Visual field test for driving aptitude

document elaborated for the CEN/TC 170 WG9

Jacques CHARLIER, Xavier ZANLONGHI

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Content

Introduction

The purpose of this document is to provide support for the definition of minimum specifications for visual field equipment for the test of vehicle drivers in agreement with European directive 2009/113/EC.

The first part is background information.

The second part is a list of questions that remain to be addressed.

Background information

It is based on several sources of information:

- European commission directive 2009/113/EC
- Report of the Eyesight Working Group
- International standard on ophthalmic instruments – Perimeters ISO12866
- National
- Clinical experience from experts

European commission directive 2009/113/EC

Annex III to Directive 2006/126/EC is amended as follows:

6. …. Where there is reason to doubt that the applicant's vision is adequate, he/she shall be examined by a competent medical authority. At this examination attention shall be paid, in particular, to the following: visual acuity**, field of vision**, twilight vision, glare and contrast sensitivity, diplopia and other visual functions that can compromise safe driving.

For group 1 drivers, licensing may be considered in "exceptional cases**" where the visual field standard** or visual acuity standard cannot be met; in such cases the driver should undergo examination by a competent medical authority to demonstrate that there is no other impairment of visual function, including glare, contrast sensitivity and twilight vision. The driver or applicant should also be subject to a positive practical test conducted by a competent authority.

Group 1:

6.1.

the horizontal visual field should be at least 120 degrees, the extension should be at least 50 degrees left and right and 20 degrees up and down. No defects should be present within a radius of the central 20 degrees.

6.2.

Applicants for a driving licence, or for the renewal of such a licence, who have total functional loss of vision in one eye or who use only one eye (e.g. in the case of diplopia)

The competent medical authority must certify that this condition of monocular vision has existed for a sufficiently long time to allow adaptation and that the field of vision in this eye meets the requirement laid down in paragraph 6.1.

Group 2:

6.4.

the horizontal visual field with both eyes should be at least 160 degrees, the extension should be at least 70 degrees left and right and 30 degrees up and down. No defects should be present within a radius of the central 30 degrees.

Report of the Eyesight Working Group

Recommendations from the Eye Sight Working Group (See annex 1 for details)

General:

For an adequate examination of a candidate’s visual field, it is necessary to perform perimetry.

Group 1:

The visual field should extend to 20 degrees above and below the horizontal meridian. Likewise, the field must not be too limited on either side of the fixation point. We therefore suggest a minimum of 50 degrees to the right and to the left.

This should comprise a sufficient number of test points (e.g. 100) within the area of interest (i.e., 120 x 40^{o}), from which a sufficient number of points (e.g. 25) is located within the central 20 degrees (radius). Their luminance should be related to that of the hill of vision, i.e., with increasing intensity towards the periphery. The luminance should be at a certain supra-threshold level; we suggest 8 dB above the threshold for older people (e.g. 80-years old). Visual fields could be measured binocularly (i.e. with both eyes together). When visual fields are measured monocularly, only defects that are overlapping, i.e. at the identical location in both eyes, should be considered.

Within the central 20 degrees of visual field (radius) no more than 2 relative defects should be present. When these defects are related to the Physiologic Blind Spot, these defects may be absolute. Within the 120 (horizontal) x 40 (vertical) degrees visual field area, no more than 7 relative visual field defects should be present.

Group 2:

The horizontal visual field should be 160 degrees, the extension should be at least 70 degrees left and right and 30 degrees up and down. No defects should be present within central 30 degrees (not even the Physiologic Blind Spot).

The method for Group 2 drivers may be similar, though the reference age may be different, e.g. 70 years of age. This would effectively request that a Group 2 driver has a sensitivity throughout the visual field that is not more than 8 dB worse than the normal sensitivity of a 70 year old subject.

Recommendations of the German Ophthalmological Society and the German Professional Association of Ophthalmologists.

Group 1:

A normal visual field in one eye or a comparable binocular visual field with a horizontal diameter of at least 120 degrees; in particular the central visual field must be normal up to 20 degrees. In total the visual field of each eye must be tested in at least 100 points. If unclear defects are detected or doubts arise as to whether the minimum requirements are met, reassessment using a Goldmann-type manual perimeter and test stimulus III/4 is to be performed.

Group 2:

Normal visual field, tested using an automatic hemispheric perimeter which examines the visual field up to 70 degrees to either side and up to 30 degrees upwards and downwards using a supra-threshold testing method. In total the visual field of each eye must be tested in at least 100 points. Alternatively the test can be performed using a manual Goldmann-type perimeter with at least four test stimuli (e.g. III/4, I/4, I/2 and I/1) in at least 12 points per test stimuli.

International standard on ophthalmic instruments – Perimeters ISO12866

This International Standard specifies requirements and test methods for instruments designed to assess differential light sensitivity in the visual field by the subjective detection of the presence of test stimuli on a defined background. It does not apply to clinical methodologies and other psychophysical tests of the visual field.

4 Requirements

4.1 General

The requirements of this International Standard shall be verified through type testing. All tests described in this International Standard are type tests. The perimeter shall conform to the general requirements specified in ISO 15004. The perimeter shall conform to the specific requirements described in 4.2 to 4.4.

NOTE These requirements are verified as described in clause 5.

4.2 Specific requirements

Note: referenced tables are given in Annex 5.

4.2.1 The test stimuli shall be presented within the tolerances specified in Table 1.

4.2.2 The luminance of the background and test stimuli shall be specified in candela per square metre (cd/m2), measured at the designated position of the centre of the entrance pupil of the patient’s eye.

4.2.3 The spectral distribution(s) of the background and the test stimuli shall be specified by the manufacturer.

4.2.4 The test stimulus size(s) and shape, including variation within the central visual field, shall be specified.

4.2.5 The viewing distance from the designated position of the centre of the entrance pupil of the eye to the fixation target shall be specified.

4.2.6 Provision for the optical correction of patient’s refractive error for the fixation-target viewing distance shall be made.

4.2.7 Provision for adequate head positioning within the instrument shall be made.

4.2.8 Means for monitoring fixation and eye position at the instrument shall be provided. This may be by operator observation or by automatic means.

4.2.9 Provision shall be made for measuring the differential light sensitivity at fixation.

4.2.10 Central-field perimeters, midperipheral-field perimeters and full-field perimeters shall have minimum test stimulus eccentricities and minimum total number of stimulus locations as specified in Tables 2 and 3 respectively.

4.2.11 The instrument shall be capable of defining the position of and quantifying the results from each tested location.

4.2.12 The test record shall have provision for recording the following data: requirements of 4.2.11, patient identification, date, examined eye, corrective lenses used, stimulus/background parameters used, age or birth date of patient, and pupil size.

4.3 Kinetic perimeters

4.3.1 If movement of the test stimulus is automatically controlled by the instrument, the movement shall be smooth, the presentation of the stimulus shall be continuous, and the speed and characteristics of stimulus movement shall be specified.

4.3.2 If the movement of the stimulus is manually controlled, the instrument mechanism shall allow the test stimulus to be moved smoothly in any direction.

4.4 Static perimeters

4.4.1 The temporal characteristics of the test stimulus presentation shall be specified.

4.4.2 The total number of stimuli for each available stimulus pattern shall be specified, together with the location of each test stimulus given in either polar or Cartesian coordinates referenced to the designated position of the centre of the entrance pupil of the patient's eye between the fixation target and the test stimulus.

5 Test methods

5.1 Checking the background luminance

Measure the background luminance at the approximate midpoint of each quadrant of the background surface using a luminance meter, and determine the difference between the measurements and the specified value.

5.2 Checking stimulus luminance

Measure the luminance of the test stimulus from the designated pupil position using a luminance meter and calculate the difference between the measurements and the specified value. If the test stimulus luminance can vary with direction, the measured values shall meet the requirements of Table 1 at all positions within one centimetre of the design pupil position. Table 4 gives the positions and luminance values to be used in making this test.

5.3 Checking the test stimulus location

Measure the position of the centre of the test stimulus and calculate the difference between the measured location and the specified location. Table 4 gives the positions to be used in making this test.

5.4 Checking the test stimulus size

Measure the area, A, of the test stimulus. Measure the distance, z, between the eye pupil position and the surface of the perimeter. Convert the area into a solid angle, W. Calculate the difference between the measured and the specified solid angles.

5.5 Checking the stimulus shape

Measure the maximum and minimum widths of the stimulus along the four oblique half-meridians at 25° eccentricity. The shape is defined as the ratio of minimum to maximum widths.

5.6 Checking the stimulus duration

Measure the duration of the test stimulus presentation and calculate the difference between the measured duration and the specified value.

5.7 Type tests

5.7.1 Projection perimeters

To fulfil the requirements of this International Standard during type testing, the tests specified in 5.2, 5.3 and 5.4 shall be conducted at the locations specified in Table 4. If because of the design of the perimeter it is not possible to test at the exact locations given in the table, the testing may be conducted at alternative locations separated from the specified locations by no more than 2° in any direction. The stimulus intensities and test stimulus sizes to be tested at each location are given in Table 4. The test shall be conducted three times at each location.

5.7.2 Fixed position stimulus perimeters

To fulfil the requirements of this International Standard during type testing, the tests specified in 5.2, 5.3 and 5.4 shall be conducted at each point (or the closest available point) and intensity specified in Table 4. Light-emitting diodes (LEDs) and optical fibres, which are typically used as stimuli in fixed-stimulus perimeters, can vary greatly one from another and tend to be directional in their output intensity patterns. Therefore, in addition to intensity, the homogeneity and directionality of the light in the area of the pupil of the tested eye shall be checked (see 5.2).

5.7.3 Checking the mechanical and functional requirements

The requirements described in 4.2.6, 4.2.7, 4.2.8, 4.2.9, 4.2.11, 4.2.12 shall be checked by observation.

Questions

The background information shows that the perimetry standard ISO12866 can be applied but that it imposes requirements that are not necessarily needed for an instrument performing tests according to the European directive (2009/113/EC) or to the recommendations from ophthalmic societies of different European countries.

EUR: European Commission Directive
EWG: Eyesight Working Group
DOG: German Ophthalmological societies
DVLA: UK department of
HUM: Humphrey
ISO: perimetry standard ISO12866

NS: no specification

We list here after the major points that should be discussed along this line:

Parameter	Status	Comments	Question
Monocular or binocular testing	Both modes are acceptable.	Some perimeters do not allow a well centred head position for performing binocular fields. Test position is different for each eye when the exam is performed under binocular conditions.	Should it be specified that if the test is performed binocularly, the head should be centred? A minimum test distance should be specified for binocular tests
Head and eyes must remain steady		Different from attention visual field	
Kinetic or static	EUR: NS Both modes are acceptable.	DOG: for kinetic perimetry, tests are different from III4e	
Control of fixation	EUR: NS DOG: Mandatory	Some perimeters do not allow control of fixation in binocular mode.	Should it be mentioned that some mode of fixation monitoring has to be provided?
Background and stimulus parameters	EUR: NS	ISO12866 does not impose Goldmann parameters.	Proposition: use 10 cd/m2 background and III4e white

	Goldmann reference is universally used with 10 cd/m2 background and III4e white stimulus.	It requires that the manufacturer specifies those parameters. The requirements are on their variability.	stimulus or other parameters with a demonstration of their equivalence. background and stimulation parameters
Stimulus presentation time	EUR: NS HUM: 400 ms	Standard test frequently use 100 up to 300 ms Justification of 400 ms is unknown	Needs to be defined
Minimum number of test points in 0-20 degrees area (eccentricity from fixation) for Group 1	EUR: no defect EWG, DOG: 25 points ISO: 60 points (0-25 deg)	ISO requires a 53 percent higher density of points	Needs to be defined Different from ISO
Minimum number of test points in 0-30 degrees area (eccentricity from fixation) for Group 2	EUR: no defect (Group 2) No definition from others. ISO: the specifications correspond to different areas: 0-25-50-75 degrees	Recommendation from Dr Zanlonghi : at least 10 points in the 20 – 30 degrees area	Needs to be defined Different from ISO
Minimum number of test points along horizontal meridian	EUR: no deficit along the horizontal meridian up to 60 deg (group 1) and up to 80 degrees (group 2) DOG: points in the area 10 degrees above and 10 degrees below the horizontal meridian ISO: maximum required horizontal extension in only 70 degrees	Test every 5 degrees along the horizontal meridian from 25 up to 80 degrees ➔ 24 points For tests in the periphery, some perimeters change the position of the fixation to allow the evaluation of periphery (Henson, Medmont, MonCv3 from Metrovision)	Needs to be defined: EUR requirement exceeds ISO requirement Is horizontal meridian “only” acceptable?
Test of sensitivity at the fovea	EUR: not required ISO: mandatory (**4.2.9** Provision shall be made for measuring the differential light sensitivity at fixation)		ISO exceeds EUR requirement
Test of stimulus location and luminance	ISO: table 4 in Annex 5	ISO requirements largely exceed the specifications of an instrument performing only the test required by EUR	Apply EUR requirements only partially

Optical refraction correction	DOG: correction for near distance ISO: Provision for the optical correction of patient's refractive error for the fixation-target viewing distance shall be made.	Recommendation from Dr Zanlonghi : test should be performed with the correction usually worn during driving Frequently the optical correction used on automated perimeters must be removed for the periphery in order to avoid masking errors	Needs to be defined ISO is not compatible

References

1- European commission directive 2009/113/EC of 25 August 2009 amending Directive 2006/126/EC of the European Parliament and of the Council on driving licence.

2- Report of the Eyesight Working Group, New standards for the visual functions of drivers, May 2005.

3- Recommendations of the German Ophthalmological Society and the German Professional Association of Ophthalmologists. Driving fitness Assessment for Road Traffic 2013 (English translation). Doc. CEN/TC 170/WG9 Number: N 41 2014-05-06.

4- ISO12866 International standard on ophthalmic instruments – Perimeters, 1999.

Annex 1 Report of the Eyesight Working Group Explanations relative to significance of Visual field

Visual field

The visual field is the perceptual space available to the fixating eye. The binocular visual field is the sum of the perceptual spaces available to both fixating eyes. An intact visual field provides the capacity to detect objects (or lights or movements) away from the fixation point. Impairments of visual field increase with age. The leading cause of visual field impairments in the elderly is glaucoma (e.g. Ramrattan, 2001). Visual field defects have been associated with a mild increase in accident risks. The typical relative risk values that were reported in the studies were about 2 (see van Rijn and Völker-Dieben, 1999 for an overview). A major problem in interpreting these studies is that there is no consensus regarding the definition of impairment. For example, in the classical and often cited study of Johnson and Keltner (1983), an impairment of visual field was defined as two or more adjacent targets that were missed. This may be a significant defect in clinical terms (pointing at disease) but, depending on the location of the defects, may have only a mild impact on driving performance. It has been shown that visual field sensitivities decrease with age (Haas et al., 1986; Jaffe et al., 1986) and as a result, Johnson and Keltner may have compared physiologically decreased normal visual fields with mildly impaired ones.

Driving simulator studies and studies involving on-road testing of subjects with impaired visual fields, have found a strong relation between the extent of the visual field defect and driving performance: Coeckelbergh et al. (2002) demonstrated that subjects with central and mid-peripheral visual field defects drove slower and needed a longer time to react. Subjects with peripheral visual field defects had increased swaying. Tant et al. (2002), in a study with hemianopic subjects, found that generally the driving performance of these subjects was low, although it was argued that a specific negative selection bias was present in the study. Only some subjects were found fit to drive after a specific training programme (Tant et al., 2001). Szlyk et al. (1992) found more crashes both in driving simulator tasks and state records during the preceding 5 years in 21 drivers with retinitis pigmentosa than in 31 healthy control subjects. Visual field size was the best predictor of real-world and simulator crashes. The same holds true for studies into the walking (or wheelchair) mobility of subjects with impaired visual fields (e.g. Kuyk et al., 1998; Lovie-Kitchin et al., 1990). Lövsund, Hedin and Törnros (1991) reported that individual variation in the group with visual field impairments was very large, making the group as a whole unsuitable for driving. Szlyk et al. (2002) studied driving behaviour in a driving simulator in subjects with mild to moderate glaucomatous damage. They found that driving performance was indeed related to the presence of glaucoma but interestingly in these subjects, contrast sensitivity rather than visual field defect was the relevant visual function. In a recent report, Szlyk found that visual field defects within 100 degrees correlated with driving performance and with accidents (Szlyk et al., 2005a). Hedin and Lövsund (1986) reported that in a group of 27 subjects with impaired visual fields (mostly homonymous defects) only 4 were capable of compensating for their defects. Homonymous hemianopia is a condition in which, due to a neurological cause (mostly stroke, traumatic brain injury or tumour) the visual field on one side in both eyes is blind. The consensus is that generally this condition is incompatible with fitness to drive although occasionally, subjects with hemianopia may drive safely (Tant, 2002; Tant et al., 2001; 2002). A major factor may be that visual field defects may be accompanied by other neurological and neuropsychological (e.g. attentional) deficits which can also strongly affect driving performance (Tant, 2002; Tant et al., 2001; 2002). It should be noted that probably many subjects with hemianopic visual field defects continue to drive, most often because their stroke has remained unnoticed to them (Gilhotra et al., 2002) but only few of the homonymous defects in this study were complete hemianopias.

Based on the literature cited above, it is evident that an adequate visual field is of utmost importance for the ability to drive safely. However, the actual cut-off value that should be set in the standards is as yet unclear. Further research is needed.

Experiments have been performed in which the visual field is expanded on the hemianopic side, using different kinds of prismatic devices. The success of these experiments is limited (see, e.g. Slzyk et al., 2005b) although currently other evaluation studies are being performed using alternative prismatic devices. The Eyesight Working Group does not favour the use of such devices in order to meet the visual field standards (see discussion on Bioptic devices).

Measurement of visual field with known or suspected abnormalities

For subjects with known or suspected abnormalities, visual fields are generally measured using a perimeter. This is a device that can present light stimuli at various locations in the visual field. The subject being tested is requested to indicate whether the stimulus has been seen. Most perimeters are rather costly but for this purpose, there is no alternative. In selected subjects, practice and education are needed before adequate and reproducible visual field results are obtained (e.g. Parrish, Schiffmann and Anderson, 1984; Lewis et al., 1986; Katz and Sommer, 1990). In addition, care should be taken that any refractive error is adequately corrected prior to testing. Failure to correct the refractive error can lead to a large number of false positive measurement results (subjects with impaired results whereas they are, in reality, not impaired). (Weinreb et al., 1986; Rabineau et al., 1989; Anderson et al., 2001; van Rijn et al., 2005). Generally, visual fields are tested monocularly; binocular fields may be extrapolated from the monocular results (e.g. Crabb et al., 1998; Nelson-Quigg et al., 2000). However, for task-oriented measurement of the visual field, it would be sufficient to measure binocular fields only. Perimetry techniques can be divided into static techniques and kinetic techniques (e.g. Goldmann perimetry). Static techniques are mostly automated. In these techniques, light stimuli are presented in pre-set areas of the visual field. In Goldmann kinetic perimetry, a light stimulus is moved (manually by an examiner) usually from the periphery towards the centre of the visual field. Kinetic perimetry does not always disclose defects of significance (e.g. in retinitis pigmentosa) and at times suffers from examiner bias. Depending on the experience of examiner, central and paracentral defects may be missed. Therefore, in general, static perimetry is strongly recommended. However, in selected subjects, kinetic perimetry may still be necessary. In particular, some subjects with neurologic visual field impairment suffer from stato-kinetic dissociation (Riddoch phenomenon). This implies that moving objects (such as in traffic situations) are perceived better than static ones. Compared to age-related testing, suprathreshold screening programmes are less sensitive and may overlook, for example, the moth-eaten fields after heavy photocoagulation (as best evident with high pass resolution perimetry - ring perimetry).

Current perimetry techniques are directed at the evaluation of disease. This shows itself in the areas and size of the visual field that is being tested, the distribution of points and the evaluation of the results (comparison with age-matched controls). This makes these techniques less suitable for the evaluation of task-oriented function as is important for driving. The Esterman technique is an exception: this is a task-oriented algorithm, implemented on a static automated perimeter. This technique has not been specifically developed for the evaluation of drivers but for visual function in general. It is unsuited for driving not only because of the position of the test points but also because of its use of a fairly intense and large stimulus (III/4e). Hence, although automated perimetry using the Esterman protocol is easier to perform than standard perimetry, it is more lenient (Crabb et al., 2004; van Rijn, 2003) and we advise against it.

For this reason it is recommended to develop a ‘traffic perimetry algorithm’, analogous to the recommendations of the German Ophthalmological Society (1999). This should preferably comprise a sufficient number of test points within the area of interest. A sufficient number of those (e.g. 25) should be located in the central area of the visual field since this area is of particular importance for perception during driving and perception in general. The luminance of test points should be related to that of the hill of vision, i.e. with increasing intensity towards the periphery. With such a test at hand, it would be possible to lay down the number of missed test points, centrally as well as in the periphery, acceptable for a driving licence. Rough guidelines about the number of points that may be missed could help for a first assessment of visual fields. However, we note that expert judgement of visual fields remains very important since, expectedly, good judgement of visual field cannot be completely performed by an automated routine. Any specification which is too detailed brings with it ambiguities, especially since the characteristics of the scotomas depend on the method used to define them. We therefore suggest that, in cases of doubt, visual fields will be judged on an individual basis by a panel of specialists (possibly in a national expert centre, see section on restricted licences) although we realise that, from a practical point of view, it may be impossible that all isolated defects will be judged on an individual basis. We therefore suggest that some rough guidelines should be developed to discriminate between those defects that are allowed, those defects that are not allowed and those that should be referred to a specialist centre for further judgement.

Measurement of visual field for screening purposes

For screening subjects with a low likelihood of visual field defects, perimetry may be less efficient since it requires rather costly equipment. There are simple devices that test the ability to detect LEDs along the horizontal meridian but their capacity to detect field defects is not known. Often, the Donders confrontation method is advocated for screening purposes. In this confrontation method, the visual field is tested by an examiner using hand movements. The sensitivity and specificity of this method are very low (e.g. Johnson and Baloh, 1991; Shahinfar et al., 1995) except perhaps for hemianopic visual field defects (Shahinfar et al., 1995). For the purpose of screening the visual fields of healthy licence candidates, there is a need for a simple, reliable and quick test that could be administered by any person.

Periodic screening of drivers

The prevalence of impairments was recently investigated in the European study mentioned above (van Rijn et al., 2005). It was found that the prevalence of impaired visual acuity and visual field is very low at young ages.

The prevalence of impairments of visual fields rises to 2.7% in the highest age groups.

Current guidelines and proposed changes

In the paragraphs below, the headings represent the current European Directive (2006). Each heading is followed by a discussion of problems and recommendations

Group 1

…

2) The horizontal visual field should be at least 120 degrees

a) Problems

- i) This cut-off value has not been properly justified
- ii) There are no requirements for the left/right/up/down extension of the visual field
- iii) There are no guidelines for the testing method
- iv) There are no requirements regarding the absence of/allowance of sporadic defects
- v) There are no rules regarding the number of attempts a candidate is allowed to make.

b) Recommendations

- i) Many studies demonstrate the importance of an adequate visual field for driving, however, adequate cut-off values have not been published. Awaiting studies in this field, there is no current basis for change of this standard. Additional research is recommended.
- ii) The solitary requirement for the horizontal extension of the visual field does not exclude the possibility of important extensive visual field defects above and below this meridian, defects of significant importance in traffic. Although, as pointed out, scientific data to support figures concerning the recommended extension are lacking, it is reasonable to propose that the visual field should extend to 20 degrees above and below the horizontal meridian. Likewise, the field must not be too limited on either side of the fixation point. We therefore suggest a minimum of 50 degrees to the right and to the left.

- iii) For an adequate examination of a candidate's visual field, it is necessary to perform perimetry. This test is costly, since it requires rather expensive equipment. It is also time consuming. Since the prevalence of visual field defects in the driving population is rather low, it may not be necessary to test all driving licence applicants by perimetry. It could be sufficient to test only those individuals in whom defects could be anticipated. Those individuals, should preferably be tested by a 'traffic perimetry algorithm'. This should comprise a sufficient number of test points (e.g. 100) within the area of interest (i.e., 120 x 40^{o}), from which a sufficient number of points (e.g. 25) is located within the central 20 degrees (radius). Their luminance should be related to that of the hill of vision, i.e., with increasing intensity towards the periphery. The luminance should be at a certain supra-threshold level; we suggest 8 dB above the threshold for older people (e.g. 80-years old). Visual fields could be measured binocularly (ie with both eyes together). When visual fields are measured monocularly, only defects that are overlapping, i.e. at the identical location in both eyes, should be considered .Visual field defects that are not overlapping (a visual field defect in one eye with no defect at the identical location in the fellow eye) are less relevant for driving. With such a test available, it would be possible to lay down the number of missed test points, centrally as well as peripherally, acceptable for a licence (see at iv).
- iv) Within the suggested 120 x 40^{o} area, isolated field defects (depressions, scotomas) may appear, e.g. due to glaucoma or chorioretinitis. If of a certain depth and size, they might be of significance in traffic. There are no data suggesting the maximum number, size and depth of such defects. Monocular drivers are (as far as we know) not hampered by the Physiological Blind Spot. Therefore a comparable scotoma in the binocular visual field could be allowed. It is reasonable that scotomas within the central 20^{o} (an area with a diameter of 40^{o} with the fixation point in the centre) are of greater importance than scotomas outside this area (Schiefer et al., 2000). Any more detailed specification brings with it ambiguities, especially since the characteristics of the scotomas depend on the method used to define them. We

therefore suggest that isolated defects be judged on an individual basis by a panel of specialists (possibly in a national expert centre, see section on restricted licences). We realise that, from a practical point of view, it may be impossible for all isolated defects to be judged on an individual basis. We therefore suggest that some rough guidelines should be developed to discriminate between those defects that are allowed and those that should be referred to a specialist centre for further judgement. These guidelines could, for example, be as follows: with the method of testing, suggested at iii), within the central 20 degrees of visual field (radius) no more than 2 relative defects should be present. When these defects are related to the Physiologic Blind Spot, these defects may be absolute. Within the 120 (horizontal) x 40 (vertical) degrees visual field area, no more than 7 relative visual field defects should be present. It should be noted that these criteria could only provide a rough guide to the judgement of visual modalities. We strongly advocate further research in this field to further justify these criteria. It should be realised that relative defects are sensitive to refractive errors. Therefore, prior to testing, refractive errors should be adequately corrected. Moreover, relative defects in peripheral visual field areas may be generated by spectacles and spectacle frames. It is common practice for diagnostic tests to test peripheral visual field areas without spectacle correction, in order to avoid inadvertent measurement of visual field defects, but this does not reflect the actual situation during driving).

v) We know that visual field testing results may be variable; first time testing often has worse results than repeated tests (e.g. Parrish, Schiffmann and Anderson, 1984; Lewis et al., 1986). Therefore, one has to allow for repeated testing in case of doubt. The adequacy of the test results may be judged by an expert).

Group 2…

3) Normal visual fields should be present in both eyes.

a) Problems

i) The term “normal” is ambiguous since the extent of the visual field depends on the shape of the face. Hence a “normal” visual field in one subject may in fact be smaller than an “impaired” visual field in another subject.

ii) One may argue that driving is a binocular activity, therefore no monocular visual field requirements should be formulated. Even in terms of a spare eye (potentially necessary for stopping the car in case of emergency) no monocular visual field requirements are necessary.

iii) The cut-off value is arbitrary, although it is reasonable to expect from a truck or bus driver that the visual field is unimpaired.

iv) There are no guidelines for the testing method.

v) There are no rules for the number of attempts a subject is allowed to make.

b) Recommendations

i) Formulate the visual field requirements in terms of numbers, e.g. horizontal visual field should be 160 degrees, the extension should be at least 70 degrees left and right and 30 degrees up and down. No defects should be present within central 30 degrees (not even the Physiologic Blind Spot). The exact numbers should follow from future research.

ii) The requirements are for binocular visual fields, see section on Group 1 drivers.

iii) See at i)

iv) See at section on Group 1 drivers. The method for Group 2 drivers may be similar, though the reference age may be different, e.g. 70 years of age. This would effectively request that a Group 2 driver has a sensitivity throughout the visual field that is not more than 8 dB worse than the normal sensitivity of a 70 year old subject. The actual requirements require further research.

v) See section on Group 1 drivers.

Annex 2 Recommendations of the German Ophthalmological Society and the German Professional Association of Ophthalmologists

Driving fitness Assessment for Road Traffic 2013 (English translation)
Doc. CEN/TC 170/WG9 Number: N 41 2014-05-06

Significance for road traffic

An intact visual field is an indispensable prerequisite for safe participation in road traffic. The significance of the visual field is equal to that of central photopic visual acuity. The predominant part of interaction in traffic relevant for the driver takes place within the range of 25° to 30° around the centre of the visual field. Even the slightest binocularly overlapping defects in the central visual field constitute absolute unfitness for driving. Besides this, drivers rely on the peripheral areas of the visual field in the horizontal meridian: before changing lanes a driver must turn his head to see whether the lane is free on the left or right. In order to make a safe judgment here he needs his horizontal visual field to almost reach the edge of his physiological boundaries. Thus no restrictions may be accepted here either. For the driver the binocular visual field is practically decisive; in cases of doubt it should be examined. If defects are found in both eyes an examination of the binocular visual field should also determine whether the defects overlap.

Method

In order to examine the visual field only evenly illuminated and well-calibrated testing devices may be used which allow for examination of the entire visual field under controlled and standardised conditions.

As a general rule, this is only ensured by use of a hemispheric perimeter. Arc perimeters do not fulfil this requirement and are thus unsuitable. Until now ophthalmic examination of the visual field for purposes of driving fitness assessment has been based on the use of manual Goldmann-type perimeters. In order to achieve a sufficiently precise examination of the visual field, at least 4 isopters must be determined which are evenly distributed across the entire visual field, at least one of which must lie within 15° eccentricity. The test stimulus relevant for ophthalmic assessment is stimulus III/4e; this must be used for determining the outer border as well as the size and position of all scotomas. The other stimuli used must be selected in regard to their stimulus parameters in such a way that the important areas of the central visual field lying within 30° can be assessed with sufficient accuracy. The two outer isopters should be determined by measuring at least 12 points; for the two inner isopters at least 8 points are required. In order to achieve sufficient spatial resolution, it is advisable not to merely use four isopters but rather a larger number, for example in accordance with the following gradation: III-4, I-4, I-3, I-2, I/1 and 0-1.

DIAGRAMM EINFÜGEN
> 120°
temp. > 70° > 40° nas.
100 test points in total
> 40 test points > 25 test points
sup.
inf.

If an automatic perimeter is used, test patterns and strategies must be employed which enable the examiner to make statements about the central and peripheral visual field which are at least comparable with what can be derived using a Goldmann-type perimeter.

The ambient luminance must be 10 cd/m² and a Goldmann III-4 stimulus or an equivalent one must be used.

It must be ensured that the central as well as the peripheral visual field is examined to a sufficient degree. The diameter of the horizontal visual field must be at least 140° (for Group 2) or 120° (for Group 1). All in all at least 100 test points should be tested within a field extending at least from 70° temporally to 40° nasally and from 40° superiorly to 40° inferiorly. The centre should be examined using a higher density of test points, i.e., the central visual field up to 20° should contain at least 25 test points. It is advisable for it to have a higher density of test points in the centre than in the periphery. In addition, the test pattern must allow for a sufficient examination of the visual field in horizontal direction both nasally and temporally, i.e., it must in particular have at least 40 test points located no further than 11° above and no further than 11° below the horizontal meridian. Using a suprathreshold testing method which allows for a classification of "normal," "relative" and "absolute" defects is a permissible strategy. In principle each eye should be examined separately because otherwise the majority of automatic perimeters commonly used today do not ensure sufficient fixation control. Visual field assessment must be based on sufficiently reliable standard values. In case of doubt inquiries should be made to the device manufacturer. If visual field loss is found in both eyes one must check to see whether it is also found in the binocular visual field. In case of doubt an examination of the binocular visual field should be performed as well. When examining spectacle wearers one should be mindful of visual field defects caused by spectacle lenses and frames; this holds in particular for lenses with a relatively strong refractive power (see Section 3.3.1).

If defects are detected during an examination conducted using an automatic perimeter which would result in denial of a driving licence or which does not allow for any conclusive assessment, then a re-examination must be performed employing the manual kinetic method and use of a Goldmann-type perimeter or an equivalent instrument. In case of doubt the result of the manual perimetry is decisive; in cases of defects in both eyes the results of the examination of the binocular visual field is decisive. If need be, a senior expert can be brought in. Meanwhile the Traffic Commission of the DOG and the

Quality Assurance Commission of the DOG have approved several automatic instruments which employ manual control of test points for kinetic perimetry. The prerequisite is that the stimulus is moved via manual control, as is the case for classic Goldmann-type perimeters, and not automatically via computer control. The list of approved instruments can be consulted on the DOG website.

Examination of visual field in accordance with Appendix 6 to DLO Section 2.1 (so-called "expanded eyesight test")

Method

The visual field must be tested using an automatic hemispheric perimeter which employs a suprathreshold testing method up to 70 degrees bilaterally and up to 30 degrees superiorly and inferiorly. All in all the visual field of each eye should be tested at not less than 100 points. Alternatively tests can be performed using a manual Goldmann-type perimeter with at least 4 isopters (e.g.. III/4, I/4, I/2 and I/1) at not less than 12 points per isopter on a device which the Traffic Commission of the DOG has acknowledged to be equivalent (see above).

Evaluation of visual field defects

A fundamental prerequisite for the evaluation of visual field results is the availability of age-corrected standard values, for only in this way can “normal” results be distinguished from “pathological” ones. Thus only instruments and programmes can be used which are based on normative studies with sufficient statistical documentation. With the exception of the blind spot, the central 20° area of the visual field must be completely free of relative or absolute defects. Up to 60° eccentricity a maximum of two relative or absolute defects may occur. On the periphery of the visual field, for example upwards, defects are permissible (upper eyelid artefacts), but not ones which are in close proximity to one another. If these criteria for normality are not fulfilled the results of the examination may not be evaluated as normal in accordance with Appendix 6 to DLO Section 2.1.2. In such cases a complete ophthalmic assessment must be made.

Evaluation of cooperation of the test subject

The cooperation of the test subject must be monitored by the programme through false-positive and false-negative catch questions and fixation checks by projection into the blind spot. In the category of false-positive catch questions the maximum permissible error rate is 20%; in the other categories the error rate may not exceed 30%. Otherwise the result is not reliably usable. The test can be repeated once. Should no usable result be obtained the second time, re-examination by an ophthalmologist must be performed.

Suggestions for practical execution

The prerequisite for correct perimetry is precise information on the refraction of the eye under examination. False refraction can lead to an erroneously pathological visual field finding. It is best to determine the current refraction. Should this not be possible the spectacles in use should at least be measured using a lens meter or one should copy the necessary information from the subject’s eyeglass prescription card. It is imperative to use the distance refraction, not erroneously the near refraction. The refraction must be entered into the perimeter correctly so as to select the right test lens for the examination dependent on the patient’s age. During the examination one must make sure that the patient’s eye is positioned properly (no tilting of the head or of the eye in front of the lens holder, removal of corrective lens for examination of the peripheral visual field, monitoring of fixation, including visual monitoring by the examiner in the course of the examination, etc.).

DLO

For driving licence classes A, A1, A2, B, BE; AM, L and T, Appendix 6 Section 1.2.2 of the DLO demands a normal visual field in one eye or an equivalent binocular visual field with a horizontal diameter of at least 120°. In particular, DLO requires that the central visual field be normal up to 20°. In total the visual field of each eye should be examined at no less than 100 points. Should unclear defects be identified or doubt arise as to whether the minimum requirements are fulfilled then manual re-examination using a Goldmann-type perimeter and isopter III/4 must be performed.

This requirement of the DLO corresponds almost exactly to the recommendations made by the Traffic Commission of the DOG. Until 2011 a normal central visual field up to 30° was required. This relaxation of requirements would seem to be acceptable, however. Should an examination be carried out in accordance with Appendix 6 Section 2.1, a normal visual field must be found (Appendix 6 Section 2.1.2).

It must be examined using an automatic hemispheric perimeter which examines the visual field up to 70° bilaterally and up to 30° superiorly and inferiorly using a suprathreshold method. Overall the visual field of both eyes should be examined at no less than 100 points. Alternatively, an examination can be performed using a manual Goldmann-type perimeter or an instrument acknowledged as equivalent by the Traffic Commission of the DOG using at least 4 isopters (for example III/4, I/4, I/2 and I/1) at no less than 12 points per isopter. This formulation also corresponds to the recommendation of the Traffic Commission. If an examination of the visual field is performed in accordance with Appendix 6 Section 2.2 the requirements made by the DLO for driving licence classes A, A1, A2, B, BE, AM, L and T (Appendix 6 Section 2.2.2) are as follows:

"Normal visual field in both eyes, at least normal binocular visual field with a horizontal diameter of at least 140°. In particular the central visual field must be normal up to 30°. In total the visual field of each eye should be examined at no less than 100 points. Should unclear defects be identified or doubt arise as to whether the minimum requirements are fulfilled then manual re-examination using a Goldmann-type perimeter with isopter III/4 must be performed."

According to Appendix 6 Section 3 for previous holders of all driving licence classes (acquisition before 31st December 1998) the old Appendix XVII to *StVZO* now applies once more. For classes 1, 1a, 1b, 3, 4 and 5 a *"normal visual field in one eye or an equivalent binocular visual field"* is required; for class 2 and public passenger chauffeur licences *"normal fields of view in both eyes"* are required. Requirement of a normal visual field in both eyes is excessive. We recommend consulting the current requirements laid out in Appendix 6 to DLO Section 2.2.2 when making assessments.

Recommendation of the DOG

For driving licence classes A, A1, A2, B, BE, AM, L and T a normal visual field in one eye or an equivalent binocular visual field is required, i.e. the binocular visual field must extend at least as far as a normal monocular visual field. For driving licence classes C, C1, CE, C1E, D, D1, DE, D1E and a public passenger chauffeur licence a normal visual field in one eye or at least a normal binocular visual field is required.

The central visual field up to 30° and the horizontal periphery must be tested particularly rigorously since the information most crucial for drivers is gained from this area. Minor impairment in the upper and lower external peripheries need not be evaluated as rigorously. In cases of visual field defects caused by visual pathway lesions the following supplements must be heeded:

1. Homonymous hemianopsia

The central 20° of the visual field must have normal sensitivity preserved in all directions. In the defective hemifield the horizontal area up to an eccentricity of 30° must be intact, in particular in the area extending 10° above and 10° below the horizontal median. The other hemifield must be completely normal. In such special cases the ophthalmologist must also ascertain sufficient driving fitness in road traffic on the part of the subject (for example by asking for number of years of accident-free driving, third-party interview). These recommendations do not hold for driving licence classes C and D or for a public passenger chauffeur licence. In case of doubt a special driving test can be considered.

2. Bitemporal hemianopsia

As long as a patient with a bitemporal hemianopsia exhibits stable fusion with binocular vision preserved one can assume that he is fit for a class-B driving licence (but not for class-C and -D licences and not for a public passenger chauffeur licence). Even in cases where fusion is only temporarily interrupted, the patient will only be able to see with one hemianopic visual field remnant, which means he will have central visual field loss or see double images. This constitutes a lack of driving fitness. Should the primary disease be progressive, ophthalmic check-ups at short intervals are necessary or no driving licence should be granted.

Appendix 6 1.2.2 Visual field requirements for Classes A, A1, A2, B, BE, AM, L and T

A normal visual field in one eye or a comparable binocular visual field with a horizontal diameter of at least 120 degrees; in particular the central visual field must be normal up to 20 degrees. In total the visual field of each eye must be tested in at least 100 points. If unclear defects are detected or doubts arise as to whether the minimum requirements are met, reassessment using a Goldmann-type manual perimeter and test stimulus III/4 is to be performed.

Appendix 6 2.1.2 Visual field requirements for classes C, C1, CE, C1E, D, D1, DE,D1E and public passenger chauffeur licences

Normal visual field, tested using an automatic hemispheric perimeter which examines the visual field up to 70 degrees to either side and up to 30 degrees upwards and downwards using a supra-threshold testing method. In total the visual field of each eye must be tested in at least 100 points. Alternatively the test can be performed using a manual Goldmann-type perimeter with at least four test stimuli (e.g. III/4, I/4, I/2 and I/1) in at least 12 points per test stimuli.

Appendix 6 2.2 Ophthalmic examination

If the prerequisites for the examination described in 2.1 cannot be met without a doubt an ophthalmic examination is required in addition.

Normal visual field in both eyes, at least normal binocular visual field with a horizontal diameter of at least 140 degrees; in particular the central visual field up to 30 degrees must be normal. In total the visual field of each eye should be tested in at least 100 points. If unclear defects are detected or doubt arises as to whether the minimum requirements are met, reassessment using a manual Goldmann-type perimeter and test stimulus III/4 is required.

Annex 3 Visual standards for driving in UK

Original chapter by Simon Keightley, 2002
Revised by Andrew Elliott, April 2004
Revision date 2008

The minimum visual field for driving in the United Kingdom is defined by the DVLA which relies firstly on the 2nd European Directive from the European Union and secondly on advice from the Honorary Advisory Panel for Vision and Driving. The width requirement is statutory as UK has adopted the 2nd EC Directive which specified this. If the standard is not achieved the applicant is considered by the Road Traffic Act 1988, to have a "relevant disability" and will not be permitted to hold a driving licence.

Group 1 drivers

The visual standard for ordinary driving is currently defined as "a field of at least 120° on the horizontal measured using the Goldmann III4e setting or the equivalent. In addition there should be no significant defect in the binocular field which encroaches within 20° of fixation either above or below the horizontal meridian." This means that homonymous or bitemporal defects which come close to fixation whether hemianopic or quadrantanopic are not usually accepted for safe driving.

Previously, any defect in the central 20 degree area was considered debarring because of the importance of the central areas in identifying detail. However, following challenges made as to the definition of a 'significant' defect, this requirement has been relaxed to allow a central defect of a size up to 3 adjoining points on the Esterman field. Full details are available in 'At a glance' (1).

Group 1 drivers who hold, or who have previously held full driving entitlement, who have a field defect which has been present for at least 12 months and which does **not** satisfy the standard, **can** be considered as exceptional cases on an individual basis, subject to strict criteria. The defect must have been caused by an event or non-progressive pathology (glaucoma and diabetic retinopathy including 'stable' lasered retinopathy are considered to be progressive) and there must be no other condition or pathology present, which is regarded as progressive and likely to be affecting the visual fields. In order to meet the requirements of European law, DVLA require confirmation of full functional adaptation, together with a satisfactory practical driving assessment, carried out at an approved assessment centre. Applicants for, or holders of, provisional licences, are not considered as exceptional cases.

The implementation of the 2nd EC Directive exceptionality clause was commenced in 2002. There is an ongoing trawl by the DVLA of drivers whose licences had been revoked between 1991 and 2002 to identify those who can be invited to apply for this exceptional consideration. This exercise is now nearing completion (as at February 2005). Ophthalmologists should inform patients if they come across any who may be in this category. For newly identified cases which may come into this category, the patient must be advised to notify DVLA as the licence must first be revoked. However ophthalmologists should inform their patients that they will then have the right to ask DVLA to consider them as an exceptional case. If DVLA agrees the patient will be invited to reapply. Interestingly it is becoming apparent that some of the applicants with major visual field defects do seem able to demonstrate adaptation and ability to drive safely, whilst others with similar defects are not.

Methods of testing

The DVLA now commonly requests visual field information from appointed optometrists. It is recommended that hospital eye units register with the DVLA to perform driving visual fields for their existing patients. This is to allow the hospital to gain further information regarding their patients and to permit the patient to perform the test in a familiar environment.

The binocular Esterman program (10dB) on the Humphrey visual field analyser is now the commonest method of testing (3, 4). Similar programs on Henson, Dyson and Medmont perimeters (only) are also acceptable. All fields must be of acceptable performance quality. Any automated test showing more than 20% of false positives is invalid and must be repeated. It is accepted that performance may improve with repeated attempts. For each test the best result from a maximum of *three* attempts will be used. It is helpful to indicate to DVLA if several attempts have been made, to avoid requests for the assessment to be further repeated.

The test may be performed with or without spectacles. It is recommended that spectacles be worn for the first attempt. Heavy frames and high ametropia, however, may restrict the peripheral field. The better visual field result will be accepted.

Bilateral uniocular central full-threshold testing alone is inadequate for the driving standard. However, these tests may be requested by the DVLA to help assess the depth and extent of the defect.

Some subjects may be unable to use an automated perimeter. In these circumstances the use of the Goldmann perimeter is acceptable. There should be accurate monitoring of fixation and adequate assessment of static points within the margins of the field using an experienced perimetrist. Older perimeters such as the Lister, Aimark or Priestley-Smith devices are not acceptable.

Visual Field Defects

Visual fields are required by the DVLA where a medical condition has produced a field defect in *both* eyes. This includes glaucoma, cerebrovascular accidents, bilateral laser treatment for retinopathies, retinitis pigmentosa and other congenital defects. Some of these situations are described below.

Homonymous neurological defects

Retro-chiasmal defects may prevent a complete 120° horizontal standard from being attained, and may also encroach within 20° of fixation. For the purposes of this standard, any field defect within 20° of fixation which is contiguous with a large homonymous defect is considered "significant" and will therefore fail the standard.

Some drivers may be discovered to have long standing defects only recently revealed by routine optometric visual field testing. These drivers may have been driving for many years and may even have passed the driving test with the defect. In these situations the DVLA may consider previous driving experience or commission a further driving test and grant a licence. Before this occurs, however, the DVLA must seek consultant ophthalmologist opinion requesting information regarding the likely aetiology and duration of the defect together with evidence that the medical condition is not progressive. On first notification of a debarring defect a licence will be revoked, as described above, unless there is clear evidence provided with the notification confirming that the defect was present before the driving test was passed.

Pituitary lesions

Lesions near the optic chiasm may give rise to bitemporal hemianopia. Esterman testing may produce a binocular field which extends to 120° by fusion of the left and right hemifields. In order to prevent the two halves of the visual field dissociating (hemislide phenomenon) there must be adequate input from both hemifields through at least one eye. Monocular Esterman testing using the full field binocular grid may be requested by the DVLA in these situations.

Glaucoma

Binocular field defects arising from advanced glaucoma are characteristically irregular and paracentral. An isolated scotoma within 20° of fixation is "significant" if it is large (for instance, if four or more adjacent Esterman spots are missed.

Diabetic Retinopathy and Laser Treatment

Bilateral diabetic maculopathy or focal laser treatment of it may cause a bilateral central field defect. In addition, substantial peripheral retinal ablation often causes patchy, inconsistent visual field performance. Four or more adjacent spots missed in the central 20° area or the inability to achieve an uninterrupted 120° horizontal field on a binocular Esterman test is unacceptable for driving. The exceptionality rules do not apply because the pathology is considered to be progressive (5).

It should be part of the informed consent to point out to the patient that although laser treatment is essential to prevent or slow down the progression of their disease, it *may* itself jeopardise their ability to drive

Monocularity

For Group 1 drivers, monocularity is defined as having no perception of light in one eye. Monocularity is not a bar to a Group 1 driving licence if the field standard is achieved i.e. there is no field defect secondary to pathology. A normal blind spot may be recorded as up to two missed spots within the central 20° of a binocular Esterman test but it is not regarded as "significant" in this situation. Note that the definition of monocularity is important as the visual field standard is tougher in this eventuality.

Group 2 drivers

The european Directive requires a *normal binocular field of vision* for Group 2 drivers i.e. a field defect in one eye is permissible only if it is totally compensated for by the field of the other eye. Monocular grandfather rights are only allowed when a Group 2 licence holder has been licensed in the knowledge of monocularity prior to 1/1/1991. For all other Group 2 licence holders the entitlement is removed if monocularity develops. For Group 2 purposes an acuity of <3/60 in one eye is regarded as rendering the driver functionally monocular. Unlike the situation that exists for exceptional cases to be considered for Group 1 licences, there are no exceptional cases allowed for Group 2 licences. As the Esterman test is recognised as a lenient test, the Group 2 driver should be able to achieve a completely full binocular visual field.

Annex 4 Humphrey functional test

HFA2 User manual, 2012

Much like the Snellen scale for central acuity, the Esterman scale is especially useful for evaluating visual capability or disability in industry, law, and government (workers' compensation, motor vehicle, aviation, and military). The Esterman test is listed as an option for many disability screenings.

The Esterman test scores are based on a relative value scale, which is divided into unequal units of 100 for monocular tests and 120 for binocular tests. Each unit is equated to one test point and is given a value of 1% in the monocular field and 0.83% in the binocular field. The inequality in the size and distribution of the units, with greater unit density in more important areas, makes the scale functional. The HFA II-i automatically yields the functional score as a percentage and prints it in the lower corner of the printout.

Monocular tests incorporate 100 points and extend 75 degrees temporally and 60 degrees nasally. Binocular tests incorporate 120 points and extend 150 degrees bitemporally. Each stimulus duration is 400 milliseconds with a single intensity Goldmann stimulus of III 4 E (10 dB). These settings have been standardized by international agreement and may not be altered by the user. You may only change the test speed.

No Trial Lenses Required for Esterman Monocular/Binocular Tests

This test is used to assess the level of a patient's functional visual disability. The Esterman tests are designed to be done using a patient's everyday correction. If the patient does not require glasses to function normally, perform the test without correction. If the patient does wear glasses to function normally, perform the monocular or binocular test using the patient's glasses. Do not use trial lenses. You still must use the eye patch when testing with the Monocular version of the Esterman test.

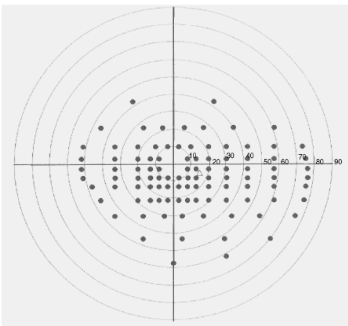

Figure F.21 Esterman Monocular Test Pattern, Right Eye

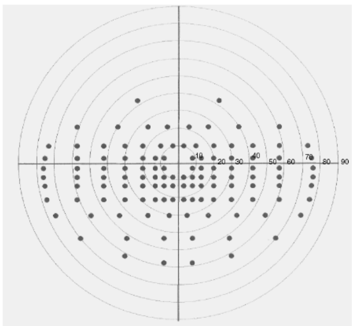

Figure F.22 Esterman Binocular Test Pattern

Annex 5 Requirements of ISO 12866

Table 1 — Requirements for stimulus presentation

Criteria	Tolerances	Test method according to
Background luminance, L_B	+25 %/−20 % of specified value	5.1
Contrast, $\Delta L/L_B$	+25 %/−20 % of specified value	5.1, 5.2
Stimulus location	within 0,5° of specified location for stimuli within 10° of the centre, within 1° for stimuli between 10° and 30° of the centre, within 2° for stimuli beyond 30°	5.3
Stimulus size	+20 %/−15 % of the specified value converted to solid angle	5.4
Stimulus duration	+/−20 % of specified value	5.6
Extent of background	not less than 2° beyond the edge of the most peripheral stimulus	

Table 2 — Minimum test stimulus pattern extension

	Central field Φ	Midperipheral field Φ	Full field Φ
Nasal	25°	40°	45°
Temporal	25°	50°	70°
Superior	25°	40°	45°
Inferior	25°	50°	60°

Table 3 — Minimum total number of potential stimulus locations

Eccentricity Φ	Central-field instrument	Midperipheral field instrument	Full-field instrument
0° to 25°	60	60	60
> 25° to 50°		30	30
> 50° to 70°			15
Total locations	60	90	105

Table 4 — Test locations and stimulus values

Azimuth Θ	Eccentricity Φ	Stimulus size	Stimulus luminance
0°	15° and 40°	III	10 dB and 20 dB
45°	15° and 40°	III	10 dB and 20 dB
90°	2°	all available	0 dB to 20 dB in steps of 5 dB 22 dB to 30 dB in steps of 2 dB 31 dB to a luminance equal to 0,1 L_B (measured with background equal to zero) in steps of 1 dB
90°	15° and 40°	III	10 dB and 20 dB
135°	15° and 40°	III	10 dB and 20 dB
180°	15° and 40°	III	10 dB and 20 dB
225°	15° and 40°	III	10 dB and 20 dB
270°	15° and 40°	III	10 dB and 20 dB
315°	15° and 40°	III	10 dB and 20 dB

NOTE Perimeters which are designed to measure only in the central field need only be checked at the Φ = 15° locations. If a size III stimulus is not available, the stimulus size nearest to a size III stimulus shall be used.