Most contact lens opticians will recognise this situation. A patient visits for the first time, wearing very old rigid lenses saying that they fit perfectly and would like a duplicate pair. Their previous practitioner has retired and of course, they have no contact lens specifications! In these circumstances, it would be really useful to have full laboratory equipment so that the majority of lens parameters could be measured and recorded for replication to take place. In most practices, this simply is not the case.

Other occasions where such information would be valuable include checking the laboratories’ accuracy as you would with spectacles before final dispensing, to confirm that the lenses are being worn in the correct eyes or to check if lens parameters have altered with time and wear.

However, in practice, there are things that we can do to obtain the most relevant parts of the specification, so allowing the verification or replication to take place with a good level of confidence.

Before any measurements are attempted, a full knowledge of rigid lens design is necessary. Although individual laboratories may make almost any configuration of back surface design, the majority fall into the following groups:

1. Spherical, with two concentric curves (bicurve or C2) or three concentric curves (tricurve or C3) or four or more concentric curves (multicurve or C4). These spherical curves usually flatten in radius towards the lens edge.

2. Aspheric, with varying options of aspheric curve designs, such as ellipse or parabola.

3. A combination of the above. Possibly a spherical central portion combined with an aspheric periphery.

COMPETENCIES COVERED:
Dispensing opticians: Contact lenses
Contact lens optician: Verification and identification
Optometrists: Contact lenses
For the purpose of this article, we will assume a tricurve lens design is being assessed. A typical lens will have the following attributes, written in this style:

\[
\begin{align*}
BOZR & : BOZD / BPZR1 : BPZD1 / BPZR2 : TD \\
BVP & : Tint : CT : Marks : Material
\end{align*}
\]

An explanation of these terms appears in Table 1.

When receiving new contact lenses from a laboratory, the tolerances should comply with those in Table 2.

For our purpose, assume the lens to be verified or measured was made to the following specification:

C3 7.80:7.70/8.60:8.50/11.25:9.50 -5.00DS, Boston XO, Blue tint, ct 0.20, with dot marking for right eye

In practice, the author would suggest that we can have a realistic attempt to measure or check all of this specification with the exception of the two peripheral radii, the 1st peripheral zone diameter and the material.

### Measuring BOZR

Usually, this is the most important or useful parameter to establish. Ideally, the practice will have a radiuscope, which may be monocular or binocular. Figure 1 shows a standard binocular version with mechanical measuring gauge. Some instruments have a digital scale or even an internal one viewed via the eye pieces. Using Drysdale’s method, it measures the distance between two images, formed at the lens surface and the centre of curvature of the lens, which equates to the radius of curvature of that lens or surface. The instrument is not difficult to use, but does require practice and dexterity.

The lens must be thoroughly cleaned with sterile water or saline and then dried. Any deposits or liquid on the lens surface will distort the images. It is then placed, concave side up on the lens holder, which must also have a drop of sterile liquid placed in it, which will help to neutralise unwanted reflections from the front surface of the lens. Positioning the lens and holder centrally is critical. This can be achieved by turning the target light on as bright as possible and observing externally the reflection on the lens surface, moving the holder to obtain the most central position possible.

Before measuring takes place, it is helpful to confirm that both of the two images are visible. By racking the instrument target up and down with the black circular dial (Figure 1A) this can be achieved. Normally, the microscope itself moves, but with some instruments, it is the stage holding the lens and holder. It may be necessary to further move the holder horizontally to improve centration before both images are available. Any distortion of image at this point suggests poor centration, a dirty or wet lens or back surface lens distortion. The images are usually a circle of dots similar to a focimeter image. Elongation of one image may suggest that the surface is toroidal. A clue to correct positioning is that an additional image of the bulb filament can be seen between the two target images.

Having found these images, the gauge needs to be zeroed before recording can take place. It should be noted that instruments may zero on either of the two images. The implication of this is that instead of reading from perhaps zero to 7.80, the gauge may move in the opposite direction, ie, from zero (or 10.00) backwards through 9.00, 8.00 etc to stop at 2.20. The actual reading of course would not be 2.20, but 10.00 – 2.20, ie, 7.80.

Having established the zero position, the gauge must be reset to record this, usually achieved by turning the horizontal metal dial as seen in (Figure 1B). The black plastic dial is then

### Table 1

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOZR</td>
<td>Back Optic Zone Radius</td>
</tr>
<tr>
<td>BPZR1</td>
<td>1st Back Peripheral Zone Radius</td>
</tr>
<tr>
<td>BPZR2</td>
<td>2nd Back Peripheral Zone Radius</td>
</tr>
<tr>
<td>BOZD</td>
<td>Back Optic Zone Diameter</td>
</tr>
<tr>
<td>BPZD1</td>
<td>1st Back Peripheral Zone Diameter</td>
</tr>
<tr>
<td>TD</td>
<td>Total Diameter</td>
</tr>
<tr>
<td>BVP</td>
<td>Back Vertex Power</td>
</tr>
<tr>
<td>Tint</td>
<td>Any tint of material, eg, blue</td>
</tr>
<tr>
<td>CT</td>
<td>Geometric Centre Thickness</td>
</tr>
<tr>
<td>Marks</td>
<td>Any identifying marks, such a ‘R’ for right lens</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOZR</td>
<td>+/- 0.05mm</td>
</tr>
<tr>
<td>Any BPZR</td>
<td>+/- 0.10mm</td>
</tr>
<tr>
<td>BOZD</td>
<td>+/- 0.20mm where blending allows measurement</td>
</tr>
<tr>
<td>Any BPZD</td>
<td>+/- 0.20mm where blending allows measurement</td>
</tr>
<tr>
<td>TD</td>
<td>+/- 0.10mm</td>
</tr>
<tr>
<td>BVP</td>
<td>Up to 5.00DS, +/- 0.12DS</td>
</tr>
<tr>
<td></td>
<td>5.00DS to 10.00DS, +/- 0.18DS</td>
</tr>
<tr>
<td></td>
<td>10.00DS to 15.00DS +/- 0.25DS</td>
</tr>
<tr>
<td></td>
<td>15.00DS to 20.00DS +/- 0.37DS</td>
</tr>
<tr>
<td></td>
<td>Over 20.00DS +/- 0.50DS</td>
</tr>
<tr>
<td>CT</td>
<td>+/- 0.02mm</td>
</tr>
</tbody>
</table>
turned again to find the next image. The gauge will record this movement and needs to be read to supply the actual BOZR in mm. Viewing the gauge carefully, readers will note that there is an outer pointer giving the decimal places and a small inner dial (Figure 1C) supplying the whole millimetres. Care must be taken when the larger pointer is near vertical, which implies that the whole number on the small dial is about to or has just altered. Mistakes are frequently made in this case, so particular note should be made of exactly where this pointer is indicating to avoid a whole digit of error.

These instruments are very sensitive, requiring a number of readings to be taken and an average final reading recorded.

In theory, by tilting the lens holder, it is possible to measure peripheral curves, but this is very dependent on levels of blending and width of the peripheral band.

Many practices, however, do not have a radiuscope. An alternative method of measuring BOZR can be performed using a keratometer. The lens needs to be held in front of the keratometer in a similar position to where the eye is normally placed. Special holders are available for this purpose (Figure 2). The post is inserted into the chin rest where the securing pins for the disposable paper wipes are usually located and the clean lens placed into the concave plastic holder with sterile liquid. The keratometer then is used in the normal way to give a direct reading from its dial. The process is quicker and easier than using a radiuscope. Without the special holder, a mock-up version can easily be made using a rule to sit on the chin rest and lean against the forehead strap. Blu-tack or similar, with a concave depression in it, holds the lens in place at the correct height for the machine. This works perfectly satisfactorily, but care should be taken over hygiene and possible damage to the lens. As keratometers are calibrated to measure convex surfaces rather than concave, errors due to aberrations do occur. Some manufacturers produce a conversion table to use, but as the errors are small, it is suggested that adding just 0.03mm to the recorded reading will give an accurate result. The author concurs with this.

**Total Diameter (TD)**
TD can be measured using a band magnifier or ‘V’ gauge.

A band magnifier (Figure 3) is a simple magnifying device (usually 7X) with a scale or graticule in millimetres and 10ths of millimetres engraved on the flat viewing surface. A lens is placed convex side out on this surface and viewed through the magnifier towards a background light source. It should be gently moved to line up with the graticule and a direct reading of TD in mm, correct to one decimal place is taken. In exactly the same manner, BOZD and any peripheral curve diameters may be recorded if the blending on the lens allows them to be seen.

At the same time, the lens can be generally viewed to assess condition and check for any identification marks that may be engraved on the front surface, such as a dot or lettering.

Alternatively, a ‘V’ gauge may be used, but this will not measure any peripheral diameters, only TD. The lens is placed in a wide area of the reducing width groove and gently slid along the narrowing channel until it touches both sides with no further movement possible. Care must be taken not to damage the lens by exerting too much pressure. (Figure 4) shows a lens in this position with a TD reading of 9.1mm.

**Back Vertex Power (BVP)**
As with any optical lens, the BVP must be established. Any standard practice focimeter may be used. If it is possible to align the focimeter vertically, this will help keep the contact lens in position. Using a small stop, less than the total diameter of the contact lens, prevents the lens from falling into the machine. A lens holder (Figure 5) is often supplied with focimeters to further help safe positioning.

The clean, dry lens should be placed concave surface down to measure BVP, centred as well as possible to avoid introducing any prismatic effect. If the lens is not placed on or very close to the stop, it will not be in the correct plane to give an accurate reading. The error will be to show a more positive or less negative reading. This can also occur if the lens has a very steep back curve, forcing the centre away from the stop.
Once positioned, a reading is taken in exactly the same way as for spectacle lenses. Should a cylindrical component be present, this will of course show in the normal way, although the axis shown will depend on the rotational position of the lens on the stop, rather than the true axis.

**Geometric Centre Thickness (CT)**
CT is very easy to measure with an appropriate thickness gauge. As seen in Figure 6, it consists of a simple dial gauge, very similar to a radiuscope, which is directly connected to a spring loaded probe. The movable leg of the probe needs to be raised, the lens inserted concave side down centrally on the fixed part and the leg gently repositioned onto convex surface of the lens. The lens position is shown as (Figure 6A). A reading is directly taken. Because CT is generally very small, say between 0.10 and 0.40mm, errors do not normally occur in taking the reading as they may with the radiuscope. Only the large pointer is observed as the reading is always less than 1.00mm, unless a scleral lens is being measured!

The thickness gauge can also be used to determine edge thickness or indeed any thickness across the lens. It is helpful in identifying prism incorporated, with the edge being considerably thicker in one meridian.

**Tint**
Most rigid contact lenses have a tint. When PMMA was popular, laboratories issued tint charts or samples as found today with spectacle lens tints. With the advance of gas permeable materials, the choice reduced considerably, but still exists. The best way to check a lens for tint is to place it against a white background, a clean tissue is ideal, and observe it in good natural light. Recording is personal rather than scientific, using terms such as ‘blue’, ‘light blue’, etc. Older PMMA lenses used numbers to identify their tint, such as 912 for light grey or 512 for dark grey, but this practice is little used today.

**Material**
There is now a large range of gas permeable materials available with varying properties of DK, wettability, hardness etc. In a practice setting, the author suggests that it is not possible to detect which material has been used to make a lens.

**In summary**
We started with a lens to be checked or measured with the following specification:

- **C3 7.80:7.70/8.60:8.50/11.25:9.50**
- **-5.00DS, Boston XO, Blue tint, ct 0.20, with dot marking for right eye**

With some measuring devices in practice, it should be possible to obtain realistic readings as below, with the exception of the scored out details:

- **C3 7.80:7.70/8.60:8.50/11.25:9.50**
- **-5.00DS, Boston XO, Blue tint, ct 0.20, with dot marking for right eye**

This is enough information to make a replacement lens with reasonable confidence. Indeed, most manufacturers today make ‘system’ lenses, which require the practitioner to supply the desired BOZR, TD and BVP (plus material and tint), leaving their programmed computer systems to calculate all other parameters. So perhaps you can obtain more information than you expected with your RGP contact lens wearers!

**References**

Keith Cavaye is currently a locum contact lens optician and consultant, an ABDO practical CL examiner, an ABDO theory dispensing marker, and sits on the GOC Investigation Committee. He is chairman of the ABDO CET Committee and member of the Contact Lens Committee, ABDO Advice and Guidelines working group, College of Optometrists Membership and Standards Committee. Past Council member BCLA and GOC. He has had various articles published on contact lenses. Previously he was professional services manager for Indigolighthouse Group, contact lens product manager for Dollond & Aitchison, and contact lens services manager for Boots Opticians.
Multiple choice questions (MCQs):
Measuring that unknown RGP in practice

1. What does not form a rigid contact lens back surface design?
   a. Paraboloidal or elliptical aspherical curves
   b. A series of spherical concentric curves
   c. Convex concentric curves to flatten the peripheral radii
   d. Aspherical and spherical curves

2. Which abbreviation is incorrectly written according to British Standards?
   a. BPZD1  
   b. BOZR  
   c. BPZR3  
   d. BZOD

3. Which statement is true regarding rigid contact lenses?
   a. It is not practical to verify the first peripheral zone diameter
   b. The tolerance on a back vertex power of -6.00D is +/-0.25D
   c. Back optic zone radius cannot be measured with a keratometer
   d. Peripheral radii are best checked using a V-gauge

4. The geometric centre thickness of a rigid corneal lens is likely to be . . .
   a. Reduced if the back curve is very steep
   b. Rejected if 0.01mm different from the specification ordered
   c. Over 1mm
   d. Between 0.1mm and 0.4mm

5. If the contact lens is not placed very close to the focimeter stop . . .
   a. A cylindrical element will be introduced
   b. The reading will be more positive than the true value
   c. The reading will be more negative than the true value
   d. A prismatic effect will distort the image

6. On which set of measurements from the practitioner do contact lens manufacturers mostly rely?
   a. BVP, TD, BOZR  
   b. BPZR1, BVP, TD  
   c. BOZD, BVP, CT  
   d. BPZD1, CT, TD, BVP

The deadline for posted or faxed response is 16 December 2014. The module code is C-33206

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