ORLab Technical Note

Ophthalmic Product Series
Issue 2
September 2008

A series of technical notes to aid understanding of standards, reasons for failure to comply and hints on avoiding the problem.

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Measurement of refractive power in nominally afocal lenses

Another (see Technical Note 1) of the common reasons for failure to comply with AS/NZS1067:2003 and the Consumer Product Safety Standard is the refractive power, in particular the spherical and cylindrical power. It is a less common reason for failure of eye protectors to AS/NZS1337:1992.

Terminology

Firstly, a mention of terminology. I have used the term “afocal” meaning not having a focus. You will also come across the term ”plano”. “Plano” comes from the time when lenses were flat form. The spherical power was ground on one surface (+ on the front or – on the back) and the cylindrical power was ground on the other. The lens with no prescription was, therefore, flat or plain on both surfaces. In these days of curved lenses, the purists point out that “plano” is not the correct term. It is, never the less, widely used in the ophthalmic professions and optical industries. “Plano” and “afocal” mean, in practice, exactly the same thing. “Un-powered” is another, rarely used, term. We also use “non-prescription” for sunglasses and eye protectors on the assumption that you need a prescription for a lens that is not afocal. On the other hand, a prescription lens could be afocal.

We also use the term “lens”. Again, the purists point out that a lens has refractive power so “afocal lens” is actually a tautology. As a result, the European practice has been to use “ocular” in sunglass and eye protection standards. This was resisted in AS/NZS1067 where the committee carefully replaced every “ocular” with “lens”. However, in the draft of AS/NZS1337 you will see that the committee has bowed to what seems to be inevitable.

What makes a lens afocal?

It is tempting to think that taking a sheet of material (which is afocal and, in the true sense of the word, plano) and bending it so it is curved like a lens will result in an afocal lens. This is not actually true. It actually leads to a small amount of negative power. In thin materials and a lower base curve it is small.

1.5mm thick 6D base refractive index = 1.5 gives -0.073D

which is within the tolerance for afocal lenses, however

1.5mm thick 9D base refractive index = 1.5 gives -0.166D

which is now outside the permissible limits. Glass sunglass lenses are often produced from flat glass, known as sagged lenses. Some plastics sunglass lenses are formed from sheet, particularly polarising lenses.

It may also seem reasonable to assume that equal curvature on the two surfaces will also give an afocal lens. Again this is not so. A lens with the same thickness and refractive index as above and +6.00D front and -6.00 back will have a power of +0.036D and +9/-9 will give +0.081D. These are within tolerance but the 9 base and 1.6mm thickness has now become doubtful (+0.086D).

Therefore, for a truly afocal lens, attention must be paid to the front and back powers individually as well as the thickness and refractive index.

This is further complicated by the test requirements which require measurement in the as-worn position. In wrap-around designs, the lens is inevitable tilted across the line of sight. The angle is variously know as “dihedral angle” or “camber”. Tilted lenses mean that light passes through the lens obliquely and additional power, known as “oblique astigmatism”, is created. This will occur with truly afocal lenses, but the effect becomes much more significant when the lenses have even small amounts of power in them. The final cause of unwanted power in lenses is simply poor quality of the mould or moulding process.

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Why nominally afocal lenses might fail

Regular defect	Lens design	Sagged type with excessive thickness or curvature
		Moulded type with incorrect optical design
	Frame design	High dihedral angle (wraparound) or high pantoscopic angle
Irregular defect	Manufacture	Uneven or insufficient heating in a sagging process
		Defects in the mould, which will be faithfully reproduced in the lenses
		Moulds have become worn
		Problems with the material flowing in the mould

Measurement of power in nominally afocal lenses

The power of ophthalmic lenses are traditionally measured in a vertometer (US terminology) or focimeter (UK terminology). These instruments were intended for assessing prescription lenses with a smallest step of 0.25D. With a very good instrument and a careful observer, accuracies of ±0.06D may be possible. When dealing with afocal lens tolerances, which may be as small as 0.06D, these are clearly impractically large. The telescope method of measurement described in AS/NZS1067 was taken from the European standard. The standards require a least uncertainty no greater than ±0.01D. The ORLAB telescope system provides a least uncertainty of ±0.005D. The telescope is used to measure the sunglass or eye protector in the as worn position so that any power in the lens and the tilt of the lens will contribute to the final value measured. In order to achieve this kind of precision, the measurement aperture required is 20mm diameter. Vertometers typically have a 5mm aperture, representative of the human pupil size. In a 20mm measurement aperture, the oblique effects of tilted curved lenses are accentuated.

Got a technical question you need help with? Submit it to orlab@unsw.edu.au.

About 20 or so years ago, automated focimeters began to appear which make the measurements automatically and quicker and easier. Some models have a least count of 0.01D. This does not mean that they are this accurate. They were not designed to measure in the as-worn position and the on-board analysis methods assume regular optics. There are a number of issues with these systems which are well covered in an ISO Technical report[1]. At this stage no one is claiming least uncertainties as small as 0.01 for them, so they do not supplant the telescope method. ORLAB now has 3 automated vertometers that are used to identify possible afocal lens failures quickly leading to full checking on the telescope. They are also to measure prescription lenses. The telescope is limited to about ±0.25. Uncertainties of measurement on these instruments is ±0.03D. Lenses for checking them are specified in ISO 8342[2] but we have not found an accredited laboratory to calibrate them.

Uncertainties and compliance

Whenever compliance is being assessed it is necessary (and obligatory for a NATA accredited laboratory such as ORLAB) to take the uncertainties of measurement into account. If a lens has been measured as, for instance, -0.057D with an uncertainty of ±0.005D it means that the power is known to lie between -0.052D and -0.062D. The method used does not allow anything more precise. If the requirement is ±0.09D, then all possible values lie within the allowed tolerance and the lens passes. Similarly a lens measured as -0.120D is in the range -0.115D to -0.125D and all values are outside the permitted tolerance and the lens fails. However, if the lens is measured as -0.087 ±0.005D then some of the possible values lie outside the allowed tolerance and some possible values lie within. So it cannot be unequivocally stated whether the lens passes or fails. We would report this as “Borderline”. This is clearly an unhelpful situation for industry and we strive to make all our uncertainties of measurement as small as possible at the same time as containing the costs of making the measurements. We accept that borderline results are often more annoying to industry than failures. They also involve lot more rechecking than clear passes and fails.

A compliance authority (like ACCC, SAI Global or BSI Benchmark) may make some interpretation and decision in these cases. A test authority (such as ORLAB) may not.

[1] ISO technical report ISO-TR 28980-2007 Ophthalmic optics - Spectacle lenses - Parameters affecting lens power measurement.

[2] ISO 9342 Optics and Optical Instruments – Test lenses for the calibration of focimeters.

Optics and Radiometry Laboratory
Room LG22 Old Main Building (K15)
UNSW SYDNEY NSW 2052

School of Optometry and Vision Science
Gate 14, Barker Street

Phone: +61 2 9385 4622 *Fax: +61 2 9313 8602* *E-mail: orlab@unsw.edu.au*