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Earth-moving machinery — Operator's field of view — Test method and performance criteria

Engins de terrassement — Visibilité de l'opérateur — Méthode d'essai et critères de performance

Reference number
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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 1, *Test methods relating to safety and machine performance*.

This second edition cancels and replaces the first edition (ISO 5006:2006), which has been technically revised. It also incorporates the Technical Corrigendum ISO 5006:2006/Cor 1:2008. The changes from the previous edition include the following:

— improved guidance on the use of mirrors;

— new guidance on maskings caused by moving excavator linkages;

— enhancement of visibility at the rectangular boundary;

— general improvements and clarifications in the language.

This corrected version of ISO 5006:2017 incorporates the following corrections:

— the second paragraph of 8.3.3.3 has been modified by the deletion of the phrases "in the forward direction" and "at the same height".

Introduction

The purpose of this document is to address the operator's visibility in such a manner that the operator can see around the machine to enable proper, effective and safe operation that can be quantified in objective engineering terms. The test method uses two lights placed at the location of the operator's eyes. The maskings due to the machine, its components and attachments are determined around the machine, on a boundary line 1 m away from the smallest rectangle that encompasses the machine and on a visibility test circle (VTC) of 12 m radius. The test method used does not include all aspects of the operator's visibility, but provides information to assist in determining the acceptability of visibility from the machine. Criteria are included in this document to provide guidance for designers as to the extent of visibility maskings that are acceptable.

Allowing for operator capability and the operation mode of the machine, the test method divides the area around the machine into six sectors: the front (sector A), to the front sides (sectors B and C), to the rear sides (sectors D and E), and to the rear (sector F).

For each of the sectors, the operator's physical characteristics are considered. Besides eye spacing of 65 mm — the nominal binocular eye spacing of a medium operator — additional adjustments can be made considering that the operator is able to turn the head and move the body torso from side to side. This allows the range of eye spacing to be enlarged up to 405 mm for the sectors A, B and C. For the sectors D, E and F, the turning of the operator's head and the rotation of the body torso are restricted by the physical aspects of the seated operator. Thus the maximum achievable eye spacing is 205 mm for sectors D, E and F. For certain machine types, the eye spacings used are less than the maximum permitted values, based on the ergonomics of the operator. This is done to maintain the current state-of-the-art of machines.

The 300 mm masking dimension on the rectangular boundary represents approximately the chest depth of personnel working in the near field of earth-moving machinery (see, for example, 2D in ISO 3411).

The established visibility performance criteria are based on the physical aspects of the human operators and ground personnel using various representative dimensions and the design of machines that have provided acceptable visibility. To establish the visibility criteria, a combination of eye spacings and masking widths are used. Multiple maskings in sectors are acceptable where there is adequate spacing between the individual maskings.

Where the direct visibility is considered inadequate, additional devices for indirect visibility [mirrors or closed-circuit television cameras (CCTV)], can be used to achieve acceptable visibility. For the rectangular boundary (RB) additional devices for indirect visibility (mirrors or CCTV) are preferred. Other aids (see ISO 16001) can be used exceptionally.

Jobsite organization can be an additional effective measure to compensate for remaining visibility maskings.

Earth-moving machinery — Operator's field of view — Test method and performance criteria

1 Scope

This document specifies a static test method for determining and evaluating the operator's field of view on a rectangular boundary around the machine and on a 12 m visibility test circle (VTC).

It is applicable to the earth-moving machines as defined in ISO 6165 that have a seated operator, and which are intended to operate on work sites and travel on public roads. It provides visibility performance criteria for machines up to the maximum operating mass according to ISO 6016, depending on the type of machine family listed in Table 1. For those machines not listed — including larger machines, derivative and other types of earth-moving machinery — the visibility test procedures can be used along with the risk assessment process defined in 10.4.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 3411, *Earth-moving machinery — Physical dimensions of operators and minimum operator space envelope*

ISO 5353, *Earth-moving machinery, and tractors and machinery for agriculture and forestry — Seat index point*

ISO 6016, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components*

ISO 6165, *Earth-moving machinery — Basic types — Identification and terms and definitions*

ISO 7135, *Earth-moving machinery — Hydraulic excavators — Terminology and commercial specifications*

ISO 16001, *Earth-moving machinery — Hazard detection systems and visual aids — Performance requirements and tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6165 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

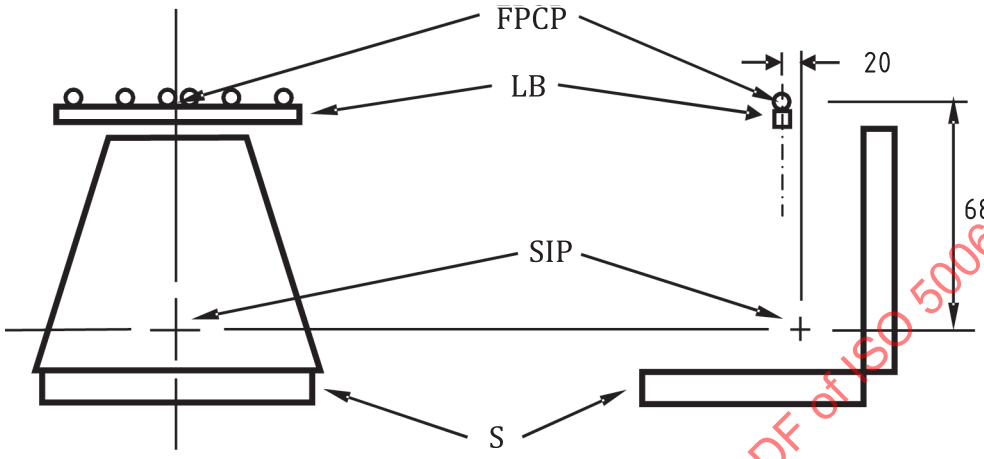
— IEC Electropedia: available at http://www.electropedia.org/

3.1
test surface
area that forms the ground reference plane for the visibility measurements

3.2
filament position centrepoint
FPCP
midpoint of the line between the light-bulb filaments

Note 1 to entry: See Figure 1.

Dimensions in millimetres



Key

LB	light bar
SIP	seat index point
S	seat
FPCP	filament position centre point

Figure 1 — Light source apparatus

3.3 Visibility test locations

3.3.1
visibility test circle
VTC
circle with 12 m radius located on the ground reference plane with its centre vertically below the *FPCP* (3.2)

Note 1 to entry: See Figure 2.

3.3.2
rectangular boundary
RB
line on the ground reference plane located at 1 m distance from the outside rectangular boundary of the machine, except for articulated-frame dumpers, where the distance is greater than 1 m to the front of the machine and graders where the distance to the rear of the machine is greater than 1 m

Note 1 to entry: See Figure 2 and 8.3.3.

3.3.3
sector of vision A
segment of the visibility test surface to the front of the machine, defined by a 9,5 m chord length for the 12 m radius that is perpendicular to the longitudinal plane passing through the *FPCP* (3.2) (X axis) with the chord length bisected by the longitudinal plane (Y axis)

Note 1 to entry: See Figure 2.

3.3.4
sectors of vision B and C
segments of the visibility test surface to the front of the machine outside sector A and bounded by the transverse plane through the *FPCP* (3.2)

Note 1 to entry: See Figure 2.

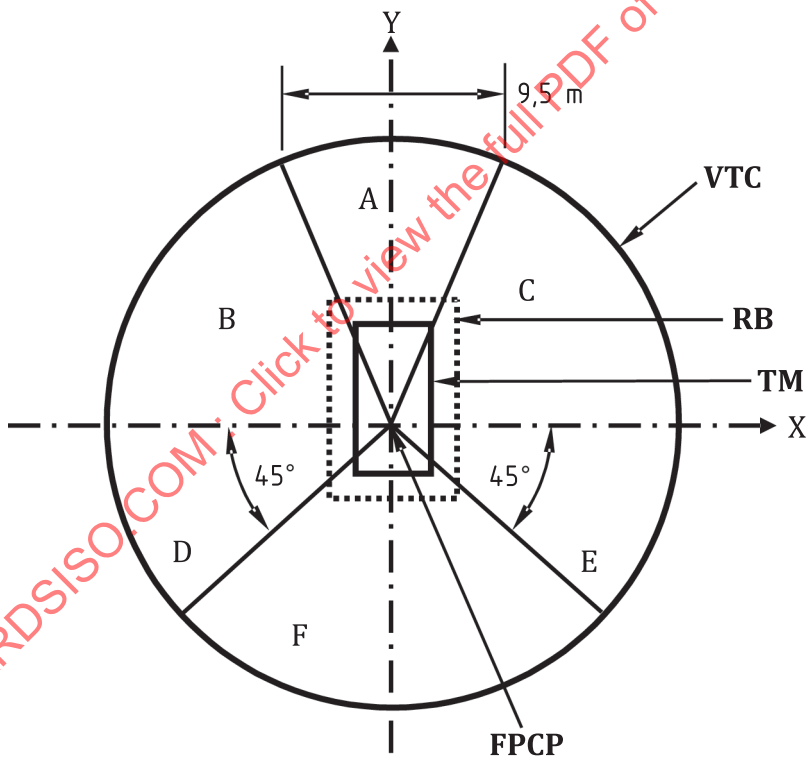
3.3.5
sectors of vision D and E
segments of the visibility test surface to the rear defined by an angle of 45° to both the right and left sides of the transverse plane passing through the *FPCP* (3.2)

Note 1 to entry: See Figure 2.

3.3.6
sector of vision F
segment of the *visibility test circle* (3.3.1) to the rear between sectors D and E

Note 1 to entry: See Figure 2.

Dimensions in metres



Key

VTC	visibility test circle
RB	rectangular boundary
TM	test machine
Y	forward direction of machine
A, B, C, D, E, F	sectors of vision
FPCP	filament position centre point

Figure 2 — Visibility test locations

3.4
masking
shadow on the 12 m *visibility test circle* (3.3.1) or the vertical test object at the *RB* (3.3.2) created because parts of the base machine or its equipment block the light rays from both of the light bulb filaments

Note 1 to entry: Examples of parts that can cause maskings include rollover protective structures (ROPS), window and door frames, exhaust pipes, the engine hood and equipment or attachment, such as bucket, boom.

3.5
light source apparatus
test unit with at least two light sources that have adjustable light spacing, 360° rotatable, with its rotation point at the *FPCP* (3.2), to simulate the range of eye positions for an operator

Note 1 to entry: See Figure 1.

3.6
visibility performance criteria
criteria intended to minimize risk to persons in the vicinity of the machine during machine operation and travelling

Note 1 to entry: These visibility performance criteria are specified as maximum allowed maskings at the 12 m visibility test circle or at the *RB* (3.3.2).

3.7
jobsite organization
rules and procedures for the jobsite that coordinate machines and people working together

EXAMPLE Safety instructions, traffic patterns, restricted areas, operator and jobsite training, machine and vehicle marking (special warning lights, warning signs, etc.), restrictions on travelling in reverse, communication systems.

3.8 Direct and indirect visibility

3.8.1
direct visibility
visibility by direct line of sight as determined by the light from the light source

3.8.2
indirect visibility
visibility with the aid of mirrors or with other visual aids, such as closed circuit TV (CCTV)

3.9
derivative earth-moving machine
machine modified or fitted with equipment or attachments that influence visibility as compared with the standard configuration of the machine

Note 1 to entry: This definition is different from the one given in ISO 6165.

4 Basic dimensions

4.1 Light spacing dimensions

The following three maximum light spacings for intended machine operations shall be used as specified in Table 1:

a) 65 mm, the light spacing that represents the binocular eye spacing of 50 % of seated earth-moving machinery operators;

b) 205 mm, the maximum light spacing that represents the range of eye movement (considering body torso and head movement) of 50 % of earth-moving machine operators when looking to a 45° angle to the rear (135° clockwise or anti-clockwise from straight ahead position);

c) 405 mm, the maximum light spacing that represents the range of eye movement (considering body torso and head movement) of 50 % of earth-moving machine operators when looking to the front (90° clockwise and anti-clockwise from the straight ahead position).

4.2 Masking dimensions

The allowable masking dimensions are specified in Table 1.

4.3 Reference dimensions for measurement purposes

The following reference dimensions for measurement shall be used:

a) 1 m, the distance used in conjunction with the RB to describe the near field (closest distance) around earth-moving machinery;

b) 1,5 m, 1,2 m and 1,0 m, the maximum height above the ground reference plane on which a visibility observation in the near field is made according to Table 2.

NOTE 1,5 m, the maximum height above the ground reference plane on which a visibility observation in the near field is made, based on the height of a small earth-moving machinery operator (1,55 m as specified in ISO 3411).

c) 12 m, the radius of the VTO on a horizontal surface measured from the FPCP.

NOTE The 1 m rectangular boundary in a) above has been modified in 8.3.3.1.

5 Test apparatus

5.1 Light source apparatus, capable of positioning a light bar horizontally with at least two halogen light bulbs (or equivalent) mounted with the bulbs vertically. Each light bulb should be horizontally movable on the light bar from 32,5 mm to 202,5 mm on each side of the light bar centre point. It shall be possible to rotate the light bar through 360° about the FCCP. The vertical centre point of the light bulb filaments shall be located 680 mm above and 20 mm in front of the seat index point (SIP) as defined by ISO 5353 (see Figure 1).

5.2 Vertical test object, 1,0 m,1,2 m, or 1,5 m high, with a suitable width (e.g. 100 mm to 150 mm), used to evaluate the maskings on the RB. See Table 2 for the test object height to be used by machine type, mass, and region of the RB. The 1,5 m test object can also be used for possible mirror evaluation (see 7.3).

5.3 Test surface, an area of firm surface, e.g. compacted earth, concrete, paved surface, with a gradient of not more than 3 % in any direction.

5.4 To determine the maskings on the VTC or the RB, a hand held **mirror** can be used to detect the line-of-sight between the light source and the ground reference plane or vertical test object. Other apparatus giving equivalent results is permitted.

6 Machine test configuration

6.1 The machine shall be equipped with attachments and equipment according to the manufacturer's specification for operation on a work site, travelling on public roads, or both.

6.2 All machine openings, such as doors and windows, shall be closed.

6.3 The machine shall be positioned on the test surface with the equipment and attachments located in the travel mode according to the manufacturer's specification — see examples in Annex A. The FPCP shall be vertically above the VTC centre point. The front of the machine shall be directed to sector A. See 8.3.3.3 for additional requirements for excavators.

6.4 The operator's seat shall be positioned such that there is no restriction or influence on the light source, such as to prevent rotation of the light bar. For ease of testing the seat or seat backrest extension may be removed.

7 Performance criteria for indirect visibility

7.1 Visibility aids

In designing machinery, direct visibility shall first be maximized. However, machine design and application can require visibility aids for the operator on many machine types. Visibility aids shall be added where there is insufficient direct visibility to meet the performance requirements in this document.

7.2 Position of display devices

The devices (e.g. CCTV display, mirror) used by the operator to view the area being monitored shall be placed such that they are in the 180° arc centred in front of the operator.

Excavators may have indirect visibility aids (e.g. mirrors) located in the 270° arc centred in front of the operator. Mirrors located behind the operator shall only be so placed to enable the operator to see the area along the sides of the machine or the area to the side of the machine which extends beyond the rear of the machine.

The centre of the mirror shall be used as the reference for mirror location. The mirror locations shall be noted in the test report.

7.3 Performance criteria for mirrors

For indirect visibility with mirrors fitted for the purpose of meeting the performance requirements of this document, the height of the reflection of a 1,5 m test object in the mirror shall be at least 7 mm for every 1,2 m that the mirror is positioned away from the FPCP. As an example, the reflection of a 1,5 m test object shall be at least 28 mm for a mirror located 4,8 m from the operator's FPCP. The mirror performance shall be evaluated at the longest distance from the mirror to the vertical test object that the mirror is intended to be used at. This evaluation may be done by physical testing, simulation or calculation. This evaluation is a linear relationship of distance from the operator eye to the mirror, distance from the mirror to the test object, and the size of the image on the mirror.

NOTE A 1,2 m test object would need to have a 5,6 mm tall reflection for every 1,2 m of viewing distance. Likewise, a 1,0 m test object would need to have a 4,7 mm tall reflection for every 1,2 m of viewing distance.

For the purposes of meeting the performance requirements of this document, mirrors shall be used in a direct manner. Using one mirror to view another is not allowed.

7.4 Performance criteria for CCTV system

CCTV systems shall comply with ISO 16001.

8 Measurement procedure

8.1 Test-surface marking and machine location on test surface

8.1.1 Mark a VTC of 12 m radius on the test surface with the two centrelines as shown in Figure 2.

8.1.2 Mark the sectors A, B, C, D, E and F on the test surface as shown in Figure 2.

8.1.3 Position the machine on the test surface as defined in 6.3.

8.1.4 Mark the RB on the test surface at a distance of 1 m from the smallest rectangle that can be placed around the vertical projection of the machine as shown in Figure 3. For excavators, the RB is measured from the front of the most forward point of the base machine according to ISO 7135, or from the dozer blade if it is standard — see A.4.

8.1.5 If the machine has a seat position that is not parallel to the longitudinal centre line of the machine, the eye spacing from Table 1 shall be rotated with the operator. The visibility performance criteria of the different sectors with respect to the longitudinal centre line of the machine shall stay the same.

8.2 Positioning of test apparatus

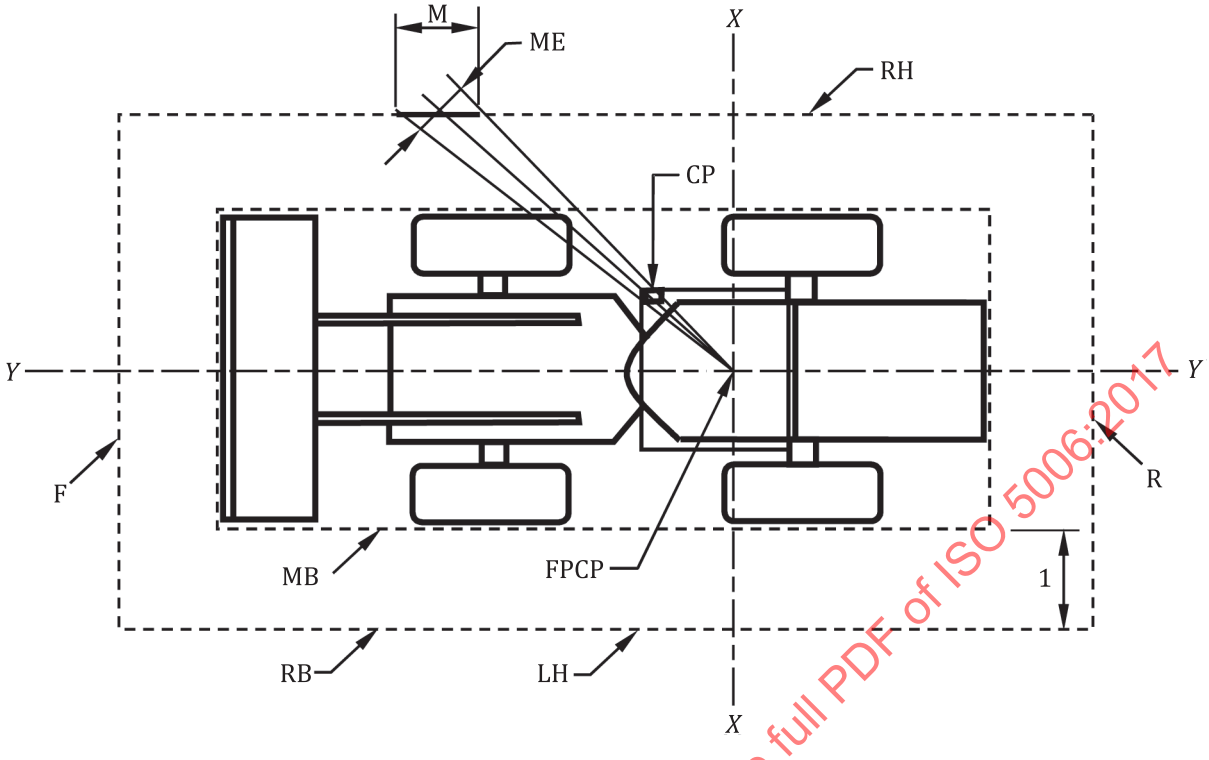
8.2.1 Mount the light source with the light bulb FPCP as defined in 5.1.

8.2.2 The light-bulb spacing arrangement with a distance of 65 mm is symmetric to the centre of the light source apparatus. If the allowed light-bulb spacings are used up to their maximum values 205/405 mm, the left and right light source can each be positioned in a way that the measurement on the 12 m VTC or the RB minimizes the maskings. For the 205 mm and 405 mm light spacings, more than two light bulbs may be used simultaneously to represent the range of eye positions. During this procedure, it is not necessary that the light sources be symmetric to the FPCP, as long as the maximum distance from the FPCP point is 102,5 mm or 202,5 mm, as appropriate for the sector being evaluated.

8.2.3 To take measurements for the visibility circle, rotate the light bar so that the line between the two light sources is perpendicular to the line between the FPCP, and the centre of the visibility masking component.

8.2.4 To take measurements for the RB, rotate the light bar to minimize the maskings.

Dimensions in metres



Key

MB	machine boundary
RB	rectangular boundary (1 m from all four sides except as noted in Table 1)
FPCP	filament position centre point
M	masking length on RB
ME	masking effective length perpendicular to light source
CP	cab post
F	front side of RB
LH	left-hand side of RB
RH	right-hand side of RB
R	rear side of RB

Figure 3 — Location and maskings RB

8.3 Measurement of maskings

8.3.1 General

Initial measurement of the maskings shall be made considering the direct visibility.

If the performance requirements are not met by direct visibility, visibility aids providing indirect visibility (e.g. mirrors, CCTV) shall be incorporated in the measurements to comply with the visibility performance criteria as required. These visibility aids shall meet the requirements of Clause 7.

For defining the indirect visibility for mirrors, use the same measurement procedure as for direct visibility (see Clause 7) to measure and record the reflection of the light source in the mirrors to the VTC and the RB. Use the same light-bulb spacing as specified in 8.3.2 for the VTC and in 8.3.3 for the RB for the sectors where the mirror is located.

Where visibility aids are used in order to meet the performance requirements of both this document and ISO 14401 series, no change to the positions of the visibility aids is permitted to be made between the two assessments (e.g. a mirror adjusted to meet ISO 14401 series requirements shall not then be readjusted to meet ISO 5006 requirements).

8.3.2 Measurement at the VTC

Adjust the light-bulb spacing as specified in Table 1 for the relevant sector. Position the light source as specified in 8.2.2 and 8.2.3.

When a masking overlaps adjacent visibility sectors, the entire width of the masking, using the light-bulb spacing for each sector as specified in Table 1, shall be evaluated using the performance criteria as specified in Table 1, for the visibility sector in which the greater part of the masking lies.

When a machine has two or more vertical components that are near each other, a light-bar spacing less than the maximum specified for the sector may be used to determine the minimum maskings (see also 8.2.2).

The requirements for a minimum spacing between two adjacent maskings as specified in 10.1 shall be considered.

Record the masking at the VTC on the ground reference plane, so that the chord length of the masking on the VTC can be determined.

It is not necessary to record maskings that have a width of less than 100 mm.

For maskings that are wider on the VTC due to some machine components (e.g. door latch, cup holder, grab handle) it is permissible to check the maskings within 1 m inside and outside of the VTC. The narrower masking width at 1 m inside or outside the test circle may be used as the masking width at the visibility circle.

The test may be carried out in a dark environment where the shadows of machine components can be directly noted on the VTC, or a mirror located on the test surface may be used to develop a line of sight to the filament to determine the point where masking occurs.

8.3.3 Measurement at RB

8.3.3.1 Adjust the light-bulb spacing as specified in Table 1 for the RB. Position the light source as specified in 8.2.2 and 8.2.4. Evaluate maskings along the RB as illustrated in Figure 3 and Figure 4 using the vertical test object height as specified in Table 2.

For the front of articulated-frame dumpers and the rear of motor graders, the distance to the RB is specified in Table 1.

8.3.3.2 Mark on the RB where the direct view to the light source is masked by machine parts. Record the maskings with their x and y coordinates. If the masking width (M) exceeds 300 mm on the RB, measure the width of the masking perpendicular to the light source (ME); see Figure 3. Record ME as the width of the masking.

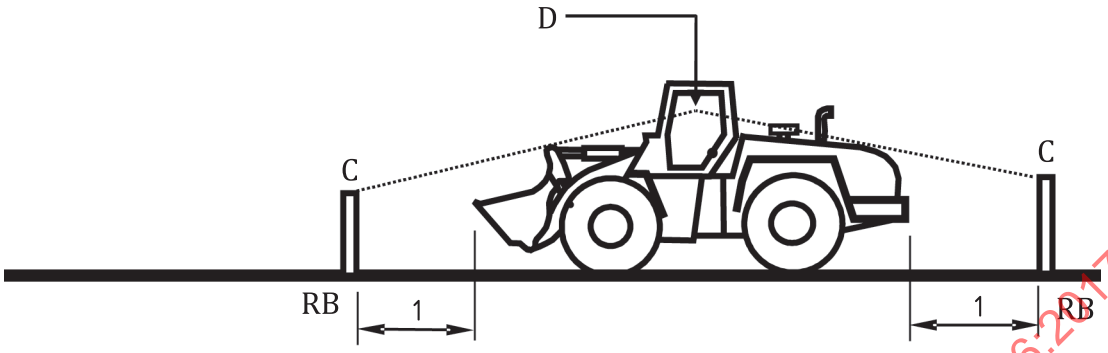
If the top of the vertical test object is masked, check if the vertical test object can be seen at least in a height of 200 mm. If seen, this point (position) on the RB boundary is not counted for masking evaluation.

The test may be carried out in a dark environment where the shadows of machine components can be directly noted on the vertical test object or a mirror located on the vertical test object can be used to develop a line of sight to the filament to determine the point where masking occurs. The visibility on the vertical test object below the test object height may be checked by the use of a mirror moved up and down the test object.

It is not necessary to record maskings that have a width of less than 200 mm.

When a machine has two or more vertical components that are near each other, a light-bar spacing less than the maximum may be used to determine the minimum maskings (see also 8.2.2).

Dimensions in metres



Key

RB rectangular boundary

C vertical test object

D FPCP

Figure 4 — Measurement at RB

8.3.3.3 The off-side visibility on excavators shall be evaluated with the linkage in a travel position as the start position. Wheeled excavators may be evaluated at an alternative travel position that is the manufacturer's specified road travel position.

Starting with the linkage in the travel position, the linkage shall be manipulated through the range of motion that keeps the bucket above ground level.

Either of the following may be used to determine if visibility aids for the side of the machine opposite from the operator (e.g. on the other side of a moving linkage from the side the operator is on) are masked:

— a computer simulation using the eye spacing of 405 mm with the light bar perpendicular to the visibility aids being evaluated;

— an operator in the seat with the eye point at the same height as the FPCP. The operator shall be allowed to move to simulate the 405 mm eye-spacing.

When maskings are created due to a lack of indirect vision (because of an obstructed view in the direction of a mirror under a specific position of boom), then direct visibility shall be ensured in the direction of the maskings. If it is technically not possible due to the size of the machinery, the following requirements shall apply.

a) If there are 2 visibility aids on the opposite side to cover the side of the RB at no time shall both be masked (e.g. on the other side of a moving linkage from the side the operator is on).

b) If there is only 1 visibility aid to cover the opposite side of the RB, it shall not be masked by linkage motion.

Mirrors used exclusively for road travel (e.g. for ISO 14401 series and typically on wheeled excavators) may be masked by linkage motion provided that they are not masked in the specified travel position of the linkage.

9 Calculation method

9.1 Calculation procedure for determining maskings at VTC or RB

A calculation procedure can be used for determination of maskings at the VTC or the RB.

The specified calculation procedure provides an alternative to the test method.

For binocular vision with an eye spacing, *s*, the masking, expressed in millimetres, is given by Formula (1) (see also Figure 5):

$$x = \left(\frac{b - s}{a} \right) r + s \tag{1}$$

where

a is the distance between the component causing the masking and the light-bulb filament, in millimetres;

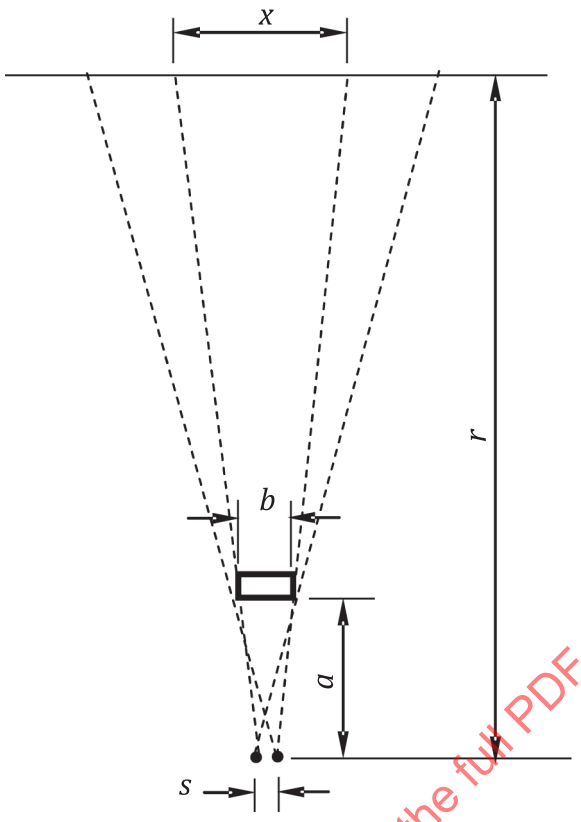
b is the width of the component causing the maskings, measured horizontally, and perpendicular to the radius from the light-bulb FPCP and the centre of the component, in millimetres;

r is the radius from the light-bulb FPCP on the test surface to the VTC on the test surface or to the RB, in millimetres;

s is the distance between the light-bulb filaments, used to represent binocular vision with this eye spacing, in millimetres;

x is the width of the masking tangent to the VTC or masking effective length (ME in Figure 3) on the RB, in millimetres.

NOTE Formula (1) is an approximate calculation of the masking and becomes less accurate as the length of the masking increases, but it provides acceptable accuracy for masking widths up to 5 m without verification by physical measurement.



NOTE For a definition of the symbols, see Formula (1).

Figure 5 — Calculation method for determining maskings

9.2 Computer-simulation

Computer-simulation based on the principles specified in this document may be used to determine the visibility maskings and provide results for the test report.

10 Evaluation method and performance criteria

10.1 Visibility performance criteria on VTC

The space between any two adjacent maskings on the VTC shall be equal to or greater than 700 mm. If this is not the case, the two maskings and the space between them shall be combined to result in one reported masking.

Adjacent narrow maskings may be combined with the space between them and treated as one larger masking to reduce the number of maskings to be reported.

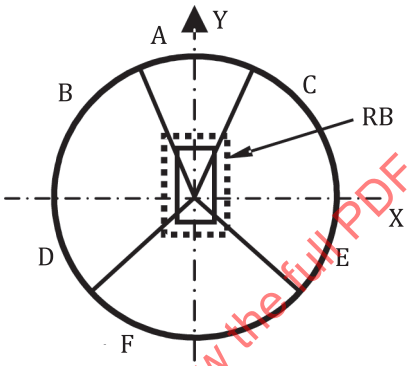
The machine meets the requirements of this document if the measurement results show no maskings or maskings smaller than or equal to the performance criteria with direct or indirect view as specified in Table 1.

NOTE 1 The visibility performance criteria are summarized in Table 1 for the different machine types/masses. The first column of Table 1 defines the type of machine and the class of machine based upon machine mass. The maximum allowed masking widths on the VTC are specified in Table 1 for each machine type/mass. Visibility criteria are specified for sectors A, B, C, D, E and F on the VTC. The first line for each visibility sector specifies the maximum allowed light-bulb filament spacing. The other lines specify the number and maximum width of maskings for each visibility sector.

NOTE 2 The visibility testing that is done with a 65 mm eye spacing for sectors A, B, and C is for test purposes and does not consider the normal head and eye movement capability of the operator of up to 405 mm. The actual size of the visibility masking as seen by the operator is less than the masking size measured with 65 mm eye spacing. As an example, the measured masking for a cab post that is 160 mm wide and located 570 mm from the FPCP would be 2 000 mm for an eye spacing of 65 mm, but the measured masking would completely disappear with an eye spacing of 205 mm — see Figure 6.

Table 1 — Visibility performance criteria

Dimensions in millimetres

Operating (empty) mass according to ISO 6016, *m*, t	**A**	**B**	**C**	**D**	**E**	**F**	**RB**
 The first row for each machine type is the allowed eye spacing. The second row is the allowed number and width of maskings.							
Wheel loader							
$m < 10$	65 --- 2 - 700	205 --- 0	205 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 --- 300
$10 \leq m \leq 25$	65 --- 2 - 700 or 1 - 1 300	205 --- 0	205 --- 0	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	65 --- 3 - 1300	405 --- 300
$25 < m \leq 30$	405 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	65 --- 3 - 1 300	405 --- 300
Skid steer loader							
All — Wheeled and crawler	65 --- 0	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	205 --- (2 - 2 100 and 2 - 1 300) or (2 - 4 000)[a]	---	---	405 --- 300

NOTE No specific criteria are specified in this table when no significant hazards exist for the machine sector, e.g. due to machine speed, distance to the test circle, machine manoeuvrability.

[a] These requirements apply across sectors D, E, F.

[b] These requirements apply across sectors A, B, C.

Table 1 *(continued)*

Operating (empty) mass according to ISO 6016, *m*, t	A	B	C	D	E	F	RB
Crawler loader							
$m < 20$	65 --- 2 - 700	205 --- 0	205 --- 0	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 --- 300
$20 \leq m \leq 30$	405 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 --- 300
Backhoe loader							
$m \leq 15$	65 --- 2 - 700	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	65 --- 1 - 1 300 and 1 - 3 000	405 --- 300
Wheel excavator							
$m < 10$ front boom	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	---	---	205 --- 0	205 --- 0	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 --- 300
$m < 10$ side boom	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	205 --- 0	405 --- 1 - 2 500	205 --- 0	205 --- 0	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 --- 300
$10 \leq m \leq 25$	405 --- 1 - 700 and 1 - 1 300	205 --- 0	405 --- 1 - 700 and 1 - 5 500	205 --- 1 - 700 and 1 - 1 300	--- No specific criteria	65 --- 1 × machine width and 2 - 1 300	405 --- 300

NOTE No specific criteria are specified in this table when no significant hazards exist for the machine sector, e.g. due to machine speed, distance to the test circle, machine manoeuvrability.

[a] These requirements apply across sectors D, E, F.

[b] These requirements apply across sectors A, B, C.

Table 1 *(continued)*

Operating (empty) mass according to ISO 6016, *m*, t	**A**	**B**	**C**	**D**	**E**	**F**	**RB**
Crawler excavator							
m < 10 front boom	205 ---------- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	----------	----------	205 ----------	205 ----------	65 ---------- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 ---------- 300
m < 10 side boom	205 ---------- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	205 ---------- 0	405 ---------- 1 - 2 500	205 ---------- 0	205 ---------- 0	65 ---------- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 ---------- 300
10 ≤ *m* < 25	405 ---------- 1 - 700 and 1 - 1 300	205 ---------- 0	405 ---------- 1 - 700 and 1 - 5 500	205 ---------- 1 - 700 and 1 - 1 300	---------- No specific criteria	65 ---------- 1 × machine width and 2 - 1 300	405 ---------- 300
25 ≤ *m* ≤ 40	405 ---------- 1 - 700 and 1 - 1 300	205 ---------- 0	405 ---------- 1 - 1 600 and 1 - 5 500	205 ---------- 1 - 700 and 1 - 1 300	---------- No specific criteria	65 ---------- 1 × machine width and 2 - 1 300	405 ---------- 300

NOTE No specific criteria are specified in this table when no significant hazards exist for the machine sector, e.g. due to machine speed, distance to the test circle, machine manoeuvrability.

[a] These requirements apply across sectors D, E, F.

[b] These requirements apply across sectors A, B, C.

Table 1 *(continued)*

Operating (empty) mass according to ISO 6016, *m*, t	A	B	C	D	E	F	RB
Rigid-frame dumper							
$m < 10$	65 --- 0	205 --- 0	205 --- 0	205 --- 0	205 --- 0	65 --- 0	405 --- 300
$10 \leq m < 20$	65 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- 0	205 --- 1 - 700 and 1 - 1 300	65 --- 0	405 --- 300
$20 \leq m \leq 50$	65 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- 0	--- No specific criteria	65 --- 3 - 1 300	405 --- 300
Articulated frame dumper							
$m < 25$	65 --- 0	205 --- 0	205 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	65 --- 3 - 1 300	405 --- 300 X = 1 500 see Figure A.6
$25 \leq m \leq 50$	65 --- 0	205 --- 0	205 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	65 --- 3 - 1 300	405 --- 300 X = 2 500 see Figure A.6
Dumper (front body)							
$m < 10$	65 --- 0	205 --- 0	205 --- 0	205 --- 0	205 --- 0	65 --- 0	405 --- 300
Grader							
$m < 15$	65 --- 2 - 700 and 1 - 1 300	205 --- 0	205 --- 0	205 --- 0	205 --- 0	65 --- 2 - 700 and 1 - 1 300	405 --- 300 Y = 2 000 see Figure A.7
Crawler dozer							
$m < 10$	205 --- 1 - 700 and 2 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700	205 --- 1 - 700	65 --- 2 - 700 and 1 - 1 300	405 --- 300
$10 \leq m \leq 18$	405 --- 0	405 --- 0	405 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	65 --- 2 - 700 and 1 - 1 300	405 --- 300

NOTE No specific criteria are specified in this table when no significant hazards exist for the machine sector, e.g. due to machine speed, distance to the test circle, machine manoeuvrability.

[a] These requirements apply across sectors D, E, F.

[b] These requirements apply across sectors A, B, C.

Table 1 *(continued)*

Operating (empty) mass according to ISO 6016, *m*, t	A	B	C	D	E	F	RB
Landfill compactor							
10 < *m* < 25	65 --- 2 - 700	205 --- 0	205 --- 0	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	65 --- 3 - 1 300	405 --- 300
25 ≤ *m* ≤ 35	405 --- 0	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	205 --- (1 - 700 and 1 - 1300) or (1 - 2 000)	65 --- 3 - 1 300	405 --- 300
Roller							
5 < *m* < 10	65 --- 0	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)[b]	205 --- 1 - 700 and 1 - 1 300	205 --- 1 - 700 and 1 - 1 300	65 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	405 --- 300
10 ≤ *m* ≤ 25	65 --- 2 - 700	205 --- 0	205 --- 0	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	205 --- (1 - 700 and 1 - 1 300) or (1 - 2 000)	65 --- 3 - 1 300	405 --- 300

NOTE No specific criteria are specified in this table when no significant hazards exist for the machine sector, e.g. due to machine speed, distance to the test circle, machine manoeuvrability.

[a] These requirements apply across sectors D, E, F.

[b] These requirements apply across sectors A, B, C.

10.2 Visibility performance criteria for RB

The machine meets the requirements of this document if the measurement results show no maskings, or maskings smaller than or equal to the acceptable maskings (300 mm), when evaluated using the eye spacing specified in Table 1 for the RB and using the test object height for each region as specified in Table 2. Equipment or attachments that do not allow visibility at the front of the RB to the target as specified in Table 2 shall be risk-assessed and either

— a recommendation shall be made in the operator's manual for the machine to not travel with those attachments or equipment attached, or

— specific job site organization recommendations shall be made in the operator's manual to keep people away from the front of the machine.

Table 2 — Vertical test object height by machine type, mass, and region of rectangular boundary

Machine type	Mass	Region of the RB			
		Front side	Left-hand side	Right-hand side	Rear side
Loader	$m < 10$ t	1,2 m	1,2 m	1,2 m	1,2 m
Loader	10 t ≤ m ≤ 30 t	1,5 m	1,5 m	1,5 m	1,2 m
Skid steer loader	All — wheeled and crawler	1,2 m	1,2 m 1,5 m in RB′ as shown in Figure A.10	1,2 m 1,5 m in RB′ as shown in Figure A.10	1,2 m 1,5 m in RB′ as shown in Figure A.10
Dozer	m ≤ 18 t	1,5 m	1,5 m	1,5 m	1,2 m
Excavator	$m < 6$ t	1,0 m	1,0 m	1,2 m	1,0 m
Excavator	6 t ≤ m ≤ 40 t	1,2 m	1,2 m	1,2 m	1,2 m
Backhoe loader	m ≤ 15 t	1,2 m	1,2 m	1,2 m	1,2 m
Rigid-frame dumper	m ≤ 50 t	1,2 m	1,2 m	1,2 m	1,2 m
Dumper (front body)	$m < 3$ t 3 t ≤ m ≤ 10 t	1,2 m 1,2 m	1,2 m 1,5 m	1,2 m 1,5 m	1,2 m 1,2 m
Articulated-frame dumper	$m < 10$ t	1,2 m	1,2 m	1,2 m	1,2 m
Articulated-frame dumper	10 t ≤ m ≤ 50 t	1,5 m	1,5 m	1,5 m	1,2 m
Grader	$m < 15$ t	1,5 m	1,2 m	1,2 m	1,2 m
Landfill compactor	$m < 10$ t 10 t ≤ m ≤ 35 t	1,2 m 1,5 m	1,2 m 1,5 m	1,2 m 1,5 m	1,2 m 1,2 m
Roller	$m < 10$ t 10 t ≤ m ≤ 25 t	1,0 m 1,2 m	1,0 m 1,2 m	1,0 m 1,2 m	1,0 m 1,2 m

10.3 Visibility maskings that exceed visibility performance criteria with direct view

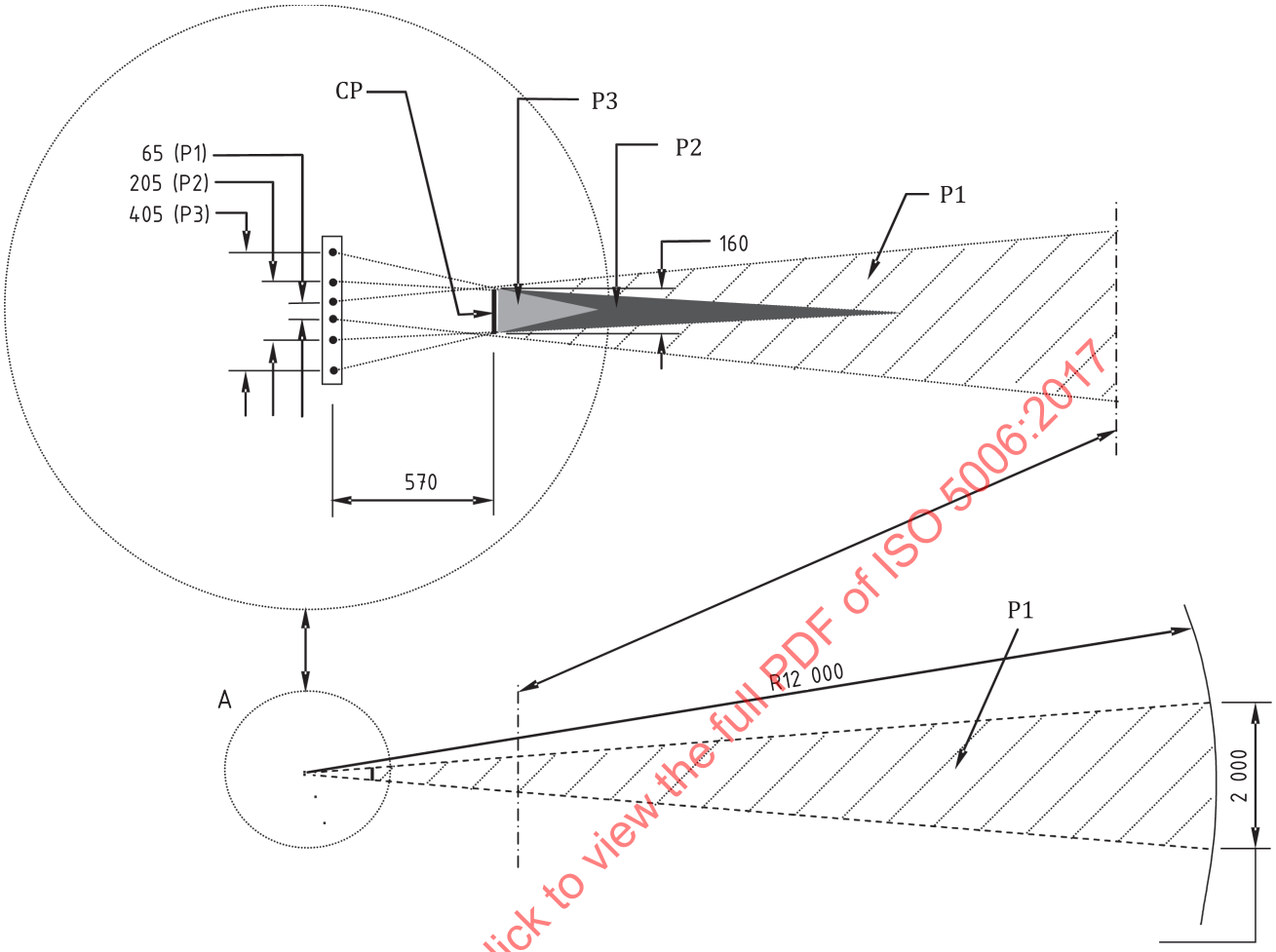
If the direct view does not comply with the performance criteria specified in 10.1 for the VTC and in 10.2 for the RB, the visibility provided by additional devices shall be considered:

a) incorporate the indirect view provided by mirrors;

b) incorporate the view provided by additional visual aids, e.g. CCTV.

The machine meets the requirements of this document if the visibility with the additional devices complies with the performance criteria in Table 1 and 10.1 and 10.2.

Dimensions in millimetres



Key

CP cab post
P1 masking width with 65 mm bulb spacing
P2 masking width with 205 mm bulb spacing
P3 masking width with 405 mm bulb spacing

Figure 6 — Example of masking width versus bulb spacing

10.4 Requirements for larger, derivative and other types of earth-moving machinery not covered in Table 1 and Table 2

10.4.1 Larger machines

For machines that are not included in Table 1 and Table 2 due to their machine mass (i.e. larger mass), the manufacturer should apply the tests and criteria as specified in this document for the highest specified category of machine mass in the respective machine family.

For those machines that do not meet the criteria, the manufacturer shall perform a risk assessment according to 10.4.3 to define the areas around the machine that need to be viewed by the operator and provide visibility aids to view these areas.

Dozers of a mass greater than 50 t equipped with a single shank ripper are allowed a masking behind single shank ripper frame.

If there are remaining visibility risk areas, the operator's manual shall identify the machine visibility risk area and recommend that jobsite organization is mandatory for the safe use of the machine.

10.4.2 Derivative and other types of earth-moving machinery

For other types of earth-moving machinery (including a combination of machine families from ISO 6165) or derivative earth-moving machinery that are not included in Table 1 and Table 2, the manufacturer should apply the tests and criteria as specified in this document. For those machines, the criteria for the most similar machine types (considering design and use) from Table 1 and Table 2 should be used. If it is not possible for those machines to meet the criteria, the manufacturer shall perform a risk assessment according to 10.4.3 to define the areas around the machine that need to be viewed by the operator and provide visibility aids to allow those areas to be viewed. The operator's manual shall identify the machine visibility risk areas and define any jobsite organization requirements for safe operation of the machine.

10.4.3 Risk assessment process for larger, derivative or other types of earth-moving machinery not covered in Table 1 and Table 2

The risks associated with the visibility of the operator around larger, derivative or other types of machines shall be evaluated with a risk assessment process to define where the operator needs to see to safely operate the machine. These risk areas include the areas in front of the machine and behind the machine where the machine can move or swing into, including the steering capability of the machine. Another risk area is the entrance point to access systems where a person could be approaching the machine. Any other specific risk areas for these machines should also be evaluated.

10.4.4 Visibility test circle and allowed masking width

For the assessment of larger, derivative and other types of earth-moving machinery, the VTC radius may be larger (preferably 24 m) and masking widths may be increased in proportion to the ratio of the larger test circle to the standard 12 m test circle.

11 Test report

The test report shall include the machine details according to 11.1 and a drawing according to 11.2.

11.1 Machine details

The machine details shall include the following information:

a) the manufacturer;

b) the model;

c) the operating (empty) mass according to ISO 6016;

d) the serial number (if applicable);

e) the operator enclosure or operator protective structure description or identification;

f) the equipment installed on the machine;

g) any other information that affects the visibility measurements;

h) the pictures (or illustration) of the machine configuration for the visibility test;

i) the position dimensions (HH and RR) used for the test as illustrated in Annex A;

j) a description of the type, specification and position of visibility aids (where fitted).

11.2 Drawing

The drawing shall illustrate the test results of the static test direct view and indirect view including the maskings (dimensions in millimetres) on the VTC by the designated visibility sector with the specific light bulb filament spacing. The distance between maskings and their positions shall be provided. Additionally, the maskings at the RB line shall be provided.

12 Visibility information for operator's manual

The machine operator's manual shall contain the following so that the operator can minimize visibility hazards when operating the machine:

a) recommendation that the operator is required to survey his/her field of vision when operating the machine;

b) information regarding the position, adjustment and the use of mirrors or visual aids (CCTV), when provided;

c) recommendation regarding the need to keep visual aids clean to maintain visibility;

d) information that for machines specified in 10.4 an appropriate jobsite organization is required to minimize hazards due to restricted visibility;

e) information that modifications of the machine configuration by any end user of the machine which result in a restriction of the machine visibility necessitates that a new risk assessment be performed (this document may be used for that purpose).

Annex A
(normative)

Dimensions and position of HH and rectangular boundary (RB)

A.1 Loader

Loader bucket shall be in the carry position — HH = 300 mm ± 50 mm. See Figure A.1.

Dimensions in metres

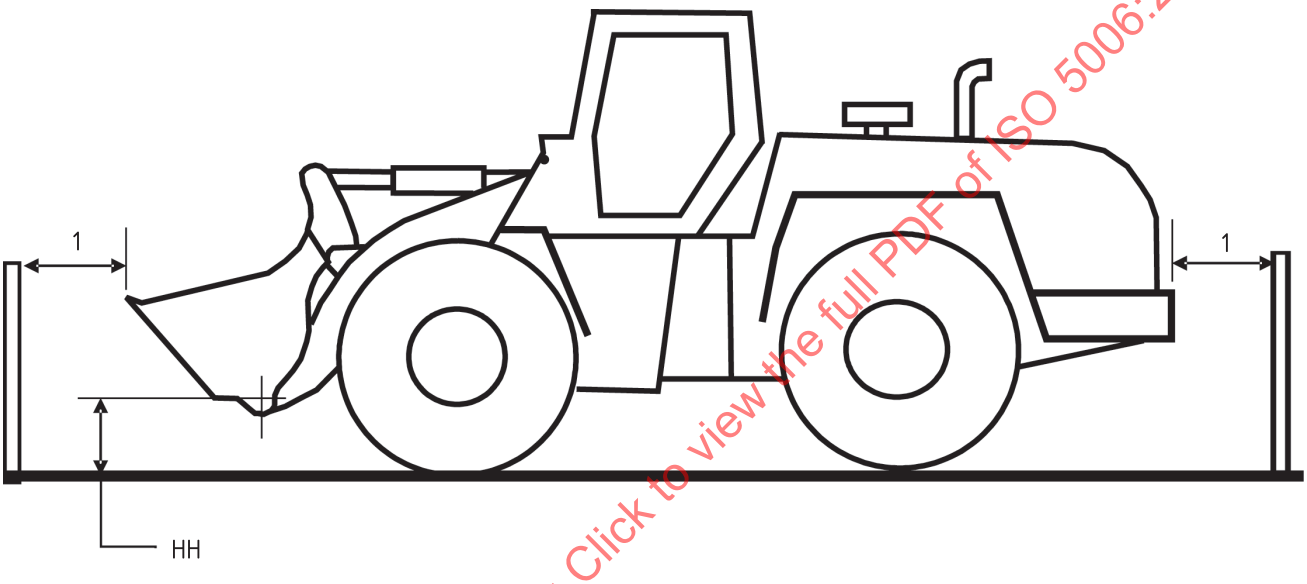


Figure A.1 — Loader