IMAGING *and*
PERIMETRY
SOCIETY

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PREFACE

In 1978, the Perimetric Standards and Perimetric Glossary of the International Council of Ophthalmology was developed and published by the IPS Research Group on Standards chaired by Jay M. Enoch. In 1990, this work was extended by the IPS Perimetric Standards, First Codicil. In 1994, the IPS determined that a further update was required. This update has evolved over a series of meetings from 1995 onward. Initially the intent of the document was to provide definitions and recommendations for the application of **differential light sensitivity (DLS) perimetry** (see Appendix I for glossary of terms), which covered most applications of perimetry to clinical practice at that time. Since then, however, perimetric instrumentation has evolved considerably to include many other forms of perimetry, some of which are now used in clinical practice. Many more are in use in the research environment. As a result, the intent of this document has been widened to include recommendations that can be generalized to apply to all types of perimetry, as well as providing an updated set of definitions and recommendations that refer primarily to differential light sensitivity perimetry.

Parallel to the development of perimetry standards published by the IPS, in 1991, the International Organization for Standardization (ISO) decided to formulate an industry standard for perimeters (ISO/TC 172/SC7). This standard (ISO 12866:1999) http://www.iso.org/iso/ defines the minimal requirements for manufacturers of differential light sensitivity perimeters. Because this standard is confined to DLS perimeters, rather than perimetry in general, it was deemed necessary to develop this codicil as a more complete guideline for the clinical and scientific application of any type of perimetry.

SCOPE

The purpose of this codicil is to set out standards, recommendations, and requirements for application of perimetry in clinical practice and scientific study. It is written for all individuals involved in perimetry, including clinicians, scientists, and manufacturers.

The codicil covers perimetric uses, implementation, psychophysics, examination strategies, stimulus characteristics, data analysis, test administration and interpretation. It is not concerned with the specification of instrument tolerances and the methods for testing such tolerances for differential light sensitivity perimeters, which is covered by the ISO (ISO 12866:1999).

Once approved by the Standards Group and by the Board of the IPS, the codicil will remain in force until revised by the IPS. It replaces the IPS Perimetric Standards, 1978 and the IPS Perimetric Standards First Codicil, 1990. This second codicil shall be reviewed every four years and either reaffirmed, modified, or replaced.

All correspondence concerning this codicil should be directed to the Secretary of the International Perimetric Society.

INTRODUCTION

The **visual field** is that portion of the external environment from which an observer can obtain visual information when fixating. The size of the measured visual field depends on the characteristics of the stimuli, the measurement conditions, and the **response criteria** of the observer.

Perimetry is the technique used to measure the extent of the visual field or to assess the **sensitivity** of the visual system to stimuli presented within the visual field. When the stimuli are presented on a flat surface, the technique is sometimes referred to as **campimetry**, which in this document will be regarded as a form of perimetry.

INDICATIONS FOR PERIMETRY

Suprathreshold tests are designed to efficiently evaluate visual field status and are used for **screening** purposes and on subjects who are inexperienced or incapable of taking detailed visual field examinations. **Suprathreshold static** or **kinetic perimetry** techniques are usually employed in these instances since the procedures should be easy to perform. With suprathreshold (static) strategies, the stimulus intensities are set a specified interval above an expected **threshold** level.

Quantification of visual field loss is performed using threshold tests. The test patterns should have adequate **spatial resolution** to permit the characterization of the visual field deficits. **Threshold** strategies estimate the sensitivity at each test location. Threshold strategies include staircase algorithms as well as other techniques based on **Bayesian** statistics.

Follow up testing procedures are designed to detect change. Provisions need to be made to allow the practitioner to compare visual fields over time.

Vision standards assessments are required to determine if an individual meets a specific level of visual capability. For disability and occupational standards, assessments of **binocular** measures of peripheral vision are often necessary. Testing procedures and patterns for binocular testing should be available. Methods that depend on attention and cognitive function may also be useful.

PERIMETRIC TECHNIQUES

There are many different forms of perimetry that are currently in use as well as many different types of perimeters.

There are static as well as kinetic forms of DLS perimetry. In static perimetry, stationary stimuli are presented at different visual field locations and the intensity[1] of the stimuli is modified depending on the subject's responses. Kinetic perimetry uses stimuli of a defined

[1] “Intensity” refers to physical units of stimulus strength, such as magnitude of visibility (size, luminance, intensity)

intensity and size that are moved from areas of non-seeing towards seeing areas of the visual field.

Standard Automated static Perimetry (SAP) measures DLS, in which a stimulus of varying **luminance** is presented on a background of specified luminance**.** The technical requirements for the design of perimeters measuring differential light sensitivity are provided in Appendix II, and also in the International Standards Organization (ISO) standard for perimeters (ISO 12866:1999; http://www.iso.org/iso).

STIMULUS CHARACTERISTICS

In addition to DLS, other types of perimetry examine the sensitivity across the visual field with spatial, temporal and chromatic variations of the stimulus. For example, **contrast** sensitivity, flicker, **motion**, and colour stimuli are used to quantify the visual field. Such stimuli can be presented with or without prior **cueing**.

In static perimetry stimulus locations are chosen to estimate the distribution of sensitivity across the visual field. The examined portion of the visual field is often confined to the central 30°. In certain situations, other regions of the visual field may be selected (macular and more peripheral visual fields). The spatial resolution is determined by the spatial arrangement (grid) of test locations. The grid of test locations preferably respects physiological zones of interest such as the vertical meridian or the nasal part of the horizontal meridian, which corresponds to its anatomical correlate, the temporal horizontal raphe of the retinal fiber nerve layer.

The **background luminance** provides a constant state of adaptation. Standard Automated Perimetry uses background luminances in the range of 1-10 cd/m^2.

In perimetry, **stimulus intensity** (based on e.g. luminance**,** size**,** contrast**,** motion **or vernier displacement, density, temporal frequency**) is usually defined on a logarithmic and instrument-dependent scale in **decibel** [**dB**] units. Spatial characteristics (e.g. stimulus size and **spatial frequency**) are expressed in degrees [º] of **visual angle**. Temporal characteristics (stimulus duration, on- and offset ramps, temporal modulation) need to be described in terms of waveform, duration [ms], and **frequency** [Hz or cycles/degree].

TEST ADMINISTRATION

There are many factors involved in achieving a reliable and valid test. The manufacturer's instructions for proper test performance should be followed and must be clear and explicit. Devices should be easily calibrated or self-calibrating.

It is critical that **room lighting** be at the level recommended by the manufacturer and should be constant throughout the test. Any external incidence of light into the cupola should be strictly avoided. The subject should be given sufficient time to adjust to the ambient lighting conditions.

PREPARING THE PATIENT

It is important that the test be fully explained and that the patient understands the purpose and process of the examination. A demonstration program can provide the practice to

better understand the test and lessen learning effects. An often overlooked source of poor test results are insufficient instructions to the patient. Large differences in sensitivity can occur with seemingly small differences in instruction sets. Most perimeter manuals provide appropriate recommendations for a standard instruction set. Use of these instructions will improve consistency of results. Instructions should be adjusted for patients that appear to have inappropriate response criteria (e.g. a large proportion of **false positive** or **false negative** responses, see below).

With rare exception it is important that the individual's appropriate (thin-rimmed) **refractive correction** be in place for the test distance when examining the central visual field within an eccentricities out to 30 degrees. A refinement can be made at the perimeter device. No glass correction is used for examination of the visual field beyond an **eccentricity** of 30 degrees.

The type of **occlusion** device for patching the non-test eye should correspond to that recommended by the perimeter's manufacturer.

If the **pupil size** is smaller than the minimum specified by the manufacturer, pupil dilation should be performed. If the pupil has been dilated, lens correction should be adjusted accordingly.

Many **perimetric artifacts** can occur due to misalignment of the head and eye. The subject should be alert, fixating, and properly aligned with regard to visual axis, brow and lens. Eyelids that interfere with the visual field can be taped open; in this case adequate artificial tears have to be provided. It is important to monitor alignment and lid position throughout the test.

Perimetry is done by the perimetrist not the perimeter. It is important that the patient is monitored throughout the test, and that realignment, rest breaks, reinstruction, and reassurance be provided if necessary.

Reliability indices (subject response indices) are used to estimate how closely a patient complies with the instructions provided. However, the rate of false positive and false negative responses, and responses to **fixation loss trials** have all been shown to have limited utility for judging the reliability of the test result.

Fixation monitoring, using **gaze tracking** or **blindspot checking** (e.g. the **Heijl/Krakau method**) and/or subjective evaluation of **fixation**, can provide valuable information on patient performance and their understanding of the test. Poor fixation, misalignment, ptosis, rapid blinking, tear film irregularities and pupil constriction can be detected. Perimetrists should note their impression of the patient’s cooperation, reliability and level of attention.

DATA DISPLAY

The general data display shall contain the type and serial number of instrument and software version, examination date and time, options for the patient name(s) and identification number, date of birth, eye examined, refractive correction, pupil size, details of the examination program and the specifications of the stimulus parameters, the perimetrist’s identity and any comment. Following is additional information usually provided

on printouts from standard DLS perimetry. Other forms of perimetry should include these where appropriate.

Subject response indices ("reliability indices") shall contain the accessible information concerning the integrity of fixation, the proportion of false-negative and false-positive responses, number of stimulus presentations, total test time and an indicator of within-test variability of response, if available.

In static perimetry, the **numerical display** shall contain the sensitivity (or size or contrast level) at each stimulus location and the corresponding deviation at each/all location(s) from the age-related normal value(s) arranged to reflect the topographical representation of the visual field.

Sensitivity values may be displayed in shades of grey (**grey scale**) or colours, explained by a key on the plot. Non-interpolated grey scales are preferred, but if interpolations are used the specific methods for this need to be stated (the location of the stimuli should be documented in the greyscale plot).

The results from kinetic perimetry are displayed as a series of iso-sensitivity borders (**isopters**). The depth and extent of localized depressions shall be made visible.

STATISTICAL ANALYSIS

The results should also be compared to an appropriate dataset of healthy subjects. Global and local characteristics of the (static) visual field can be summarized into a series of **visual field indices**. An index of the overall function is given by a mean value across all test locations, and an index of localised perturbation is given by the variance or standard deviation of values. A topographical representation of the statistical visual field abnormality is provided by **probability plots**. These plots compare the subject's results, at each test location, to the distribution found in a healthy sample. The plots may (e.g. the **pattern deviation** plot] or may not (e.g. the total deviation plot) be corrected for general sensitivity loss due to refractive media opacity, reduced pupil size etc.[2] Other useful methods to represent the visual fields include the **cumulative defect curve** ("**Bebie curve**") and **boxplot** displays.

Analyses of a series of visual fields of the same eye can help to distinguish real change from random variability. Such analyses can be local (separate for each test location), sectoral (on groups of test locations) or global (visual field indices). Learning and aging effects as well as changes in test variables should be considered. Details of the methodology for each statistical procedure should be specified.

Any perimeter should be able to export and import digital data in one or more universal formats (ASCII, comma-delimited text file, XML). This committee endorses the Digital Imaging and Communications in Medicine (DICOM) standard (http://medical.nema.org/).

[2] The age range and size of the sample, together with the detailed methodology (including subject recruitment and perimetric experience) for acquisition of the normative database should be provided by the manufacturer of the perimeter.

INTERPRETATION OF VISUAL FIELD FINDINGS

Interpretation of visual fields requires an appreciation of the patient's medical history, an understanding of anatomy and pathology, knowledge of psychophysics and the relevant methods of statistical analysis and of potential artifacts, and the ability to synthesize this information. The interpretation should assign the **visual field defect** to a specific pattern and, in case of follow up, take a stand on deterioration, improvement or stability of the current visual field with respect to previous results. A number of tools described in this codicil are available to assist clinical decision-making.

Appendix I: IPS glossary of terms and definitions

Absolute (visual field) defect – no measurable vision left at the limits of the testing device

Artifacts – an abnormality in the visual field caused by anything other than physiologic abnormalities; some common artifacts in visual field testing include inexperience, poor reliability, short-term fluctuation, trial frame lens rim, edge artifact, prominent eyebrow, ptosis, fatigue, small pupil, incorrect refraction, incorrect fixation, and dim projector bulb

Bayesian – refers to methods in statistics named after the Reverend Thomas Bayes (c. 1702-1761), in particular, the use of prior probabilities, as opposed to frequency or proportion, coupled with current sample data, for estimation of the a posterior probability distribution from which all decisions and inferences are made.

Background luminance – the luminance of the background upon which the test stimuli are presented

Bebie curve –a more detailed method than the boxplot for displaying the magnitude of depressed locations on the visual field; deviations are plotted by rank order and the curve is equivalent to a cumulative frequency curve turned on its side (Reference: Bebie H, Flammer J, Bebie TH. Graefes Arch Clin Exp Ophthalmol 228:242-245, 1990)

Binocular visual field – the visual field of an individual with both eyes open

Blindspot checking – e.g. the Heijl-Krakau method of fixation monitoring (used in Humphrey perimeters) presents moderately bright stimuli periodically at the expected location of the physiologic blind spot; a patient should not respond when stimuli are presented here if they are fixating properly

Boxplot – display of the range values (e.g. total deviation) in a visual field test, showing the extreme range along with the median, 15^{th} and 85^{th} percentile values

Blur – spreading of the available light energy over a larger retinal area causing the edge of a stimulus to lose sharpness; improper refraction, lens opacities, and inability to form tears are common causes of blur

Campimetry – this term is used interchangeably with perimetry; an instrument for determining the visual field

Ceiling effect – when threshold data cannot take on a higher value due to limitation of the instrumentation

Contrast – the difference between the stimulus and background luminances defined as $(L_s – L_b)/L_b$, where L_s and L_b represent the luminance of the stimulus and background; referred to as Weber contrast

Corrected loss variance (CLV) – the loss variance is "corrected" to remove the effect of within test variability; CLV represents the measurement of the local nonuniformity of the

visual field corrected for within test variability**;** this is one of the global indices computed for the Octopus perimeter. The formula is given in Table 1.

Corrected pattern standard deviation (CPSD) –the pattern standard deviation (PSD) is "corrected" to remove the effect of within test variability: The formula is given in Table 1.

Cueing – a visual prompt at the fixation spot indicating the next phase, i.e., beginning a test trial

Cumulative defect curve – *see Bebie curve*

Differential light sensitivity (DLS) – ratio of the background luminance (LB) to the threshold differential luminance (DLT), DLS = LB/DLT, where the difference between the threshold stimulus luminance (LT) and the background luminance is DLT = LT – LB

Decibel (dB) – in perimetry, the intensity of a stimulus expressed as 0.1 log-unit of attenuation of the maximal available stimulus; the higher the dB, the dimmer the stimulus intensity

Diagnostic performance – for a good diagnostic performance, the test should correctly identify the proportion or percentage of those with a medical condition (sensitivity) and the proportion of normal individuals that do not have a medical condition (specificity)

Density – the spatial distance between test locations on the visual field

Dynamic range – range from the lowest to the highest threshold obtainable; different perimetric tests vary in dynamic range

Eccentricity – angle from fixation point to a position in the visual field measured in visual angle on the retina

Examination time – duration required to complete a perimetric test

False negative – in perimetry, when a patient fails to respond to a stimulus that is expected to be visible

False positive – in perimetry, when the patient responds to a stimulus that could not have been seen

Fixation – maintain gaze in a constant direction

Fixation loss trials – when the patient responds to a stimulus presented in the expected position of a physiologic blind spot (e.g. when using the Heijl-Krakau blindspot checking method with the Humphery Visual Field Analyzer)

Fixation monitoring – assessing the ability of the patient to maintain gaze by the experimenter's observation and/or methods such as the Heijl-Krakau blindspot checking method or gaze tracking with the Humphrey Visual Field Analyzer, or a pupil position monitoring device such as with the Octopus perimeter

Floor effects – when threshold data cannot take on a lower value due to instrument limitations

Gaze tracking – assessing the ability of the patient to maintain fixation throughout a visual field test; it is a type of eye tracking used in Humphrey Visual Field Analyzer

General height – a representative location in the most normal region of the field, chosen as the 7th location in rank ordering of total deviations; this threshold value at this location is associated with the effects of general depression and is used to convert total deviation to pattern deviation on the Humphrey Visual Field Analyzer

Grey scale – threshold sensitivity values displayed as shades of grey, smoothed with interpolated values between actual test locations

Isopters – a contour or boundary line of equal retinal sensitivity in the visual field; Goldmann kinetic perimetry may be used to generate isopters

Kinetic perimetry – uses a mobile stimulus moved by a perimetrist (such as in Goldmannn kinetic perimetry); semi-automated forms of kinetic perimetry are available on some perimeters, such as the Octopus

Loss variance (LV) – the local heterogeneity of a visual field defect; LV is small in visual fields with generalized damage; however, LV increases with the number and depth of localized scotomas; LV is a global index used in particular by the Octopus perimeter. The formula is given in Table 1.

Luminance – the amount of light that is emitted from a particular area, and falls within a given angle on the retina; the units are in candela per square meter (cd/m^2)

Mean defect (MD) – weighted average of the total deviation values in a visual field test; the more important and less variable deviations near the center of the field are weighted more than those at the edge. The formula is given in Table 1.

Mean sensitivity (MS) – the average of the threshold sensitivity values in a visual field test. The formula is given in Table 1.

Normative values – the measurements and visual field indices that have been calculated based on data from a cohort of normal individuals with specific demographic inclusion and exclusion criteria

Numerical display – the value in decibels (dB) is presented for each visual field test location on a visual field printout, which can be the absolute threshold, total deviation, or pattern deviation values

Occlusion – preventing light from entering the eye; typically an eye patch or instrument-based occluder is used to prevent the stimuli from being seen by the eye not being tested
Pattern deviation (PD) – the localized loss at each tested point, after the removal of the effects of any generalized loss; pattern deviation decibel (dB) values are the total deviation values minus the general height

Pattern standard deviation (PSD) – a global index that measures the degree to which the shape of the patient's measured field or hill of vision departs from the normal age-corrected reference field model; the value is expressed in decibels (dB). The formula is given in Table 1.

Perimetry – also known as the visual field test; a test that produces a map of the field of vision to check whether there is damage to any area within this map; perimetry is conducted within a defined range of eccentricities, usually within the central 30 degree radius from fixation

Pupil size – the opening within the iris that allows light to pass into the eye; the size changes with iris constriction and exposure in response to light, but also with medication and other factors

Probability plot – highlights locations where deviations exceed those found in fewer than 5%, 2%, 1%, or 0.5% of normal subjects for total and pattern deviation values

Refractive correction – lenses fixed before the eye to focus the stimulus optimally on the retina

Response criteria – in perimetry, a patient's bias in responding to the stimuli; it can be influenced by their motivation and expectation for detecting stimuli, as well as by instructions given to them

Retest variability – the difference in threshold measurements within one or between visual field tests; short-term variability usually refers to within a test and long-term refers to between test sessions.

Reliability indices (subject response indices) – estimators of patient compliance with test instructions that include measures of false positives, false negatives and fixation loss responses

Scatter – in perimetry, the distribution of light falling on the retina after contact with various anatomical features and ocular media

Scotoma – a depression in the visual field indicating reduced sensitivity in that area

Screening – tests that are designed to quickly detect a defect in the visual field; usually suprathreshold

Sensitivity – *a.* diagnostic sensitivity: proportion or percentage of those with a medical condition who are correctly identified by a diagnostic test; *b.* the patient's ability to perceive the stimulus relative the background, measured in dB

Spatial frequency – a unit of measurement that describes a stimulus by the number of cycles per degree of visual angle

Spatial resolution – a measure of how closely two stimuli can be and still be perceived as separate

Specificity – diagnostic specificity: proportion or percentage of normal individuals identified by a diagnostic test as not having a medical condition

STARD initiative - acronym for Standards for Reporting of Diagnostic Accuracy; a set of guidelines published in *Lancet*, vol 361, issue 9351, p 71; the objective of the STARD initiative is to improve the accuracy and completeness of reporting in studies of diagnostic

accuracy, to allow readers to assess the potential for bias in the study (internal validity) and to evaluate its generalizability (external validity)

Static perimetry – a systematic measurement of visual sensitivity within a prescribed area of the visual field; this is accomplished by keeping the size and location of targets constant and varying the brightness until threshold for the dimmest target the patient can see at each of the test locations is found

Stimulus intensity – a measure of the power emitted by a light source in a particular direction per unit solid angle, based on a standardized model of the sensitivity of the human eye; the standard unit of measure for perimetry is the apostilb

Suprathreshold – a stimulus at a predetermined intensity level above expected threshold that is presumed to be intense enough for a healthy eye to easily see; often used for screening

Temporal frequency – a measure of the number of repeating events (i.e., stimulus presentations) per unit time; defined as a number of cycles, or periods, per unit time (i.e. cycles per second)

Threshold – the intensity level of the just barely perceptible stimulus

Total deviation – the difference between a patient's threshold sensitivity and the age-corrected normal sensitivity from the perimeter's internal normative database at each tested location of the visual field

Visual field – the extent of vision with the eye fixed on a particular location; the normal field of vision for an eye extends approximately 60 degrees superiorly, 75 degrees inferiorly, 105 degrees temporally, and 60 degrees nasally from its center; the term visual field is often used interchangeably with perimetry, although most perimetry examinations are constricted to just a portion of the visual field

Visual field defect – a reduction in sensitivity within the visual field relative to normal age-matched sensitivity

Vernier displacement – the distance needed between two stimuli for both to be detected as separate stimuli

Visual angle – The angle a viewed object subtends on the retina; the angle is formed by drawing two lines from opposite edges of the viewed object to the resultant edges of its representation on the retina; the two lines cross within the eye about 7 mm behind the vertex of the cornea; the visual angle is the angle formed at this crossing.

Visual field indices – statistical values that summarize the static visual field globally and locally; examples are mean sensitivity, mean deviation, loss variance and pattern standard deviation

Appendix II: Standards for the evaluation of perimetric tests.

The **examination time** should be reported, including the time required to set-up the instrument and to instruct the patient.

Studies that evaluate new visual field tests in terms of **diagnostic performance** (**sensitivity** and **specificity**) should follow the guidelines set out by the **STARD initiative** (Standards for Reporting of Diagnostic Accuracy; Bossuyt & Reitsma, The STARD Initiative, *Lancet* Vol 361, issue 9351, p 71).

Normative values are often used to interpret the results of visual field tests (eg. probability maps, visual field indices). The demographic details of the reference dataset (number of subjects, age distribution) as well as enrollment and inclusion criteria should be clearly described along with the statistical methods used to derive the normative limits.

The **retest variability** (reliability) should be estimated for individual threshold estimates (pointwise analysis) as well as for any other indices of the visual field (eg. global indices) which the instrument provides.

The **dynamic range** of the instrument's stimulus scale, as well as any **floor-** and **ceiling effects** in the distribution of threshold estimates, should be estimated, either by comparison to established methods of perimetry (eg. Standard Automated Perimetry) and / or by quoting the difference between the mean or median threshold obtained in healthy observers and the upper limit of stimulus intensity.

It should be investigated how robust the test is to errors, for example those caused by optical degradation (**blur** and **scatter**) and suboptimal patient responses. Subject acceptance can be examined using questionnaires.

1 Collection of Perimetric Formulas

1.1 MS – Mean Sensitivity

$$MS = \frac{1}{m} \sum_{i=1}^{m} \overline{x}_i \tag{1}$$

Symbol	Meaning
$\overline{x}_i$	averaged local value for test location i[1]
m	number of tested locations (outside the blind spot)

Reference [2] (consistent with [4])

1.2 MD (Octopus) – Mean Defect

$$MD_{Octopus} = \frac{1}{m} \sum_{i=1}^{m} (z_i - \overline{x}_i) \tag{2}$$

Symbol	Meaning
z_i	age corrected normal value of test location i
$\overline{x}_i$	value of test location i (estimated as $\overline{x}$) if repeated measurements are available
m	number of tested locations (outside the blind spot)

Reference [3]

1.3 MD (HFA) - Mean Deviation

$$MD_{HFA} = \left[\frac{1}{m} \sum_{i=1}^{m} \frac{(x_i - z_i)}{S_{1i}^2} \right] : \left[\frac{1}{m} \sum_{i=1}^{m} \frac{1}{S_{1i}^2} \right] \tag{3}$$

Symbol	Meaning
S_{1i}^2	variance of the normal field measurement at location i
z_i	normal reference threshold at location i
x_i	measured threshold of test location i
m	number of tested locations (excluding the blind spot)

Reference [1]

[1] $\overline{x}_i = \frac{1}{n} \sum_{k=1}^{n} x_{ik}$, where x_{ik} is the k-th repetition at location i

1.4 LV (Octopus) - Loss Variance

$$LV = \frac{1}{m-1}\sum_{i=1}^{m}(z_i - \overline{x}_i - MD_{Octopus})^2 \tag{4}$$

Symbol	Meaning
$MD_{Octopus}$	Mean Defect as defined above
z_i	age corrected normal value of test location i
$\overline{x}_i$	value of test location i (estimated as $\overline{x}$) if repeated measurements are available
m	number of tested locations

Reference [4] (consistent with [3])

1.5 PSD (HFA) - Pattern Standard Deviation

$$PSD = \sqrt{\left[\frac{1}{m}\sum_{i=1}^{m} S_{1i}^2\right] * \left[\frac{1}{m-1}\sum_{i=1}^{m}\frac{(x_i - z_i - MD_{HFA})^2}{S_{1i}^2}\right]} \tag{5}$$

Symbol	Meaning
MD_{HFA}	Mean Deviation as defined above
S_{1i}^2	variance of the normal field measurement at location i
z_i	normal reference threshold at location i
x_i	measured threshold of test location i
m	number of tested locations (excluding the blind spot)

Reference [1]

1.6 SF (Octopus) - Short-term Fluctuation

$$SF_{Octopus} = \sqrt{\frac{1}{m}\sum_{i=1}^{m}\left(\frac{1}{n-1}\sum_{j=1}^{n}(x_{ij} - \overline{x}_i)^2\right)} = \sqrt{\frac{1}{m}\sum_{i=1}^{m} s_i^2} \tag{6}$$

Symbol	Meaning
x_{ij}	measured DLS value at location i in repetition j
$\overline{x}_i$	value of test location i (estimated as $\overline{x}$) if repeated measurements are available
n	number of repetitions
m	number of tested locations with short-term repetition

Reference [3](and [4])

1.7 SF (HFA) - Short-term Fluctuation

$$SF_{HFA} = \sqrt{\left[\frac{1}{10}\sum_{i=1}^{10} S_{2i}^2\right] * \left[\frac{1}{10}\sum_{i=1}^{10} \frac{(x_{i1} - x_{i2})^2}{2S_{2i}^2}\right]} \tag{7}$$

Symbol	Meaning
S_{2i}^2	normal intratest variance at location i
x_{i1}	measured threshold of test location i
x_{i2}	repeated measured threshold of test location i
10	fixed number of repeated test locations

Reference [1]

1.8 LF - Long-term Fluctuation

$$LF = \sqrt{\frac{1}{m}\sum_{i=1}^{m} s_i^2} \tag{8}$$

Symbol	Meaning
s_i^2	long-term variance for the measured location i
m	number of tested locations with long-term repetition

Reference [4]

1.9 CLV (Octopus) - Corrected Loss Variance

$$CLV = LV - \frac{1}{n} SF_{Octopus}^2 \tag{9}$$

Symbol	Meaning
LV	Loss Variance as defined above
$SF_Octopus$	Short-term Fluctuation as defined above for Octopus
n	number of repetitions

Reference [4] (consistent with [3])

1.10 CPSD (HFA) - Corrected Pattern Standard Deviation

$$CPSD = \begin{cases} 0 & PSD^2 \leq k * SF_{HFA}^2 \\ \sqrt{PSD^2 - k * SF_{HFA}^2} & PSD^2 > k * SF_{HFA}^2 \end{cases} \tag{10}$$

Symbol	Meaning
PSD	Pattern Standard Deviation as defined above
SF_{HFA}	Short-term Fluctuation as defined above for the HFA
k	$= 1.28$ for the 30-degree field $= 1.14$ for the 24-degree field

Reference [1]

References

[1] D.R.Anderson, V.M. Patella. **Automated Static Perimetry**, 2nd Edition, Mosby St. Louis, 1999

[2] J.Flammer. **The Concept of Visual Field Indices**, Graefe's Arch Clin Exp Ophthalmol , 224: 389 - 392, DOI: 10.1007/BF02173350, Springer Verlag Heidelberg, 1986

[3] J.Flammer, S.M. Drance, L. Augustiny, A. Funkhouser. **Quantification of Glaucomatous Visual Field Defects with Automated Perimetry**, Invest Ophthalmol Vis Sci. 1985, 26: 176-181

[4] U.Schiefer, J. Paetzold, B. Wabbels, F. Dannheim. **Konventionelle Perimetrie, Teil 4: Statische Perimetrie: Befundauswertung – Indizes – Verlaufskontrolle - Perimetrie im Kindesalter**, Der Ophthalmologe 103: S. 235 - 256, DOI: 10.1007/s00347-005-1304-5, Springer Medizin Verlag Heidelberg, 2006