Brien Holden Vision Institute

SPHERO-CYLINDRICAL REFRACTION

THINK

A best vision sphere refraction only measures spherical refractive error (myopia, hyperopia or presbyopia) – it does not measure astigmatism.

Spherical lenses only correct spherical refractive errors – they will not correct astigmatism.
If a person has significant astigmatism, they will not see clearly or comfortably with spherical lenses only.

A person with significant astigmatism needs a sphero-cylindrical refraction.

AIM

This unit teaches you how to do a subjective sphero-cylindrical refraction.

LEARNING OUTCOMES

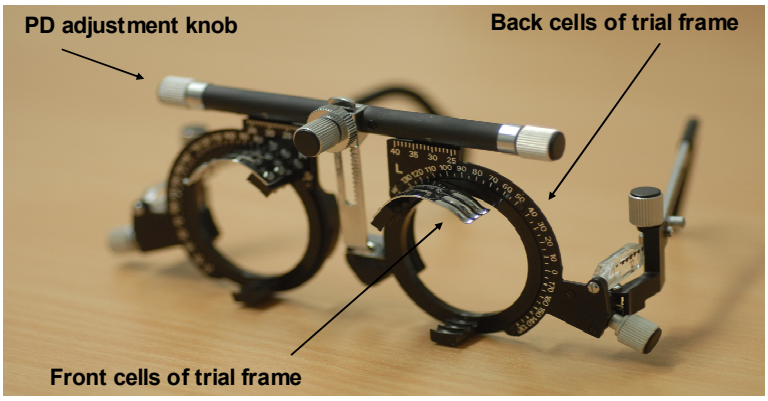
When you have worked through this unit you should be able to:

- explain when a sphero-cylindrical refraction is necessary
- demonstrate the correct use of a cross cylinder
- demonstrate how to do a sphero-cylindrical refraction.

REVIEW: SPHERO-CYLINDRICAL REFRACTION

REFRACTIVE ERROR	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. • Spherical lenses correct myopia, hyperopia and presbyopia. • Cylindrical lenses correct astigmatism.
ASTIGMATISM	• In an eye with astigmatism, light from an object does not focus evenly at one point, but instead it focuses at two different points. • Astigmatism may occur in an eye which also has myopia or hyperopia, or just by itself. • Astigmatism is corrected with cylindrical lenses. Astigmatism that is mixed with other refractive errors is corrected with sphero-cylindrical lenses. Both of these sorts of lenses are called astigmatic lenses. • Both the power and the axis of the astigmatic lens must be correct to give clear vision.
VISUAL ACUITY	• Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. • Common causes of poor VA are: – refractive error (this person needs spectacles to see clearly) – eye health problem (this person has a health problem with their eyes).
PINHOLE VISUAL ACUITY	• The pinhole test is a simple test that lets you find out whether poor VA is caused by refractive error or an eye health problem. • To measure pinhole VA, the person must look through a pinhole at a distance VA chart. • If VA improves with a pinhole → the person has a refractive error. This does not mean that the eyes are definitely healthy. It is possible for an eye to have a refractive error and an eye disease at the same time. We should always examine the health of the eye even if the pinhole VA is good. • If VA does not improve with a pinhole → the person has an eye health problem or amblyopia (a lazy eye). • The best corrected VA (after a refraction) should be at least the same as the pinhole VA.
MEASURING INTERPUPILLARY DISTANCE (PD)	• PD is the distance (in mm) between a person's pupils. • Distance PD is the distance between the pupils when the person is looking at something far away. • Near PD is the distance between the pupils when the person is looking at something close. • Distance PD is always greater than near PD because the eyes converge when they look at things that are close to them.

REVIEW: SPHERO-CYLINDRICAL REFRACTION (cont.)

TRIAL FRAME	
TRIAL LENS SET	• A trial set is a collection of spherical, cylindrical and prism lenses, as well as some accessory lenses. • These lenses are used to measure a person's refractive error. • Plus and minus trial lenses (spherical lenses) are either labelled with a "+" or "–" sign, or surrounded by a coloured rim. • Cylindrical trial lenses come in plus and minus powers, but usually we only use the minus cylinders to do a refraction. • Cylindrical lenses have two small axis marks that show the direction of the axis of the cylinder.
GOALS OF REFRACTION	• A refraction must find. – the lenses that give the person the clearest vision, and – the lenses that give the person the most comfortable vision. • The clearest and most comfortable lens is always the lens that has the least amount of minus power (or most amount of plus power) but still gives the best VA.
MEASURING REFRACTIVE ERROR	• Objective refraction methods include: – retinoscopy – auto-refraction. • Subjective refraction methods include: – best vision sphere refraction – sphero-cylindrical refraction – near refraction.

MEASURING ASTIGMATISM

SPHERO-CYLINDRICAL REFRACTION

A sphero-cylindrical refraction (or simply a sphero-cyl refraction) measures the amount of astigmatism that a person has so that astigmatic lenses can be prescribed.

All refractions start with a best vision sphere (BVS) refraction.

After the BVS refraction you have to do a sphero-cyl refraction if:

- pinhole visual acuity (VA) is better than BVS VA (VA with BVS spherical lenses),

  OR

- BVS VA is worse than 6/9.

A person who has astigmatism needs a cylindrical (or sphero-cylindrical) lens that:

- is the correct cylindrical power, and
- is placed at the correct orientation in front of the eye (the axis of the cyl must be at the correct angle).

A sphero-cyl refraction finds the correct power and axis orientation of the cylindrical lens so that the person with astigmatism can see clearly and comfortably.

CROSS CYLINDER

A cross cylinder (or simply a cross cyl) is a piece of equipment that is used to do a sphero-cyl refraction. A cross cyl is sometimes called a Jackson Cross Cyl (JCC).

Every cross cyl has two axes: a minus axis and a plus axis. Cross cyls come in several powers, but the most common cross cyl used is a ±0.50 D cross cyl.

A cross cyl looks like a trial lens that has a long handle, which is at 45° to the axes. There are small marks engraved or painted on the edge of the lens. These marks tell you what the power of the cross cyl is, and where the axes of the cross cyl are.

The axes of the cross cyl are usually shown by two coloured dots or lines (usually red / orange for the minus axis and white / black for the plus axis).

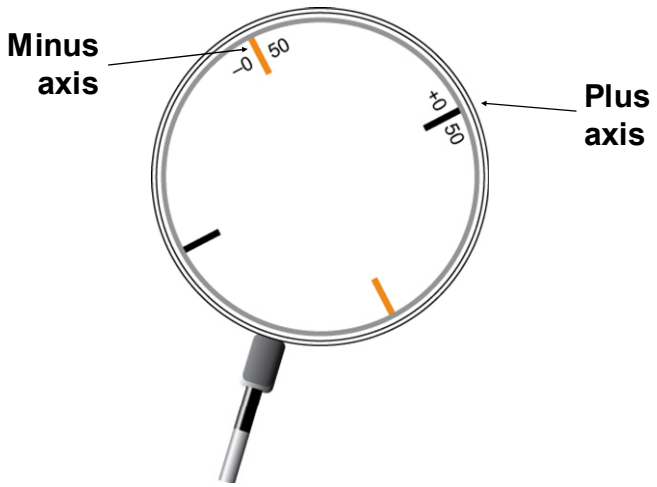


Figure 18.1: *A ±0.50 D cross cylinder*

MEASURING ASTIGMATISM (cont.)

MAINTAINING EQUIVALENT SPHERE

Maintaining equivalent sphere during a sphero-cyl refraction is important because it helps you to keep the person's accommodation controlled.

Whenever you change the power of a minus cylindrical trial lens in a trial frame by 0.50 DC you must also change the power of the spherical lens by 0.25 D:

- If you add –0.50 DC to a trial frame, you must balance it by adding +0.25 D of sphere power.
- If you remove –0.50 DC from a trial frame, you must balance it by removing +0.25 D of sphere power.

You can think of spherical lens power as being twice as strong as cylindrical lens power.

Cylindrical power = ½ x Spherical power

When you maintain equivalent sphere you are making sure that the overall BVS doesn't change and that accommodation is kept relaxed.

METHOD

METHOD

People often find the sphero-cyl refraction the most difficult and confusing part of their eye examination.

The accuracy of a sphero-cyl refraction depends on:

- a good sphero-cyl refraction technique
- the instructions that you give the person.

There are three parts to a sphero-cyl refraction:

- Astigmatism search
- Finding the cylinder axis
- Finding the cylinder power.

Like a BVS refraction, the best way to learn how to do a sphero-cyl refraction is to do it yourself as often as possible. With practice you will become fast and accurate. This unit will show you how to do a sphero-cyl refraction using two learning methods:

- Step-by-step instructions with examples
- Flow charts (in the summary).

After working through these, you will be ready to do your first sphero-cyl refraction.

BEFORE YOU BEGIN

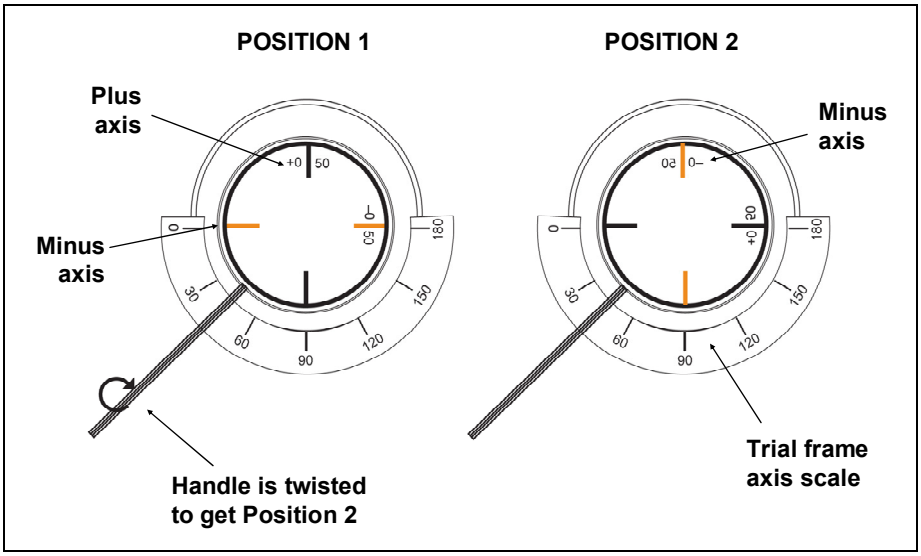
- Put the BVS sphere lens or lenses in the back cells of the trial frame.
- Occlude the left eye (remember we always refract the right eye first).
- Tell the person to look at a distant target:
  - A circle target or an ○ shape (about the size of the 6/12 letters) is best

  → You can make your own ○ target. (Make sure the circle is absolutely round and the thickness of the line is even.)
  - If you do not have an ○ target, you can ask the person to look at a letter on the VA chart instead. Choose a letter that is two or three lines larger than the smallest line that the person can see.
- Hold the cross cyl and tell the person:

  "This test will make the circle (or letter) look blurry, but I want you to tell me which makes it look better: one or two."

  "You should also tell me if one and two look the same."

STEP-BY-STEP INSTRUCTIONS

ASTIGMATISM SEARCH	This part of a sphero-cyl refraction is to find out: • if the person has any astigmatism at all, and if so… • the approximate axis of the person's astigmatism.
STEP 1	Hold the cross cyl in front of the right eye. Rotate the cross cyl so that the minus axis of the cross cyl is at 180° (horizontal). This is position 1 for the cross cyl.
STEP 2	Ask the person: ***"Does the circle (or letter) look better with number one? Or …"*** Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Now the minus axis of the cross cyl should be at 90° (vertical). This is position 2 for the cross cyl. Finish your question: ***"….with number two? Or do they look the same?"***  ***Figure 18.2:*** *Astigmatism search at 90° and 180°* If the circle (or letter) looked better in position 1 or 2: → Put a –0.50 DC trial lens in the trial frame with its axis in the same direction as the minus axis of the cross cyl in the better position: *If position 1 was better, place the axis of the –0.50 DC trial lens at 180°* *or* *If position 2 was better, place the axis of the –0.50 DC trial lens at 90°.* → Then go to ***Finding the Cylinder Axis***. If the circle (or letter) looked the same in positions 1 and 2: → Go to Step 3.

STEP-BY-STEP INSTRUCTIONS (cont.)

STEP 3

Rotate the cross cyl so that now the minus axis of the cross cyl is at 45°. This is position 1 for the cross cyl.

Ask the person: ***"Can you see better with number one? Or …"***

Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Now the minus axis of the cross cyl should be at 135°. This is position 2 for the cross cyl.

Finish your question: ***"…with number two? Or do they look the same?"***

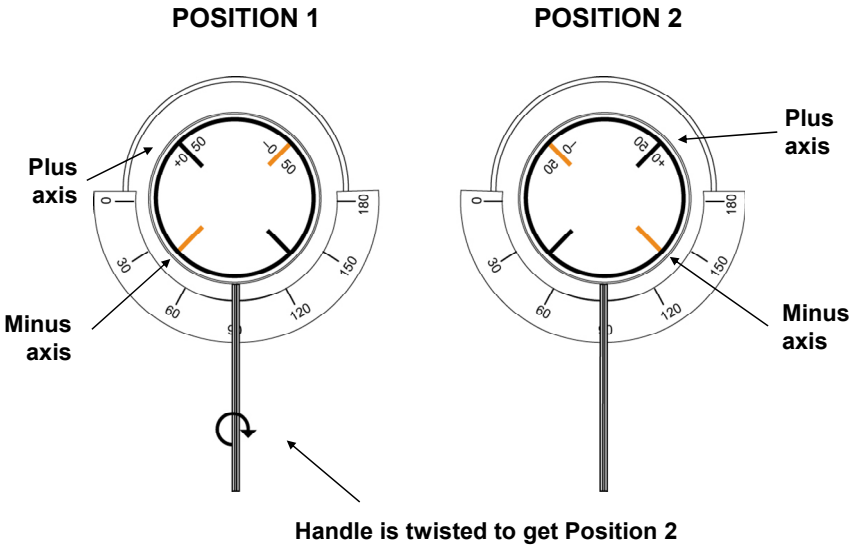


Figure 18.3: *Astigmatism search at 45° and 135°*

STEP 4

If the circle (or letter) looked better in position 1 or 2:

→ Put a –0.50 DC trial lens in the trial frame with the axis in the same direction as the minus axis of the cross cyl when it was in the better position.
If position 1 was better, place the axis of the –0.50 DC trial lens at 45°
or
If position 2 was better, place the axis of the –0.50 DC trial lens at 135°.
→ Then go to ***Finding the Cylinder Axis***.

If the circle (or letter) again looked the same in position 1 and 2, and the BVS VA is *good*:
→ The person probably has no astigmatism
→ You can prescribe the BVS lenses.

If the circle (or letter) again looked the same in position 1 and 2, and the BVS VA is *poor*:
→ Choose a –0.50 DC lens and place its axis at180°
→ Go to ***Finding the Cylinder Axis***.

EXAMPLE:

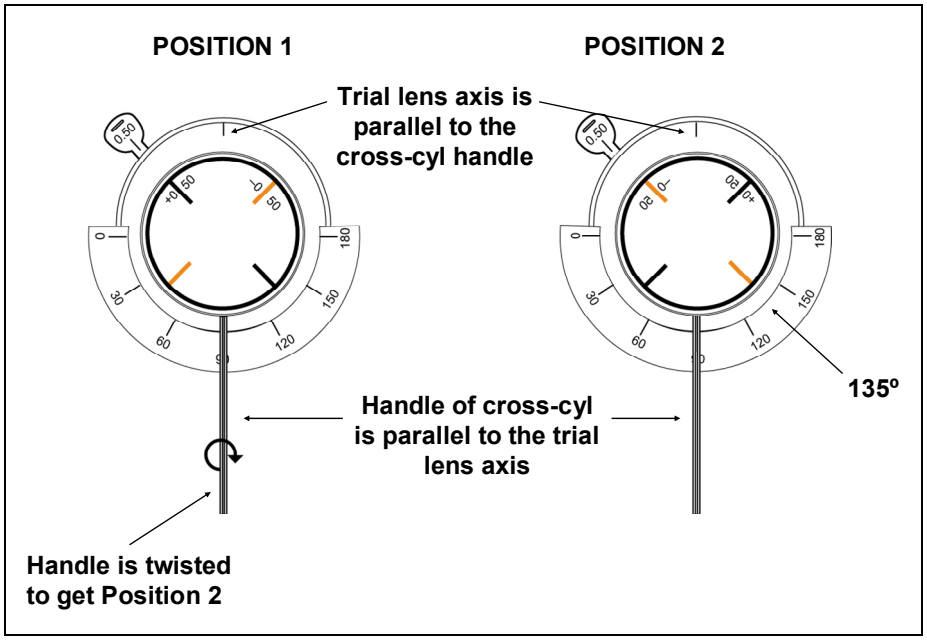
Step 1: You hold a cross cyl in front of a person's right eye.

Step 2: You show the person position 1 (minus axis at 180°) and position 2 (minus axis at 90°).
The person tells you that number one and two look the same.

Step 3: You rotate the cross cyl and show the person the next position 1 (minus axis at 45°) and position 2 (minus axis at 135°).
The person tells you that number one was clearer.

Step 4: You look at the position of the minus axis in position 1.
You see that the red dots (the minus axis) are at 45°, so you know that the axis of the person's astigmatism is closer to 45°.
You put a –0.50 DC trial lens into the trial frame with its axis at 45°.

STEP-BY-STEP INSTRUCTIONS (cont.)

FINDING THE CYLINDER AXIS	After you have found the approximate axis of the person's astigmatism, you need to find the exact axis location.
STEP 1	Look at the axis of the –0.50 DC trial lens that you have put into the trial frame. Hold the handle of the cross cyl parallel to (along the same line as) the axis of the –0.50 DC trial lens.
STEP 2	Ask the person: ***"Does the circle (or letter) look better with number one?*** ***Or …"*** Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Finish your question: ***"….with number two? Or do they look the same?"***  ***Figure 18.4:*** *Finding the axis direction of the person's astigmatism*
STEP 3	If the circle (or letter) looked better in position 1 or 2: → Rotate the cylindrical trial lens in the trial frame so that its axis mark moves towards the minus axis of the cross cyl when it is in the better position. Rotate the handle of the cross cyl as well (so that the handle of the cross cyl is parallel to the new axis of the cylindrical trial lens). → Then go to Step 4.  When you are finding the cylindrical axis you must always hold the handle of the cross cyl parallel to (lined up with) the axis of the cylindrical lens. If the circle (or letter) looked the same in position 1 and 2: → the axis of the cylindrical trial lens in the trial frame is correct → you have found the axis of the person's astigmatism → go to ***Finding the Cylinder Power.***

STEP-BY-STEP INSTRUCTIONS (cont.)

STEP 4

Repeat Steps 2 and 3 until the person tells you that the circle (or letter) looks the same with number one and number two.

EXAMPLE:

Step 1: The person tells you that the circle (or letter) looks better with number one.

Step 2: Rotate the axis of the cylindrical trial lens in the direction of the minus axis of the cross cyl (when the cross cyl is in position 1).
Rotate the handle of the cross cyl so that the handle is parallel to the new axis position of the trial lens.

Step 3: Show the person the new position 1 and position 2.

- The person tells you that position 2 is better.
  You rotate the axis of the cylindrical trial lens in the direction of the minus axis of the cross cyl (when it is in position 2).
  You rotate the handle of the cross cyl to keep it parallel with the axis of the cylindrical trial lens.

Step 4: Show the person the new position 1 and position 2.

- The person tells you that both positions seem the same.
- This means that the axis of the cylindrical trial lens in the trial frame is correct.

→ **You now know the exact axis of the person's astigmatism.**

BRACKETING OF SPHERO-CYLINDRICAL REFRACTION

You can save time (and effort) by using the logical technique of "bracketing".

You can think of bracketing as playing a game of "guess the number" with your friend. This is a game where your friend thinks of a number and you have to guess it.

Example:
You guess the number is 90 → your friend tells you that it is lower
You guess the number is 45 → your friend tells you that it is higher
You guess the number is 65 → your friend tells you that it is lower
You guess the number is 55 → your friend tells you that you are correct!

Do you notice that each time you guess a new number you choose one that is halfway between the two numbers you already know? This is the most efficient (fastest) way to guess the number.

When you use bracketing to find the exact cylinder axis, you use a similar method.

EXAMPLE:
You do an astigmatism search, and find an approximate axis of 90º
→ you put a –0.50 DC trial lens at axis 90º into the trial frame.
You hold the handle of the cross cyl at 90º (parallel to the axis of the –0.50 DC trial lens)
→ the two axes of the cross cyl are now at 45º and 135º
→ you show the person two options again.
The person tells you that the circle (or letter) looks better with "number one"
(when the cross cyl is positioned with its minus axis at 45º)
→ you turn the trial lens axis to 65º (this is about halfway between 90º and 45º).
You now hold the handle of the cross cyl parallel to the axis of the cylindrical trial lens (at 65º)
→ the two axes of the cross cyl are now at 20º and 110º
→ you show the person two options again.
The person tells you that the circle (or letter) looks better with "number one"
(when the cross cyl is positioned with its minus axis at 20º)
→ you turn the trial lens axis towards 20º, but choose a number that is between 45º and 65º (you know from before that the number is higher than 45º so you do not turn it all the way to 20º – you just turn it in that direction)
→ you turn the trial lens axis to 55º (this is halfway between 45º and 65º)
You now hold the handle of the cross cyl at 55º
(parallel to the new axis direction of the –0.50 DC trial lens)
→ the two axes of the cross cyl are now at 10º and 100º
→ you show the person two options again.
The person tells you that position 1 and position 2 look the same
→ the axis of the trial lens in the trial frame is correct
→ **the axis of the person's astigmatism is 55º.**

STEP-BY-STEP INSTRUCTIONS (cont.)

FINDING THE CYLINDER POWER	Once you have found the exact axis of a person's astigmatism, you need to find the cylinder power that will correct it.
STEP 1	Look at the axis of the cylindrical trial lens in the trial frame. Hold the cross cyl so that the minus axis of the cross cyl is parallel to the cylindrical trial lens axis (along the same line).
STEP 2	Ask the person: ***"Does the circle (or letter) look better with number one? Or …"*** Now twist the handle of the cross cyl so that the person is looking through the other side of the lens. Finish your question: ***"….with number two? Or do they look the same?"***
STEP 3	If the circle (or letter) looks better in position 1 (with the cross cyl minus axis parallel to the cylindrical trial lens axis): → Rotate the cylindrical trial lens in the trial frame so that its axis mark moves towards the minus axis of the cross cyl when it is in the better position. → remove the cylindrical trial lens from the trial frame and replace it with a cylindrical trial lens that is 0.25 DC "stronger" (more minus cyl). → make sure that you keep the axis of the cylindrical trial lens the same! → repeat Steps 1 and 2 until the person tells you that the circle (or letter) looks the same with number one and number two – then you have found the power of the person's astigmatism.

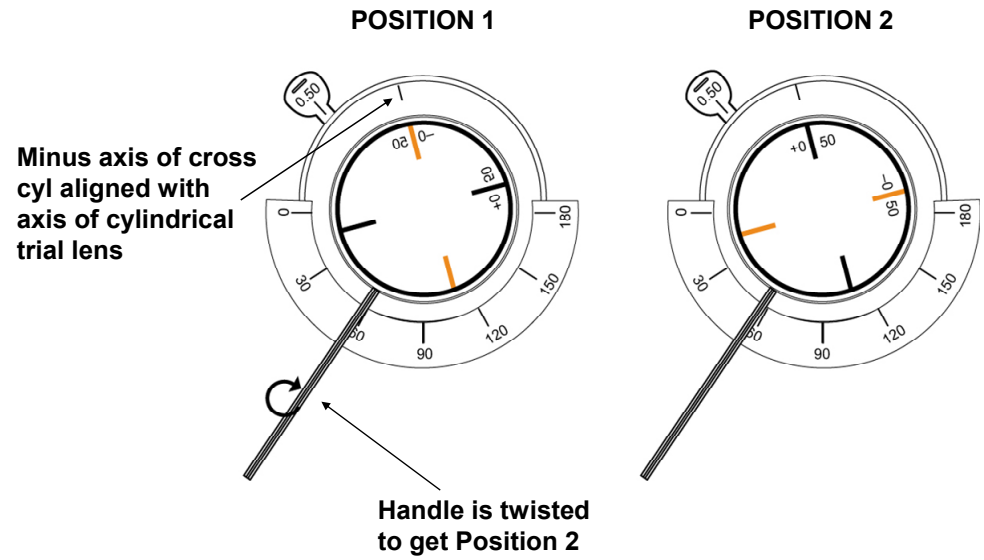


Figure 18.5: *Finding the power of the person's astigmatism*

Whenever you add –0.50 DC to a trial frame, you must maintain the equivalent sphere by adding +0.25 D of sphere power.

This is extremely important!

If you do not do it you can lose control of the accommodation!

STEP-BY-STEP INSTRUCTIONS (cont.)

STEP 3 (cont.)	If the circle (or letter) looks better in position 2 (with the cross cyl plus axis parallel to cylindrical trial lens axis): → remove the cylindrical trial lens from the trial frame, and replace it with a cylindrical trial lens that is 0.25 DC "weaker" (less minus cyl). → make sure that you keep the axis of the cylindrical trial lens the same! → repeat Steps 1 and 2 until the person tells you that the circle (or letter) looks the same with number one and number two – then you have found the power of the person's astigmatism. If the circle (or letter) looked the same in position 1 and 2: → the power of the cylindrical lens is correct → you now know the power of the person's astigmatism (cylinder power) → go to Step 4. If the power of the preferred cylindrical trial lens is changing back and forth between two powers that are close together (say just 0.25 DC different): → the exact cylinder power required probably lies somewhere between those two trial lens powers. → choose the '"weaker" (least minus) of the two cylindrical trial lenses as the final cylinder power.  Check the VA often. You should only add cylinder power if the VA improves.
STEP 4	Move the occluder from the left eye to the right eye and repeat the sphero-cyl refraction for the left eye.
STEP 5	Proceed to +1 Test and Binocular Balance.  **REMEMBER!** Whenever you add –0.50 DC to a trial frame, you must maintain the equivalent sphere by adding +0.25 D of sphere power. **This is extremely important!** If you do not do it you can lose control of the accommodation!
EXAMPLE 1	The trial frame has two lenses in front of one eye: +1.00 D and –0.50 DC. The other eye is occluded. You increase the power of the cylindrical trial lens by 0.25 DC twice: → first you change the cylindrical trial lens from –0.50 DC to –0.75 DC → then you change the cylindrical trial lens from –0.75 DC to –1.00 DC. You have added a total of –0.50 DC to the trial frame, so you must also add +0.25 D of sphere power (to maintain the equivalent sphere). You: → first put a +1.25 D trial lens in the back of the trial frame and → then remove the +1.00 D trial lens.

STEP-BY-STEP INSTRUCTIONS (cont.)

EXAMPLE 2

The trial frame has two lenses in front of one eye: –1.00 D and –0.50 DC.
The other eye is occluded.

You increase the power of the cylindrical trial lens by 0.25 DC twice:
→ first you change the cylindrical trial lens to –0.75 DC
→ then you change the cylindrical trial lens to –1.00 D.C

You have added a total of –0.50 DC to the trial frame, so you must also add +0.25 D of sphere power.

You:
→ first remove the –1.00 D trial lens, and
→ then put a –0.75 D trial lens in the back of the trial frame.

REMEMBER!
Adding +0.25 D of sphere power is the same as:
- **Increasing plus power by 0.25 D**
  (Example 1: +1.00 D becomes +1.25 D)
- **Decreasing minus power by 0.25 D**
  (Example 2: –1.00 D becomes –0.75 D)

EXAMPLE 1

The trial frame has two lenses in front of one eye: +1.00 D and –1.00 DC.
The other eye is occluded.

You decrease the power of the cylindrical trial lens by 0.25 DC twice:
→ first you change the cylindrical trial lens from –1.00 DC to –0.75 DC
→ then you change the cylindrical trial lens from –0.75 DC to –0.50 DC.

You have removed a total of –0.50 DC from the trial frame, so you must also remove +0.25 D of sphere power (to maintain the equivalent sphere).

You:
→ first put a +0.75 D trial lens in the back of the trial frame, and
→ then remove the +1.00 D trial lens.

EXAMPLE 2

The trial frame has two lenses in front of one eye: –1.00 D and –1.00 DC.
The other eye is occluded.

You decrease the power of the cylindrical trial lens by 0.25 DC twice:
→ first you change the cylindrical trial lens to –0.75 DC
→ then you change the cylindrical trial lens to –0.50 DC.

You have removed a total of –0.50 DC from the trial frame, so you must also remove +0.25 D of sphere power.

You:
→ first remove the –1.00 D trial lens and
→ then put a –1.25 D trial lens in the back of the trial frame.

REMEMBER!
Removing +0.25 D of sphere power is the same as:
- **Decreasing plus power by 0.25 D**
  (Example 1: +1.00 D becomes +0.75 D)
- **Increasing minus power by 0.25 D**
  (Example 2: –1.00 D becomes –1.25 D)

SUMMARY: SPHERO-CYLINDRICAL REFRACTION

MEASURING ASTIGMATISM

Sphero-cylindrical refraction:

- Measures the amount of astigmatism that a person has, so that astigmatic lenses can be prescribed.
- You must do a sphero-cyl refraction if:
  - pinhole visual acuity (VA) is better than best vision sphere (BVS) VA
  - BVS VA is worse than 6/9.
- A person who has astigmatism needs an astigmatic lens that has:
  - the correct cylindrical power
  - been placed at the correct orientation (correct cyl axis).

Cross cylinder:

- A cross cylinder (or cross cyl) is sometimes called a Jackson Cross Cyl (JCC).
- All cross cyls have two axes: a minus axis and a plus axis.
  These two axes are perpendicular (at 90°) to each other.
- The minus axis is usually marked with red or orange dots.
  The plus axis is usually marked with white or black dots.

METHOD – SPHERO-CYL REFRACTION

- There are three parts to a sphero-cyl refraction:
  - Astigmatism search
  - Finding the cylinder axis
  - Finding the cylinder power.

Before you begin:

- Put the BVS sphere lens (or lenses) in the back cells of the trial frame.
- Occlude the left eye.
  Remember: always test the right eye first.
- Tell the person to look at a distant target
  - an O shape is best (the size of the 6/12 letters)
  - a letter on the distance VA chart that is two or three lines bigger than the smallest letters that the person can see can also be used.
- Hold the cross cyl in front of the person's eye and tell them:

  "This test will make the circle (or letter) look blurry, but I want you to tell me which is better: ***one*** *or* ***two****. You should also tell me if* ***one*** *and* ***two*** *look the same."*

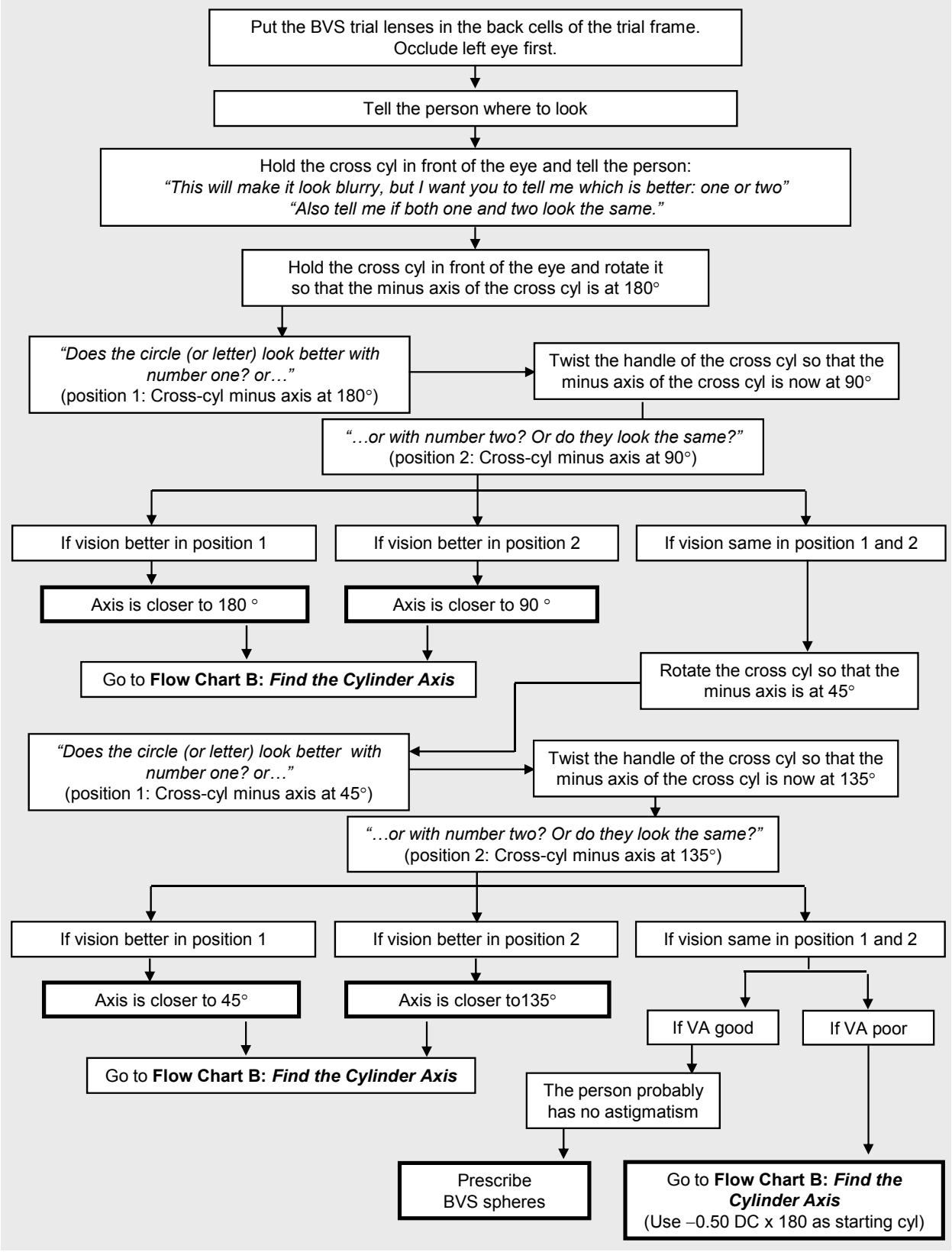
FLOW CHARTS

On the following pages are flow charts that summarise the three parts of a sphero-cyl refraction:

- Astigmatism search
- Finding the cylinder axis
- Finding the cylinder power.

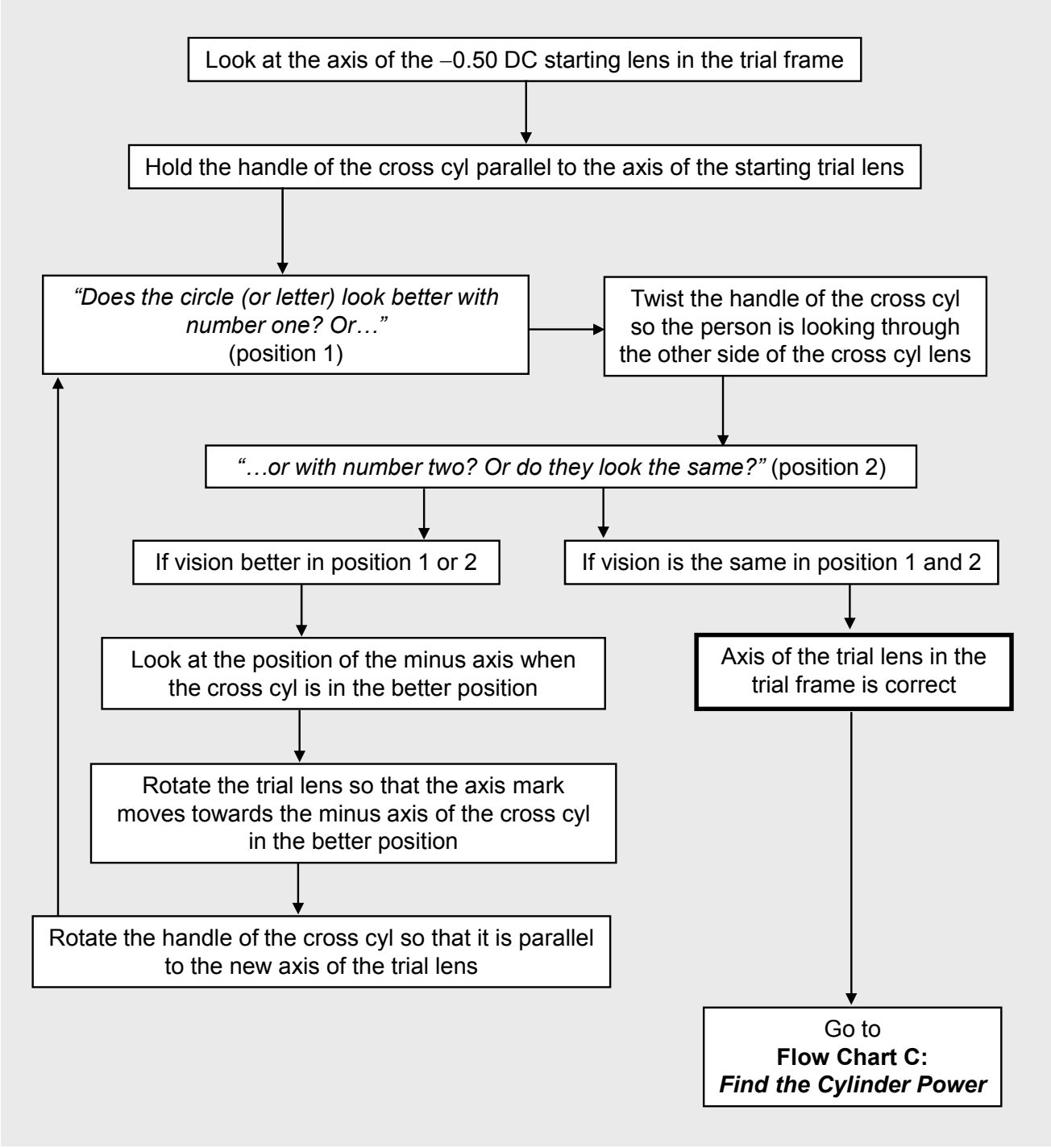
SUMMARY: METHOD - SPHERO-CYLINDRICAL REFRACTION

Flow Chart A: Astigmatism Search



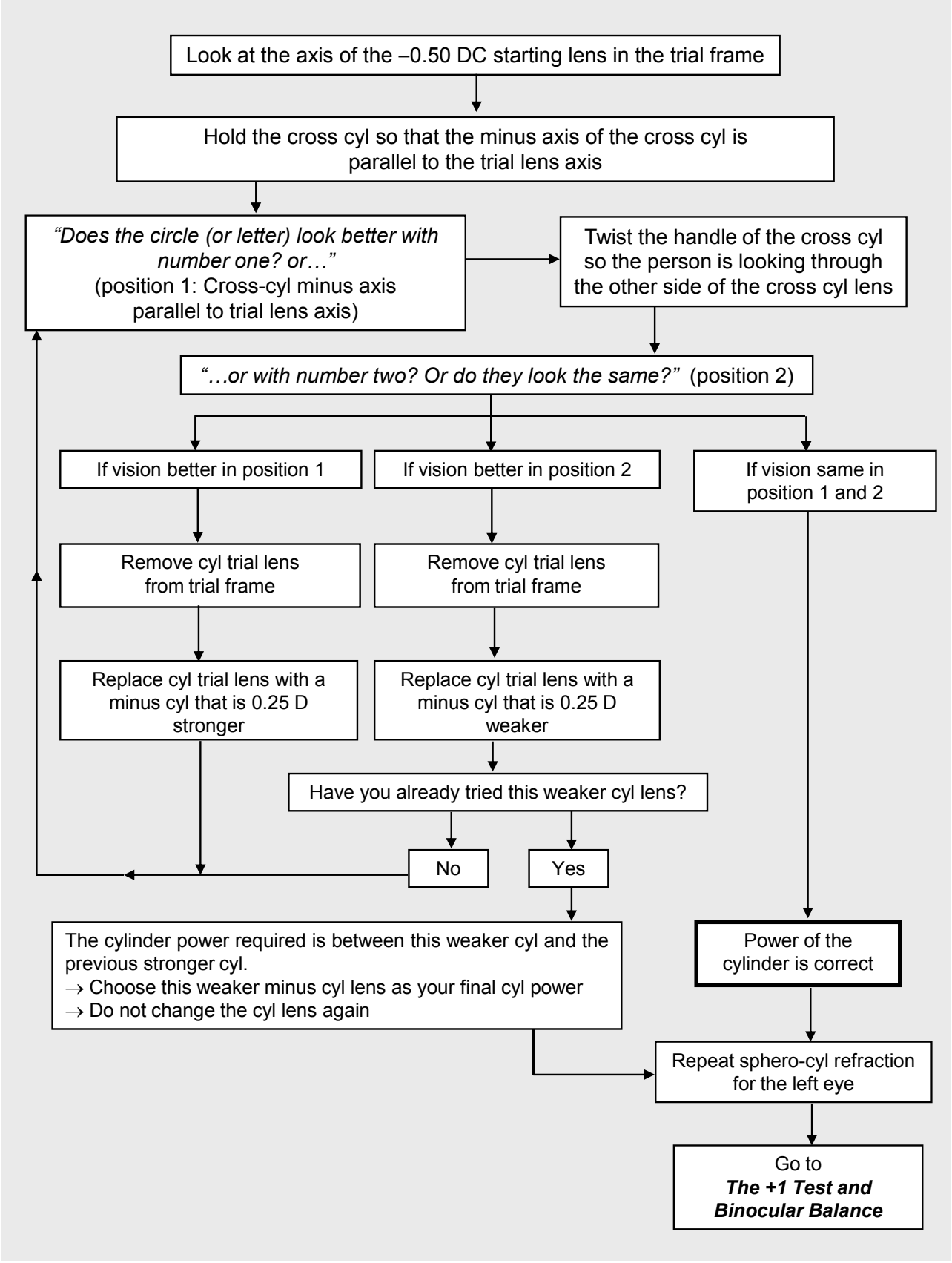
SUMMARY: METHOD - SPHERO-CYLINDRICAL REFRACTION (cont.)

Flow Chart B: Finding the Cylinder Axis



SUMMARY: METHOD - SPHERO-CYLINDRICAL REFRACTION (cont.)

Flow Chart C: Finding the Cylinder Power



TEST YOURSELF QUESTIONS

1. **How do you decide whether or not to do a sphero-cylindrical refraction after your best vision sphere refraction?**

_____

_____

2. **What does a sphero-cylindrical refraction measure?**

_____

_____

3. **Why is it best to ask the person to look at an ○ shaped target when we do the cross cyl test?**
(Hint: Think about the way astigmatism distorts a person's vision.)

_____

_____

4. **Why is bracketing helpful?**

_____

_____

5. **If you put a –0.50 DC trial lens in the trial frame, by how much must you change the sphere?**

_____

_____

6. **If you remove a –1.00 DC trial lens from the trial frame, by how much must you change the sphere?**

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7. **Why do you change the sphere power by 0.25 D when you change the cylinder power by 0.50 DC? (i.e. why is it important to maintain the equivalent sphere?)**

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