STANDARDS

History

Over the years various standards have been recommended by the AOA and manufacturing groups. In 1956 the ASA (American Standards Association) formed a committee to draw up ophthalmic standards. The Z80 standards were approved in 1964. These were recommended standards without the force of law.

In 1972 the ANSI (American National Standards Institute) Z80.1-1972 standards were approved. These were less strict than the 1964 standards. The new standards included definitions, diagrams for the drop ball test of hardness, and regulations respecting corrected curve lenses. On Feb. 2, 1972, the US FDA (Food and Drug Administration) announced that virtually all ophthalmic lenses must be impact proof as specified in Z80.1-1972.

In 1979 a new set of standards was promulgated, Z80.1-1979. This further loosened the standards of Z80.1-1972. Some of the key changes were:

☞ Dioptric tolerances for spectacle lens powers were loosened to ±0.13D for powers below 6.50D and ±2% for powers above 6.50D.

☞ The tolerance of the add was tied to the power of the distance prescription.

☞ Vertical prism up to 1/3p.d. or 1mm decentration of optical center was considered acceptable.

☞ Horizontal prismatic imbalance of 2/3p.d. or 2.5mm decentration was considered acceptable.

☞ Segment location must be within ±1mm of specification.

☞ Specified base curves could deviate by ±0.75D.
Waves and other imperfections in the lens are OK so long as inspection with a focimeter finds negligible power error.

☞ Requirements for peripheral performance were deleted.

☞ Hardening capable of surviving the drop-ball test was required of all lenses but certain kinds of lenses were exempt from actual testing after manufacture. These included:

prism segment multifocals
lenses with slab-off prism
lenticular cataract lenses
iseikonic lenses
one piece multifocals
biconcave lenses, myodiscs, minus lenticular lenses
laminated and cemented assemblies

☞ Minimum thickness requirements were removed so long as the lens survives the drop ball test. Minimum thickness was still required for heat treated lenses.

ANSI Z80.3-1973 is a standard for non-prescription sunglasses and fashion eyewear. It requires drop ball or some equivalent test but really says nothing about optical quality.

The Canadian Government Specifications Board brought out in 1978 a standard 140-GP-1M. It is essentially the same as Z80.1-1972 with a few slight exceptions.

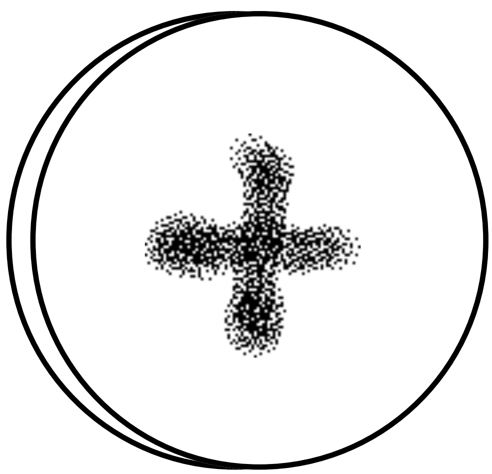
Toughened Lenses

The infamous drop ball test drops a 5/8 inch 15 gram steel ball 50 inches on a lens mounted convex side up on a neoprene gasket. If the lens doesn't shatter, it passes. This test is said to have originated as a sales gimmic. A lens salesman devised it as a readily portable apparatus to demonstrate his company's new hardened lenses. The test has no special relation to actual working conditions, but at least it is readily reproducible.

Plastic lenses are impact resistent without any treatment.

Some protection is given by untreated glass lenses, but better protection is given by toughened lenses. There are two possible processes. Both work by forming a tough layer of glass enclosing a softer interior, a "case hardened" lens.

In the heat treatment glass is heated to its softening point and then rapidly cooled. The result of this is that outer glass layers cool more rapidly than interior layers. As the interior cools to the same temperature as the outer surfaces, it contracts and exerts tension on the rigid outer surface producing an outer compressive envelope enclosing the interior of the lens under tensile stress. The resulting structure is resistant to force because compression on one surface is not followed by expansion and cracking at the opposite surface. The process produces great stress in the structure which may be seen with a polariscope as the typical "Maltese cross" pattern. The process must be carried out separately for each lens since the timing of the cycle depends on lens parameters. It takes about 20 minutes. Lenses must have a certain minimum thickness for heat treatment, 2mm center thickness and 1mm edge. Thinner lenses will warp. High minus lenses more than -10.00D, lenses over 52mm in diameter, lenses with sharp corners, and drilled or slotted lenses may **not** be heat treated.



Maltese cross pattern

In chemical toughening, sodium ions in the superficial lens matrix are replaced by larger potassium ions. Replacement produces a layer of compressive stress. The usual bath includes 99% KNO_3 and 0.5% silicic acid heated to 470°C. The temperature is critical. The process takes 19 hours including 2 hours preheating, 16 hours in the salts, and 1 hour slow cooling. That is why chemical tempering costs more than heat treatment. It has been shown that chemically tempered lenses of a given thickness are tougher than heat treated lenses. Lenses substantially thinner than 2mm are as tough as 2mm thick heat treated lenses.

Lens Power Standards, the Carter Criterion, and All That

The question of the accuracy and adequacy of a refraction or a prescription lens is simple for spherical lenses. The error in filling a spherical prescription is just the difference between the power specified in the prescription and the power ground in the spectacle lens. For spherocylinder lenses, however, the problem is tougher. One way is to subtract the specified and supplied lens powers using the obliquely crossed cylinder formulas to deal with the cylinder components.

John H. Carter used that method in an article called "On the Significance of Axis Error" published in the *Alumni Bulletin of the Pennsylvania College of Optometry* in 1966 used that method to establish a criterion for acceptable cylinder axis error. He restricted himself to the case in which a spectacle prescription differs from the correct prescription only in the axis of the cylinder. Sphere and cylinder powers are identical. Carter assumed that a spectacle lens is acceptable as long as the over-refraction of a patient wearing the lens has a cylinder power less than some specified permissible value. Applying the Thompson formula to this problem, the permissible error in cylinder axis is given by

$$\Delta\theta=1/2\cos^{-1}[1-1/2(C_O/C_R)2]$$

where C_R is the cylinder power of the correct prescription and C_O is the power of the permissible cylinder on over refraction. The results of using this equation with various values of prescription cylinder and acceptable cylinder error are shown in the table below.

C_R \ C_O	0.125	0.25	0.375	0.50
0.125	30	∞	∞	∞
0.25	15	30	48.5	∞
0.50	7	15	22	30
0.75	5	9.5	14.5	19.5
1.00	3.5	7	11	14.5
1.50	2.5	5	7	9.5
2.00	2	3.5	5.5	7
2.50	1	3	4.5	5.5
3.00	1	2.5	3.5	5
3.50	1	2	3	4
4.00	1	2	2.5	3.5
5.00	0.5	1.5	2	3

The body of the table gives the number of degrees of error to the nearest half degree in axis location of a cylinder of given power which will be acceptable within the limits of a given permissible cylinder. For example, if we're willing to accept 0.25D of cylinder on over refraction, a one diopter cylinder must be located to within ±7°.

It's interesting to compare the Carter criterion and the Z80 standards. The latter allow ±3° error in axis for cylinders of 0.12D to 0.37D power, ±2° error in axis for cylinders of 0.50D to 1.00D power, and ±1° error in axis for cylinders of power greater than 1.00D. These Z80 standards appear much more stringent than those of the Carter criterion. They coincide with the Carter criterion fairly well if one chooses C_O=0.125, so that column one of the table above is applicable. Divide the entries in this column by a safety factor of two to get a result only slightly larger than the Z80 standards for cylinder powers greater than 0.75D. A safety factor of three would bring the two criteria into almost exact agreement. For cylinders of 0.50D or less, however, there is still a great discrepancy.

