National Academy of Opticianry

Continuing Education Course

Approved by the American Board of Opticianry

Vertex Distance, Effective Power, and Compensated Power – Tilt – Wrap

National Academy of Opticianry
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PREFACE:

This continuing education course was prepared under the auspices of the National Academy of Opticianry and is designed to be convenient, cost effective and practical for the Optician.

The skills and knowledge required to practice the profession of Opticianry will continue to change in the future as advances in technology are applied to the eye care specialty. Higher rates of obsolescence will result in an increased tempo of change as well as knowledge to meet these changes. The National Academy of Opticianry recognizes the need to provide a Continuing Education Program for all Opticians. This course has been developed as a part of the overall program to enable Opticians to develop and improve their technical knowledge and skills in their chosen profession.

The National Academy of Opticianry

INSTRUCTIONS:

Read and study the material. After you feel that you understand the material thoroughly take the test following the instructions given at the beginning of the test. Upon completion of the test, mail the answer sheet to the National Academy of Opticianry, 8401 Corporate Drive, Suite 605, Landover, Maryland 20785 or fax it to 301-577-3880. Be sure you complete the evaluation form on the answer sheet. Please allow two weeks for the grading and a reply.

CREDITS:

The American Board of Opticianry has approved this course for One (1) Continuing Education Credit toward certification renewal. To earn this credit, you must achieve a grade of 80% or higher on the test. The Academy will notify all test takers of their score and mail the credit certificate to those who pass. You must mail the appropriate section of the credit certificate to the ABO and/or your state licensing board to renew your certification/licensure. One portion is to be retained for your records.

AUTHOR:

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INTENDED AUDIENCE:

This course is intended for opticians of all levels.

COURSE DESCRIPTION:

This course will explain how the vertex distance - the distance between the back surface of a lens and the apex of the cornea - affects the effective power of a lens. It will further be explained how altering that vertex distance affects the effective power and how to compensate for that change, to ensure that the patient has maximum vision. Formulas will be used to explain the changes.

LEARNING OBJECTIVES / OUTCOME

At the completion of this course the student should be able to:

- Explain vertex distance
- Discuss the changes as a plus lens is moved closer to or away from the eye
- Discuss the changes as a minus lens is moved closer to or away from the eye
- Use formulas to compensate for the effective changes of power caused by differences in vertex distance

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Vertex Distance – The Definition

According to *the Dictionary of Ophthalmic Optics*, the definition is stated thusly:
“The straight line measurement in millimeters (z axis) from the back or ocular surface vertex of a mounted spectacle lens to the apex of the cornea.” For a more practical definition, it is the straight line distance in millimeters from the back surface of any lens (mounted in spectacles or not) to the apex of the cornea.

Vertex Distance – Effective Power

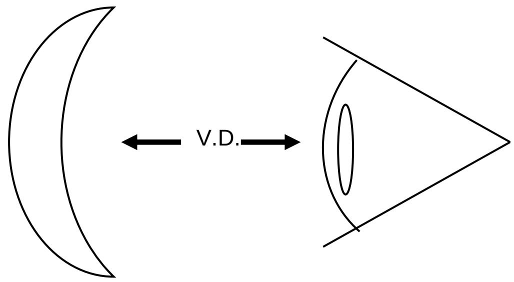
The vertex distance of the finished eyeglasses must be established. Since the front surface of a high minus lens may essentially be plano, the center thickness about 2.0 mm, and the bevel moved towards the front of the lens, the back vertex will probably lie in the plane of the eyewire groove or slightly behind it. A vertex measurement made to either the front or back of the eyewire can be adjusted by the distance of the groove from either to establish the lens vertex distance.

When a difference exists between the doctor's specified vertex distance (use 14 mm if not specified) and the spectacle vertex distance, the compensated prescription must be determined. In the case of a sphere Rx, a single computation is required. For a compound Rx, however, two computations must be made--one for the power in each of the two principal meridians. The difference between the two compensated meridianal powers yields the power of the compensated cylinder.

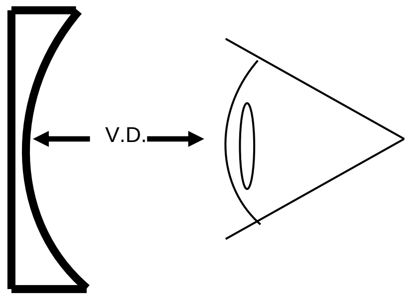
One method of making this computation is to convert the power into focal length in millimeters (f = 1000/D). To this, add the change in vertex distance if vertex distance is increased, or subtract the change if vertex distance is decreased. Then convert the resultant amount into power (D = 1000/f). The answer is the compensated power in the new position.

When fitting lenses of relatively low power, the distance at which the patient was refracted and the distance at which the lenses are fitted is of little significance. However, as the power increases, the distance has an effect on the way a patient sees out of the lenses. In effect, if the power is not compensated for when the lens is fit at a difference vertex distance that the patient was refracted, there is effectively a different prescription from the one that was intended by the refractionist/doctor. For that reason, it’s important to understand what happens as the vertex distance changes. Most doctors will make a note on the prescription if the power is of significant power as to what the refracting vertex was. If not, the dispenser should contact the prescriber to find out.

When a plus lens is moved closer, the effect of the power decreases. In addition, as a plus lens is moved away from the eyes it increases the effect of the power.



When a minus lens is moved closer, the effect of the power increases. In addition, as a minus lens is moved away from the eyes it decreases the effect of the power.



This change is referred to as the *effective power* of the lens.

Effective Power/Compensated Power

Therefore, if there has been a change in the vertex distance from the distance that the patient was refracted, there has been a change in the effective power. This means that in order for the patient to be able to see appropriately, there must be a compensated power change.

Vertex Distance

The refractionist may write the refractive distance in different forms such as Vtx, Vx., V.D., or R.V.

The wearing vertex is often abbreviated as WVtx, W.Vx., W.V.D.

When to compensate: spectacles all powers greater than 7.00 Diopters in either principle meridian must be compensated. For contact lenses, all powers greater than 4.00 Diopters in either principal meridian must be compensated.

For spherical contact lens design, compensate the sphere only because the actual lens power is based on the spherical component of the Rx. When a spherical contact lens is properly designed, the lacrimal lens along the steeper meridian is less than 4 Diopters. When a toric lens is designed, both meridians of power must be compensated. This will be discussed further in a contact lens module.

Vertex Distance & Compensation

A Distometer or millimeter rule is used to measure vertex distance. Some corneal reflection pupilometers also have a method for measuring vertex distance. In addition, some phoropters and slit lamps can be used for measuring vertex distance.

For spectacles, if the power in **any** meridian is greater than 7.00D, an adjustment to the power must be made if the frame is fit at a different distance other than the Rx vertex distance. (Remember, for reference purposes, when compensating for contact lens powers, the Rx must be compensated for if the power is in any meridian is greater than 4.00D.)

Remember: (CAP) Closer add plus

Vertex Power Compensation

Simple formula

The simple formula for determining the effective power when moved by millimeters is: diopters squared, divided by 1000. That value is multiplied by the millimeter of change.

$EP = D^2 / 1000 \text{ X mm of change}$

- Whereby EP = Effective power
- D^2 = dioptric power of lens meridian squared

The compensated power is the result of adding to or subtracting from the diopter power as follows:

- Minus lens moving closer - subtract to reduce the diopter power
- Plus lens moving closer - add to increase the diopter power
- Plus lens moving farther away - subtract to reduce the diopter power
- Minus lens moving farther away - add to increase the diopter power

Example 1:

A -12.00 D sphere lens is refracted at 12mm and the lens will sit at 9 mm from the apex of the patient's cornea.

12.00 squared = 144, 144/1000 = .14

The movement is 3mm closer to the patient's eye, with a minus lens.

3 x .14 = .42

EP = -12.42 D

Because the effective power is greater than was needed by the patient the compensated power must be reduced by the difference. Therefore, the compensated power is calculated thusly

.42D or 0.50 D is subtracted from -12.00 to compensate the lens power to -11.50 D.

Example 2:

A +12.00 D sphere lens is refracted at 12mm and the lens will sit at 9 mm from the apex of the patient's cornea.

12 squared = 144, 144/1000 = .14

The movement is 3mm closer to the patient's eye, with a plus lens.

3 x .14 = .42

EP = +11.58 D

Because the effective power is less than was needed by the patient, the compensated power must be increased by the difference. Therefore, the compensated power is calculated thusly:

.42D or 0.50 D is added to +12.00 to compensate the lens power to +12.50 D.

Example 3:

A +12.00 D sphere lens is refracted at 9 mm and the lens will sit at 12 mm from the apex of the patient's cornea.

12 squared = 144, 144/1000 = .14

The movement is 3mm further away from the patient's eye, with a plus lens.

3 x .14 = .42

EP = +12.42 D

Because the effective power is greater than was needed by the patient the compensated power must be decreased by the difference. Therefore, the compensated power is calculated thusly:

.42D or 0.50 D is subtracted from +12.00 to compensate the lens power to +11.50 D.

Example 4:

A -12.00 D sphere lens is refracted at 9 mm and the lens will sit at 12 mm from the apex of the patient's cornea.

12 squared = 144, 144/1000 = .14

The movement is 3mm further away from the patient's eye, with a minus lens.

3 x .14 = .42

EP = -11.48 D

Because the effective power is less than was needed by the patient, the compensated power must be increased by the difference. Therefore, the compensated power is calculated thusly:

.42D or 0.50 D is added to -12.00 to compensate the lens power to -12.50 D.

Each principle meridian must be calculated independently.

When compensating for compound powers of a spectacle Rx, you must compensate for the TOTAL power of each meridian.

Example 5:

Given an Rx of -10.00 – 2.00 X 090, refracted at 9 mm and the lens will sit at 12 mm from the apex of the patient's cornea.

The total power in the 090 meridian is -10.00, therefore:

10 squared = 100, 100/1000 = .10

The movement is 3mm further away from the patient's eye, with a minus lens.

3 x .10 = .30

EP = -9.70 D

Because the effective power is less than was needed by the patient in this meridian, the compensated power must be increased by the difference. Therefore, the compensated power in this meridian is calculated thusly:

.30D is added to - 10.00 to compensate the lens power in the 090 meridian to -10.30 D. Don't round off until final calculation.

The total power in the 180-degree meridian is -12.00. Again, the movement is 3mm further away from the patient's eye, with a minus lens.

Therefore:

12 squared = 144, 144/1000 = .14

The movement is 3mm further away from the patient's eye, with a minus lens.

3 x .14 = .42

EP = -11.48 D in the 180 meridian.

Because the effective power is less than was needed by the patient in this meridian, the compensated power must be increased by the difference. Therefore, the compensated power in this meridian is calculated thusly:

.42 is added to -12.00 to compensate the power in the 180 meridian to -12.42. Don’t round off until final calculation.

Using the powers as calculated, the power would be -10.30 – 2.12 X 090

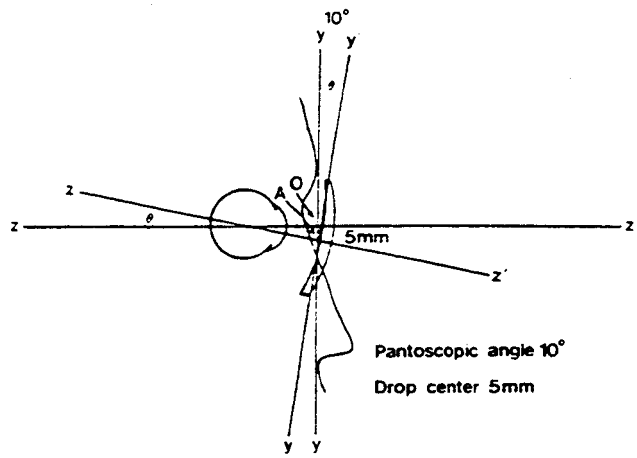
That makes the final Rx -10.25 – 2.25 X 090

Other Considerations of Position of Wear

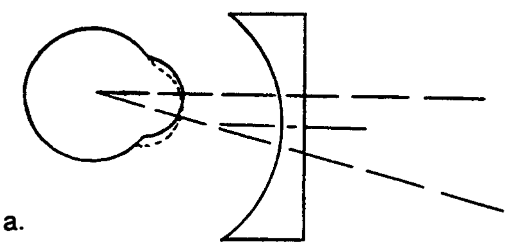
Lens Positioning

The position of the distance viewing centers (the point in the shape through which the visual axis passes with the eyes in the primary position) distance viewing centers (DVC) must be established. Horizontally, the DVC separation will be equal to the patient's distance PD. The vertical position of the DVC can be determined using any of the techniques associated with progressive addition lenses.

Knowing the location of the DVC and the edging (mechanical) center of the shape, the desired location of the lens’ optical center (OC) can be ascertained. The location of the OC below the DVC is related to the amount of pantoscopic tilt which will be needed in the spectacles when finally fitted. As a rule-of-thumb, for every 2 degrees of pantoscopic tilt, the optical center of the lenses should be placed 1mm below the distance viewing center. This measurement must be given to the laboratory in terms of millimeters above or below the edging (mechanical) axis as the case may be.



Additionally, placing the lens' optical center in front of or closer to the patient's pupil may significantly minimize the wearer's awareness of the color fringes of high index lenses. A problem encountered when raising the optical center from frame center is a resulting increase in lens edge thickness at the bottom eyewire. Be sure that the pantoscopic tilt matches your vertical optical center placement to avoid unwanted aberrations.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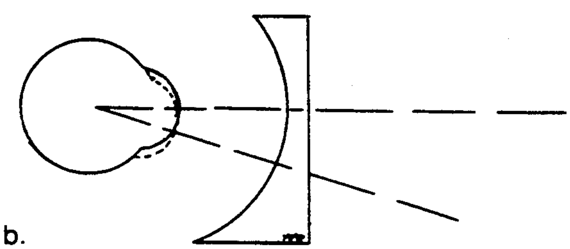
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Martin's Tilt Formula

The formula is:

$$\text{New Sphere power} = D\left(1+\frac{\sin^2 a}{3}\right)$$

$$\text{Induced Cylinder power} = D(\tan^2 a)$$

Where:

- D = the dioptric power of the meridian of tilt
- a = the angle of excessive tilt

Martin's Formulae for tilted lenses demonstrates the relationship between the optical center placement and the amount of lens tilt we should use. When a lens is tilted excessively (either vertically or horizontally) its spherical power is changed and cylinder power is induced.

Consider the following example:
What is the effect of a -10.00D sphere lens that is mounted in a frame with 10 degrees of pantoscopic tilt and the optical center is placed directly in front of the pupil?

Using Martin's formulae:

$$\text{New Sphere power} = D\left(1+\frac{\sin^2 a}{3}\right)$$

$$\text{Induced Cylinder power} = D(\tan^2 a)$$

Where:

- D = the dioptric power of the meridian of tilt
- a = the angle of excessive tilt

Example: As diagramed earlier, there should be no pantoscopic tilt on a frame when the optical center falls directly in front of the pupil. Therefore, in this example, there are 10 degrees of excessive tilt.

$$\text{New Sphere power} = -10.00\left(1+\frac{\sin^2 10}{3}\right) = -10.10\text{D}$$

$$\text{Induced Cylinder power} = -10.00(\tan^2 10) = -0.31\text{D}$$

The resultant prescription is: -10.10 -0.31 x 180

The induced cylinder power is of the same sign as that of the power being tilted (in this case minus). The axis of the cylinder induced is the same as the axis of the rotation of the lens. For pantoscopic or retroscopic tilt the axis of rotation is 180 degrees. If placing more or less face form on a lens, the axis of rotation would be 90 degrees.

Placing the optical center in front of the pupil and ignoring the amount of pantoscopic tilt results in quite a change in the prescription of this lens. Unlike the case of vertex distance changes, where a new lens power must be ordered to compensate for positional change, this situation does not call for an alteration of the original prescription. Simply change the amount of tilt or optical center placement until the proper relationship is achieved. In this case, lowering the frame to raise the position of the pupil would be more desirable than decreasing the pantoscopic tilt. In any case, careful frame selection can circumvent these problems.

Failing to recognize the relationship between lens tilt and the vertical placement of the optical center does not result in a severe alteration of the prescribed power in lenses below +/- 6.00 diopters. Nonetheless, we should not ignore this relationship because of the increased use of aspheric surface and high index lenses even in these relatively lower powers. Also, some patients have abnormally low tolerances for other seemingly slight discrepancies.

The placement of the optical center before the pupil is dependent upon the tilt of the frame. The following rules apply:

Placement of the Center with Respect to the Tilt

As previously mentioned, the optical center should be 1mm lower than the pupil for every 2 degrees of pantoscopic tilt.

By being attentive during frame selection and by being aware of the relationship between the tilt and the optical center placement, you can be sure you will increase patient satisfaction and reduce the amount of time spent on trial and error adjustments.

Wrap Sunwear/Eyewear

Wrap sunwear is pervasive; what began as performance technology to increase protection and performance for athletes became a trend. The technology of properly fabricated wrap Rx sunwear is different from conventional Rx sunwear. Wrap Rx sunwear requires specific bevel techniques and placement. The patient looks through the lens in wrap eyewear at a different point than in standard eyewear. Using the wrong technology on lenses will compromise the wearer's vision. However, using the correct lens technology but the wrong curve for the lenses presents a plethora of problems. Here are the issues and the solutions.

Understanding the Technology of Wrap Sunwear

Most frames are made with a standard positive face form (referred to as the wrap angle) that is around 10 degrees or less. However, more frame wrap means the base curve of the frame is +8.00D or greater. Some frames may have a +6.00D base, but the wrap angle of the overall frame dictates that the lens design needs to be changed in order to optimize the patient's vision. Bending any frame to the point that the wrap angle is greater than 10 degrees will affect the patient's vision. Since a patient's standard eyewear is generally fabricated in lenses that have a flatter profile, they may have difficulty switching to wrap sunwear unless the lens design and fabrication is changed.

If a frame has 10 degrees of wrap, standard lenses with a flatter profile should work well in the frame.   However, if the frame has a wrap angle over 10 degrees, unless the lens design is changed or optimized, the patient will not have good quality vision.

Compromises

Using the wrong base curve for the frame may allow good vision for the patient, but the sunwear will have a poor appearance and/or have the lenses pop out. Using the wrong base curve for the prescription may make the glasses look good, but the vision of the patient will be compromised.

The problems of using the wrong base curve lens for the frame

Corrected curve lenses maximize the vision of patients. They are designed with base curves and ocular curves that generally result in a flatter profile and work well in flat profile frames. However, using them in wrap design frames with a steeper curve to the eyewire will result in less than desirable cosmesis.

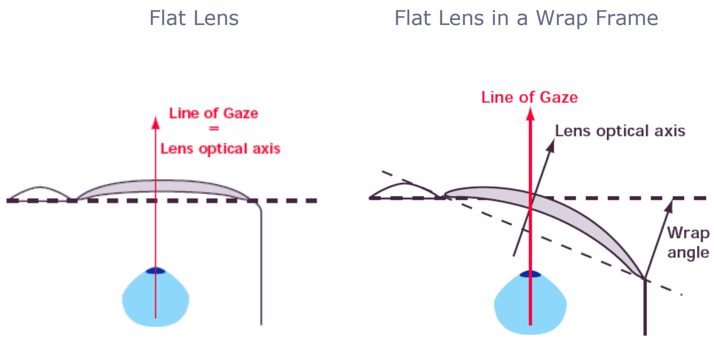
When a +6.00D or flatter base lens is used in a +8.00D base frame, it can force the frame out of alignment, cause the lenses to pop out of the frame, and/or have gaps between the eyewire and the lens, because the potential lens bevel and the frame bezel are mismatched. Mechanically, they don’t fit the wrap frames. Cosmetically, they are just plain ugly.

The problems of using the wrong base curve lens for the prescription

If we look at the standard power range of +8.00 base curve lenses, we see that the ranges of power are limited. In reality, only 7% of all prescriptions require a +8.00D base curve. Since this is the case, if we use a +8.00D base curve on all lenses, we are outside the recommended base curve of 93% of all prescriptions.

Prescription Error

Flat profile lenses may read in a focimeter as prescribed, but if wrap design frames are worn, they are positioned differently in front of the patient’s eyes and the patient’s vision will be compromised. The Panoramic (wrap) angle which characterizes wrap frames introduces prescription error. The actual as worn optical power, which is perceived by the observer even for straight up gaze, is different from the focimeter reading.



As patients look straight ahead in a flat lens profile lens that is positioned in a standard profile frame, their line of gaze matches the lens optical axis. However, that same flat profile lens in a wrap frame causes the line of gaze and the lens' optical axis to not match. The patient is looking through unwanted prism, because the wrapped lenses are tilted around the vertical axis of the lens, creating base out prism, affecting binocularity.

The solution is to use base-in prism to compensate. In addition to inducing prism, as the frame is wrapped, the effect of the power also changes. That's where power compensated calculation formulas come in. However, remember that any time the patient moves his/her eyes away from the optical center of the lens, there is induced prism, and the power changes as well.

Compromises of using a +8.00D base lens for prescriptions that belong to other base curves, using standard undersized +8.00D base lenses and using spherical lenses in wrap eyewear, will all result in unwanted astigmatism, distortion, and reduced field of view.

Optimizing the Rx

Optimizing the prescription can include the use of freeform surfacing technology, the use of aspheric/atoric design, and the use of lenticular carriers.

Can you do this yourself? If you are diligent, you may be successful for a number of prescriptions. However, it's more than just the formula and standard calculation. That's why most specialty labs and some lens companies have sophisticated software programs that calculate the correct formulas and designs into their lenses. The PD placement, vertex distance, and the OC placement have to be calculated into the formula. Because the calculated formulas work on one or two issues at best, it's probably best left to the labs. Perhaps the best answer is to have the lenses done accurately by a certified lab or one that specializes in the wrap design technology.

Wrap Eyewear

Wrap eyewear is now being used in non-sunwear applications, so all of the information presented here applies to both types of eyewear. Technology is constantly evolving and it will be incumbent upon you as a professional to stay up-to-date with the applications for all eyewear for your patients/customers.

Conclusion

As an Eyecare professional, optician, technician, it is incumbent upon you to understand how moving lenses/eyewear will affect your patient, and what you must do in order to remedy any concerns for them.

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