BS ISO 14490-8:2011

BSI Standards Publication

Optics and optical instruments — Test methods for telescopic systems

Part 8: Test methods for night-vision devices

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National foreword

This British Standard is the UK implementation of ISO 14490-8:2011.

The UK participation in its preparation was entrusted to Technical Committee CPW/172/4, Optics and Photonics - Telescopic Systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Part 8: Test methods for night-vision devices

Optique et instruments d'optique — Méthodes d'essai pour systèmes téléscopiques —

Partie 8: Méthodes d'essai pour dispositifs de vision de nuit

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14490-8 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 4, *Telescopic systems*.

ISO 14490 consists of the following parts, under the general title *Optics and optical instruments — Test methods for telescopic systems*:

— *Part 1: Test methods for basic characteristics*

— *Part 2: Test methods for binocular systems*

— *Part 3: Test methods for telescopic sights*

— *Part 4: Test methods for astronomical telescopes*

— *Part 5: Test methods for transmittance*

— *Part 6: Test methods for veiling glare index*

— *Part 7: Test methods for limit of resolution*

— *Part 8: Test methods for night-vision devices*

Optics and optical instruments — Test methods for telescopic systems —

Part 8:
Test methods for night-vision devices

1 Scope

This International Standard describes the test methods for determining the performance of night-vision devices as specified in ISO 21094.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

ISO 11664-2, *Colorimetry — Part 2: CIE standard illuminants*

ISO 14490-1, *Optics and optical instruments — Test methods for telescopic systems — Part 1: Test methods for basic characteristics*

ISO 14490-7, *Optics and optical instruments — Test methods for telescopic systems — Part 7: Test methods for limit of resolution*

ISO 21094, *Optics and photonics — Telescopic systems — Specifications for night vision devices*

3 General requirements for the test conditions and preparation of tests

Measurements shall be carried out under the normal conditions of the work area, namely:

— air temperature: (20,0 ± 5,0) °C;

— relative humidity of the air: 40 % to 60 %.

During measurements, the temperature shall not vary by more than ± 2 °C and the relative humidity shall not vary by more than 4 %.

The measurements should be carried out in conditions in which the test specimen is protected from stray light and electrical and strong magnetic fields.

The recommended illuminance in the test room is 0,01 lx to 0,04 lx.

Measurements of the basic characteristics of night-vision devices shall be carried out with the aid of a dedicated power supply.

The use of an external power supply is acceptable subject to its voltage not departing from the nominal voltage of the dedicated power supply by more than ± 0,1 V.

The testing of instruments equipped with a source of radiation shall be carried out while the source is switched off.

The source of radiation used in collimators and other instruments for measuring the characteristics of production prototypes of night-vision devices shall be incandescent lamps which have a filament colour temperature, T_c, of (2 856 ± 50) K, unless otherwise stated. The instability of the voltage on incandescent lamps, at the time of measurement, shall not exceed 0,3 %.

It is important that the spectral characteristics of the source of radiation cover the full range of spectral sensitivity of the image intensifier. The transmission spectrum of filters placed in collimators or in front of a night-vision device shall correspond to the sensitivity spectral region of the test specimen.

When measuring the characteristics of production samples, the use of incandescent lamps, where the filament colour temperature, T_c, is different from the one specified above, is acceptable.

The objectives of collimators used in test arrangements may be lens, mirror or catadioptric systems.

Integrating spheres may be used for uniform illumination of scales and reticles in collimators.

During all measurements of the characteristics of night-vision devices, the luminance of the image intensifier screen shall be the optimum for the observer.

In the assessment of results (see 4.4, 5.4, 6.4, 7.4, 8.4, 9.4, 10.4, 11.4, 13.4 and 14.4), repeatability shall be stated in accordance with ISO 5725-1. The assessment of the correctness of the average value obtained, i.e. the assessment of the systematic error, shall be carried out either analytically or by comparison of the measurement results obtained in different test laboratories.

4 Test method for measuring magnification and difference in magnification

4.1 General

The measurement of magnification is based on the measurement of the image size of an object within the field of view of the night-vision device.

The magnification, Γ, is calculated in accordance with the following equation:

$$\Gamma = \frac{\tan w'}{\tan w} \tag{1}$$

where w and w' are the angles between the conjugate rays and the optical axis in object space and in image space respectively.

For night-vision devices with variable magnification, Γ shall be measured for the maximum and minimum magnifications.

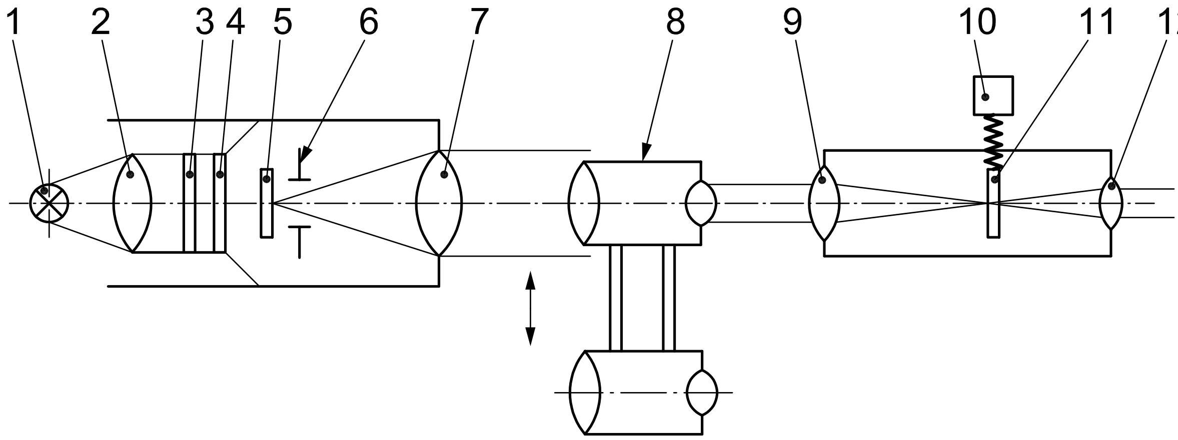
Depending on the value of magnification and the size of the field of view of the night-vision device, the measurements of Γ shall be carried out in accordance with the arrangements shown in Figure 1 or Figure 2.

The diameter of the collimator lens used in these arrangements shall exceed by 15 % to 20 % the lens diameter of the test specimen.

The diameter of the telescope objective lens used shall exceed by 15 % to 20 % the diameter of the pencil of light that emerges from the test specimen.

4.2 Requirements for the test arrangements and their principal parts

4.2.1 Requirements for the test arrangement shown in Figure 1



Key

1 source of radiation
2 condenser
3 filter
4 diffusing plate
5 collimator scale with cross-lines [a]
6 opaque diaphragm with aperture
7 collimator lens
8 test specimen
9 telescope objective lens
10 telescope read-out device
11 reticle
12 telescope eyepiece

[a] For this method, a scale without cross-lines may be used. When testing as specified in other test methods, the use of a cross-line can be indispensable. For the sake of unification, it is recommended that a scale with cross-lines be used in all test arrangements.

Figure 1 — Arrangement for measurement of the magnification and difference in magnification of night-vision devices with fields of view up to 12° and magnifications up to 1,5×

The linear size of the collimator scale shall be such that the size of the image of the scale at the image intensifier screen of the night-vision device would cover 1/5 to 2/5 of the diameter of image intensifier screen.

For the scale (5), the line widths and the spaces between them shall have dimensions that are at least 2½ times greater than the limit of resolution of the test specimen, so that they can be clearly resolved.

The marginal part of the scale (5) shall be opaque; this is achieved by means of a diaphragm (6).

The range of the scale of the telescope read-out device (10) (see Figure 1) shall be at least 25 mm with a read-out error of no more than 0,05 mm.

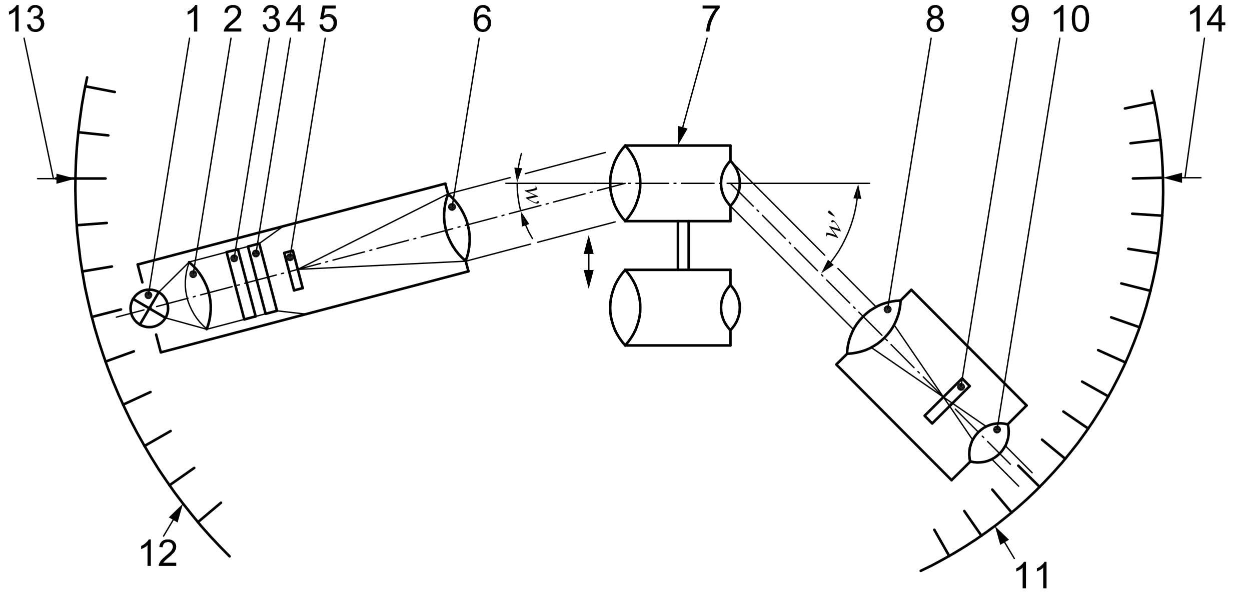
Aberrations of the optical systems of the collimator and telescope shall be within the limits that allow for the specified precision of measurements.

NOTE The requirements for the aberrations of the optical systems might be less severe if corrections for the real angular sizes of the scale divisions and of the telescope scale movement read-out mechanism are applied to the measurement results.

It is important that the spectral characteristics of the source of radiation cover the long-wavelength cut-off of the image intensifier.

It is recommended that the support beneath the test specimen allows for its movement normal to the collimator axis, in order to enable successive measurements to be made of the magnification in each channel of the night-vision device.

4.2.2 Requirements for the test arrangement shown in Figure 2



Key

1 source of radiation
2 condenser
3 filter
4 diffusing plate
5 scale with cross-lines
6 collimator lens
7 test specimen
8 telescope objective lens
9 reticle with cross-line
10 telescope eyepiece
11 angle-measuring device
12 angle-measuring device
13 fixed indexes
14 fixed indexes

Figure 2 — Arrangement for measurement of the magnification and difference in magnification of night-vision devices with any field of view and any magnification

The focal plane of the collimator lens shall bear a scale with cross-lines, where the line width shall exceed the limit of resolution of the night-vision device under test at least by 2½ times.

The field of view of the collimator and that of the telescope may not exceed 1°.

The focal plane of the telescope lens shall have a reticle with cross-lines or a straight line.

The use of a telescope in accordance with the arrangement shown in Figure 1 is acceptable, provided the telescope read-out device and the reticle remain stationary.

The axes of rotation of the angle-measuring devices shall be situated as close as possible to the objective and eyepiece of the night-vision device under test.

In addition to the test arrangement shown in Figure 2, two other versions of this test arrangement are acceptable:

a) the test specimen is mounted on the angle-measuring device while the other angle-measuring device bears the collimator (Figure 2, key items 1 to 6) or the telescope (Figure 2, key items 8 to 10);

b) two independent angle-measuring devices use a common axis of rotation, which shall be situated approximately in the middle of the test specimen.

In any version, the vignetting of bundles of rays that enter or emerge from the night-vision device under test shall be reduced to the minimum.

The angle measurement error of the angle-measuring devices (Figure 2, key items 11 and 12) shall not exceed 6 minutes of arc.

4.3 Sequence of measurements

4.3.1 Sequence of measurements in arrangement of Figure 1

— Adjust the eyepiece of the test specimen to 0 D (0 m^{-1}).

— Mount the test specimen, or one of its channels, so as to obtain an image of the central point of the scale in the centre of the image intensifier screen.

— By adjustment of the objective (provided that the objective of the night-vision device is focusable) and of the eyepiece, obtain a sharp image of the scale.

— Determine the number, n_1, of divisions of the telescope read-out mechanism that conforms to as large a number as possible of collimator scale divisions.

— Remove the test specimen from the support and determine the number, n_2, of divisions of the telescope read-out mechanism that corresponds to the previously selected number of collimator scale divisions.

4.3.2 Sequence of measurements in arrangement of Figure 2

— Mount the test specimen, or one of its channels, in the test position in such a manner that the image of the collimator cross-line would be found in the centre of the image intensifier screen and the collimator scale would be observed sharply through the eyepiece of the telescope.

— Rotate the angle-measuring device and collimator by the angle, w, and take a reading of the angle.

— Rotate the angle-measuring device and telescope by the angle, w', until the previously selected line of the telescope scale coincides with the image of the selected line of the collimator scale, and take a reading of this angle.

4.4 Assessment of results

The angular magnification measured in the test arrangement shown in Figure 1 shall be calculated in accordance with the following equation:

$$\Gamma = \frac{n_1}{n_2} \tag{2}$$

where

n_1 is the number of divisions of the telescope read-out mechanism;

n_2 is the number of the collimator scale divisions.

Calculations in accordance with Equation (2) shall be carried out for each channel of the night-vision device.

The difference in magnification, $\Delta\Gamma$, expressed as a percentage (%), shall be calculated in accordance with Equation (3):

$$\Delta\Gamma = \frac{\Gamma_{max} - \Gamma_{min}}{\Gamma_{min}} \times 100\ \% \tag{3}$$

where

Γ_{max} is the maximum angular magnification;

Γ_{min} is the minimum angular magnification.

The angular magnification measured in the test arrangement shown in Figure 2, shall be calculated in accordance with the Equation (1).

The repeatability of the measured value of angular magnification of the night-vision device shall not exceed 1 % of the average value. The repeatability of the measured value of the difference in channel magnification shall not exceed 2 %.

5 Test method for measuring night-vision device gain

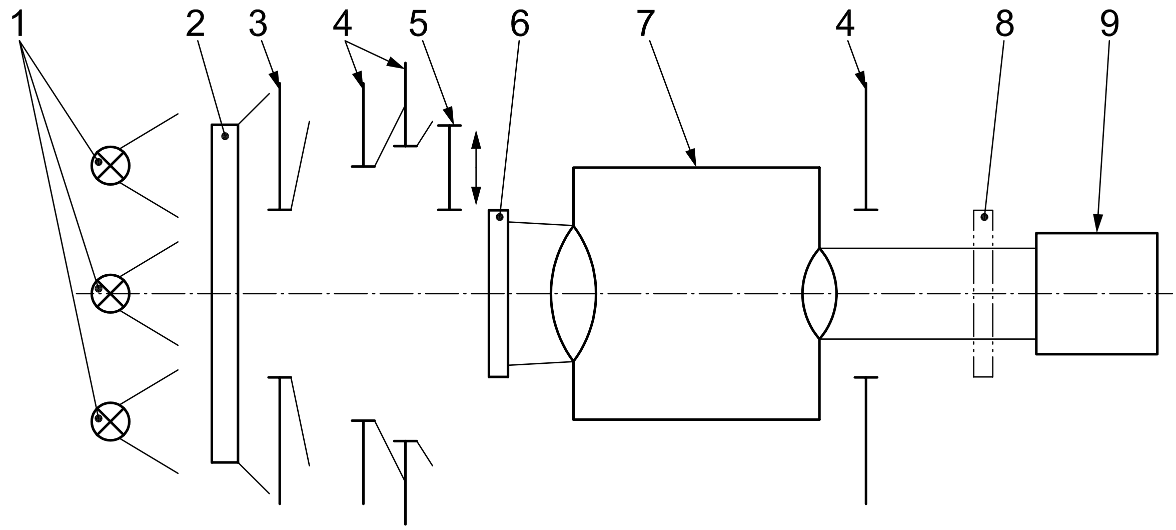
5.1 General

The test method for measuring night-vision device gain consists of measuring the ratio of the luminance of the output screen, measured in the plane of the exit pupil, to the luminance of the object of observation. This test method is based on the assumption that both the radiation from the diffuse translucent screen (Figure 3, key item 2) and that emerging from the eyepiece of the test specimen obey the Lambert law within ±20° from the screen normal and from the optical axis of the eyepiece, accordingly.

NOTE See 7.1 for an explanation of the concept of exit pupil as applied to night vision devices.

5.2 Requirements for the test arrangement and principal parts

Measurement of night-vision device gain shall be carried out using the test arrangement shown in Figure 3.



Key

1 incandescent lamps
2 diffuse translucent screen
3 field diaphragm
4 glare baffles
5 shutter
6 filter
7 test specimen
8 neutral filter
9 luminance meter

Figure 3 — Arrangement for measuring night-vision device gain

The colour temperature of lamp filaments shall comply with CIE standard illuminant A, in accordance with ISO 11664-2.

The luminance of the diffuse translucent screen shall be within the limits of $1 \cdot 10^{-3}$ to $3 \cdot 10^{-3}$ cd/m^2 across the area limited by the opening in the diaphragm. The size of this opening shall allow for the illumination of an area of 1/5 to 2/5 of the diameter of the image intensifier screen but it shall not be less than 7 mm. The number and position of incandescent lamps shall be such as to ensure that these requirements are met.

The spectral transmittance of the filter is to be specified by the manufacturer and shall comply with the radiation spectrum of the image intensifier screen.

The number and position of glare baffles, as well as the sizes of the apertures in the baffles, shall be selected in such a manner as to reduce as much as possible the influence of any stray light on the measurement result. The shutter shall have matt black surfaces.

The transmittance of the neutral filter shall ensure that the measurements with the luminance meter are carried out at the same measurement distance in each setup, according to Figure 3. The acceptance angle of the luminance meter shall not exceed 5°.

5.3 Sequence of measurements

Mount the test specimen in the test arrangement shown in Figure 3.

The voltage on the image intensifier shall be the rated voltage or one recommended by the manufacturer of the image intensifier.

Close the shutter. Adjust the luminance meter to image the screen onto its detector. Take a reading, L_1, from the luminance meter scale. Open the shutter, insert the neutral filter if required and take a new reading, L_2, from the luminance meter.

Remove the night-vision device and the filter (if applicable) from the test arrangement shown in Figure 3 and position the luminance meter at the same distance from the screen as it was from the last surface of the eyepiece.

Close the shutter and take a reading, L_3, from the luminance meter. Then open the shutter and take a new reading, L_4.

5.4 Assessment of results

Night-vision device gain should be calculated in accordance with the following equation:

$$K = \frac{\frac{L_2}{\tau} - L_1}{L_4 - L_3} \qquad (4)$$

where τ is the average transmittance of the neutral filter in the spectral range of the radiation from the image intensifier screen.

The repeatability of measurement results shall be better than 20 % of the measured night-vision device gain value.

NOTE In order to obtain an unambiguous result for the measurement, the tests can be carried out at the saturation range. For most modern image intensifiers this range starts at an illuminance of $(1 \ldots 3) \cdot 10^{-3} \cdot$ lx.

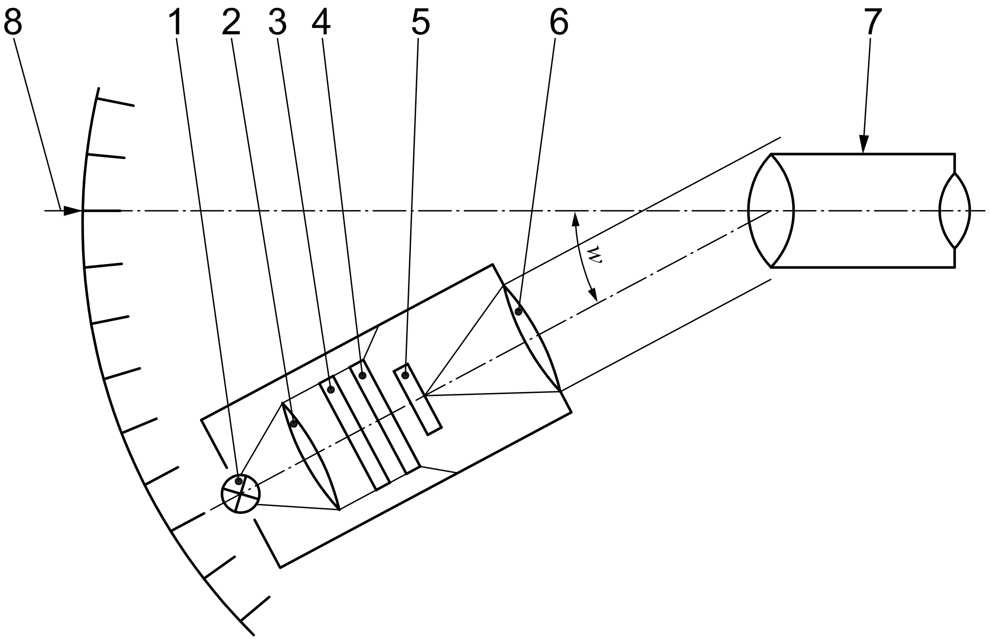
6 Test method for measuring the angular field of view in object space

6.1 General

According to ISO 14132-1, the field of view of a night-vision device is defined by the angle between two rays that propagate from two marginal points of an infinitely distant object, which are still visible through the night-vision device.

6.2 Requirements for the test arrangement and principal parts

Measurement of the field of view of the night-vision device is to be carried out using the test arrangement shown in Figure 4.



Key

1 source of radiation
2 condenser
3 filter (optional)
4 diffusing plate
5 scale with cross-line
6 collimator lens
7 test specimen
8 angle-measuring device

Figure 4 — Arrangement for measuring the angular field of view in the object space

The collimator shall meet the requirements given in 4.2.2.

NOTE The use of a collimator without a filter and without an opaque diaphragm with aperture (see Figure 1) is acceptable.

The axis of rotation of the angle-measuring device should be situated as close to the objective of the test specimen as possible.

An optional version of the test arrangement where the test specimen is situated at the angle-measuring device and the collimator is stationary, is acceptable.

The angle measurement error of the measuring device shall not exceed 6 minutes of arc.

With any version of the test arrangement, the vignetting of the bundle of rays that enters the night-vision device shall be reduced to the minimum.

6.3 Sequence of measurements

— Focus the eyepiece of the test specimen to obtain a sharp image of the image intensifier screen.

— By moving the collimator, determine the angles of rotation, $\pm w$, with the angle-measuring device, at which the image of the collimator scale first gets to one edge of the image intensifier screen and then to the other.

— The angle, $2w$, is to be taken as the field of view.

6.4 Assessment of results

The repeatability of the measured value of the angle of view shall be better than 15 minutes of arc or, in relative units, 3 % of the size of the field of view.

7 Test method for measuring exit pupil diameter and eye relief

7.1 General

Instruments equipped with image intensifiers rarely have real exit pupils, in which case the procedure described in ISO 14490-1 shall be used for determining exit pupil diameter and eye relief.

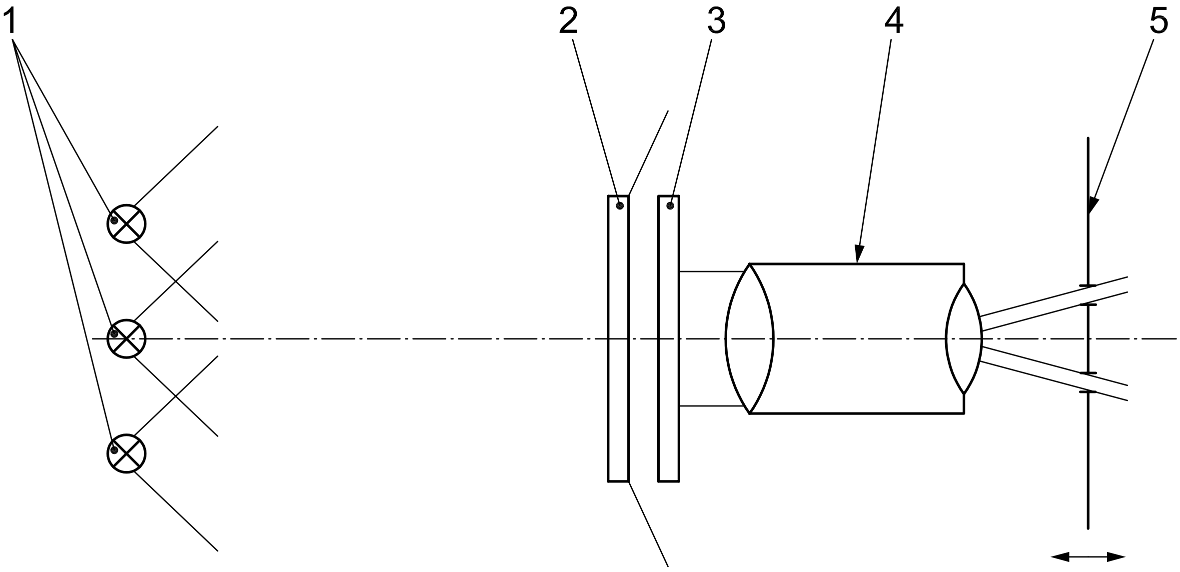
In all other cases, a reference aperture size and position has to be specified to enable evaluation of image quality related characteristics. The diameter of the reference aperture shall be (6 ± 0,1) mm. The reference aperture shall be positioned at a distance determined according to 7.3 and should be considered as an exit pupil.

Instruments with a fixed interpupillary distance shall provide a wider cross section over which the screen can be observed and shall be assessed according to 7.3.1. The same applies to instruments intended for hands-free operation (like helmet or head-mounted systems) where permanent correction of the relative positions of the observer's eye and the eyepiece cannot be provided.

For all other instruments, the procedure described in 7.3.2 shall be used.

7.2 Requirements for the test arrangement and its principal parts

Measurement of the eye relief of the night-vision device is to be carried out using the test arrangement shown in Figure 5.



Key

1 source of radiation
2 diffusing screen
3 neutral filter
4 test specimen
5 diaphragm with aperture(s)

Figure 5 — Arrangement for measuring eye relief

The source of radiation shall provide a uniform (as assessed by the observer) brightness of the image intensifier screen.

NOTE 1 This requirement is achieved by selection of the number of sources of radiation and the transmission characteristics of the diffusing screen.

NOTE 2 The use of a single source of radiation is acceptable.

The diffusing screen and the neutral filter should provide a brightness of the image intensifier screen that is optimum for the observer.

The centre of the aperture shall be located on the axis of radiation emerging from the eyepiece of the test specimen.

7.3 Sequence of measurements

7.3.1 Head or helmet-mounted instruments and binoculars with fixed interpupillary distance

— The diaphragm shall have two openings of 1 ± 0,1 mm diameter and 6 ± 0,1 mm apart (centre to centre).

— Locate and centre the diaphragm as close as possible to the eyepiece of the test specimen, observing the image intensifier screen through the diaphragm openings for best symmetry (minimum disparity).

— Moving the diaphragm away, find a position on the diaphragm just before a shading appears in the area of the circumference of the image intensifier screen. The whole field of view shall be visible through each of the openings.

— This position of the diaphragm shall be fixed. The distance from the diaphragm to the eye lens of the eyepiece of the test specimen is to be taken as the eye relief.

7.3.2 Other image intensifier devices

— The diaphragm shall have a central opening of (1 ± 0,1) mm diameter.

— Locate and centre the diaphragm as close as possible to the eyepiece of the test specimen observing the image intensifier screen through the diaphragm opening for best symmetry (minimum disparity).

— Moving the diaphragm away, find a position on the diaphragm just before a shading appears in the area of the circumference of the image intensifier screen. This position of the diaphragm is to be fixed. The distance from the diaphragm to the eye lens of the eyepiece of the test specimen is to be taken as the eye relief.

— Optionally, the procedure may be repeated with the diaphragm having a central opening of 3 mm to 6 mm diameter, according to the manufacturer’s preference. The measurement of eye relief may be carried out with other sizes of diaphragm opening.

7.3.3 Assessment of results

The eye relief of head or helmet-mounted instruments should be stated in accordance with 7.3.1. The eye relief of other types of instruments should be preferably stated for 1 mm diameter of the diaphragm opening. If an optional diaphragm opening is chosen, the relevant axial position shall be stated together with the opening diameter used.

The repeatability of the eye relief measurement result shall be better than 0,8 mm.

8 Test method for measuring the error of zero-position of the dioptre scale

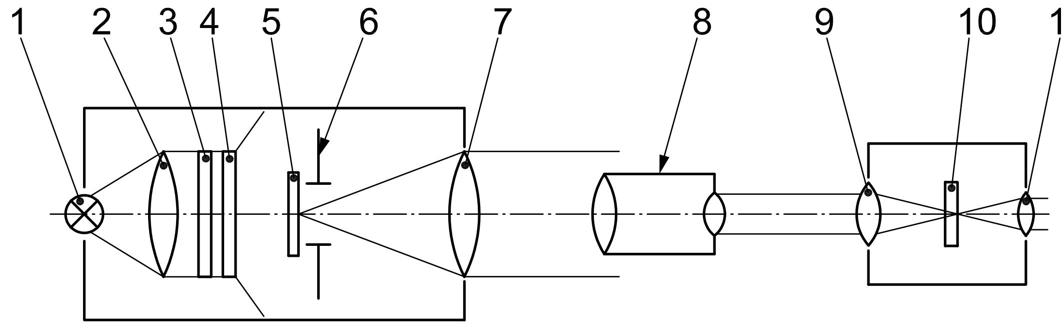
8.1 General

The zero-position of the dioptre scale of the test specimen shall correspond with the setting of the night-vision device eyepiece that provides a correct position of the image intensifier screen in the focal plane of the eyepiece.

The dioptre adjustment enables the use of a night-vision device by an observer whose vision is not normal.

8.2 Requirements for the test arrangement and its principal parts

The measurement of the zero-position of the dioptre scale of the test specimen shall be carried out using the test arrangement shown in Figure 6.



Key

1 source of radiation
2 condenser
3 filter
4 diffusing plate
5 scale
6 opaque diaphragm with aperture
7 collimator lens
8 test specimen
9 dioptre adjustment telescope lens
10 dioptre adjustment telescope reticle
11 dioptre adjustment telescope eyepiece

Figure 6 — Arrangement for measuring the error of zero-position of the dioptre scale and the range of dioptre adjustment

The collimator (Figure 6, key items 1 to 7) shall meet the requirements given in 4.2.1.

NOTE 1 The use of an autocollimator without a filter and diaphragm is acceptable.

NOTE 2 The use of any object that possesses adequate brightness and contrast relative to the background, instead of the collimator, is acceptable. For checking the zero-position of the dioptre scale, the object is to be placed at a distance that corresponds to “infinity” for the test specimen.

The collimator should provide a brightness of the image intensifier screen that is optimum for the observer.

The dioptre adjustment telescope (Figure 6, key items 9 to 11) shall provide a measurement of convergence (divergence) of the bundle that exits the night-vision device eyepiece, in the range of ± 5 m^{-1}.

8.3 Sequence of measurements

— Focus the eyepiece of the dioptre adjustment telescope to obtain a sharp image of the reticle of the dioptre adjustment telescope.

— Move the dioptre adjustment telescope lens into the zero-position.

— In the absence of the test specimen from the test arrangement, observe the sharp image of the scale.

— Insert the test specimen into the test arrangement and set the eyepiece of the night-vision device successively to its different dioptre scale markings.

— While observing the scale image, adjust the focussing of the dioptre adjustment telescope to obtain a sharp focus and record the reading from the dioptre adjustment telescope scale.

— The difference between readings from the eyepiece scale and dioptre adjustment telescope scale is the error of zero-position of the night-vision device dioptre scale.

8.4 Assessment of results

The repeatability of the result of measurement of the error of zero-position of the dioptre scale and of the range of dioptre adjustment shall be within 0,3 m^{-1}.

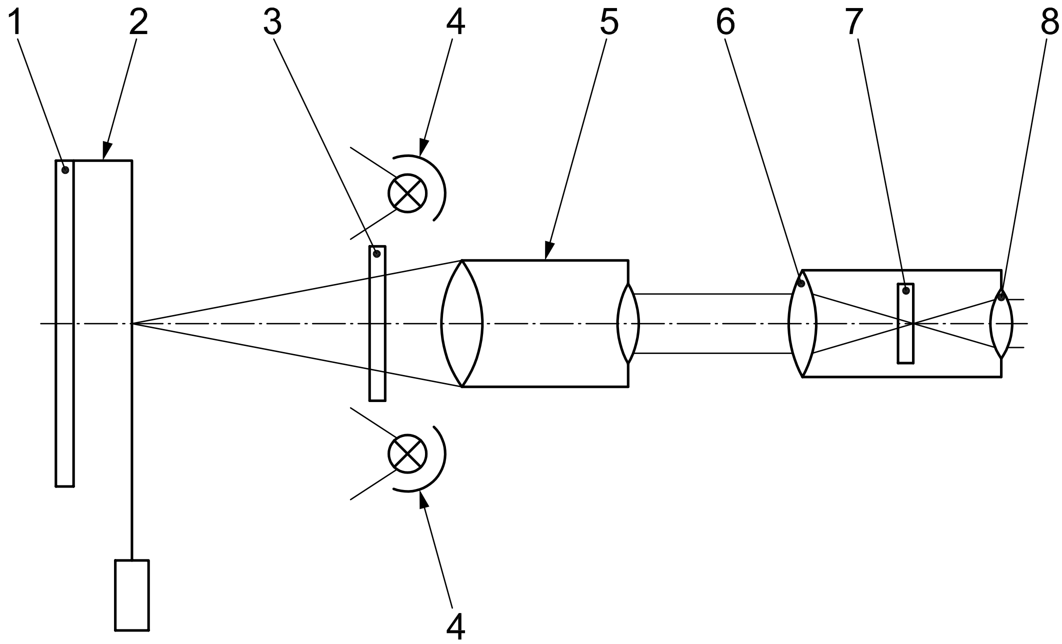
9 Test method for measuring the angle of image rotation around the optical axis relative to the object and the difference of image rotation angles

9.1 General

Night-vision devices that include prisms and/or mirrors are subject to compulsory testing in accordance with this method.

9.2 Requirements of the test arrangement and its principal parts

Measurement of the angle of image rotation around the optical axis relative to the object and the difference of image rotation angles shall be carried out using the test arrangement shown in Figure 7.



Key

1 screen
2 cord with pendulum (target)
3 neutral filter
4 sources of radiation
5 test specimen
6 telescope lens
7 reticle with angle measuring mechanism
8 telescope eyepiece

Figure 7 — Arrangement for measuring the angle of image rotation around the optical axis relative to the object and difference of image rotation angles

The surface of the target (screen) shall diffuse the incident radiation.

A pendulum is to be suspended at the end of a cord in front of the target. The colour of the cord shall be different from the colour of the target.

The width of the image of the cord at the image intensifier screen shall exceed by at least 2½ times the limit of resolution of the test specimen. The length of the image of the cord on the screen shall be at least 10 mm.

In order to give a higher contrast of the image of the cord ends, the use of two targets of reduced height, instead of one whole target, is acceptable.

The sources of radiation and the neutral filter shall make the brightness of the image intensifier screen optimal for the observer.

The field of view of the telescope lens should allow at least a 10 mm diameter of the central part of the image intensifier screen to be observed. In the plane of the reticle there shall be an image of the cord with pendulum of at least 10 mm in length.

The reticle with cross-line shall be equipped with an angle measuring mechanism, the measurement error of which shall not exceed 30 minutes of arc. Otherwise it is acceptable to mount the complete telescope on a rotating drum with an angle measuring mechanism.

An optional version of the test arrangement is acceptable, where a collimator with a reticle is used instead of the target and cord with pendulum.

9.3 Sequence of measurements

— Install the test specimen into the measurement position shown in Figure 7. The distance between the cord and the test specimen shall exceed the close distance of observation while the distance between the cord and the telescope shall be compatible with the practical infinity for the telescope objective lens. The distance between the test specimen and the telescope lens should be such that any vignetting of the bundle emerging from the eyepiece of the test specimen is eliminated.

— Focus the eyepiece of the test specimen onto the image intensifier screen.

— Determine the position of the image of the cord at the telescope reticle.

— Remove the test specimen from the test arrangement and observe the image of the cord at the telescope reticle.

— By means of the angle measuring mechanism, note the sign and amount of rotation of the image of the cord around the optical axis.

When a considerable distortion of the image of the cord at the image intensifier screen is observed, the telescope reticle should be brought into coincidence with the image of the cord ends. In this case, the measurements should be carried out in two mutually perpendicular directions. For this purpose, the test specimen is to be rotated by 90° around the optical axis of its objective. The larger of two measurements of the image rotation angle should be taken as the measurement result.

9.4 Assessment of results

The repeatability of the result of measurement of the angle of image rotation around the optical axis relative to the object and the difference of image rotation angles shall not exceed 40 minutes of arc.

10 Test method for measuring non-parallelism of the axes of bundles of rays emerging from the eyepieces of the night-vision device

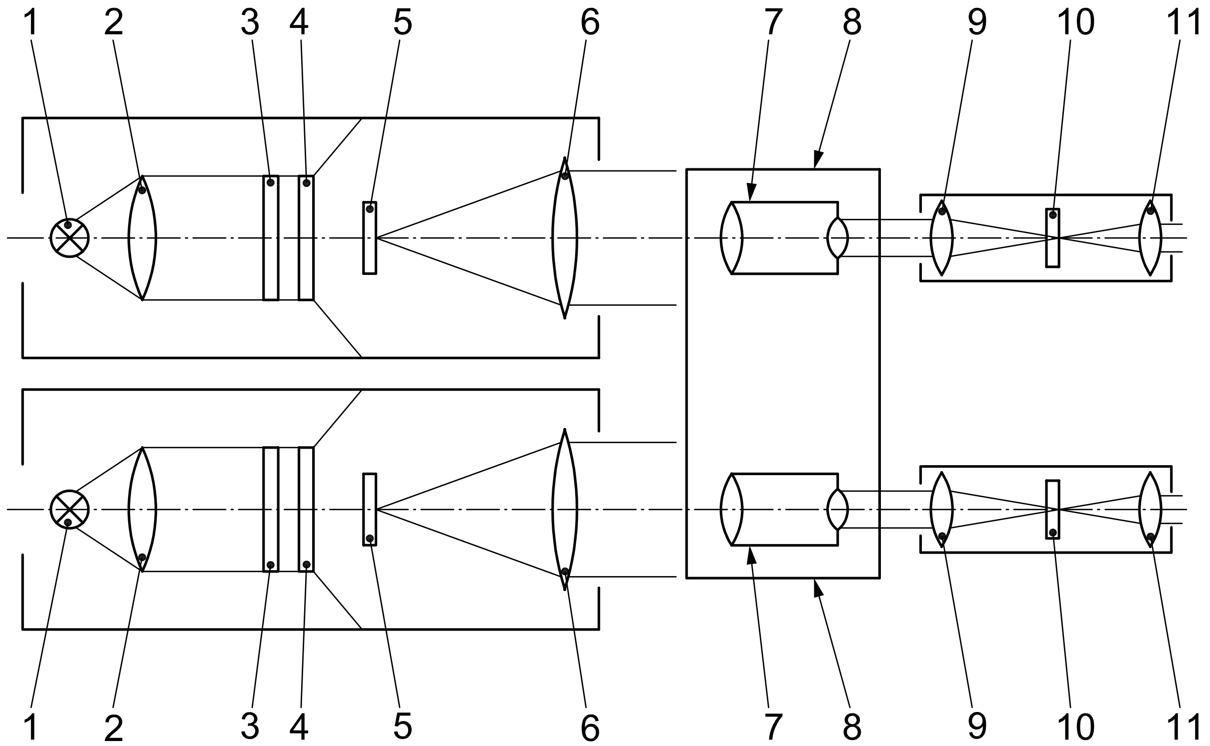
10.1 General

In order to allow for normal binocular vision and to reduce the observer's fatigue during long-term observation, the axes of bundles of rays emerging from eyepieces of binoculars shall be parallel. The degree of non-parallelism is defined by the physiological properties of the human eye. For devices equipped with one objective and two eyepieces, the axes of bundles emerging from the eyepieces shall also be parallel.

NOTE Types of non-parallelism of the axes of binocular instruments (convergence, divergence and dipvergence) are defined in ISO 14132-2.

10.2 Requirements of the test arrangement and its principal parts

Non-parallelism of the axes of bundles of rays emerging from eyepieces of night-vision devices is measured using the test arrangement shown in Figure 8.



Key

1 source of radiation
2 condenser
3 filter
4 diffusing plate
5 reticle with cross-lines
6 collimator lens
7 channel of test specimen
8 test specimen support
9 telescope lens
10 reticle with cross-line (two-coordinate reticle)
11 telescope eyepiece

Figure 8 — Arrangement for measuring non-parallelism of the axes of bundles of rays emerging from eyepieces

In the test arrangement shown in Figure 8 two similar collimators (key items 1 to 6) and two telescopes (key items 9 to 11) are used.

The use of one collimator and one telescope is acceptable. The test specimen is placed on a device that enables successive insertion of channels of the test specimen into the test position. Possible variations of spatial position of the axes of the night-vision device during this movement should not exceed $(2/\Gamma)$ minutes of arc, where Γ is the angular magnification of the test specimen. With magnifications of $\Gamma > 4\times$, possible variations of spatial position of the axes should not exceed 1/2 minute of arc.

The collimators shall meet the requirements given in 4.2.1. The use of a collimator without a filter and diaphragm with aperture (shown in Figure 1) is allowed.

The parallel telescopes shall have reticles in the focal plane of their objectives; one telescope shall have a reticle with cross-lines and the other one shall have a two-coordinate reticle with scale markings not more than 5 minutes of arc apart. The focal planes of both collimator objectives should be equipped with reticles with cross-lines.

The optical axes of collimators and telescopes shall be parallel. Non-parallelism shall not exceed $(2/\Gamma)$, where Γ is the angular magnification of the test specimen. With magnifications of $\Gamma > 4\times$, non-parallelism shall not exceed 1/2 minute of arc.

The measurement range of the measuring telescope shall be at least 100 minutes of arc along each axis.

The support for the test specimen shall enable rotation around two mutually perpendicular axes.

10.3 Sequence of measurements

— Focus the eyepieces of the parallel telescopes to obtain sharp images of the reticles.

— In the absence of the test specimen, the images of the centres of the collimator reticles shall be coincident with the centres of the cross-lines of the telescope reticles.

— Mount the test specimen on the support as shown in the test arrangement (see Figure 8).

— By rotation of the test specimen support, make the centre of the cross-lines of one collimator coincident with the centre of the reticle of the appropriate telescope.

— Using the scale of the other telescope, measure the amount of non-coincidence of the image of the reticle centre of the other collimator with the reticle centre of the other telescope, in both horizontal and vertical directions.

10.4 Assessment of results

The repeatability of the results of the measurements of non-parallelism of axes of bundles of rays emerging from eyepieces of night-vision devices shall not exceed 5 minutes of arc.

11 Test method for measuring the limit of resolution

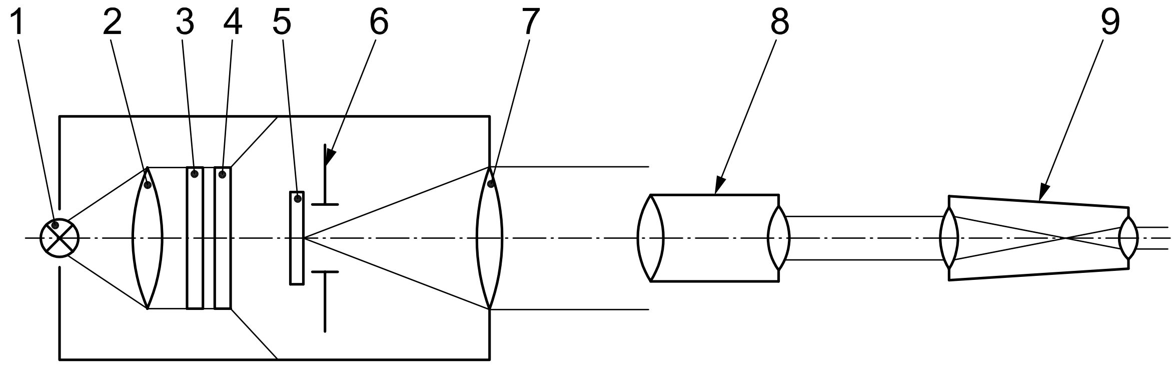
11.1 General

The limit of resolution is defined as the minimum angular separation between two adjacent bright (or dark) bars of a bar-type resolution test target that are visible separately through the night-vision device.

The limit of resolution is to be measured at the centre of the field of view, centred in the same manner as in 7.1, for an optimum value of object luminance, standard value of object contrast and rated value of voltage on the image intensifier tube. The test specimen shall be at maximum magnification with the auxiliary telescope centred on the optical axis of the eyepiece (of the test specimen) at an axial position defined by the test method described in Clause 7. In cases where an auxiliary telescope is not used, the eye pupil should not have any decentration.

11.2 Requirements for the test arrangement and its principal parts

Measurements shall be carried out using the test arrangement shown in Figure 9.



Key

1 source of radiation
2 condenser
3 filter
4 diffusing plate
5 test target
6 opaque diaphragm with aperture
7 collimator lens
8 test specimen
9 auxiliary telescope (optional)

Figure 9 — Arrangement for measuring the limit of resolution

The collimator shall meet the requirements given in 4.2.1 and Figure 1.

The dimensions of the elements of the test target shall be expressed in minutes of arc. The test target consists of black lines on a white (transparent) background. The pattern of the test target shall be in accordance with ISO 14490-7. The luminance of the bright background is to be $1 \cdot 10^{-3}$ cd/m^{-2} ±15 %. The contrast of lines (ratio of the difference of the transmittances of the background and lines to their sum) shall be at least 0,85.

The image of the test target at the image intensifier screen shall cover at least 1/3 of the screen diameter.

It is recommended that an aperture of (6 ± 0,1) mm be placed behind the eyepiece at a distance corresponding to the eye relief (measured in accordance with Clause 7) while the aperture centre should coincide with the centre of the beam emerging from the eyepiece.

The voltage on the image intensifier shall be as recommended by the manufacturer and shall provide the best resolution.

In order to reduce general glare, an opaque baffle with aperture should be used.

When testing high resolution devices, an auxiliary telescope with a magnification of about 1,5× and an entrance pupil with an aperture greater than 6 mm should be placed directly behind the aperture.

11.3 Sequence of measurements

— When it is possible to focus the objective lens of the test specimen, focus it to infinity.

— Adjust the eyepiece of the test specimen for 0 D (0 m^{-1}).

— Determine the part of the test target pattern with lines of minimum width where all four directions of the lines are detectable.

11.4 Assessment of results

If the focal length of the collimator lens is F_c, expressed in mm, and the resolvable part of the test target has S line pairs per mm (lp/mm), then the resolving power, expressed in line pairs per milliradian (lp/mrad), is

$$R\left[\frac{\text{line\_pairs}}{\text{mrad}}\right] = 10^{-3} \cdot S\left[\frac{\text{line\_pairs}}{\text{mm}}\right] \cdot F_c[\text{mm}] \quad (5)$$

The error in the focal length of the collimator lens shall not exceed ±5 %.

The limit of resolution may be expressed in minutes of arc, in the number of lp/mrad, or in the number of line pairs per minute of arc. Recalculation of the value of the limit of resolution (expressed in minutes of arc) into one expressed in lp/mrad, shall be done according to the following equation:

$$R\left[\frac{\text{line\_pairs}}{\text{mrad}}\right] = \frac{1 \cdot 10^{-3}}{\pm[\text{minutes\_of\_arc}] \cdot 2{,}9 \cdot 10^{-4}} = \frac{3{,}4}{\alpha} \quad (6)$$

The experiment shall be repeated at least three times. The best value obtained shall be taken as the result.

12 Test method for measuring working resolution and for determining range of vision

12.1 General

According to Clause 11, limit of resolution is measured under optimised values of object luminance which under real observation conditions can only rarely be achieved.

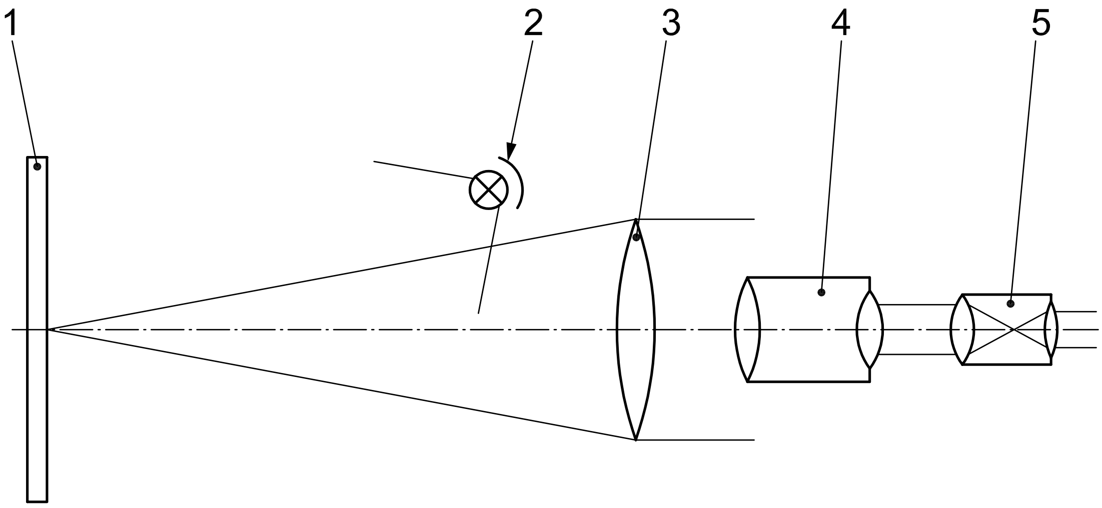
Therefore a working resolution is to be measured under standardized conditions of object luminance.

For comparison purposes, an orientation range and an identification range will be calculated from the working resolution measured.

These correspond to the ranges at which targets with object patterns of 5 and 25 line pairs per metre (lp/m) respectively could be resolved.

12.2 Requirements for the test arrangement and its principal parts

Measurements shall be carried out using a test arrangement similar to that shown in Figure 10.



Key

1 test target
2 light source
3 collimator lens
4 test specimen
5 auxiliary telescope

Figure 10 — Arrangement for measuring working resolution

The test target is a positive high contrast diffusely reflecting target in accordance with ISO 14490-7; luminance of the bright background is $1 \cdot 10^{-3}$ cd/m^{-2} ±15 %; contrast is ≥ 0,85.

The light source has a colour temperature of (3 200 ± 200) K (e.g. slide projector with neutral density filters and adjustable aperture stop).

The collimator shall have a lens with sufficiently low longitudinal colour (an achromat of 100 mm diameter with a focal length of 10 m approximately would be sufficient).

The auxiliary telescope shall have an entrance pupil of 7 mm and a magnification of 1,5× (higher magnifications would decrease the illuminance on the observer's retina).

12.3 Sequence of measurements

Determine the working resolution of the night-vision device by locating the part of the target pattern with the finest lines where all directions of lines are resolvable.

The resolution shall be calculated according to the formulae given in Clause 11.

12.4 Assessment of results

Calculate the range of vision using the following equation:

$$D_L = 1\,000 \bullet \frac{R}{S_L} \tag{7}$$

where

D_L is the range of vision (orientation or identification), expressed in m, for discrimination type L;

S_L is the spatial frequency, expressed in lp/m, in the object plane for discrimination type L;

R is the resolution, expressed in lp/mrad, of the night-vision device in object space.

If the resolution is given in line pairs per minutes of arc, the following formula shall be used:

$$D_L = 3{,}4 \cdot 10^3 \cdot \frac{R}{S_L} \tag{8}$$

Table 1 — Types of discrimination

Type of discrimination L	**Spatial frequency** S_L (lp/m)
Orientation	5
Identification	25

EXAMPLE:

R = 2,0 lp/mrad

$D_{orientation}$ = 400 m

$D_{identification}$ = 80 m

NOTE Discrimination levels were derived from field tests in observation of game animals.

The low resolution criterion (5 lp/m) relates to discrimination of the aspect ratio of a target, e.g. determining whether an oblong object is standing or lying.

The high resolution criterion (25 lp/m) allows an observer to identify details of an object, e.g. points of the antlers of a red deer.

Assuming that the body of a game animal has a critical target dimension of half a metre, the spatial frequencies selected correspond well with the recommendations given by the US Army's Night Vision Laboratory as indicated in Table 2. Hence the terms "orientation" and "identification" have been adhered to.

Table 2 — Discrimination levels

Discrimination level	Meaning	Spatial frequency (lp/m) for target with a critical dimension of 0,5 m
Detection	An object is present	$4{,}0^{+2{,}0}_{-1{,}0}$
Orientation	The object is approximately symmetrical (or not) and its orientation may be discerned	$5{,}6^{+1{,}6}_{-1{,}0}$
Recognition	The class to which the object belongs may be discerned	$16{,}0^{+3{,}2}_{-2{,}8}$
Identification	The object can be described to the limit of the observer's knowledge	$25{,}6^{+6{,}4}_{-5{,}6}$
NOTE Adapted from Reference [3].		

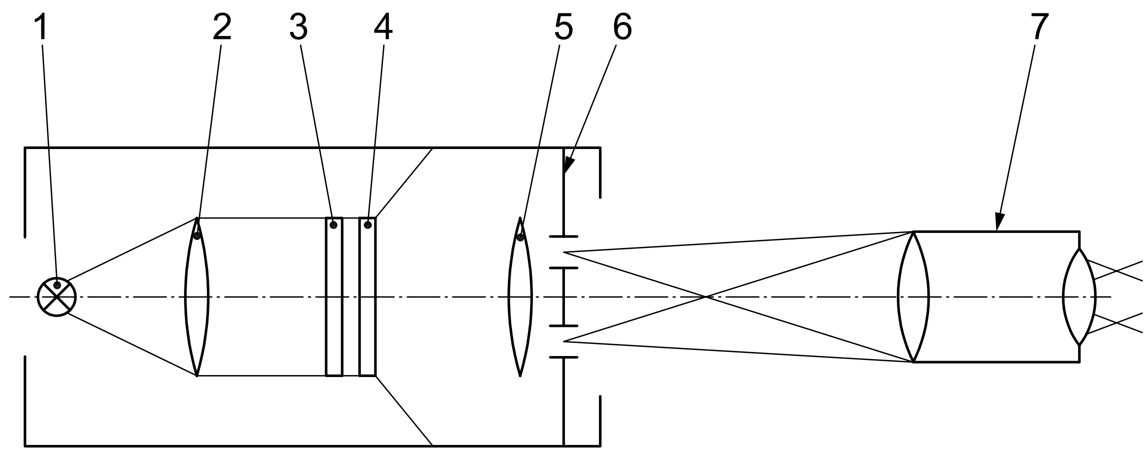
13 Test method for measuring the close distance of observation

13.1 General

With a test specimen of variable magnification, the minimum object distance shall be measured over the range of magnifications. The largest value shall be stated as the close distance.

13.2 Requirements for the test arrangement and its principal parts

The measurement of the close distance of observation of night-vision devices shall be carried out using the test arrangement shown in Figure 11.



Key

1 source of radiation
2 condenser
3 neutral filter
4 diffusing plate
5 collimator lens
6 test target
7 test specimen

Figure 11 — Arrangement for measuring the close distance of observation

Any collimator from arrangements shown in Figures 1 to 5 may be used in the illumination system (Figure 11, key items 1 to 6). In this case, a collimator is used purely for illumination purposes. The use of a test target with another type of illumination arrangement is also possible. A test target shall be placed in front of the collimator lens.

The test object used as the object of observation shall have apertures (slits) where the diameter (width) and distance between edges exceeds by at least 2½ times the limit of resolution of the test specimen.

When testing night-vision devices for which the close distance of observation exceeds 8 m, the test object may have one aperture (slit) with a diameter of at least 25 mm. The use of the collimator lens barrel as the object of observation is acceptable.

13.3 Sequence of measurements

The following operations should be carried out during the measurement of the close distance of observation.

— Install the test specimen as close as possible to the collimator lens.

— Moving the night-vision device away from the illuminated test target, determine the position of the objective of the night-vision device where the apertures (slits) in the test target or the edge of the collimator lens barrel are in sharp focus.

— Changing the focus of the night-vision device, find the shortest distance between the objective of the night-vision device and the test target or the edge of the collimator lens barrel where the test target is still in sharp focus (this distance is the close distance of observation).

— By means of an appropriate measuring instrument, measure the close distance of observation.

13.4 Assessment of results

The repeatability of the results of measuring the close distance of observation shall be better than 40 mm for night-vision devices that have a close distance of observation shorter that 0,5 m, and better than 6 % for those with a close distance of observation of more than 0,5 m.

14 Test method for imperfections in the field of view

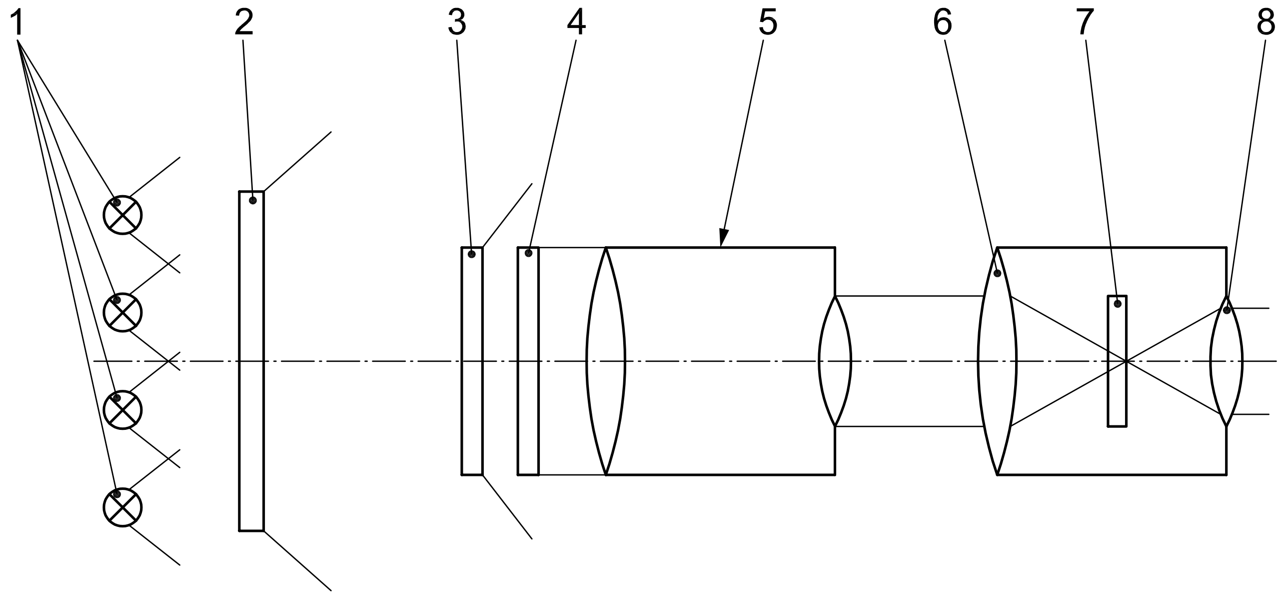
14.1 General

In the absence of any radiation entering the night-vision device, the image intensifier screen shall manifest no bright spots in a fixed position.

When the night-vision device is illuminated with radiation of uniform spatial luminance, dark spots might be observable.

14.2 Requirements for the test arrangement and its principal parts

The test for imperfections in the field of view shall be carried out using the test arrangement shown in Figure 12.



Key

1 source of radiation
2 diffusing plate
3 neutral filter
4 shutter
5 test specimen
6 telescope lens
7 telescope reticle (scale)
8 telescope eyepiece

Figure 12 — Arrangement for testing night-vision devices for imperfections in the field of view

Depending on the selection of the number of sources of radiation used, the transmission characteristics of the diffusing plate and the distance between the plate and the test specimen, a uniform (in the observer's opinion) luminance of the whole image intensifier screen shall be achieved.

The design of the shutter shall enable blocking of the radiation of the sources that enters the objective of the test specimen.

The focal length of the telescope lens shall exceed that of the eyepiece of test specimen by 5 to 6 times.

The telescope (Figure 12, key items 6 to 8) shall be capable of rotation around two mutually perpendicular axes to allow the whole image intensifier screen to be viewed. The measurement error of angles of rotation shall not exceed 1°.

The linear distance between adjacent lines of the reticle shall be such that there is an equivalent spacing in the plane of the image intensifier screen of 0,025 mm. The angular distance between adjacent lines of the reticle shall not exceed 3 minutes of arc. The reticle shall permit measurement of spot sizes along two mutually perpendicular directions.

14.3 Sequence of measurements

The following operations shall be carried out during testing for imperfections in the field of view.

— Focus the eyepiece of the test specimen onto the image intensifier screen.

— Close the shutter in front of the test specimen and confirm that there are no bright spots on the image intensifier screen.

— Having opened the shutter, measure the sizes of dark spots on the image intensifier screen. Using the values of the focal length of the telescope lens, f_o, and the eyepiece of the test specimen, f_e, and taking into account the scale spacing of the telescope reticle, L_c, calculate the spot size according to the equation:

$$d = \frac{L_c \times n_c \times f_e}{f_o} \tag{9}$$

where

d is the spot diameter;

n_c is the number of reticle divisions that the spot covers.

The calibration of telescope scale spacing, by means of normalized spots, is acceptable.

Measuring spot sizes in angular values is acceptable.

The telescope should be rotated for measuring spot sizes that are situated in the area of the circumference of the image intensifier screen.

14.4 Assessment of results

The repeatability of the results of measurement of spot sizes shall be better than 0,06 mm or an equivalent value in angular measure.

15 Test method for measuring the continuous work time of a night-vision device

15.1 General

This test method is based on assessment of the work time of a night-vision device from the moment it was switched on until the moment the image intensifier screen luminance is reduced by a factor of two, or until the image intensifier shuts off. It is assumed that the night-vision device is working in passive mode.

15.2 Requirements for the test arrangement and its principal parts

For measuring the continuous work time of a night-vision device, the test arrangement shown in Figure 3 shall be used.

15.3 Sequence of measurements

The following operations shall be carried out when measuring the continuous operation time of the night-vision device.

— Install the test specimen in accordance with the test arrangement shown in Figure 3.

— Measure the luminance every hour from the time when the test specimen was switched on.

— Measure the time required for the luminance of the radiation emerging from the eyepiece of the test specimen to drop by a factor of 2,0 to 2,2 times. The time that was measured is taken as the continuous work time of the night-vision device.

The tests shall be carried out on three examples of the night-vision device.

15.4 Assessment of results

The minimum value of the three measurements is taken as the final test result.

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[1] ISO 14132-1, *Optics and optical instruments — Vocabulary for telescopic systems — Part 1: General terms and alphabetical indexes of terms in ISO 14132*

[2] ISO 14132-2, *Optics and optical instruments — Vocabulary for telescopic systems — Part 2: Terms for binoculars, monoculars and spotting scopes*

[3] BIBERMAN, LUCIEN M. *EO Imaging: System Performance and Modelling,* page 102; Ontar Corporation 2000, (ISBN 0-9654811-1-5)

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