OLA White Paper

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ANSI Z80.1-2005

ANSI Z80.1-2005, American National Standard for Ophthalmics – Recommendations for Prescription Ophthalmic Lenses, was given final approval by ANSI with an effective date of December 19, 2005. This revision replaces ANSI Z80.1-1999 and contains two significant changes: the tolerance on cylinder axis and the tolerance on progressive lens refractive power.

Tolerance on Cylinder Axis

A comparison of ANSI Z80.1-1999 and ANSI Z80.1-2005 shows the following tolerances on cylinder axis.

Tolerance on Direction of Cylinder Axis

Nominal Value of Cylinder (D)	≤ 0.25	.375	.50	> 0.50 to ≤ 0.75	> 0.75 to ≤ 1.50	> 1.50
Axis Tolerance ANSI Z80.1-1999	± 7°	± 7°	± 5°	± 5°	± 3°	± 2°
Axis Tolerance ANSI Z80.1-2005	± 14°	± 7°	± 7°	± 5°	± 3°	± 2°

Basis for the Change

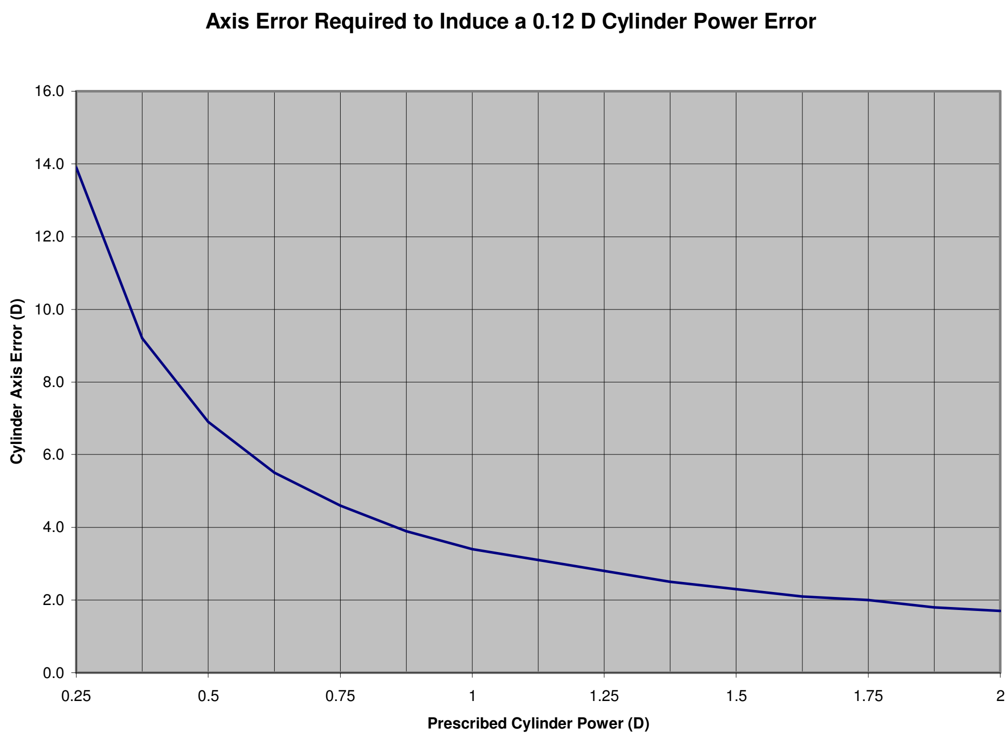
It is apparent that the tolerance on the cylinder axis for cylinders below 0.75 D has been increased.

The Z80 Committee approached the tolerance on cylinder axis by asking how far the axis must be shifted in order to introduce an error in the cylinder power equivalent to a cylinder power tolerance of 0.12 D. This can be calculated by the following equation.

$$\alpha = \sin^{-1} (C / 2F_1)$$

Where:
α = the angle
C = resultant cylinder power error (0.12 D)
F_1 = prescribed cylinder power

The graph below illustrates the result of this calculation. This result was used to establish the tolerance for the low cylinders (0.50 D and less).



There is precedence in using this approach. Dr. Glen Fry used a similar methodology to arrive at the same conclusions in 1977 and was published in *Optometric Weekly* in an article entitled "Tolerances for Cylinder Axis". That analysis expanded the tolerances in the 1972 standard to those of the 1979 standard. ANSI Z80.1-1999 used the same tolerances as the 1979 standard. Despite the fact that Dr. Fry's analysis indicated that the cylinder axis tolerance for low cylinder powers should be expanded to those indicated in the above graph, the ANSI Z80 Committee at that time thought the expansion would be too extreme to be accepted.

Why Change Now?

In 2004 the majority of presbyopes used progressive lenses. It is common that progressive lenses have small amounts of unwanted cylinder at the distance reference point. This is recognized in ISO standards for semi-finished blanks which allow more cylinder for progressive lenses than standard multifocal and single vision semi-finished blanks. The presence of even a small amount of cylinder can significantly change the prescribed cylinder axis.

Consider an Rx which has prescribed cylinder of -0.25 D @ 180 ^{0}. This Rx is ground into a semi-finished blank having unwanted cylinder of -0.09 D @ 45 ^{0} (which is equal to the ISO tolerance). The result, as shown below in Figure 1, is a crossed cylinder with a resultant cylinder of -0.26 D @ 10 ^{0}.

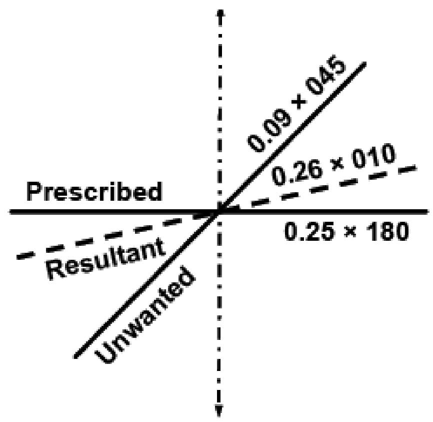


Figure 1 – Resultant Cylinder and Cylinder Axis

Effect on the Wearer

How might the increased tolerance on cylinder axis affect the wearer?

As noted above, a 14^0 axis error for a 0.25 cylinder produces a cylinder power error of 0.12 D. The 1999 standard allowed a 7^0 axis error which produces a cylinder power error of 0.06 D. Consequently, the difference in cylinder power error between the two standards is 0.06 D.

How does the cylinder power error affect the wearer? Simply stated, it moves the circle of least confusion by one-half the amount of the error as shown in Figure 2.

The 1999 standard allowed a 7^0 axis error for a -0.25 D cylinder which produces a cylinder power error of 0.06 D. Consequently, the wearer will experience a change in the circle of least confusion of 0.03 D. The 2005 standard allows a 14^0 axis error for a -0.25 D cylinder which produces a cylinder power error of 0.12 D. Consequently, the wearer will experience a change in the circle of least confusion of 0.06 D. Obviously, the difference in the circle of least confusion between the 1999 and 2005 standards is 0.03 D, a difference most wearers will not notice.

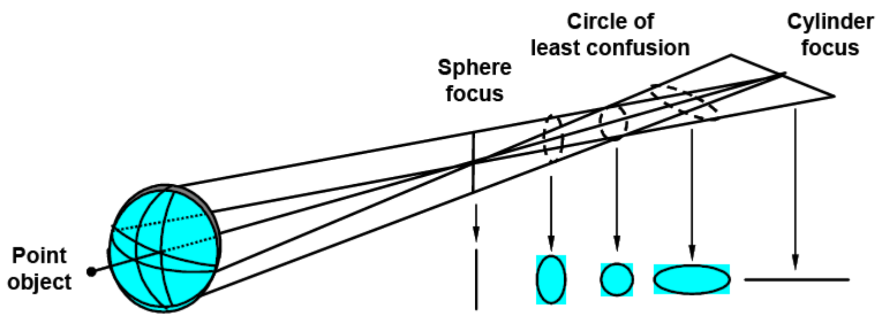


Figure 2 – Circle of Least Confusion

Refractive Power Tolerance

The US has no tolerances on front curves for semi-finished blanks. Manufacturers therefore follow the International Standard Organization (ISO) tolerances for front surface accuracy of semi-finished blanks. The ISO standard tolerances (ISO 10322-1 for semi-finished single vision and multifocal lens blanks and ISO 10322-2 for semi-finished progressive lens blanks) are different in recognition of the fact that progressive lenses are more difficult to manufacture than single vision and standard multifocal lens blanks. The ISO standards are:

ISO 10322-1, Semi-finished Single Vision and Multifocal Lens Blanks

Surface power of the meridian with the highest absolute surface power	Tolerance on surface power $\frac{F_1 + F_2}{2}$	Tolerance on astigmatism for spherical surfaces $\lvert F_1 - F_2 \rvert$
$\geq$ 0.00 and $\leq$ 2.00	± 0.09	0.04
>2.00 and $\leq$ 10.00	± 0.06	0.04
>10.00 and $\leq$ 15.00	± 0.09	0.04
15.00 and $\leq$ 20.00	± 0.12	0.06
>20.00	± 0.25	0.06

NOTE - F_1 and F_2 are the surface powers of the principal meridians

ISO 10322-2, Semi-finished Progressive Lens Blanks

Distance surface power of the meridian with the highest absolute surface power	**Tolerance on the distance surface power** $\frac{F_1 + F_2}{2}$	**Tolerance on astigmatism specified by the manufacturer** $\lvert F_1 - F_2 \rvert$
≥ 0.00 and ≤ 10.00	± 0.09	0.09
>10.00 and ≤ 15.00	± 0.12	0.12

NOTE - F_1 and F_2 are the surface powers of the principal meridians

The ISO tolerances are for surface power while the US typically uses surface curve. Converting the above table from surface power to surface curve (in 1.530 D) for CR-39 (refractive index of 1.498) yields the following:

Surface curve (1.530 D) in the meridian of highest absolute surface curve	**Tolerance on surface curve** $\frac{F_1 + F_2}{2}$	**Tolerance on astigmatism for spherical curves** $\lvert F_1 - F_2 \rvert$
≥ 0.00 and ≤ 10.64	± 0.096	0.043
>10.64 and ≤ 15.96	± 0.096	0.043

NOTE - F_1 and F_2 are the surface curves in the principal meridians

The most common step tooling used by laboratories is 0.125 D. The means that at the extreme of the tooling, the error due to tooling can be 0.0625 D. In the case where the errors are additive and each is at the extreme of the tolerance, the error on a CR-39 progressive lens can be 0.1585 D (0.096 due to the semi-finished blank tolerance and 0.0625 D from the step tooling). It was for this reason that the tolerance, due to manufacturing capability at the extremes of the tolerances, and cognizant of the fact that ANSI standards are meant to be minimum standards, was set at 0.16 D.

The refractive power tolerance for single vision and standard multifocal lenses did not change from that of ANSI Z80.1-1999. The refractive power tolerance for progressives in ANSI Z80.1-2005 is:

ANSI Z80.1-2005 Tolerance on Distance Refractive Power for Progressive Lenses

Absolute Power of Meridian of Highest Power	Tolerance on Meridian of Highest Power	Cylinder ≥ 0.00 D ≤ 2.00 D	Cylinder > 2.00 D ≤ 3.50 D	Cylinder > 3.50 D
From 0.00 up to 8.00 D	± 0.16 D	± 0.16 D	± 0.18 D	± 5%
Above 8.00 D	± 2%	± 0.16 D	± 0.18 D	± 5%

Effect on the Wearer

What is the effect on the wearer when the refractive power tolerance is increased by 0.03 D?

A paper that was published in the May 2005 edition of *Optometry and Vision Science* by Jim Sheedy, et al, "Evaluation of an Automated Subjective Refractor" reported that the repeatability of refraction on 60 patients at the 95% LoA was -0.49 to +0.46 D. This indicates that an increase in the tolerance from 0.12 D to 0.16 D should, for the average patient, be non-problematic.

Another paper by Mark Bullimore, et al, "The Repeatability of Automated and Clinical Refraction" reported the repeatability of refraction on 86 patients at the 95% limits of agreement was -0.36 to + 0.40 D (*Optometry and Vision Science*, Vol 75, No. 8, August 1998). This indicates that an increase in the tolerance from 0.12 D to 0.16 D should, for the average patient, be non-problematic.

Another paper by Judith Perrigin, et al, "A Comparison of Clinical Refractive Data Obtained by Three Examiners" reported the repeatability of refraction on 32 subjects was 98% within ± 0.50 D (*American Journal of Optometry & Physiological Optics*, Vol 59, No 6). This again indicates that an increase in the tolerance from 0.12 D to 0.16 D should, for the average patient, be non-problematic.

Consequently, the conclusion to be drawn from the above clinical studies indicates that the typical user should experience no problems from the expanded tolerances of refractive power.

Conclusion

The two significant changes in ANSI Z80.1-2005 are justified from a manufacturing capability point of view and also from a consistency viewpoint.

The decrease in visual acuity on the wearer should be negligible.