



**SASOM**

South African Society  
of Occupational Medicine

FOUNDED IN 1948

## THE SOUTH AFRICAN SOCIETY OF OCCUPATIONAL MEDICINE

# Vision Testing in Occupational Health ©

SASOM GUIDELINE 36.

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# Occupational Medicine Practice

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# Vision Testing in Occupational Health

## 1 INTRODUCTION

Vision testing is probably one of the most important elements of the fitness adjudication aspect of the occupational medical evaluation. This procedure outlines the different types of vision testing, their application in occupational health, and how to perform them.

## 2 SCOPE

This procedure applies to all occupational health staff members required to perform vision testing.

## 3 PURPOSE

The purpose of this procedure is to identify the presence & extent of impaired visual function.

### SPECIFIC INDICATIONS IN INDUSTRY

At pre-employment and periodic examination

- Employees whose occupations will make special demands on their visual function such as:
  - Visual Acuity:
    - Drivers and operators of hazardous self-propelled mobile equipment,
    - Operators of equipment with hazardous moving parts
    - Employees required to see small objects or small print. (small print, circuit boards, etc.)
  - Peripheral Vision (visual fields)
    - Drivers and operators of hazardous self-propelled mobile equipment,
    - Workers in hazardous environments (near equipment with hazardous moving parts, near heights)
  - Colour Vision
    - Quality control staff
    - Seafarers
    - Laboratory technicians
    - Electricians
  - Depth perception
    - Drivers and operators of hazardous self-propelled mobile equipment,

- Employees required to work on sensitive equipment (ie. circuit boards) in complex circumstances (inside machinery).
  - Night vision
    - Employees listed above who are required to have good visual acuity in circumstances of low ambient lighting, or in which intermittent glare is a feature (night driving).
- Employees who may become exposed to agents that may damage vision in the course of their work. Such environmental hazards include:
  - Chemicals: irritating or corrosive substances, (ie. after injuries on duty).
  - Physical agents: infrared light
- Employees with a past history of industrial exposure to the above agents, or a history of poor vision.

## 4 PROCEDURE

### VISUAL ACUITY<sup>1</sup>

Visual acuity often is referred to as “Snellen” acuity. The chart and the letters are named for a 19th-century Dutch ophthalmologist Hermann Snellen (1834–1908) who created them as a test of visual acuity.

One’s visual acuity is an indication of the clarity or clearness of one’s vision. It is a measurement of how well a person sees. The word “acuity” comes from the Latin *acuitas*, which means sharpness.

#### The Apparatus

The following devices are to be considered:

- An electronic visual acuity tester (ie. Keystone Orthoscope; Bausch & Lomb Orthorator; AOC Site-Screener; Titmus Vision Tester; Keystone Telebinocular; OPTEC 2000 Vision Tester, Projector with screen).
- A hand-held lens device, with a set of standardised reading cards (ie. the “Bioptor”)
- A wall-mounted reading card, with standardised images. (ie. a Snellen chart). Note that the Snellen chart was primarily designed for far vision, although it can be adapted for near vision.

Applications:

- All occupations in which acuity is important (ie. drivers, pilots, operators of mobile equipment, quality control personnel).

Best device:

- The SnellenChart provides the best value for money, without compromising on the required legal standard.

- Note that the Snellen Chart's main application is for the measurement of far vision; however it has been adapted for testing near and intermediate vision (United States Department of Transport form FAA 8500-1)<sup>2</sup>. (see appendix 3)
- Note that the Traffic Authorities use the orthorator at their testing centres, so this tends to set a standard – even though this equipment standard is NOT recorded in law.
- Note that the Code of Practice for the Training of Operators of Lifting Equipment (under the Driven Machinery regulations of the OH&SA)<sup>3</sup> mentions the Purdue University test, which is part of the test battery built into the orthorator. This, too, does NOT prescribe the orthorator as a minimum standard, but the suggestion often leads people to think this way.

### The Patient

Reads the images in the electronic device or off the Snellen chart, as instructed.

### The Examiner

- Explains test and prepares subject.
- If the subject is unable to read, use an “illiterate chart”.
- Stands at the chart, and points to the images one by one, whilst the subject calls out the letters, or up, down, left, right in the case of the illiterate chart.
- Keeps a watch that the subject keeps one eye covered, and does not peep past.
- See common errors below.

### The Technique

#### **SnellenChart testing of Far Visual Acuity**

- Each eye will be tested separately, and both eyes together.
- Snellen 6 metre (20-foot) eye chart may be used as follows:
- The Snellen chart should be illuminated by a 100-watt incandescent lamp placed 1.2m in front of and slightly above the chart.
- The chart or screen should be placed 6m from the applicant's eyes and the 6/6 line should be placed 1.6m above the floor.
- A metal, opaque plastic, or cardboard occluder should be used to cover the eye not being examined.
- The examining room should be slightly darkened with the exception of the illuminated chart or screen.
- If the applicant wears corrective lenses, the uncorrected acuity should be determined first, then corrected acuity.
- Common errors:
  - Failure to shield the applicant's eyes from extraneous light.
  - Permitting the applicant to view the chart with both eyes.
  - Failure to observe the applicant's face to detect squinting.

- Incorrect sizing of projected chart letters for a 6m (or 3m) distance.
- Failure to focus the projector sharply (if image is projected, rather than using a physical chart).
- Failure to obtain the corrected acuity when the applicant wears glasses.
- Failure to note (and where relevant to require the removal of) contact lenses.

Directions furnished by the manufacturer or distributor should be followed when using substitute devices for the above testing.

### Testing of Near Visual Acuity, using a hand-held chart

A useful validated test chart is the US Dept of Transport Form 8500-1 (see appendix 3)<sup>2</sup>. It can be downloaded off the internet. If acquired in this way, ensure that a high quality copy is obtained, and printed by a high quality printer.

- The chart should be held at 16 inches (40.6cm) from the test subject for near vision, and 32 inches (81.3cm) for intermediate vision.
- In order to assure a constant distance from the test subject, it is useful to attach a knotted string of the correct length through the test chart, which can be held at the correct distance by the subject during the test procedure.

This image illustrates this idea, but note the form is not the Form 8500 mentioned above!



Near Vision Card with 16" (40 cm) Cord (#270900)

- Use the scale on the left side of the chart to determine visual acuity measured at 40cm, and on the right side for to determine visual acuity at 81 cm.
  - Start with binocular testing, using the near vision set along the left border.
  - Point to each of the four numbers on the top line, observe the responses for comprehension, speed and accuracy.
  - Then cover the top line with a white card. Make sure that the card does not cause shadow on the line to be read. Ask the test subject to identify only the first number on the line below the covering card.
  - Repeat this procedure for each or each other line (moving quickly down the chart to avoid tiring the test subject) until the person hesitates or misidentifies a symbol.
  - Move back up one line and ask the subject to identify all the letters on that line.
  - If the person identifies all numbers correctly go to the next lower line and ask the person to identify all the numbers on that line.
  - The visual acuity is recorded as the last line on which at least 3 of the 5 letters are read correctly. Always test until the threshold line.
  - After binocular testing, proceed with testing each eye separately. Try to us an occluder that is not too uncomfortable, such as two pairs of symmetric glasses that can be used for covering both eyes, one at a time.
- Common errors:

- Failure to obtain a high quality test chart (poor quality image, or poor quality printer).
- Failure to keep the test distances (40 or 81 cm).
- Failure to assure adequate lighting.

Directions furnished by the manufacturer or distributor should be followed when using substitute devices for the above testing.

### Interpretation of the Test

The value given to the outcome should be expressed in accordance with the last row in which the subject was able to make no more than one error. Each eye is scored, with & without lens correction (glasses) then a score for both eyes (binocular).

	<b>Left</b>	<b>Right</b>	<b>Both</b>
VA: (Far) (no glasses)	6/6	6/6	6/6
VA: (Near) (no glasses)	6/6	6/6	6/6

### Patterns of acuity abnormalities

Myopia (near sightedness (from Greek myopia "near-sightedness"): is a refractive defect of the eye in which distant objects appear blurred because the eye focuses their images in front of the retina instead of on it.

Hypermetropia (far sightedness): a defect of vision caused by an imperfection in the eye (often when the eyeball is too short or when the lens cannot become round enough), causing inability to focus on near objects.

Presbyopia: (Greek word "presbys" meaning "old person") describes the condition where the eye exhibits a progressively diminished ability to focus on near objects with age.

### Grading of impairment

Impairment is relative to the "normal" score of 6/6. Any deviation from 6/6 could therefore be regarded as an "impairment".

However, various tasks require varying degrees of visual acuity – so a score of less than 6/6 does NOT automatically equal INCAPACITY (unfit to work).

*See appendix 1 for suggested standards of vision for various occupations.*

### Record Keeping

The electronic devices have score sheets that should be used, and the subject should sign the test card. Alternatively, the Snellen values can be recorded directly into the medical record sheet.

## Quality Control

Technician's role in quality control:

The technician should ensure he (she) is skilled in the use of the equipment, and the proper maintenance schedule.

### Equipment Quality Control

The electronic devices cannot be calibrated; quality is maintained through keeping the lenses clean (especially the eyepiece), and the internal mechanism dust-free. Refer to the technical manual for the appropriate maintenance schedule.

The Snellen chart's quality is simple - ensure that: (also see common errors above!)

- The sizes of the images are correct. (see table below, and Appendix)
- The chart is clear & crisply printed.
- The chart is not covered in a reflective material.

Table listing the correct sizes of the letters for each row of a Snellen chart.

<b>Snellen Row</b>	<b>Size of Letters</b>
6/60	88.7mm
6/40	59.1mm
6/30	44.4mm
6/24	35.5mm
6/18	26.6mm

<b>Snellen Row</b>	<b>Size of Letters</b>
6/15	22.2mm
6/12	17.7mm
6/9	13.3mm
6/6	8.9mm
6/4	5.9mm



## **PERIPHERAL VISION (VISUAL FIELDS)**

The complete visual field, as seen by both eyes simultaneously, comprises the central, or foveal, vision, with which we see the sharpest detail, and the peripheral, or side, vision (which best detects movement). Manual and computer-generated visual field tests can be performed to check for gaps in the peripheral vision that can indicate eye diseases such as macular degeneration and glaucoma, nervous system problems because of stroke, head injury, tumours, brain swelling, or any condition causing poor circulation to the brain.

Taking a point directly ahead as zero degrees, the **normal human visual field** extends to approximately 60 degrees away from the midline nasally (past the nose, toward the opposite side) in each eye, and to 100 degrees temporally (towards the ears, or outwards), yielding a horizontal span of about 160 degrees. In the vertical plane, the range extends from approximately 60 degrees above and 75 below the horizontal meridian.

### The Apparatus

The following devices are to be considered:

- The Novissphere (a new non-electronic test device developed in South Africa)<sup>4</sup>
- Nothing (for the clinical “confrontation” test)
- An electronic peripheral vision tester (ie. the “Orthorator”, Keystone vision screener)

Applications:

- All occupations in which peripheral vision is important (ie. drivers, pilots, operators of mobile equipment, quality control personnel).

Best device:

- The Novissphere is favoured, although it should be noted that this device has **not been officially validated for this use, in South Africa.**
- Alternatively, the “Confrontation Test” is effective and efficient, and costs nothing but a little time.
- Note that the Traffic Authorities use the orthorator at their testing centres, so this tends to set a standard – even though this equipment standard is NOT recorded in law.

### The Patient

Responds as instructed.

### The Examiner

Explains test and prepares subject.

### The Technique

The Novissphere

This device is endorsed by specialists at the university of Witwatersrand. It has a number of advantages over the confrontation test, and is the technique of choice in the occupational health setting. It is reliable, reproducible, inexpensive, quick and non-invasive.

The equipment required:

- The Novissphere
- An otoscope with a paediatric earpiece attached (small point-source of light)



Project the otoscope onto the external surface of the Novissphere, set to dim illumination.

The projecting instrument should be held about 2 cm from the surface of the Novissphere – this is automatically set if a paediatric attachment is used.





Grasp the handle on the Novissphere between thumb and forefinger and place the instrument over the patient's eye to rest lightly on the cheek and the brow. The little finger rests on the patients face to steady the holding hand. The handle on the Novissphere must be moved periodically to a different position by rotating the Novissphere. This will prevent the handle (and your fingers) from obstructing the target light.



Instruct the patient to look at your own eyes through the aperture. The eye not being tested should be covered. Keep watching the patient's eye through the hole to be sure that the fixation is steady and that the patient is looking at you and not at the target light. Ask the patient if the target light is visible "out the corner of his eye". Move the spot of light to a different location and ask the question again.

Repeat this procedure until you are satisfied that the entire visual field has been reasonably screened



according to the clinical situation.	
<p>To increase the sensitivity of the test, ask the patient to comment on the quality and relative brightness of the target light in the different positions. Relative field defects can be picked up in this manner.</p> <p>To make sure the patient is not malingering, shine the light away from the Novissphere every now and again asking the same question: "do you see the light here?" whereupon the patient should answer: "no".</p>	

Note that it is not necessary that the sponge lining of the Novissphere is always in contact with the patient's face. It is sometimes easier to tilt the instrument medially (leaving a gap between the outer part of the instrument and the temporal area lateral to the patient's eye). This allows the patient to look at your eye without excessive ocular abduction. It does not matter if some of the surrounding room is visible through this gap and the test is just as valid.

Further notes are provided in appendix 3.

#### The "Confrontation" visual field exam

- The subject may be required to sit on the examination couch with eyes at the same level as the examiner.
- The examiner explains that
  - The subject is required to keep his eyes on the eyes of the examiner, and that the test is to determine how well he can see out of the "corners of his eyes".
  - He is going to hold his hands out at angles to the subject, and that he is going to flicker his fingers to see if the movement is visible to the subject.
- The examiner proceeds as follows:

Start with the temporal (lateral) visual field, right eye.

- Sit or stand opposite the test subject and give him a card to cover his left eye, have him focus his right eye on your nose. Ask him to look at your nose and not look at anything else. The subject covers one eye with a card.

- The examiner holds a hand next to the subject's head, on the same side as the open eye, at the level of the ear. Make a fist with three fingers on each hand, leaving two fingers sticking out. The two free fingers are wiggled back & forth, to create a moving image.
- The examiner brings his left hand forward steadily, into the subject's visual field. The subject is instructed to say "now" when he sees the fingers.
- Once the subject says "Now," indicating he has seen your wiggling fingers, reposition them below his ear and repeat the test still using your left hand. The test is conducted with the wiggling fingers at a superior and inferior position.

Now test the nasal (medial) visual field of the right eye as follows;

- Repeat the manoeuvres, moving the wiggling fingers (now using right hand) forward from a position in line with the nose. Once the subject says "Now," indicating he has seen your wiggling fingers, reposition them above & below the level of the nose and repeat the test still using your right hand.

Ask the subject to move the card from his left eye to his right eye and repeat the test. This time, use your opposite hands and conduct the test at a superior and inferior position like before.

- The flicker of the fingers should be repeated in a manner that is not predictable, and in all the four quadrants

See images overleaf



## The Electronic Tests of peripheral vision

- The technique is described by the manual that is provided. Usually, the method depends on the examiner pressing a button the results in a brief flash at predetermined angles (70° nasal).
- The subject is required to indicate if the flash was seen, and from which side.

## Other tests (for interest):

- Tangent screen exam or Goldmann field exam

Here the patient is asked to sit approximately 3 feet from a screen with a target on the center. The eye that isn't tested is covered during the exam. While the patient stares at the target the examiner will move an object toward the patient's visual field. The patient signals the examiner when the object comes into view. This exam allows the patient's visual field to be mapped.

- Automated perimetry exam

The patient sits in front of a concave dome with a target in the center. The eye that is not being tested is covered. A button is given to the patient to be used during the exam. The patient is set in front of the dome and asked to focus on the target at the center. A computer then shines lights on the inside dome and the patient clicks the button whenever a light is seen. The computer then automatically maps and calculates the patient's visual field.

## Interpretation of the Test

Most people have normal peripheral vision, but any abnormality should be noted, and considered in the light of the job requirement.

## Patterns of peripheral vision abnormalities

Many variations of impaired peripheral vision exist:

- Monocular vision (blind in one eye).
- Hemianopia: loss of vision of an entire side of the visual field.
- Scotomata: patches of loss in the visual field.
- Tunnel vision: loss of the peripheral visual field in both eyes.

“Tunnel vision” is particularly important. It can be caused by:

- Retinitis pigmentosa, glaucoma, severe cataracts.
- Pituitary stalk mass (i.e. tumour) compressing the optic chiasm
- Hallucinogenic drugs.
- Alcohol intoxication causes tunnel vision. In addition, the vision becomes blurred or double since eye muscles lose their precision causing them to be unable to focus on the same object.

- In aviation circumstances:
  - Altitude sickness, hypoxia in passenger aircraft.
  - Sustained (1 second or more) high acceleration. Typically, flying an airplane with a centripetal acceleration of up to or over 39 m/s<sup>2</sup> (4gs) with the head towards the center of curvature, common in aerobatic or fighter pilots. In these cases tunnel vision and brownout may proceed to or g-force induced Loss Of Consciousness
  - Exposure to oxygen at a partial pressure above 1.5-2 atmospheres, producing central nervous system oxygen toxicity, notably while diving. Other symptoms can include dizziness, nausea, blindness, fatigue, anxiety, confusion and lack of coordination.
  - Prolonged exposure to air contaminated with heated hydraulic fluids and oils, as can sometimes happen in passenger aircraft.

Grading of impairment

Taking a point directly ahead as zero degrees, the normal human visual field extends to approximately 60 degrees away from the midline nasally (past the nose, toward the opposite side) in each eye, and to 100 degrees temporally (towards the ears, or outwards), yielding a horizontal span of 160 degrees. In the vertical plane, the range extends from approximately 60 degrees above and 75 below the horizontal meridian.

The minimum visual field required for driving is 70 degrees temporal, with a span of 115 degrees in the horizontal plane (see extract from NRTA below).

Impairments should be considered with this in mind. However, it should be remembered that impairment could involve a shrinking of the visual field, or patchy losses of parts of the visual field.

Extracts from the National Road Traffic Act: <sup>4</sup>
<b>Code 8 Drivers:</b> <i>(ii) a minimum visual field of 70 degrees temporal, with or without refractive correction, in respect of each eye, or where the minimum visual field in respect of one eye is less than 70 degrees temporal, or where one eye is blind, a minimum total horizontal visual field of at least 115 degrees with or without refractive corrector;</i>
<b>PrDP Drivers:</b> <i>(ii) a minimum visual field of 70 degrees temporal in respect of each eye, with or without refractive correction.</i>

Record Keeping

The electronic devices have score sheets that should be used, and the subject should sign the test card. Alternatively, the values can be recorded directly into the medical record sheet.

Quality Control

Technician's role in quality control:

The technician should ensure he (she) is skilled in the use of the equipment, and the proper maintenance schedule.

### Equipment Quality Control

The electronic devices cannot be calibrated; quality is maintained through keeping the lenses clean (especially the eyepiece), and the internal mechanism dust-free. Refer to the technical manual for the appropriate maintenance schedule.

## **COLOUR VISION**

Colour vision is the ability to discriminate light on the basis of its wavelength. The normal human eye can distinguish millions of subtly different colours. However, abnormalities of this physiological function exist, some of which are important in occupational health.

Normal colour vision requires the use of specialized receptor cells called cones, which are located in the retina of the eye. There are three types of cones, termed red, blue, and green, which enable people to see a wide spectrum of colours. An abnormality, or deficiency, of any of the types of cones will result in abnormal colour vision.

It is important to understand the nature of the colour vision required, in order to determine the correct standard and therefore the correct test. A graduated requirement could be considered as below:

### **The Apparatus**

The following devices are to be considered:

<b>Standard</b>	<b>Test Devices</b>
Primary colours	Basic colour charts (ie. Snellen)
Secondary-tertiary Colours	More detailed colour charts, Lanterns (ie. Holmes-Wright type B lantern)
Hues, contrasts & saturation	Ishihara, Bioptor.

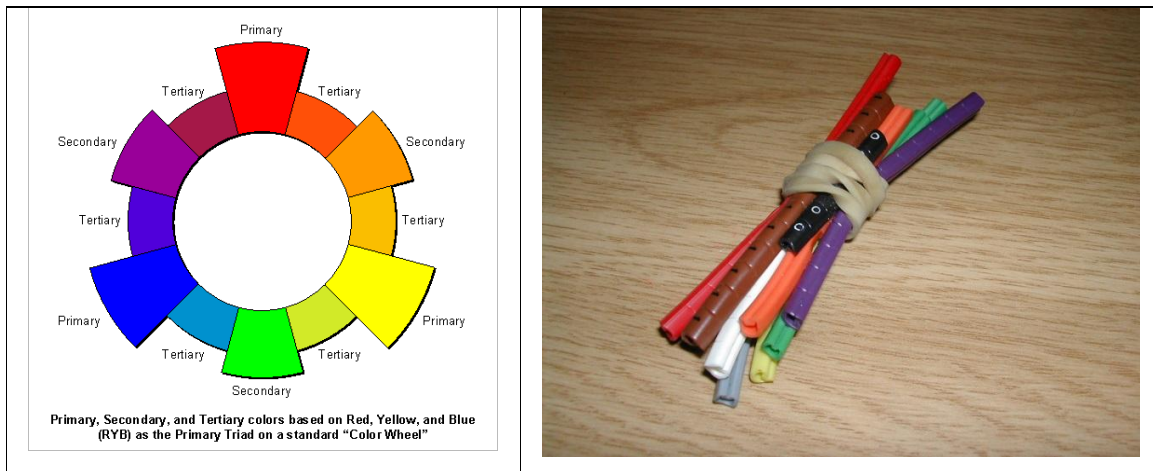
Applications:

- All occupations in which colour vision is important (ie. quality control personnel, sea farers, lab technicians, employees who work with electrical wiring).

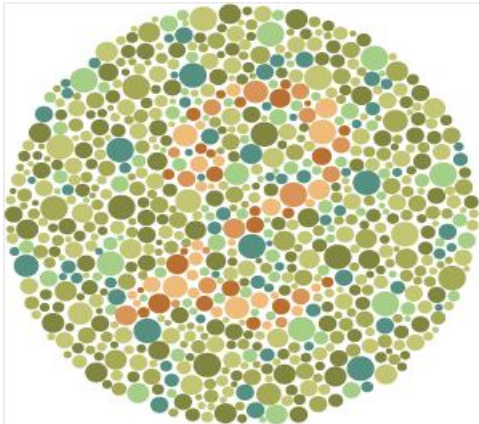

Best device:

- The best device is the one which best matches the real-life circumstances for which the test is being applied. Hence, for electricians use coloured wires, with at least the primary & secondary colours represented, plus white & black.





- Where hues, contrasts and saturation are important (ie lab technicians and certain quality control personnel), use the Ishihara test.
- Other tests include the lantern tests (ie. Holmes-Wright type B lantern test), usually prescribed for testing seafarers.

Ishihara test plates	Holmes-Wright type B lantern test
	

The Patient

Responds as instructed.

The Examiner

Explains test and prepares subject.

The Technique

This depends upon the test applied, but is usually simple & straight forward – the tester points to the colour, and the subject is requested to name the colour.

Language may be an issue – an interpreter may be required.

### Interpretation of the Test

Where specialist equipment is used, (eg. the Ishihara test battery), the abnormal findings are listed in the manual. Typically, abnormalities are easily identified.

### Patterns of colour vision abnormalities

There are three basic variants of colour blindness.

- Red/green colour blindness (deuteranopia) is the most common deficiency, affecting 8% of Caucasian males and 0.5% of Caucasian females. The prevalence varies with culture.
- Blue colour blindness (protanopia) is an inability to distinguish both blue and yellow, which are seen as white or gray. Protanopia is quite rare and has equal prevalence in males and females. It is common for young children to have blue/green confusion that becomes less pronounced in adulthood.
- Blue colour deficiency often appears in people who have physical disorders such as liver disease or diabetes mellitus.

A total inability to distinguish colours (achromatopsia) is exceedingly rare. These affected individuals view the world in shades of gray. They frequently have poor visual acuity and are extremely sensitive to light (photophobia), which causes them to squint in ordinary light.

Researchers studying red/green colour blindness in the United Kingdom reported an average prevalence of only 4.7% in one group. Only 1% of Eskimo males are colour blind. Approximately 2.9% of boys from Saudi Arabia and 3.7% from India were found to have deficient colour vision. Pre-term infants exhibit an increased prevalence of blue colour blindness. Achromatopsia has a prevalence of about 1 in 33,000 in the United States and affects males and females equally.

### Grading of impairment

This could be graded in terms of the colours that are not seen, and the degree (severity) to which the impairment is present.

### Record Keeping

The electronic devices have score sheets that should be used, and the subject should sign the test card. Alternatively, the values can be recorded directly into the medical record sheet.

### Quality Control

Technician's role in quality control:

The technician should ensure he (she) is skilled in the use of the equipment, and the proper maintenance schedule.

Equipment Quality Control

The electronic devices cannot be calibrated; quality is maintained through keeping the lenses clean (especially the eyepiece), and the internal mechanism dust-free. Refer to the technical manual for the appropriate maintenance schedule.

## **DEPTH PERCEPTION (&STEREOPSIS)**

This is the ability to perceive spatial relationships, especially distances between objects, in three dimensions.

Depth perception arises from a variety of depth **cues**. These are typically classified into:

- Binocular cues that require input from both eyes (Stereopsis, yielding depth from binocular vision through exploitation of parallax).
- Monocular cues that require the input from just one eye (eg. Size: distant objects subtend smaller visual angles than near objects).
- A third class of cues requires synthetic integration of binocular and monocular cues by the human brain.

The physiology of near vision depth perception is different to that of far vision depth perception.

- Near depth perception. The presence of functional stereopsis (two eyes) tends to be more important, and the angles subtended by the various objects in the field of view play a significant role in the perception of depth (binocular cues). An example in industry: maintenance work on complex machinery or the wiring of electrical cabling in electrical switching boxes.
- Far depth perception. This is entirely derived from monocular clues. Examples in industry: drivers are required to judge the distances of oncoming traffic driving, operators of mobile lifting equipment are required to lift, place and manoeuvre materials.

The important message from this is that one does not always require two eyes (binocular vision) to be able to perceive “depth”.

### The Apparatus

The following devices are to be considered:

Devices that test for stereopsis:

- An electronic depth perception tester (ie. the Keystone Orthoscope; Bausch & Lomb Orthorator; Titmus Vision Tester; OPTEC 2000 Vision Tester)
- A hand-held lens device, with a set of standardised reading cards (ie. the “Bioptor”)
- Other tests for stereopsis: Bagolini, Randot, synoptophore and the Netherlands organisation for applied scientific research (TNO).

Clinical tests of depth perception:

- threading a needle, horizontal Lang two-pencil test.

Applications:

- All occupations in which depth perception is important (ie. drivers, pilots, operators of mobile equipment).

Best device:

- Far vision depth perception:

- The best device is the one which best matches the real-life circumstances for which the test is being applied. Hence, either construct simulated work circumstances and see how the applicant performs, or do on-the-job testing.
- Near vision depth perception:
  - For tasks requiring depth perception that are performed at a workstation, the clinical tests should suffice, and the horizontal Lang two-pencil test has been tested to be reliable<sup>7</sup>.

The Patient

Responds as instructed.

The Examiner

Explains test and prepares subject.

The Technique

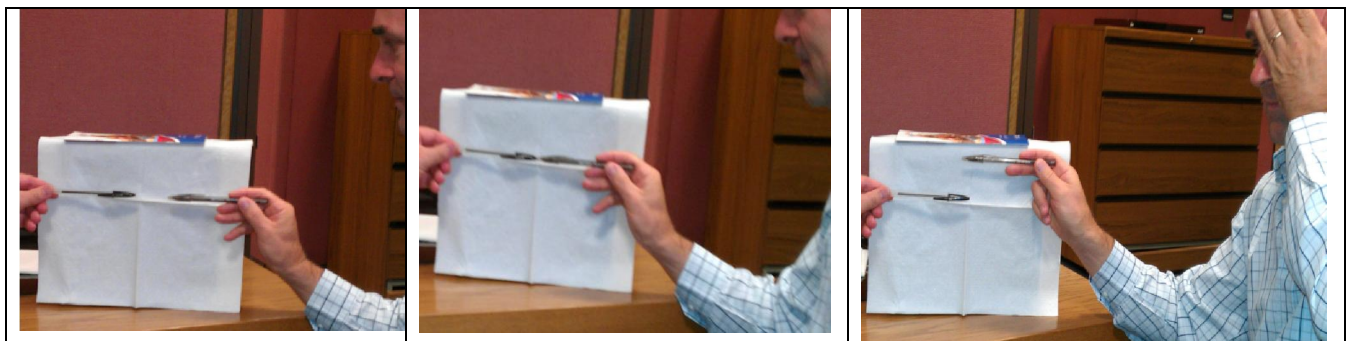
Electronic Tests of peripheral vision

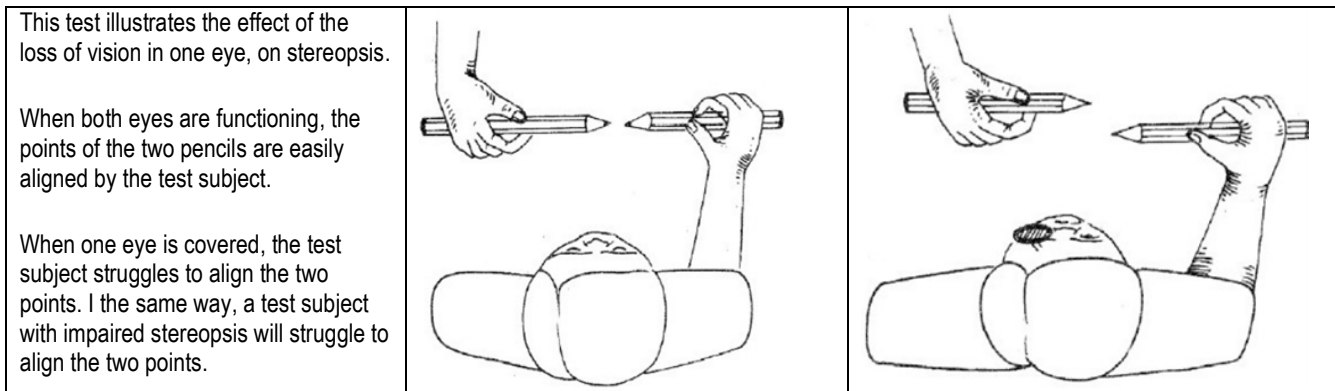
- The technique is described by the manual that is provided.
- Usually, the method depends on the device presenting an image to the subject that contains multiple objects; some of these are perceived to be “closer” to the subject than the others, through clever manipulation of the source image & the lenses.
- The subject is required to identify the objects that appear closer.

Clinical Tests

The subject is simply requested to perform tasks that require intact distance (depth) perception, such as:

- Threading a needle
- Horizontal Lang two-pencil test





### Interpretation of the Test

Interpretation can be difficult when the test is done on the special vision testing equipment (NOT favoured). Many people are unable to “see” the depth, even though their depth perception is normal.

It is much easier to interpret tests that closely simulate the job (such as the clinical tests, or on-the-job testing).

### Patterns of depth perception abnormalities

Impaired depth perception is only likely to occur when there are impairments in other modalities of vision, such as:

- Recent loss of an eye, prior to adaptation and development of monocular cues
- Newly acquired spectacles, especially as bifocals or multifocals.
- Newly acquired intra-ocular lens replacement.

### Grading of impairment

No formal grading exists. The degree of impairment should be judged individually in each case.

### Record Keeping

The electronic devices have score sheets that should be used, and the subject should sign the test card. Alternatively, the values can be recorded directly into the medical record sheet.

### Quality Control

Technician's role in quality control:

The technician should ensure he (she) is skilled in the use of the equipment, the proper maintenance schedule, or the performance of the clinical test.

Equipment Quality Control

The electronic devices cannot be calibrated; quality is maintained through keeping the lenses clean (especially the eyepiece), and the internal mechanism dust-free. Refer to the technical manual for the appropriate maintenance schedule.

## NIGHT VISION

Night vision is the ability to see in a dark (or poorly lit) environment. Humans have poor night vision compared to many animals.

In occupational health, there are many occupations that are required to function in poorly illuminated circumstances. However, there is no scientifically validated technique by which to test “night vision”. Instead, we use the visual acuity test as a proxy, and deduce the subjects ability to function in poor light from that.

In other words, if an employee is required to see in poor light, then as a minimum normal visual acuity (6/6) is required in normal light.

### The Apparatus

The following devices are to be considered:

- An electronic night vision tester (ie. the “AAA Driver Vision screener”, Keystone Orthoscope)
- All occupations in which “night vision” is important (ie. night drivers & operators of mobile equipment at night).

Best device:

- **There is no scientifically validated test for “night vision”.**
- Again, the best device may be the one which best matches the real-life circumstances for which the test is being applied. Hence, either construct simulated work circumstances (tasks in a darkened room) and see how the applicant performs, or do on-the-job testing.

### The Patient

Responds as instructed.

### The Examiner

Explains test and prepares subject.

### The Technique

As for visual acuity.

### Interpretation of the Test

Normal visual acuity in normal light is required, as a minimum.

### Patterns of acuity abnormalities

As for visual acuity.

### Grading of impairment

As for visual acuity.

### Record Keeping

The electronic devices have score sheets that should be used, and the subject should sign the test card. Alternatively, the values can be recorded directly into the medical record sheet.

### Quality Control

Technician's role in quality control:

The technician should ensure he (she) is skilled in the use of the equipment, and the proper maintenance schedule.

Equipment Quality Control

The electronic devices cannot be calibrated; quality is maintained through keeping the lenses clean (especially the eyepiece), and the internal mechanism dust-free. Refer to the technical manual for the appropriate maintenance schedule.



## 5 REFERENCES

1. "Anatomy, Physiology and Pathology of the Human Eye" by Ted M. Montgomery, Optometric Physician.US Department of Transport's web site.
2. Code of Practice for the Training of Operators of Lifting Equipment (Government Gazette No.34876, 21 December 2011). Section 9.2 (a-b), Page 14) (under the Driven Machinery regulations of the OH&SA.
3. Correspondence with Clive Novis, inventor of the Novisphere.
4. Regulations of the National Road Traffic Act, (Government Gazette No: 20963, 17/03/2000).
5. Merchant Shipping Act 57 of 1951, in the Merchant Shipping (Eyesight and Medical Examination) Regulations, 2004 (Government Gazette 26878 of 15 October 2004)
6. British Standards Institute Standard: BS 4274-1:2003. "Part 1: Test Charts for clinical determination of distance vision acuity – Specification". Note that the standard quoted in the seafarer regulations (appendix 1) is "BS4274-1960"; this was replaced by BS 4274-1:2003.
7. Indian Journal of Ophthalmology. Year : 2010 | Volume : 58 | Issue : 4 | Page : 287-290. Horizontal Lang two-pencil test as a screening test for stereopsis and binocularity. Monisha E Nongpiur, Pradeep Sharma. Rajendra Prasad Centre for Ophthalmic Sciences, All India Institute of Medical Sciences (AIIMS), New Delhi, India.

## 6 Document History

Version No	Change	Date
01	Extensive changes to peripheral vision section. Inclusion of correct size table in the QA element of the section on visual acuity testing. Addition of this document history section	14 Sep 2009
02	New material on "Grading of impairment"	20 Sep 2009
03	Addition of Appendix 1: Recommended vision standards by type of occupation	08 Jan 2010
04	More detail added to "Confrontation Test" for testing visual fields	07 Mar 2010
05	Addition of the Novisphere testing technique for peripheral vision. Further amendments to the "Confrontation Test". Addition of a section on optometrists & standards for forklift operators.	07 Aug 2010
06	Correction of the normal range of visual fields	20 Aug 2010
07	Addition of the US Department of Transport's form FAA 8500-1 for testing near and intermediate acuity. Also the references to this in the text of the document. Addition of step-wise testing for near and intermediate vision. Addition of standards for drivers and merchant seamen. Update of appendix 5 (visual testing of lifting equipment) with respect to changed requirements issued by the Department of Labour.	18 Nov 2012
08	Addition of the horizontal Lang two-pencil test for near-vision depth perception	10 Jan 2013
09	Repeal of the National Code of practice which requires medical certification and vision testing for operating equipment. (Appendix 5: Optometrists and visual	12 June 2013

	testing of lifting equipment)	
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## 7 Appendix 1: Recommended vision standards by type of occupation

### Part A: Legislated Standards

*This is not an exhaustive list of all visual standards prescribed by SA legislation, but a list of those commonly encountered.*

Standards for **driving on public roads** as prescribed by the Regulations of the National Road Traffic Act, (Government Gazette No: 20963, 17/03/2000).

The far vision and peripheral vision requirements for **code 8 (light motor vehicle) drivers** are as follows:

- (i) according to the Snellen rating a minimum visual acuity, with or without refractive correction, of 6/12 (20/40) for each eye, or where the visual acuity of one eye is less than 6/12 (20/40) or where one eye of the person concerned is blind, a minimum visual acuity for the other eye of 6/9 (20/30); and*
- (ii) a minimum visual field of 70 degrees temporal, with or without refractive correction, in respect of each eye, or where the minimum visual field in respect of one eye is less than 70 degrees temporal, or where one eye is blind, a minimum total horizontal visual field of at least 115 degrees with or without refractive corrector; or*

The far vision and peripheral vision requirements for **heavy duty truck drivers** (code C1, C, EC1 or EC ) are as follows:

- (i) according to the Snellen rating a minimum visual acuity, with or without refractive correction, of 6/9 (20/30) for each eye; and*
- (ii) a minimum visual field of 70 degrees temporal in respect of each eye, with or without refractive correction.*

This section continues overleaf...

Standards for **merchant seamen**, as prescribed by the Merchant Shipping Act 57 of 1951, in the Merchant Shipping (Eyesight and Medical Examination) Regulations, 2004 (Government Gazette 26878 of 15 October 2004)

**Table: Visual standards**

	<i>Distant vision</i>				<i>Near vision<sup>b</sup></i>	<i>Colour vision<sup>c</sup></i>	<i>Visual fields<sup>d</sup></i>
	<i>Basic visual acuity standard (unaided)</i>		<i>Higher visual acuity standard (aided if necessary)<sup>e</sup></i>				
	<i>Better eye<sup>b</sup></i>	<i>Other eye</i>	<i>Better eye<sup>b</sup></i>	<i>Other eye</i>			
<b><i>Deck department<sup>f</sup></i></b>	not less than	not less than	not less than	not less than			
1. Seafarers required to undertake watchkeeping duties	6/60	6/60	6/6	6/12	N8 for charts, weather maps and N12 for other reading tasks with or without visual aids	Ishihara or Lantern	No pathological field defect
2. Others (aided vision if necessary)	Sufficient to undertake duties efficiently						
<b><i>Other departments<sup>g</sup></i></b>							
1. Engine room (includes electrician) and radio	6/60	6/60	6/18 6/9 <sup>b</sup>	6/18	N8 to read instruments and gauges on controls	Ishihara	Sufficient to undertake duties efficiently
2. Others (aided vision if necessary)	Sufficient to undertake duties efficiently						

**Notes:**

- (a) In all cases where visual aids (spectacles or contact lenses) are required to meet the higher standard, a spare pair must be carried when seafaring. When different visual aids are used for distance and near vision, a spare pair of each must be carried.
- (b) For seafarers who become monocular in service with no evidence of progressive eye disease in the remaining eye, monocular vision is permitted.
- (c) Aids to colour vision, such as red-tinted x-chroma, chromas lenses and chromagen lenses, are not permitted.
- (d) Seafarers who suffer pathological field defects (i.e. not new entrants, deck officers and monocular seafarers) should have a field of vision at least 120° in the horizontal measured by the Goldman perimeter using the iii/4 setting (or equivalent perimetry). In addition there should be no significant defect in the binocular field which encroaches within 20° of fixation above or below the meridian. Homonymous or bitemporal defects which come close to fixation whether hemianopic or quadrantopic are not acceptable.
- (e) No diplopia, congenital night blindness, retinitis pigmentosa or any other serious or progressive eye disease is permitted.

## COLOUR AND FORM VISION TESTS

These tests are applicable to seafarers required to undertake watchkeeping duties in the deck department.			
	Test	Method of test	Standard
1. New entrants and all first-time applicants for certification in terms of the seafarer certification regulations.	<p><b>Form test</b> Using cards based on Snellon's principle, the candidate is to view the cards indirectly through a polished mirror at a virtual distance of 6 metres from the eye. The cards have 7 lines. The 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> and 7<sup>th</sup> lines corresponding to the standards 6/24, 6/18, 6/12, 6/9 and 6/6, respectively.</p> <p><b>Lantern test</b> The candidate is to view, through large and small apertures, coloured lights, red, green and white in the mirror mentioned above, from the approved lantern positioned directly in front of the mirror so that the front part of the lantern is exactly 3.05 metres from the mirror. The candidate is to sit beside the lantern with his or her eyes more or less in line with the front of the lantern. The testing room must be so darkened as to exclude all daylight.</p>	<p><b>Form test</b> Candidates are to read a card with both eyes and then different cards with each eye separately. Cards are to be read from left to right, top to bottom. The eye not being used is to be covered with a small card. The cards and means of illumination must be in accordance with BS4274-1960 and must be contained in a cabinet placed so that the centre of a Snellon's card as viewed is at the height of the eye of an average person in a sitting position.</p> <p><b>Lantern test</b> To acquaint the candidate with the lantern colours, the candidate is to read one complete circuit of large aperture lights. The candidate is then required to name the coloured lights as they appear in four complete and one broken circuit of small apertures. Large apertures show the coloured lights singly i.e. red, green or white. The small apertures show the coloured lights in pairs in any combination of the three colours or in the same colour.</p>	<p><b>Form test</b> <i>Without aids to vision</i> The candidate is to read correctly down to and including line 7 with the better eye, line 6 with the other and line 6 with both eyes. <i>With aids to vision</i> First without the aids to vision, the candidate is to read correctly down to and including line 5 with the better eye, line 3 with the other eye and line 3 with both eyes. Then with the aids to vision, the candidate is to read correctly down to and including line 7 with the better eye, line 6 with the other eye and line 6 with both eyes.</p> <p><b>Lantern test</b> A candidate who mistakes red for green or vice versa, in the large or small apertures is taken to have failed the test. A candidate who on more than six occasions in four full and one broken circuit of the small apertures, confuses red for white or white for green or vice versa, is taken to have failed the test. A candidate is permitted to read the lights with or without aids to vision, but aids to vision that are designed to correct or adjust colour vision deficiencies may not be used.</p>
2. Other applicants for certification in terms of the seafarer certification regulations, and all applicants for pilotage exemption.	As for item 1, except "Ishihara" card test may be used instead of lantern test.	As for item 1, except "Ishihara" card test may be used in stead of lantern test.	<p><b>Form test</b> <sup>51</sup> (a) Candidate under 40 years of age—as for item 1. (b) Candidate being 40 years of age or older— <i>Without aids to vision</i> The candidate is to read correctly down to and including line 7 with the better eye, line 5 with the other eye and line 5 with both eyes. <i>With aids to vision</i> First without aids to vision, the candidate is to read correctly down to an including line 3 with both and then either eye. Then with aids to vision, the candidate is to read down to an including line 7 with the better eye, line 5 with the other eye and line 5 with both eyes.</p> <p><b>Lantern test</b> As for item 1, except that a candidate who has previously passed the lantern test may be taken to have passed this test if he or she reads correctly the "Ishihara" plates 1, 11, 15, 22 and 23.</p>

**Notes:**

1. Binocular vision is a requirement for new entrants. Seafarers who become monocular in service are required to meet the standard for the better eye, specified in the table above.
2. A candidate who requires darkness adaptation in the lantern test is permitted a period of 10 minutes in a darkened room for his or her eyes to adapt to the darkness.
3. A candidate who fails the form or lantern test may repeat the test at the discretion of the Authority.
4. Candidates will be notified in the appropriate form of the test results, or if their case has been referred for consideration.
5. A candidate who is ill on the day of the test or who is on medication at the time of the test stands a chance of failing the test. These candidates should be given an option of attempting the test at a later time when well.
6. Candidates are to declare to the eyesight examiner whether or not they will be using contact lenses during the tests. A candidate who fails to declare the use of contact lenses will be penalised by being prohibited from completing the test for a period of two years from the date he or she last completed the test, and the results of that test will be revoked in writing by the Authority.
7. A candidate who uses aids to vision to pass the form test must show the eyesight examiner two pairs of such aids to vision.

**Part B: Summary table of some recommended standards for occupations, some not specifically prescribed by law**

Job/Task	VA far	VA near	Both eyes required?	Ok for lens correction?	Colour Vision**	Visual fields***	Depth perception
Driver – Code 8	6/12 (better eye 6/9 if weaker eye <6/12)	6/12	No*	Yes	No	Cat P2	Yes
Driver – Code 10+ and operators of mobile plant equip (construction regs)	6/9 each eye	6/12	Yes	Yes	Yes-V1	Cat P1	Yes
Driver – Forklifts or other mobile equipment	6/12 (better eye 6/9 if weaker eye <6/12)	6/15	(Yes) – see footnote****	Yes	Yes-V1	Cat P1	Yes
Driver – Tower Crane	6/12 (better eye 6/9 if weaker eye <6/12)	6/12	(No) – but consider risk	Yes	Yes-V1	Cat P2	Yes
Work at Heights	6/15	6/15	(No) – but consider risk	Yes	No	Cat P2	Yes
Operator of large hazardous stationary machines	6/15	6/12	No	Yes	Yes-V1	Cat P2	Yes
Operator hazardous hand-held equip.	6/15	6/15	No	Yes	No	Cat P2	Yes
Lab Worker	6/15	6/9	No	Yes	Yes-V1 V2/V3 if titrating	No	Yes
General worker	6/18	6/18	No	Yes	No	No	No
Electricians	6/15	6/9	No	Yes	Yes – V2/V4	No	Yes
Computer (Office Work)	6/18	6/12	No	Yes	No	No	No
Fire Fighter	6/15	6/12	Yes	(Contacts)	No-V1	Cat P1	Yes
Professional Diver	6/9	6/9	Yes	No	No	Cat P2	Yes

**Notes:**

- \*: Long-standing monocular vision is acceptable for code 8 drivers. However, for employees with recent loss of vision in one eye, they should be temporarily reassigned until they have successfully adapted to monocular vision (usually 3-6months).
- \*\*: Cat V1: Primary colours only. Cat V2: Secondary & tertiary colours. Cat V3: contrasts & hues (Ishihara). Cat V4: Other (eg. coloured wires (electricians), Holmes-Wright type B lantern (seafarers))
- \*\*\*: Cat P1: 70 degrees temporal, or where one eye is blind, a minimum total horizontal visual field of at least 115 degrees. Cat P2: 70 degrees temporal. (A normal visual field refers to at least 50 degrees nasal and 70 degrees temporal vision).
- \*\*\*\* Binocular vision enables adequate peripheral vision and to a lesser extent depth perception. Depth perception can be acquired even in the absence of binocular vision, whereas peripheral vision cannot. However, a reduction of peripheral vision (ie. monocular) may be acceptable when the vehicle being operated is slow-moving, and where the movement of people around it is minimal.

## 8 Appendix 2: Visual Acuity

*Adapted from the article "Anatomy, Physiology and Pathology of the Human Eye" by Ted M. Montgomery, Optometric Physician.*

Visual acuity often is referred to as "Snellen" acuity. The chart and the letters are named for a 19th-century Dutch ophthalmologist Hermann Snellen (1834–1908) who created them as a test of visual acuity.

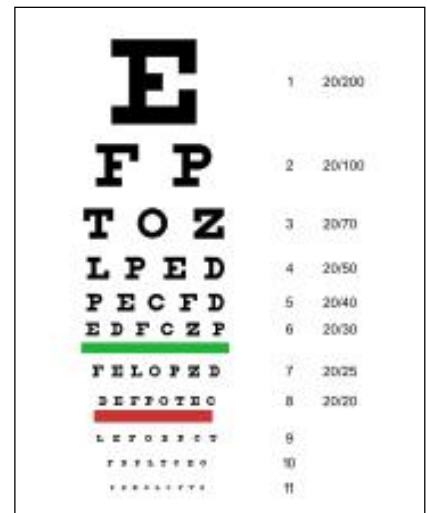
One's visual acuity is an indication of the clarity or clearness of one's vision. It is a measurement of how well a person sees. The word "acuity" comes from the Latin *acuitas*, which means sharpness.

### The SnellenChart

The traditional Snellen chart is printed with eleven lines of block letters. The first line consists of one very large letter, which may be one of several letters, for example E, H, or N. Subsequent rows have increasing numbers of letters that decrease in size. A person taking the test covers one eye, and reads aloud the letters of each row, beginning at the top. The smallest row that can be read accurately indicates the visual acuity in that eye.

The symbols on an acuity chart are formally known as "optotypes". In the case of the traditional Snellen chart, the optotypes have the appearance of block letters, and are intended to be seen and read as letters. They are not, however, letters from any ordinary typographer's font. They have a particular, simple geometry in which:

- the thickness of the lines equals the thickness of the white spaces between lines and the thickness of the gap in the letter "C"
- the height and width of the optotype (letter) is five times the thickness of the line.



Only the ten Sloan letters C, D, E, F, L, N, O, P, T, Z are used in the traditional Snellen chart.

Wall-mounted Snellen charts are inexpensive and are sometimes used for approximate assessment of vision, e.g. in a primary-care physician's office. Whenever acuity must be assessed carefully (as in an eye doctor's examination), or where there is a possibility that the examinee might attempt to deceive the examiner (as in a motor vehicle license office), equipment is used that can present the letters in a variety of randomized patterns.

BS 4274-1:1968(British Standards Institution) "Specification for test charts for determining distance visual acuity" was replaced by BS 4274-1:2003 "Test charts for clinical determination of distance visual acuity — Specification". It states that "the luminance of the presentation shall be uniform and not less than 120 cd/m<sup>2</sup>. Any variation across the test chart shall not exceed 20 %."

According to BS 4274-1:2003 only the letters C, D, E, F, H, K, N, P, R, U, V, and Z should be used for the testing of vision based upon equal legibility of the letters.

## 20/20 or 6/6 visual acuity

The reason that the number “20” is used in visual acuity measurements is because, in the United States, the standard length of an eye exam room (that is, the distance from the patient to the acuity chart) is about 20 feet.

In South Africa, where meters are used instead of feet, a typical eye exam room is about 6 meters long. Six meters is 19.685 feet, which is close to 20 feet, and usually is considered to be “close enough” to optical infinity. Therefore, instead of using 20/20 for normal vision, a notation of 6/6 is used in South Africa.

The scores, such as 6/9, are assigned to each eye. These scores are recorded against each row of letters on the Snellen chart. (see image). The score is awarded in accordance with the row of letters that the person can read without making more than one error. The top value of this score (ie “6”), describes the distance between the person and the object. The bottom value (ie. “9”), describes the distance from the object that a person with normal vision would be able to see it. Therefore:

- “6/6” means the object, which is at **6m** from the person, is seen with the same clarity as a normal person would see it a **6m**. (ie. “normal” vision)
- “6/9” means the object, which is at **6m** from the person, is seen with the same clarity as a normal person would see it a **9m**. (ie. slightly less than “normal” vision).

Someone with 20/20 or 6/6 vision (visual acuity) is just able to decipher a letter that subtends a visual angle of 5 minutes of arc (written 5') at the eye. (5' of arc is 5/60 of a degree, because there are 60' of arc in 1 degree.) What this means is that if you draw a line from the top of a 20/20 letter to the eye and another line from the bottom of the letter to the eye, the size of the angle at the intersection of these two lines at the eye is 5' of arc.

Also, the individual parts of the letter subtend a visual angle of 1' of arc at the eye. It does not matter how far away something is from the eye; if it subtends an angle of 5' of arc at the eye, then a person with 20/20 visual acuity will just be able to distinguish what it is.

A person with 20/20 vision could stand 30 feet away from a test chart and just decipher a 20/30 letter on the chart, since at that distance a 20/30 letter would subtend an angle of 5' of arc at the person's eye. That same person could stand 80 feet away from the chart and be able to decipher a 20/80 letter, or 200 feet away to be able to decipher a 20/200 letter.

## 20/20 compared with other acuities

Someone with 20/20 visual acuity does not have “perfect” vision, since it is quite possible to see better than 20/20. The less the bottom number in the visual acuity ratio, the better the acuity; and the greater the bottom number, the worse the acuity. Therefore, 20/15 acuity is better than 20/20 acuity, and 20/30 acuity is worse than 20/20 acuity. Also, 20/15 acuity is equivalent to 6/4.5 acuity, while 20/30 acuity is the same as 6/9 acuity.

As noted before, although 20/20 is “normal” visual acuity for most people, it is possible (and, in fact, very common) to be able to see better than that. For instance, many people have 20/15 visual acuity. A person with 20/15 acuity can stand 20 feet away from an object and see it as well as a person with 20/20 acuity moving up to 15 feet away from the object to view it.



If that is true, let's take a person with 20/15 vision looking at an object from 100 feet away. Where would a person with 20/20 vision need to stand to see the object just as well? The answer is 75 feet away from the object. (That is,  $15/20 \times 100 \text{ feet} = 75 \text{ feet}$ .)

It even is possible, although not too common, for someone to have 20/10 visual acuity. Let's say a person with 20/20 vision can just detect a ship which is 25 miles away out on the ocean. A person with 20/10 acuity could be 50 miles away from the ship and still be able to just detect it. That is, if a person with 20/10 acuity can just tell what an object is, a person with 20/20 vision would need to stand half that distance away to be able to see what it is.

You can use the same rationale when considering someone with less than 20/20 acuity. Consider a person with 20/40 visual acuity (which is what someone needs in most states to acquire a driver's license). If a person with 20/20 acuity can just read a sign which is 60 feet down the road, the person with 20/40 acuity would have to be 30 feet away to read the same sign. Also, a person with 20/15 acuity could be 80 feet away, and a person with 20/10 acuity 120 feet away, to read the same sign.

## Near visual acuity

Besides a person's visual acuity being tested at a far distance, one's near acuity also can be tested. Testing typically is done by holding a nearpoint Snellen acuity card at 40 centimeters (about 16 inches). Just as on a far acuity chart, a 20/20 letter on a near chart subtends a visual angle at the eye of 5' of arc (5 minutes of arc, or 1/12 of a degree).

Without a lens correction, a myopic (nearsighted) person generally will have better visual acuity at near than at far, while a hyperopic (farsighted) person generally will have better acuity at far than at near. Until the early to mid-forties, a person with 20/20 distance acuity usually also has 20/20 acuity at near. However, once presbyopia sets in, one's uncorrected near visual acuity decreases, creating the need for reading glasses or bifocals.

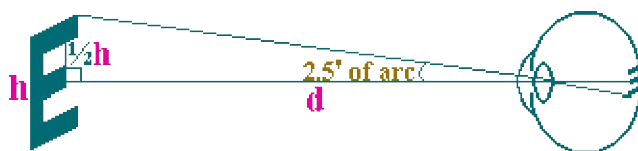
## Size of a 20/20 letter

When an eye doctor sets up an examination room, care should be taken in calibrating the size of the letters on the visual acuity chart (which usually is projected onto a highly reflective screen).

The correct size of a 20/20 letter can be calculated using the diagram below, where

- the letter's visual angle subtended at the eye is 5' of arc (5 minutes of arc), one-half of which is 2.5' of arc,
- $d$  is the distance (or virtual distance, if using a mirror), along the line of sight, from the eye to the chart in feet, and
- $h$  is one-half the height of the 20/20 letter in millimeters.

As an example, let's say that the viewing distance,  $d$ , is 20 feet.



Since a right angle is formed by the line of sight and the plane of the acuity chart, then simple trigonometry can be used:

1.  $2.5' \text{ of arc} \div 60 = 0.04167^\circ$
2.  $\text{tangent } 0.04167^\circ = h \div d = h \div 20 \text{ feet}$
3.  $0.0007272 = h \div 6'096 \text{ millimeters}$
4.  $h = 0.0007272 \times 6'096 \text{ millimeters}$
5.  $h = 4.433 \text{ millimeters}$
6.  $2h = \text{total height of a 20/20 letter at 20 feet} = 8.87 \text{ millimeters (at 200 feet} = 88.7\text{mm)}$

In general, to find the size of a 20/20 letter (in millimeters), multiply 0.4433 by d (where d is the viewing distance in feet). That is:

$$.4433 \text{ mm/ft} \times d \text{ ft} = \text{height of 20/20 letter in mm.}$$

Table listing the correct sizes of the letters for each row of a Snellen chart.

Snellen Row	Size of Letters
6/60	88.7
6/40	59.1
6/30	44.4
6/24	35.5
6/18	26.6

Snellen Row	Size of Letters
6/15	22.2
6/12	17.7
6/9	13.3
6/6	8.9
6/4	5.9

## Optical infinity

When an eye is looking at a far away distance (such as at the horizon or at the moon or at a star). The rays of light entering the eye are virtually parallel, and the crystalline lens of the eye is thin and relaxed because, essentially, there is zero accommodation.

When an optometrist or an ophthalmologist examines and performs a refraction on someone's eyes, it is optimal for the object being viewed (presumably an acuity chart) to be as far away as possible from the patient. This is so that the incoming rays of light are as close to parallel as possible, and the amount of accommodation (increased curvature) of the crystalline lens of the eye will be negligible.

Due to space limitations, though, this viewing distance (= "d" in the diagram above) can be only a few meters away from the patient in an examination room. Therefore, the goal of an eye doctor should be to position the eye chart at "optical infinity," or the least distance at which there is no significant accommodation by the crystalline lenses of a patient's eyes.

Traditionally, optical infinity has been accepted to be 20 feet or, approximately, 6 meters. However, at this distance, there is an accommodative demand on the eye of about 1/6 D (one-sixth of a diopter), which can be significant. For many people, an accommodative fluctuation during an eye examination of more than 1/8 D can result in a variable endpoint in measuring a person's refractive error, and 1/6 D is even greater than 1/8 D.

As a result, it is recommended that the viewing distance (d) in an examination room should be long enough to create no more than a 1/8 D accommodative demand on any patient's eyes. One could argue, then, that optical infinity, for purposes of examining the refractive error of the human eye, is at least 8 meters or 26¼ feet, rather than merely 6 meters or 20 feet!

If lack of space is a problem, front-surface reflective mirrors usually can be utilized to increase the virtual viewing distance in an exam room. From the previous section, it can be seen that the height of a 20/20 letter on an acuity chart, located at a viewing distance from a patient's eyes of **d = 26¼ feet**, is as follows:

.4433 millimeters/foot × 26¼ feet = 11.63 millimeters.

## Criticism

Snellen charts have been the target of some criticism. The fact that the number of letters increases while the size decreases introduces two variables, rather than just one. Some people may simply (or unconsciously) memorize the Snellen chart before being tested by it, or between tests of one eye and the other, to give the impression that their vision is good. Several studies indicate that the crowding together of letters makes them inherently more difficult to read. Another issue is that there are fairly large and uneven jumps in acuity level between the rows. To address these concerns, more modern charts have been designed that have the same number of letters on each row and use a geometric progression to determine the size of each row of letters. Also, some letters are harder to distinguish than others, such as P vs F, C vs G, Q vs O, etc.

9 Appendix 3: a near vision test card

**U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION**

## NEAR VISION ACUITY

SLOAN LETTERS

This chart should be held at 16 inches (40.6 cm) for near vision and 32 inches (81.3 cm) for intermediate vision from the eyes and illuminated with 10-25 foot candles. Use the scale on the left side of the chart to determine visual acuity measured at 16 inches and use the scale on the right side to determine visual acuity at 32 inches.

16" Linear Snellen Scale		32" Linear Snellen Scale
20 200	C K V R N H D O	20 100
20 100	V R N H Z                      D C K S O	20 50
20 80	S O C Z N                      H R V D K	20 40
20 60	N H R O C                      C V H R N                      V Z S K D	20 30
20 50	C V O R D                      D O S K R                      S K H Z N	20 25
20 40	H E V Z O                      H Z D O V                      R K N C D	20 20
20 30	* O O *                      * R O *                      D H Z * *	20 15
20 25	* * * * *                      * * * * *                      * * * * *	20 12.5
20 20	* * * * *                      * * * * *                      * * * * *	20 10

**AERONAUTICAL CHART READING**

**AIRPORT DATA**

**AIRPORTS**

**OBSTRUCTIONS**

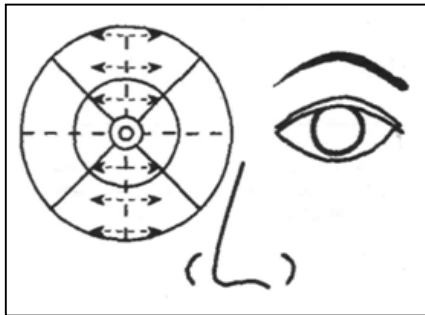
**RADIO AIDS TO NAVIGATION AND COMMUNICATION BOXES**

**MISCELLANEOUS**

AAM Form 8500-1 (04-93) Supersedes Previous Edition

## 10 Appendix 4: using the Novissphere

Taken from the instruction leaflet provided with the Novissphere.



### Detecting neurological field defects by noting changes across the vertical midline.

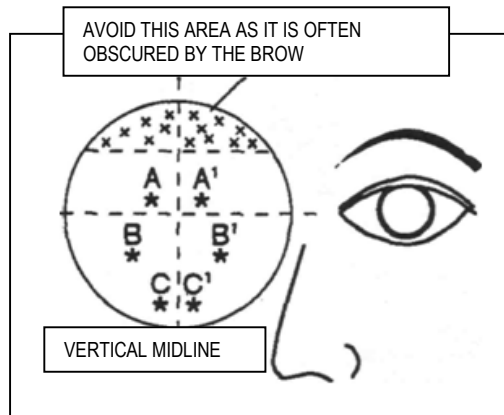
Hold the Novissphere in position over one of the patient's eyes. Instruct the patient to keep his eye fixed on you all the time. Now project the target light about 2cm above and to the side of the aperture and ask if it is seen. Then move the light slowly in a horizontal direction across to the other side as shown in figures. If the light suddenly disappears as the vertical midline is crossed, then you have a field loss which respects the vertical midline in that eye. Repeat this below the aperture in the inferior meridians and at various

distances from the aperture. Then repeat the procedure on the other eye

**Figure 1:** Detecting neurological field defects by noting changes across the vertical midline.

Note that many neurological lesions produce relative field defects. To pick these up you must ask the patient to comment on the quality and brightness of the target light. If the light suddenly dims as the vertical midline is crossed then a relative field loss exists which is just as clinically important as an absolute field loss.

Another technique for screening for neurological lesions is to place the target light again about 2cm above and to the side of the hole. But now, instead of moving the target light across the surface of the Novissphere, just change its position to a point equidistant from the hole but on the other side of the midline as shown in figure 4. Repeat this "paired point test" in various positions. If the patient only sees the points to one particular side of the midline then a midline-respecting field defect has been demonstrated for that eye. Again you should ask the patient to compare the quality of each of the paired points (if both are seen) in order to detect relative field defects.



**Figure 2:** Paired point testing. This drawing shows 3 pairs of points. Each point in the pair is exactly as far from the midline as the other point in the pair. Ask the patient to compare the quality of the target light at point A compared to at point A1. Then repeat for other paired points.

## 11 Appendix 5: Optometrists and visual testing of lifting equipment

*The Driven Machinery Regulations (GNR. 145, 18/02/2005) of the Occupational Health and Safety Act, 1993 (85 of 1993): National code of practice for the evaluation of training providers for lifting machine operators required employees who operate lifting machines (ie. Forklifts) are to be in possession of a valid training certificate.*

**THIS CODE OF PRACTICE HAS BEEN REPEALED (withdrawn by GN 201 / GG 36258 / 20130322), SO THIS REFERENCE IS ONLY FOR “RECORD” PURPOSES (AND TO PROVIDE AN EXPLANATION FOR THIS STANDARD)**

Herewith an extract from the code of practice:

*Before commencing training or re-certification training every learner shall provide the accredited provider with the following:*

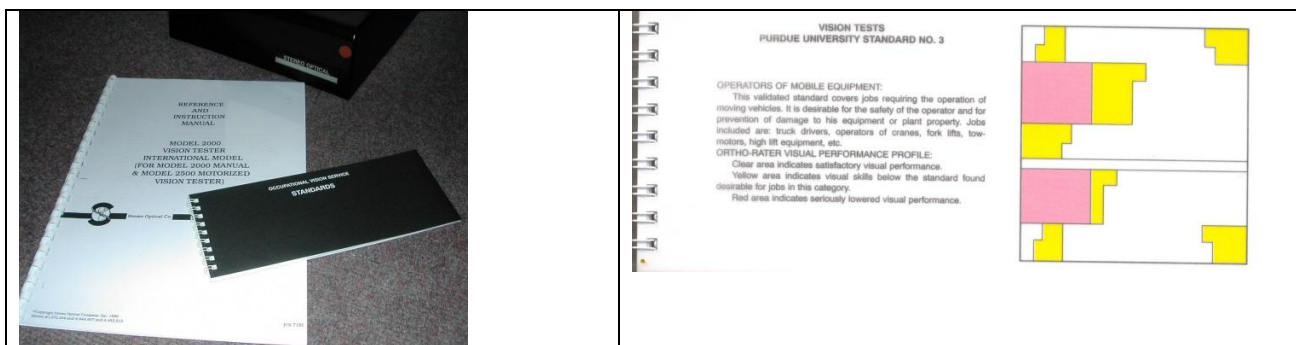
- a. A declaration from the employer confirming the physical and psychological fitness of the learner to undergo the intended training;*
- b. An optometrist's certificate confirming the learner has adequate day and night vision, and depth perception (e.g. Purdue University standard vision test No. 3): Provided that a valid Professional Driver's Permit can also be accepted in lieu of the optometrist certificate and physical fitness of the learner to undergo the intended training;*

Requirement “b” was re-phrased in the Government Gazette, 21 December 2011;

*“An eye test result issued by a person trained to carry out such tests, confirming that the learner has adequate day and night vision, and depth perception (e.g. Purdue University standard vision test No. 3): Provided that a valid Professional Driver's Permit can also be accepted in lieu of the eye test results”.*

Some comments

The “Purdue University standard vision test No. 3” is the depth perception test used by the model 2000 Stereo Optical Vision Tester. The code uses this as a reference, but it is not the only test for depth perception.



The code refers to “adequate day and night vision”. It is assumed that this refers to visual acuity. The standard for day vision is given in the SASOM guideline, and is similar to the requirement for heavy duty truck drivers, although some discretion is allowed, depending upon the risk of injury to personnel. There is NO ACCEPTED TEST FOR “NIGHT VISION”.