Technical Bulletin — Optimizing lens thickness with frame data

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Understanding Finished Lens Thickness

Semi-finished lens blanks are surfaced to the desired prescription powers to produce a *finished* lens. For the optical laboratory, accurate surfacing calculations rely on a precise description of the spectacle frame shape in order to determine the proper thickness and size of the finished lens. First, the laboratory must determine whether a given semi-finished lens blank is large enough for the chosen frame in order to ensure that the finished lens completely "cuts out" after edging. Second, the laboratory must accurately estimate the required thickness of the finished lens in order to ensure that the lens is as thin and lightweight as possible, with no excess thickness, once edged to the final shape for the frame.

Lens thickness is directly related to the size of the finished lens. Specifically, the center thickness of a plus-powered lens or the edge thickness of a minus-powered lens is proportional to the *square* of the finished lens diameter (Figure 1). For a given *minimum* thickness, which usually occurs at the edge of plus lenses and the center of minus lenses, the *maximum* thickness at the center of a plus lens or the edge of a minus lens can be estimated using the following formula with the accompanying "K" values from Table 1:

$$\text{Maximum} = \text{Diameter}^2 \times \text{Power} \div K + \text{Minimum}$$

Table 1. The value of the constant K to use in the above formula for estimating the center thickness of a plus lens or edge thickness of a minus lens is based upon the refractive index of the lens material.

Material Index	1.50	1.53	1.59	1.60	1.67	1.70	1.74
K Value to Use	4000	4240	4720	4800	5360	5600	5920

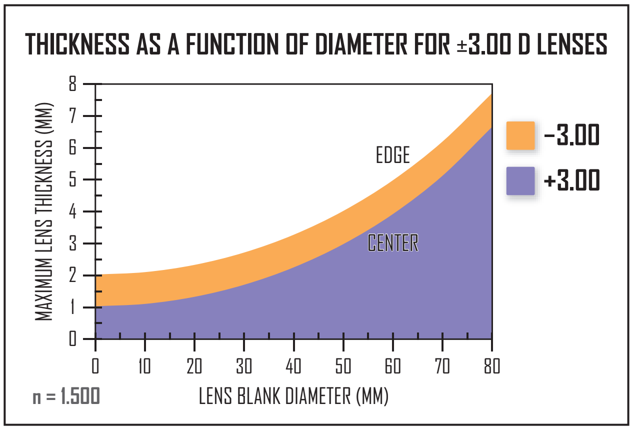

Figure 1. The center thickness of a plus lens and the edge thickness of a minus lens increase significantly with the diameter of the finished lens, as shown by these graphs of +3.00 and −3.00 D lenses, with a minimum edge thickness of 1 mm and a minimum center thickness of 2 mm.

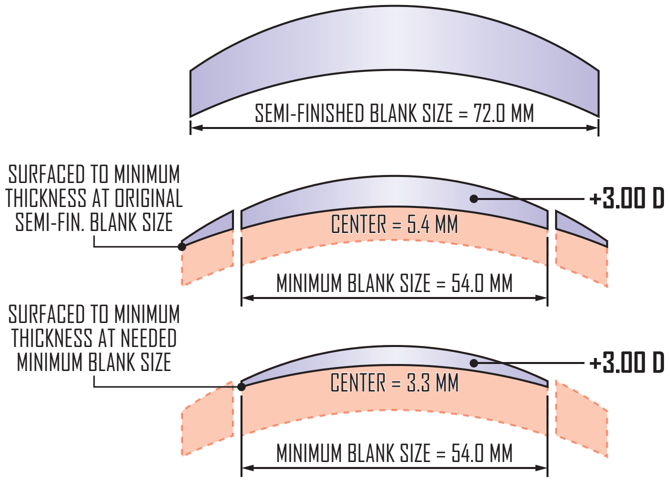

Figure 2. Surfacing the semi-finished lens blank to the center thickness needed for the minimum blank size of the edged lens shape can significantly reduce thickness and weight in plus-powered lenses and progressive-addition lenses.

For minus-powered lenses, the maximum thickness occurs at the edge of the lens, so excess lens material is simply cut away when the lens is edged to the shape of the frame. For plus-powered and progressive-addition lenses, on the other hand, the maximum (center) thickness of the finished lens is generally fixed once the lens has been surfaced. Accurate calculation of the center thickness is therefore crucial in order to ensure that the finished lens is no thicker than necessary, once edged to the desired shape. At the same time, the minimum (edge) thickness of the edged lens must be sufficient to ensure adequate cut-out, provide structural stability in the frame, and prevent chipping, typically at least 1 to 2 mm.

The initial semi-finished lens blank is generally much larger than necessary for the edged lens. Because lens thickness varies with the diameter of the finished lens, achieving the optimal center thickness for the finished lens requires first estimating the *minimum blank size* required for the job, which is the smallest lens diameter that will completely fill the area of the lens aperture of the frame, once the finished lens has been decentered to the desired interpupillary distance (PD). Basing the calculation of lens thickness on the minimum blank size required for the finished lens shape, as opposed to the full diameter of the semi-finished lens blank, allows the laboratory to minimize excess thickness and weight (Figure 2).

Understanding Frame Geometry

The laboratory generally calculates the thickness and minimum blank size requirements of the finished lens based upon the final size and shape of the edged lens after the necessary horizontal and vertical decentration has been applied to obtain the specified PD and segment height (if any). The accuracy of these surfacing calculations will obviously depend upon the amount of information supplied regarding the intended lens size and shape. The various dimensions of the lens aperture of a spectacle frame are specified using the *Boxing System* of measurement from Table 2 (Figure 3).

Table 2. The Boxing System is commonly utilized to specify frame dimensions, although frequently only the eyesize and bridge are supplied to the laboratory.

Frame Dimension	Measurement Definition
A or Eyesize	Width (horizontal size) of the bounding box tangent to the edges of the lens shape
B or Depth	Height (vertical size) of the bounding box tangent to the edges of the lens shape
DBL or Bridge	Minimum distance between the right and left lens apertures of the frame
Effective Diameter	Diameter of the circle on the geometric center that completely encloses the lens shape

Many eyecare professionals frequently supply only the eyesize (A) and bridge (DBL) to the laboratory when ordering lenses, since approximate values for these dimensions are readily available from markings on the frame. Unfortunately, relying on incomplete or inaccurate measurements of the dimensions of the spectacle frame or lens shape will not yield optimum results in many cases. In fact, capturing the exact size and shape by electronically tracing the lens aperture with a frame tracing device is the most accurate method, when the frame is made available to the laboratory (Figure 4). But this may not be possible if the frame is not supplied with the order.

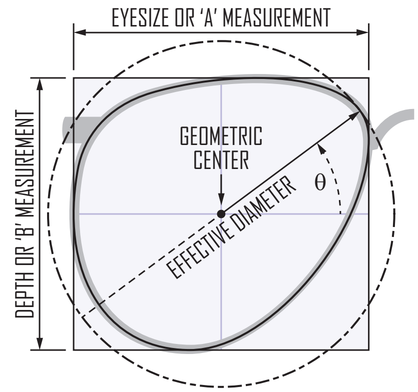

Figure 3. Frame dimensions are often specified for lens surfacing calculations using the Boxing System of measurement.

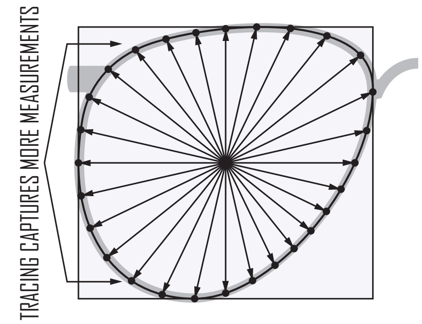

Figure 4. Electronically tracing the frame captures more measurements of the finished lens shape, resulting in more accurate lens size and thickness calculations.

For instance, different lens shapes with the same eyesize (A) may require significantly different minimum blank sizes. Consequently, when provided with only the eyesize of the frame, the laboratory must frequently err on the side of caution by assuming a larger minimum blank size than what may strictly be necessary for the job in order to ensure proper cut out. This may result in unnecessary lens thickness and weight in many cases (Figure 5).

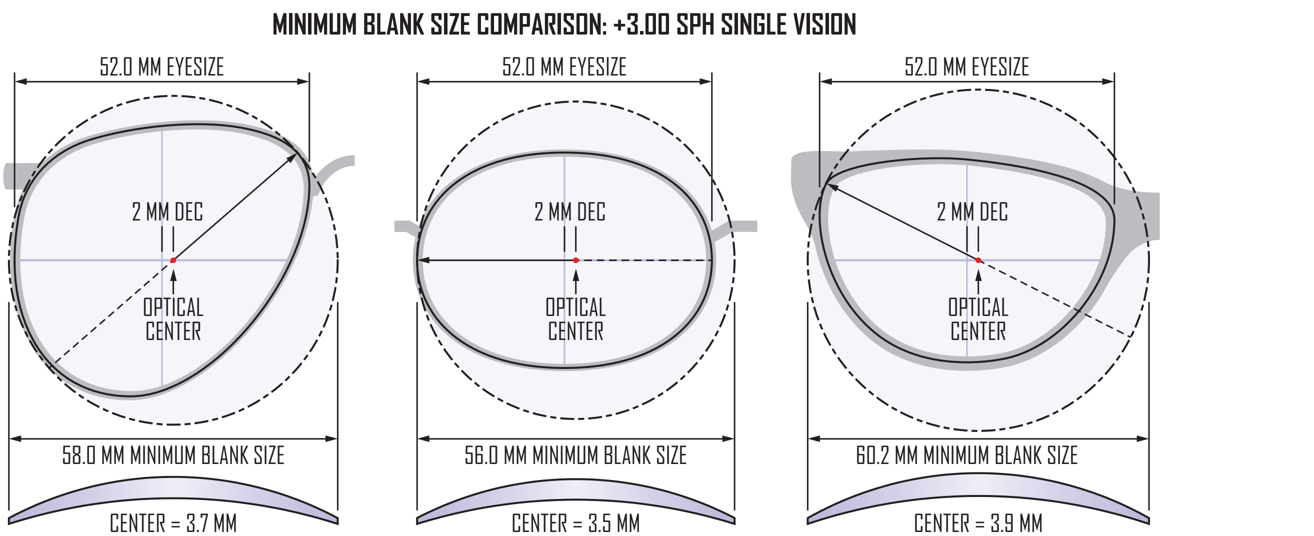

Figure 5. Even for the same eyesize (A), the shape of the lens aperture of the frame will significantly influence the minimum size of the lens blank needed for the finished lens, depending upon the combination of decentration, depth (B), effective diameter, and angle of the effective diameter, resulting in different lens thickness requirements.

Lens Thickness and Frame Geometry

The eyesize (A) of the frame, alone, does not adequately characterize the geometry of the lens shape. The minimum blank size will also depend upon the depth (B) of the lens shape, the effective diameter, and the angle of the effective diameter. Further, the dimensions of the finished lens must be adjusted accordingly for the decentration of the optical center or multifocal/progressive segment of the lens from the geometric center of the lens aperture of the frame. Although this discussion has so far assumed that the minimum blank size for thickness calculations will be circular in shape, this is not necessarily the case for plus lenses with cylinder power or for progressive lenses, since the edge thickness of these lenses will vary around the perimeter of the finished lens blank. Surfacing calculations must therefore evaluate the thickness of the finished lens through multiple meridians of the lens shape.

For plus lenses with cylinder power, the thickness is constrained by the meridian of the finished lens that results in the thinnest edge around the perimeter of the lens shape. This will depend upon the relationship between the power through each principal meridian, the cylinder axis, the decentration, and the dimensions of the lens shape, factors that often interact with each other in unpredictable ways (Figure 6). For progressive lenses, the thickness calculations involved become even more complex due to the varying topography of progressive surfaces and to the use of variable vertical prism to reduce thickness. Computing the optimal combination of prism-thinning and lens thickness requires mathematically modeling the progressive lens using the exact lens size and shape. Otherwise, the resulting lens may be unnecessarily thick and heavy for the chosen frame or, conversely, may not cut out fully in the frame (Figure 7).

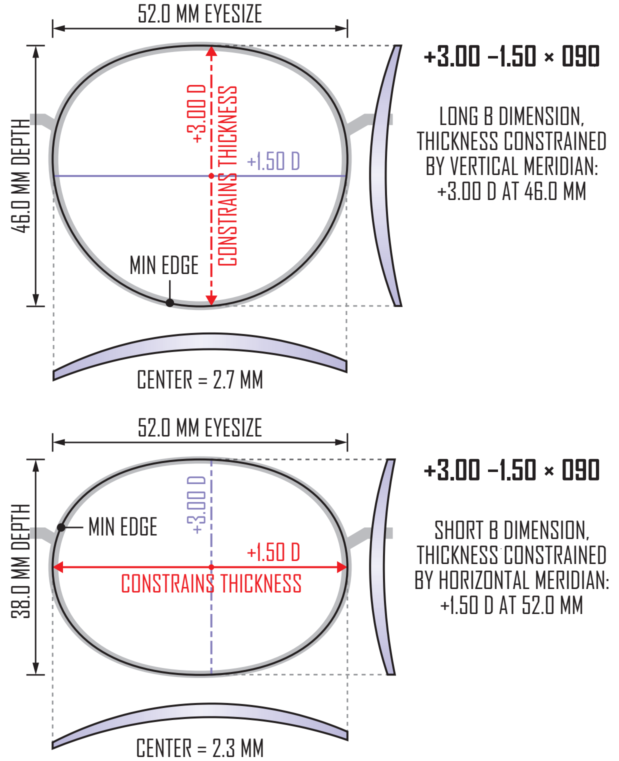

Figure 6. The thickness of plus lenses with cylinder power will be influenced by the relationship between the cylinder axis and the dimensions of the lens shape.

In conclusion, supplying the actual spectacle frame or an electronic tracing of the frame to the laboratory is the best way to ensure adequate lens cut-out with minimal lens thickness and weight, while keeping lab turnaround time short. Frame tracing captures hundreds of points around the frame perimeter, allowing surfacing calculations to model the exact size and shape of the finished lens. This results in the thinnest, most comfortable lenses possible.

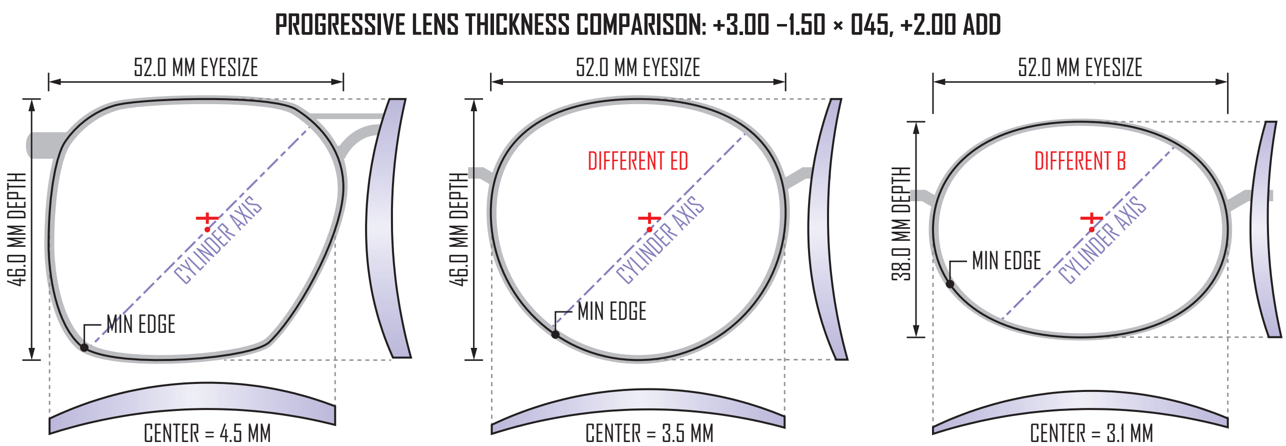

Figure 7. The complex surfacing calculations required for progressive lenses are also sensitive to the shape of the lens aperture of the frame, resulting in potentially significant differences in lens thickness, weight, and minimum blank size, even for the same eyesize (A) or the same combination of eyesize and depth (A and B).

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