

# Italian Journal of Ophthalmology

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*REPRINTS*

# Visual Acuity Measurement Standard

## CONSILIUM OPHTHALMOLOGICUM UNIVERSALE

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Unanimously approved by the Visual Functions Committee,  
Santa Margherita Ligure, Italy  
May 25, 1984  
Presented to the Consilium Ophthalmologicum Universale,  
Approved for Distribution Kos, Greece October 5, 1984

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#### PREFACE

This document has been prepared by the Visual Functions Committee of the International Council of Ophthalmology in consultation with the optometric profession. Since ophthalmologists and optometrists both measure visual acuity in a clinical setting, it is desirable that both follow the same standards. The guidelines included in this document, however, are not binding upon individual practitioners in either profession.

While this standard is written for practitioners, manufacturers need to provide the necessary materials. The Committee requests that manufacturers and designers of visual acuity tests adhere to the principles expressed in this document. This document expands on the earlier Recommendation on Visual Acuity Standardization of the International Council of Ophthalmology (Kyoto, 1978). The Committee will be pleased to consider questions and additional issues for the next review of this standard. Please refer to Section XIV regarding the review of this standard.

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## **PREAMBLE**

A.1 One of the most difficult questions encountered, when considering a clinical visual acuity standard, is to define what is being measured. The distinctions made between normal vision, visual impairment, visual disability, and visual handicap, are defined in the Recommendation on the Classification of Visual Performance (International Council of Ophthalmology, Kyoto, 1978) and in the International Classification of impairments, Disabilities and Handicaps (WHO, Geneva, 1980). Visual acuity is one of the important measurements used to assess these qualities.

A.1.1. Visual Impairment refers to the organ of vision. It indicates a limitation in one or more of its basic functions: visual acuity, field of vision, night vision, etc.

A.1.2. Visual Disability refers to the individual. It indicates a limitation of the ability to perform certain defined visual tasks such as reading, writing, orientation, mobility.

A.1.3. Disability in a socio-economic sense is often expressed as a percentage value. Various agencies may use different formulas in defining disability.

A.1.4. Visual Handicap refers to the individual's general functioning in the actual environment. It may indicate a lack of physical independence, lack of economic independence, or lack of social integration.

A.2. This document is limited to the clinical measurement of visual acuity. It does not cover the interpretation of these measurements. Even within these constraints, we encounter problems when we seek to relate clinical visual acuity measurements to data obtained in interference measures of resolution, to spatial frequency characteristics in contrast sensitivity functions, to visual evoked potential measures of acuity, to optokinetic drum readings, to preferential looking measurements, and many more. Test field size, retinal area tested, test luminance, pupil size, target contrast, as well as test format, prior experience with the material and the cognitive component, all influence the result. In the common clinical tests, additional complex issues enter into the measurement, including familiarity with letters and their forms, characteristics of type fonts employed (style, upper vs. lower case, use of serifs, etc.), interactions between neighboring stimuli (e.g., crowding effects of amblyopia), the effects of grouping letters in the word format, the emotional nature of certain words, etc.

A.3. A format broadly applicable to categorizing non-simple sensory responses (P. Fitts) is particularly useful in characterizing many of the tests of visual acuity. This format divides tests into four general categories. Each successive category has a higher cognitive component.

A.3.1. Detection measures: Do you see one or two objects, or breaks in the line? Is there a break in the ring? Do you see lines? etc. Objectively, one can determine whether the eyes follow when the grating was shifted to the left.

A.3.2. Descriptive measures: Which way does the break in the ring point? Which way do the fingers point? Which way are the lines pointing? Draw or describe the figure you see, etc.

A.3.3. Interpretive measures: What letter or number is it?

A.3.3.1. Recognition combines elements of description and interpretation.

A.3.4. Interactive measures: These involve interactions usually between elements used in interpretive measures. Do those letters form a word? What word is it? Are you familiar with that word or group of words? Does the word have special meaning for you, or does it evoke an emotional response? For example: in English, the following letter groupings have been shown to provide different "acuties": EPRA (nonsense), PRAE (old English), PARE (less common), REAP, PEAR (common), RAPE (emotional).

A.4. Different letters need not have equal probability of correct interpretation. For example, among the 26 letters used in English, there is only one letter which is a base-down triangle, the letter A. Thus, if the observer is guessing, the probability for its correct identification is certainly not 1:26. One need only sense the outline and not the internal fine structure.

A.5. Arguments have been advanced suggesting that the letters be white against a black back-ground. These arguments are countered by difficulties in controlling the clinical test room environment and because the more familiar reading format is favored. Further, light adaptation is best controlled using a white background at photopic stimulus levels.

A.6. Clinical visual acuity measurements are affected by uncorrected errors of refraction including astigmatism, spurious resolution, the presence of different types of amblyopia (e.g., meridional), cloudy media, the accuracy of fixation, etc.

A.7. Thus, the original question remains: what are we measuring? In the above framework, the optokinetic nystagmus tests measures detection, the illiterate "e" test determines a descriptive threshold, the familiar multi-letter chart provides an interpretative measure, and word recognition covers many aspects of the interactive level. Resolution and its measurement is a component of all clinical tests of visual acuity.

A.8. A reference test is considered necessary as a means of relating the many different test materials in use. One primary standard or reference test must be used to establish equivalence between many different optotypes. This equivalence, established through comparisons made in normal observers with limited refractive errors, may or may not extend to individuals with certain visual disorders. Such inconsistencies may, in specific cases, provide useful diagnostic information.

## **DISCUSSION OF PRINCIPLES**

### **B. Purpose of Measurement**

B.1. Clinical visual acuity may be measured in a variety of ways and for a variety of purposes. The underlying parameters of all types of visual acuity measurements are those of visual resolution. Visual resolution, as used in optics and visual science, refers to the ability to just detect a break in a line or the separation of parallel lines or points of light (minimum separable). This class of thresholds can be measured using short bars, Landolt rings, gratings or other targets.

B.1.1. In clinical measurements resolution capability is inferred, but the exact relationship may be at least partially obscured by the added, complex factors mentioned earlier.

B.2. Once measured, visual acuity findings must be interpreted. It is recognized that the intended interpretation of the measurement may influence the choice of measurement technique.

Some possible interpretations of visual acuity measurement include its use:

- (1) to aid the clinician during the course of refraction and to verify the optimal correction of refractive errors;
- (2) as a screening device (e.g., school tests) to suggest the presence or absence of ocular abnormalities;
- (3) to monitor the effects of disease, its course and/or its treatment;
- (4) to determine the visual aids needed for certain tasks for individuals with normal vision and for those with subnormal vision;
- (5) to estimate an individual's ability to perform a certain task (e.g., prior to issuance of a driver's license).

B.3. Interpretation, for whatever purpose, must always take place in the context of other findings; it cannot be done in isolation. This document is limited to the measurement of visual acuity in a clinical setting; it does not cover its interpretation. Whatever the application, it is desirable that the visual acuity measurement be as accurate, reliable and reproducible as is practical.

### **C. Certification and Licensing**

C.1. With regard to licensing requirements and job-related criteria, the responsibility of the eye-care practitioner is usually limited to the accurate measurement of visual acuity.

C.2. It is the responsibility of the licensing or appointing authority to evaluate these measurements.

C.3. It is desirable that the clinician specify the equipment used, and/or the conditions used for the measurement (if the latter are known) so that the licensing or appointing authority can judge the significance of that measurement. (The clinical office is ordinarily not equipped for fine specification of test conditions.)

#### D. Reference optotype

D.1. Since it is impractical and impossible to eliminate the diversity of letters, digits and other symbols used in visual acuity charts, it is desirable that all optotypes in a set be evaluated for equal recognizability and calibrated to a standard test object.

D.2. The Landolt Ring or Landolt 'C' (terms used interchangeably in the literature) is the most widely accepted reference optotype for use in the vision testing laboratory. It is an interrupted circle whose stroke width and gap width are one-fifth of its outer diameter. The two borders of the break in the ring should be parallel and there should be no serifs. Its major advantage is that it contains only one, easily measured, element of critical detail which represents the only difference between its various presentations (usually 4 or 8 orientations).

D.3. The Landolt ring can be used as a four-position test or as an eight-position test. Arguments supporting an eight-position test include:

- (1) superior assessment of vision in different forms of astigmatism;
- (2) superior correlation with symbols having oblique components;
- (3) lower probability of false positive judgments. Arguments supporting the four-position test include:
  - (1) the test is simpler to explain to the patient and is easier to conduct;
  - (2) visual resolution in the oblique meridians in the normal observer is less than in the vertical and horizontal meridians;
  - (3) most astigmatism is with or against the rule;
  - (4) the four-position test has been shown to correlate better with tests using common clinical optotypes.

D.4. There is no absolute answer to this difference in approach. Therefore, the Committee accepts either option and encourages further research. This issue should be reconsidered at the time of review of this standard. The sample of observers chosen to participate in the tests for calibration of optotypes with the primary standard should exclude those with high astigmatic errors, high refractive errors, and reduced vision. The Committee tends to favor the four-position Landolt ring for the primary reference optotype and has written the standard accordingly.

#### E. Selection of Clinical Optotypes

E.1. The Landolt ring test tends to be poor for general clinical application for the following reasons: For single optotypes, if the break in the ring is presented in other than simple compass or clock directions, it is difficult for patients to describe the position of the break in the ring; lateralization problems may exist for some patients particularly children; if the patients are in doubt (and the "C" is a familiar letter in their alphabet), their bias may be towards stating that the break in the ring is to the right. When multiple optotypes are presented on a line, patients may confuse the tester by not starting at the beginning of the line or by reading backwards when forward reading is expected, or by losing their place and repeating a response. Communication errors such as these can lead to erroneously low estimates of visual acuity.

E.2. For clinical use, letters or numbers are more widely accepted. Their advantages include: (1) familiarity; (2) the tester may learn the chart by heart and can easily recognize sequence errors; (3) the patient requires minimal instruction. The most important disadvantage is that most letters contain multiple elements of critical detail which are not of the same size. For example: "elements of critical detail" that characterize a "V" are the slope of its sides and the triangular gap. What "element of critical detail" distinguishes a "T" from an "I"? Is it the stroke width of its horizontal bar, the length of half the bar or the length of the full bar? Inter-letter differences are much greater for some letter groups (e.g., A, O, T, V) than for others (e.g., B, R, S, H). Equal sizes of different letters and different letter designs, therefore, do not imply equal recognizability. The differences between optotype sets are compensated for by calibration against the established standard.

## **F. Selection of Chart Design**

F.1. When optotypes are arranged in a chart format, the spatial parameters of the chart design can significantly affect the visual acuity score obtained. This is especially important when there is reduced vision. It is well-known that in amblyopia visual acuity for single optotypes can be substantially better than visual acuity measured with the same optotypes in chart format. It has been shown that for a large and diverse low vision population, acuity measurements obtained from tests using reading material are usually significantly worse than the visual acuity measured with letter charts. Clearly, these issues and others discussed above must be carefully considered when optotypes are being arranged in the form of charts.

## **G. Selection of Calibration Procedures**

G.1. In the Visual Acuity Standard which follows, it is recommended that comparisons/ correlations be made using single optotypes. This approach is justified for presentation of individually projected or presented optotypes, or even for a small number of targets employed in a test instrument.

G.2. It is argued by some that this approach is time consuming and also that it is not exactly comparable to using a test chart format. Since targets are commonly presented in a multi-letter chart format, this clearly is a subject for careful research. The Committee calls on interested parties to conduct such research in order to determine the corrections needed to make the chart format and the single optotype format compatible. Pending such research the Committee supports the use of the single optotype format for the calibration procedure.

G.3. Research is also needed to determine whether the conditions used for testing with cathode ray tube displays and other display terminals are acceptable for visual acuity measurements. Similar consideration should be given to low-contrast charts.

## **H. Order of Testing and Non-Standard Tests**

H.1. When measuring visual acuity, it is often desirable to measure the worst of the two eyes first (if known), then the eye with the better acuity and, if indicated, then to evaluate binocular visual acuity. It is desirable to record entrance pupil size at the time of measurement. If vision is poor, it is often useful to evaluate visual acuity using an artificial pupil of small dimensions.

H.2. Presentation conditions other than those indicated in the standard are sometimes indicated for special testing. It is desirable that the use of non-standard test conditions be recorded with the test result. Special presentation conditions may include: unusual projection methods; response time limits; chromatic backgrounds; low contrast testing; testing at very low or very high luminance levels; testing with, single letters or with variable degrees of "crowding". Such special presentation conditions can be useful in identifying deficits that are peculiar to certain visual disorders.

## **VISUAL ACUITY MEASUREMENT STANDARD**

### **I. Purpose of the Standard**

I.1 The purpose of this document is to define a standardized method and standardized stimulus conditions for the clinical measurement of visual acuity at photopic levels with high contrast optotypes.

I.2 This standard, an international one, is intended to encourage increased uniformity in testing of visual acuity as part of the routine office ophthalmic examination. Considering the vast array of optotypes in use worldwide, as well as the diversity in methods of presentation, one must accept the fact that full compliance with an international visual acuity standard, however desirable, may be difficult to achieve and, if achieved, will only be achieved slowly.

## II. Definition of Clinical Visual Acuity

II.1 In visual science the term "visual acuity" refers to the ability of the visual system to resolve detail. A test of visual acuity is a measurement of that ability. The visual acuity score of an individual should express the reciprocal of the angular size of the critical detail within the smallest optotype that can be correctly recognized by that individual. The Landolt ring shall be the standard optotype, and the gap in the Landolt ring shall be taken as the critical detail.

II.2 "Clinical visual acuity", as measured in the routine office ophthalmic examination, is defined in this standard as a measurement of the ability to recognize black, high-contrast optotypes on a white background. This measurement is related to visual resolution, but the relationship is a very complex one. This issue is discussed in the Preamble and Discussion of Principles.

II.3 Other optotypes, which have been shown to be acceptable alternatives to the standard Landolt ring, often require a more sophisticated judgment than the simple detection of a gap or other critical element. The patient will utilize recognition and interpretation clues, based on familiarity with such elements as letters and digits; thus, the visual resolution threshold implied in letter recognition measurements is influenced by optotype familiarity (or lack thereof) and by recognition and interpretation skills.

## III. Reference Optotype

III. 1 The reference optotype is the Landolt ring, whose stroke width and gap width are one-fifth of the outer diameter of the ring. The borders on the gap of the Landolt ring shall be parallel and there shall be no serifs. Four separate optotype orientations: gap up, down, right and left are to be used for the standard test. (The eight-position Landolt ring alternative is discussed in the Discussion of Principles, Section D.)

III. 2 Landolt rings, although suitable as a primary standard, may not be the most practical for a clinical test. Other optotypes may be used for the clinical measurement of visual acuity. In order for alternative optotypes to be acceptable, chart designers or manufacturers should establish the equivalence of alternative optotypes to the Landolt ring by methods specified in Section XIII.

## IV. Specification of the Sizes of Optotypes

IV. 1 The size of each Landolt ring on a given chart should be specified in terms of the distance (in meters) at which the gap width of that ring subtends one minute of an arc (or the distance at which the external diameter of the ring subtends five minutes of an arc). The sizes of the rings on a given chart may also be specified in terms of the visual angle subtended at a specified distance.

IV.2 Clinical optotypes, calibrated in compliance with Section XIII of this document, are to be specified in terms of the distance (meters) at which the gap of the equivalent Landolt ring subtends one minute of the arc. The calibrated set of optotypes may have a dimension such as the overall height which is common to all the members of the set. In such a case, the size of this dimension will have a direct relationship to the gap width of the Landolt ring by a factor determined in the correlation procedure. This factor should be identified on the visual acuity chart. In the case of a set of optotypes where there is no dimension common to the different members of the set (e.g., "picture" optotypes for illiterate patients), the members of one group or row of a specified size must have the same relative sizes as a group or row of a different size. The size of any given group must be identified by a specified dimension of one particular member of the set.

IV.3 M-units are commonly used to indicate the relative size of optotypes. For Landolt rings, M-units express the distance (in meters) at which the outer diameter subtends 5 minutes of an arc. Thus, the outer diameter of a 1M Landolt ring subtends 5 minutes of an arc at 1 meter, and its gap width subtends 1 minute of an arc at that distance. For other optotypes, 1M should indicate equivalence to a 1M Landolt ring. Note: in Snellen's original writings the term 'D' is used to denote this value.

## **V. Progression and Range of Optotype Sizes**

V.1 It is recommended that:

(1) manufacturers and designers make charts with optotype sizes in steps of constant ratio (geometric progression); and that:

(2) this ratio is to be 1:10 0.1 or 1:1.2589.

This ratio is also referred to as 0.1 log unit (base 10). Each step in this progression represents approximately a 4:5 ratio, three steps represent approximately a 1:2, 10 steps represent a factor 10 exactly.

Use of the sizes given in Table I implements this principle for the case of Landolt rings. Table LA gives specifications for the design of a visual acuity chart with this progression. Table LB gives notations to designate the resulting letter sizes at three levels of accuracy; the first by precise specification, the second by close approximation (tolerance 1%), and the third by a less exact but still clinically acceptable approximation (tolerance 5%).

## **VI. Spacing of Optotypes**

VI. 1 It is desirable that constant space-to-optotype size ratios be maintained throughout the acuity chart so that the difficulty of the visual task is uniform at all measurement levels. Spacings should not be altered from uniformity in order to obtain an aesthetic alignment of the ends of the lines.

VI.2 The distance between adjacent optotypes on charts must not be less than the width of an optotype. In the interest of uniformity, an upper limit to the lateral spacing that is equal to twice the specified lower limit is suggested. The distance between lines must not be less than the height of the larger of the two lines of optotypes. Again, in the interest of uniformity, an upper limit to the vertical spacing that is equal to twice the specified lower limit is suggested. For families of optotypes that have non-uniform heights or widths, the above specification refers to the average heights and the average widths. It is desirable that further research be conducted on this question, and that this issue be reviewed at the time of the next revision.

VI. 3 Exceptions may be made because of the nature of certain optotypes' shape (Arabic, Chinese, Hebrew, etc.), and the desirability of projecting a single line of letters, using a fixed display area.

## **VII. Number of Optotypes for Each Size**

VII. 1 The presentation of optotypes from a given set should be as diversified as possible and should be randomly ordered. It is highly desirable that chart designers or manufacturers provide at least 5 optotype presentations of each size, to be displayed on a single line, if possible. This may not be practical in certain projection devices when testing with large letter sizes. If more than five letters are used, it may be desirable to use two lines.

## **VIII. Testing Distance**

VIII. 1 At this time there is no single uniformly accepted testing distance. A proposal is made which offers certain logical advantages. The Committee recommends careful consideration be given to this option for the reasons stated. Obviously, other commonly used far testing distances are accepted pending the development of a wider consensus.

VIII.2 It is suggested that the standard testing distance be 4 meters. Metric specification is desirable and preferred. Clinical testing at longer distances (e.g., 5 meters and 6 meters) is accepted. Mirror systems are accepted. Clarification follows below.

VIII.3 Neither a 4, nor a 5 or 6 meter testing distance represents true optical infinity. For refractive purposes, a 0.25 diopter negative correction added to the maximum plus or minimum minus refractive correction makes the patient's visual system optically conjugate with infinity when using a 4 m testing distance. Since most trial sets use 0.25 diopter lens steps, this is a useful property. Note: the dioptric difference between 4, 5 and 6 meters is small. Steps of 0.20 D (corresponding to 5 meters) and 0.167 D

(corresponding to 6 meters) are not available in trial lens sets. No implications about acceptable errors in refractive error determinations should be drawn from recommendations of any standard testing distance.

VIII.4 Six, five and four meters, and twenty feet have been used by different groups of practitioners, but few examining rooms are built for a 6-meter or 20-foot distance today.

VIII.5 A 4-meter 'far' test distance coupled with a 40 centimeter near test distance allows readily convertible and comparable 4/4 and 40/40 test size designations.

VIII.6 Licensing authorities requiring out-standing visual performance at far distances will have to consider whether the 4-meter testing distance (or other finite testing distances) satisfies their criteria for the determination of 'distance' visual acuity (see Section VIII.3.). It is desirable that the testing distance employed be specified (see Section C.3).

VIII.7 Testing at 1 meter can be particularly useful for low vision. It greatly extends the measurement range and yields a Snellen fraction with numerator 1 which is easily converted or compared to other values. Even shorter test distances may be needed for some low vision patients or for children. See Section XII.

VIII.8 For testing at intermediate and close distances, it is desirable that attention be given to matching the test distance and the refractive correction.

VIII.9 Whatever the test distance used, it is desirable that this distance be accurately measured and maintained to within a quarter of the step size used. For the recommended step size of 0.1 log unit (base 10), the tolerance would be +/- 0.025 log unit (approximately +/- 5%).

## **IX. Specification of the Measured Visual Acuity**

IX.1 Visual acuity is determined by establishing the smallest optotypes that can be identified correctly by the patient at a given observation distance. There are several alternative notations for indicating the visual acuity. Refer to Table II for a comparison of these notations.

### **Snellen Notation:**

IX.2 Visual acuity (V) can be written as a Snellen fraction (m/M) in which the numerator (m) indicates the test distance and the denominator (M) indicates the distance at which the gap of the equivalent Landolt ring subtends 1 minute of arc.

$$\frac{\text{m test distance in meters}}{\text{M letter size in M-units}}$$

IX.3 Some difficulties can occur when using projected charts that have assorted optotypes and variable magnification adjustable for different distances. The size notations on the chart may be in the form of Snellen fractions that are intended to represent the visual acuity for a standard testing distance. If a different testing distance is used, the magnification should be adjusted to provide equivalence. If the actual test distance differs from the standard test distance as labeled on the chart, it is desirable that the actual test distance be indicated (e.g., 4/8 equivalent, measured at 5 m).

### **Decimal Notation:**

IX.4 Decimal notation is the decimal expression of the Snellen fraction. It does not convey the actual test conditions since it eliminates reference to the test distance. By doing so it facilitates comparison between measurements made at different distances. Decimal visual acuity values should not be confused with disability estimates which are sometimes expressed as percentages. Visual Angle Notation: sometimes called Minimum Angle of Resolution or MAR)

IX.5 The visual angle (in minutes of an arc) subtended by the gap in the equivalent Landolt ring can be used to indicate visual acuity.

E.G., 4/4 equals a 1' angle or MAR = 1'; 4/8 equals 2', MAR = 2'; etc.

#### **Log MAR Notation:**

IX.6 Log MAR (Logarithm of the Minimum Angle of Resolution) refers to the logarithm (base 10) of the visual angle in minutes of arc of the gap in the equivalent Landolt ring optotype and can also be used to indicate visual acuity. Depending on the problem, this notation can be most useful when analyzing or graphically plotting visual acuity scores because equal linear steps on the Log MAR scale represent equal ratios in the standard size sequence.

#### **Determining Visual Acuity Scores**

IX.7 A line of optotypes is generally considered to have been read correctly when more than 50% (e.g., 3 of 5, 4 of 6, etc.) of the optotypes presented have been read correctly. The recorded acuity score shall identify the size of the smallest optotype that, according to this criterion, can be recognized, but it is desirable that this be qualified by indicating the fraction of optotypes that were missed at that size level, or the fraction of additional optotypes from the next smaller row that has been identified correctly. Consequently, scores may be recorded such as 4/8 +2of5', to indicate correct reading of the 8M optotypes at 4 meter and additional correct identification of two of five letters on the next smaller line.

IX.8 When patients achieve partial success at several different size levels, clinically it is most informative to record the exact responses.

#### **X. Light Adaptation, Luminance and Contrast**

X.1 It is desirable that the patient be allowed adequate time to light adapt to the test environment prior to the initiation of testing.

X.2 The optotypes provided by manufacturers are to be black on a white background where the luminance of the black optotypes should not exceed 15% of that of the white surrounding field.

Table I: Dimensions and notations for a series of Landolt ring optotypes designed for presentation at 4 meters.					
Table I.A Dimension to be Used for the Preparation of Landolt Rings for use at 4 m			Table I.B Notations to Designate Optotypes (In M-Units = distance in m at which gap subtends 1 min of arc)		
Size of Gap and Width of Stroke		Outer Diameter of Ring in mm	Precise M-unit (design value)	Approximate M-units for Clinical Use	
in min. of arc at 4m	In Millimeters			Preferred	Accepted
0.50	0.58	2.92	2.00	2.0	2
0.63	0.73	3.67	2.52	2.5	2.5
0.79	0.92	4.62	3.18	3.2	3
1.00	1.15	5.82	4.00	4.0	4
1.26	1.46	7.32	5.04	5.0	5
1.59	1.84	9.22	6.34	6.3	6
2.00	2.34	11.61	7.98	8.0	8
2.51	2.92	14.61	10.05	10.0	10
3.16	3.68	18.40	12.65	12.5	12
3.98	4.63	23.16	15.92	16	15
5.01	5.83	29.16	20.05	20	20
6.31	7.34	36.71	25.24	25	25
7.94	9.24	46.21	31.77	32	30
10.00	11.64	58.18	40.00	40	40

It is acceptable for the clinician to use approximate values when designating the sizes of optotypes on a chart. For this purpose a tolerance of 0.25 line equivalent (+/-0.025 log unit, base 10) (approx. 5%) is acceptable. The chart designer, however, should prepare the optotypes so that their dimensions follow the precisely specified geometric progression, rather than the approximate values used by the clinician. Accuracy within 0.1 line equivalent (+/-0.01 log unit, base 10) (approx. 2%) is required.

The materials used should minimize the degradation of contrast with aging of the chart, or of other equipment components. The white background on the commercially supplied chart should extend at least 1 degree beyond the array of optotypes.

X.3 It is difficult to establish a uniform test luminance standard between nations. (For example, the current recommended practice in the United States of America is to use a test luminance of 85 cd/m<sup>2</sup>. in the Federal Republic of Germany the level is 300 cd/m<sup>2</sup>, while in the United Kingdom a minimum of 120 cd/m<sup>2</sup> is employed, etc.).

For clinical purposes it is desirable that test chart luminance not be less than 80 cd/m<sup>2</sup>. It is desirable that the luminance level employed be specifiable. Relatively high luminance levels reduce the effects of modest variations in luminance. This is desirable for purposes of comparing visual acuity data obtained in different clinical settings. Relatively low luminance levels result in larger pupil sizes and reduced depth of field. This is desirable for refractive purposes.

X.4 It is desirable that tests be installed so that the effects of glare and reflections are minimized. For projected charts in particular, it is desirable that degradation of contrast by ambient light should be avoided or at least minimized.

X.5 In the presence of pathology, test conditions may have to be altered. Some patients need added light, others perform better with less light. Manufacturers should provide the practitioner with data on the expected luminance level for their product, as well as other calibration data. The ability to vary test conditions in a predictable and reproducible way is a desirable feature in a purchased device, i.e., it is desirable to be able to vary the test conditions, to repeat them and to specify the luminance conditions which were used. Manufacturers should also provide some practical guide to indicate when it is desirable to change the lamps or other components.

X.6 Other luminous conditions may be more appropriate when testing for specific vocational purposes.

## XI. Near Visual Acuity

XI.1 For an optimal comparison between distance and near visual acuity tests it is desirable that the test conditions, optotypes and chart design employed be the same. A desirable standard test distance is 40 cm, which provides easy correlation with a 4 m testing distance. Testing at other distances is accepted. It is desirable that the actual test distance be measured and specified in all instances.

XI.2 In order to best estimate a patient's reading and writing capabilities at a near distance the use of continuous text material is desirable. Such a test will not necessarily yield the same result as an individual letter test. The presence of paracentral scotomata or of hemianopic defects may interfere more with the reading of continuous text than it does with letter recognition. Moreover, the use of continuous text introduces additional cognitive issues as discussed earlier. Discrepancies between visual acuity measured using reading material and visual acuity measured using letter charts may have diagnostic value.

XI.3 Different styles of typeset print may not be equally legible even though the letters are the same size. There could be merit in assigning M-unit ratings to typeset print based on equivalence to the Landolt ring standard, following the same procedures as recommended for distance visual acuity test optotypes. However, the influence of variables such as type style, letter spacing and inter-line spacing make this impractical. Until common type faces are calibrated against Landolt rings, the Committee recommends that the M-rating of typeset material that contains few or no numbers or capital letters be based upon the distance at which the height of lower-case letters such as "o", "m", and "x" subtends 5 minutes of arc. Capital letters, numbers and letters with ascenders (such as "d") or descenders (such as "p") are not considered when assigning M-ratings.

XI.4 To specify the letter height of typeset materials in M-units the following approximations may be useful: 1M = 1.5 mm (actually 1.454), 1M = 1 / 16 inch (actually 0.92/16) or M-rating = mm size x 0.7 (actually 0.69).

XI.5 M-units (or a similarly calibrated rating) Can be used in combination with the testing distance to express near visual acuity as a Snellen fraction. For example, 0.40/1 (in meters) or 40/ 100 (in centimeters) indicates the ability to read 1M print at 40 cm and would be equivalent to a distance visual acuity (measured at 4 m) of 4/ 10. For normally sighted patients there usually will be good concordance between distance visual acuity as measured with a letter chart and reading visual acuity measured with typeset material.

## XII. Visual Acuity Measurement in the Low Vision Range

XII.1 1 Many practitioners record only a visual acuity estimate, such as "hand movements" or "count fingers" when visual acuity is too low to be measured on the usual distance chart. This is not desirable. That is, meaningful visual acuity measurements in the low vision range can be made down to at least the 1/60 level. Below this level the macular area generally ceases to function and visual performance is often better characterized by visual field parameters and eccentric viewing skills than by a visual acuity value. In the lowest range, it is more desirable to use notations such as "hand motion, full field" / "hand motion in restricted field" / "light perception with projection" / "light perception, false projection" / "no reliable light perception", etc.

XII.2 Measurements to the 1/60 level can be made by using any existing chart with letter sizes up to 60 M at a 1 m distance. It is desirable to give the presbyopic patient 1 diopter over the distance correction. Where commonly used distance charts have only one or two letters on the largest lines (see Section VII), testing at 1 m can increase the accuracy of visual acuity measurement by providing added letters per line.

XII.3 Table III shows the full range of visual acuity values in the recommended step size of 0.1 log unit from normal vision to near blindness. A geometric progression as recommended in this document can cover this entire range; a single linear progression cannot conveniently cover this large a range.

XII.3.1 The left-hand section of the table specifies the Classification of Visual Performance, used by WHO in the International Classification of Diseases (ICD-9) and recommended by the International Council of Ophthalmology (Kyoto, 1978).

Table II: Conversion of different visual acuity notations.

Snellen Notation indicating measurement at:				Decimal notation (independent of test distance)	Visual Angle (independent of test distance)	Log MAR
6 m	5 m	4 m	20 ft			
see Section: IX.2				IX.4	IX.5	IX.6
6/3.0	5/ 2.5	4/ 2.0	20/ 10.0	2.00	0.50	- 0.3
6/3.8	5/ 3.2	4/ 2.5	20/ 12.5	1.60	0.63	- 0.2
6/4.8	5/ 4.0	4/ 3.2	20/ 16	1.25	0.80	- 0.1
6/6.0	5/ 5.0	4/ 4.0	20/ 20	1.00	1.00	0.0
6/7.5	5/ 6.3	4/ 5.0	20/ 25	0.80	1.25	+ 0.1
6/9.5	5/ 8.0	4/ 6.3	20/ 32	0.63	1.6	+ 0.2
6/12	5/10.0	4/ 8.0	20/ 40	0.50	2.0	+ 0.3
6/15	5/12.5	4/10.0	20/ 50	0.40	2.5	+ 0.4
6/19	5/16	4/12.5	20/ 63	0.32	3.2	+ 0.5
6/24	5/20	4/16	20/ 80	0.25	4.0	+ 0.6
6/30	5/25	4/20	20/100	0.20	5.0	+ 0.7
6/38	5/32	4/25	20/125	0.16	6.3	+ 0.8
6/48	5/40	4/32	20/160	0.125	8.0	+ 0.9
6/60	5/50	4/40	20/200	0.10	10.0	+ 1.0
6/75	5/63	4/50	20/250	0.08	12.5	+ 1.1
6/95	5/80	4/63	20/320	0.06	16.0	+ 1.2
6/120	5/100	4/80	20/400	0.05	20.0	+ 1.3

The above scales are based on the geometric progression recommended in Section V. The constant ratio between lines is 1:10 0.1 or 1:2589. This progression provides several advantages:

(a) Ease of calculation. Each step represents a 4:5 ratio, three steps represent a 1:2 ratio, 30 steps represent a factor 10.

(b) Ease of use at different distances. If distance values based on this progression are used (such as: 1, 2, 4, 5, 10, 20), the same values reoccur with only a shift of one more positions. The value '6' does not appear in this progression and consequently yields different values (see column 1 of this table). The value '6.3' (see Table III, center section) does yield consistent values.

(c) Ease of conversion. Most of the commonly used test distances and letter sizes appear within this sequence. Exceptions are the decimal visual acuity values: 0.7 and 0.9 and the Snellen fraction: 20/70. These values represent half steps.

(d) This scale is consistent with the Classification of Visual Performance as shown in Table III, left section.

Values in this table (except the Log MAR series) have been rounded to the preferred clinical approximations indicated in Table I, B column 2. For clinical record keeping further rounding within 0.25 of a step (as in Table I, Bm column 3) may be accepted. For this purpose only, '6.3' may be rounded and recorded as '6'.

The first column indicates the three ranges: Normal Vision, Low Vision, and Blindness, that have replaced the dichotomy of legally seeing / legally blind. The second column provides a further division in seven ranges, useful for clinical statistics. The third column indicates how each of these ranges corresponds to four lines on a clinical visual acuity chart as recommended in this document. Decimal visual acuity notation is used in this column, since these values apply irrespective of test distance.

XII.3.2 The center section of the table illustrates the measuring ranges that can be obtained with a single test chart designed according to the recommended standard. If the test distances are varied according to the same rule, the same test values reoccur in shifted positions so that no new numeric values are needed. In this section of the table Snellen fractions are used, since it is desirable to indicate the distances at which the measurements were made. To be in compliance with the recommended ratios a test distance of 630 cm should be used for the '6 m' test distance; a 600 cm test distance represents a 5% deviation from the desired value.

XII.3.3 The right-hand section of the table indicates alternative visual acuity notations used in visual science: the visual angle subtended by the gap width of the Landolt ring and the Log MAR value derived from it. Strictly speaking, these values refer to characteristics of the Landolt ring. By

inference they may also be used to refer to optotypes calibrated in accordance with this standard. Like decimal notation, these values are independent of the distance at which the measurement was made.

XII.3. 4 Throughout this table the preferred approximations from Table I.B, Column 2 have been used. For clinical record-keeping (left and center section) the simpler approximations from Table I.B, Column 3 can also be accepted. For use in calculations (as in the right-hand section) and for chart design the values should not be rounded.

### **XIII. Calibration of Clinical Optotypes against the Reference Optotype**

This section is directed to designers and manufacturers of visual acuity tests.

#### **Purpose of Calibration**

XIII.1 The purpose of the calibration procedure is to establish the numeric correspondence between performance with the reference or standard optotype and performance with the clinical optotype. To this end, the relationship between optotype size and frequency of correct identification needs to be obtained for the reference optotype as well as for the optotypes under consideration (frequency of seeing curves).

#### **Optotype Sizes and Standard Optotype Grades**

XIII.2 Optotype sizes should be specified by the manufacturer as described in Section IV. Enough steps should be included to establish a frequency of seeing curve (see Section XIII.7).

XIII.3 For the different optotypes in a clinical test, evidence should be presented that they normally do not show large differences with respect to recognizability. (See also Section XI11.10).

#### **Test Area**

XIII.4 The comparison tests are to be performed using a circular test field with a 4-degree diameter. Its luminance shall be at least 160 cd/ m<sup>2</sup> and the value used should be specified by the manufacturer. The luminance shall be held to a value +/-10% of the selected value. It may be desirable that an artificial pupil be used, preferably of about 3 mm diameter.

XIII.5 The area surrounding the test field should have a diameter of approximately 15 degrees; it should not be brighter than the test field and should be homogeneous to the extent that it does not influence the measurement. The average luminance value employed should be specified by the manufacturer.

#### **Presentation of the Test Types**

XIII.6 In making a measurement of visual acuity with the 4-position Landolt ring, a sufficient number of presentations should be made in order to allow satisfactory statistical evaluation. (See Discussion of Principles, Section D. for the 8-position Landolt ring alternative). The test must be conducted one ring at a time. For successive presentations the ring positions are to be arranged in random order. The clinical: optotypes to be tested are similarly to be presented one at a time, in random order, until a series of presentations has been completed. In each series of presentations using the same set of optotypes each of the different optotypes in the set must be presented approximately the same number of times.

XIII.7 The range of sizes of Landolt Rings and comparison optotypes should include a size large enough to yield a frequency of seeing of virtually 100%. Measurements are to be made with both the Landolt rings and the optotypes (being investigated) of the same size. When this has been completed, the process is repeated with smaller and smaller sizes until the failure rate corresponds to the level of guessing. The sizes used must differ by a ratio of 1:10<sup>0.5</sup> (approximately 1:1.1222) or less, i.e., by a

difference of 0.05 log unit or smaller. Each optotype is to be exposed for no longer than 3 seconds with a judgment period of up to 4 seconds between exposures. In order to produce such fine gradations of optotype size, extended test distances may be used (10 meters or more).

XIII.8 The comparison tests are to be performed monocularly, using ten subjects without ocular pathology. The subjects shall be fully corrected; their visual acuity shall be 4/4 or better; their refractive error before correction shall not exceed +3.0 or -3.0 diopters spherical equivalent, with no more than 1 diopter of regular astigmatism.

### Assignment of an Acuity Score

XIII.9 If, before the end of the test, the subject claims to be unable to recognize the test types, the subject is still obliged to make a guess. The subject is not informed before the end of the test whether or not any mistakes were made. The number of errors per optotype size will be re-corded. The frequencies of seeing will be plotted against the logarithm of the optotype size. The points on the graph for each set of optotypes, may be fitted with a curve. From this curve one can estimate the size at which the frequency of seeing for that set of optotypes is 50%. These values represent the thresholds for the Landolt rings and for the other set of optotypes from which the chart designer can derive the correlations.

CLASSIFICATION of VISUAL PERFORMANCE			EQUIVALENT VISUAL ACUITY VALUES obtainable with a single test chart used at various distances (the chart has 13 lines ranging from 4 M to 63 M)						Alternative notations for Landolt rings:		
			at 6.3 m	at 5 m	at 4 m	at 3 m	at 20 ft	at 10 ft	visual angle of the gap	Log MAR	
(NEAR)	Range of Vision	1.6	6/4					20/12.5		0.63°	-0.2
	Normal Vision	1.25	/5	5/4	4/4		/16			0.8°	-0.1
		1.0	/6.3	/5	/4		/20			1.0°	0
		0.8	/8	/6.3	/5		/25	10/12.5		1.25°	+0.1
NORMAL VISION	Near-normal vision	0.63	6/10	/8	/6.3		20/32	/16		1.6°	+0.2
		0.5	/12.5	5/10	/8		/40	/20		2.0°	+0.3
		0.4	/16	/12.5	4/10		/50	/25		2.5°	+0.4
		0.32	/20	/16	/12.5		/63	10/32		3.2°	+0.5
LOW VISION	Moderate Low Vision	.25	6/25	/20	/16	1/4	20/30	/40		4.0°	+0.6
		.20	/32	5/25	/20	/5	/100	/50		5.0°	+0.7
		.15	/40	/32	4/25	/6.3	/125	/63		6.3°	+0.8
		.125	/50	/40	/32	/8	/160	10/80		8.0°	+0.9
LOW VISION	Severe Low Vision	.10	6/63	/50	/40	1/10	20/200	/100		10.0°	+1.0
		.08		5/63	/50	/12.5		/125		12.5°	+1.1
		.063			4/63	/16		/160		16°	+1.2
		.05				/20		10/200		20°	+1.3
BLINDNESS	Profound Low Vision	.04				1/25				25°	+1.4
		.032				/32				32°	+1.5
		.025				/40				40°	+1.6
		.02				/50				50°	+1.7
(NEAR) BLINDNESS	Near-Blindness	.016				1/63				63°	+1.8
		.0125								80°	+1.9
	Total Blindness	.01								100°	+2.0

The above table combines several of the principles discussed in this document. See X11.3 for discussion. The left section displays the International Classification of Visual Performance, in which the old dichotomy between "legally seeing" and "legally blind" has been replaced with three ranges: Normal Vision, Low Vision and Blindness.

The center section illustrates the measuring ranges that can be obtained with a single test chart designed according to the standard recommended in this document.

The right section indicates the visual angles subtended by Landolt ring gaps and the resulting log MAR values

## **Assessing the Equivalence of Optotypes**

XIII.10 When the measurements described above have been repeated monocularly with ten or more subjects with best correction and normal visual acuity (4/4 or better). The threshold values for each kind of optotype are averaged. If the two averages differ by more than 0.02 log units (approx. 4.6%), the two kinds of optotypes cannot be said to be equivalent. They may be made equivalent by modifying the design or by enlarging or contracting the size of the non-standard optotype series by the appropriate ratio.

## **XIV. Review of This Standard**

XIV.1 A standard is meant to be a stable entity, yet all points are not established by experimental certainty, deficiencies are periodically revealed and need correction, new developments in tests are occurring, etc. Thus, a standard may be an evolving document and needs to be re-viewed periodically and should not be regarded as immutable.

XIV.2 Thus, on a repeatable four-year cycle, after approval by the Concilium Ophthalmologicum Universale, this standard will be reviewed for modification by the Visual Functions Committee of the Concilium. Those offering suggestions or improvement should contact the Secretary of the Visual Functions Committee, at the following address:

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