99	0.01	90
6	3.94	0.04	90
9	3.87	0.10	90
12	3.77	0.17	90
15	3.64	0.27	90