BS EN ISO 16001:2017

BSI Standards Publication

Earth-moving machinery – Object detection systems and visibility aids – Performance requirements and tests (ISO 16001:2017)

Documents
Document Sharing Hub

Full document details: BS EN ISO 16001:2017

National foreword

This British Standard is the UK implementation of EN ISO 16001:2017. It is identical to ISO 16001:2017. It supersedes BS ISO 16001:2008, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/513/1, Earth moving machinery (International).

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2018
Published by BSI Standards Limited 2018

ISBN 978 0 580 83385 4

ICS 53.100

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2018.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS EN ISO 16001:2017

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 16001

December 2017

ICS 53.100

English Version

Earth-moving machinery - Object detection systems and visibility aids - Performance requirements and tests (ISO 16001:2017)

Engins de terrassement - Dispositifs de détection d'objets et d'aide visuelle - Exigences de performances et essais (ISO 16001:2017)

Erdbaumaschinen - Objekterkennungssysteme und Sichthilfsmittel - Leistungsanforderungen und Prüfverfahren (ISO 16001:2017)

This European Standard was approved by CEN on 23 November 2017.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

© 2017 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.

Ref. No. EN ISO 16001:2017 E

Documents
Document Sharing Hub

Full document details: BS EN ISO 16001:2017

European foreword

This document (EN ISO 16001:2017) has been prepared by Technical Committee ISO/TC 127 "Earth-moving machinery" in collaboration with Technical Committee CEN/TC 151 “Construction equipment and building material machines - Safety” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2018, and conflicting national standards shall be withdrawn at the latest by June 2018.

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

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 16001:2017 has been approved by CEN as EN ISO 16001:2017 without any modification.

AVA Documents
Document Sharing Hub

Full document details: BS EN ISO 16001:2017

Contents

Page

Foreword ... **iv**
Introduction ... **v**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms and definitions ... **1**
4 Performance requirements and tests ... **3**
4.1 General requirements ... 3
4.1.1 Test to determine the detection zone boundary ... 3
4.1.2 Test body requirements ... 3
4.1.3 Evaluation of test results ... 3
4.2 Location and fixing of ODS and VA components ... 3
4.3 Operator station components ... 4
4.3.1 Location and images of monitor ... 4
4.3.2 Warning devices for ODS ... 5
4.4 System activation and initial check ... 6
4.4.1 System activation on engine start ... 6
4.4.2 System activation from stand-by mode ... 6
4.5 ODS detection time ... 6
4.6 Continuous self-checking ... 7
4.7 Warning device disablement for ODS ... 7
4.8 Electromagnetic compatibility and physical environment operating conditions ... 7
5 Marking and identification ... **7**
6 Operator's manual ... **8**
6.1 Operator's manual ... 8
6.2 Other information documents ... 8
Annex A (informative) **Selection of ODSs and VAs** ... **9**
Annex B (normative) **Test procedure for closed-circuit television (CCTV) systems — Additional performance requirements and tests** ... **17**
Annex C (normative) **Test procedure for radar sensors** ... **23**
Annex D (normative) **Test procedure for ultrasonic detection systems** ... **28**
Annex E (normative) **Test procedure for ultrasonic transponder systems** ... **36**
Annex F (normative) **Test procedure for electromagnetic (EM) signal transceiver systems** ... **46**
Annex G (normative) **Particular performance requirements and tests for CCTV system with surround view** ... **53**
Annex H (normative) **Particular performance requirements and tests for visual ODS** ... **55**
Annex I (normative) **Test procedure for vision systems based on morphological recognition** ... **62**
Bibliography ... **74**

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 16001:2008), which has been technically revised.

The main change compared to the previous edition is as follows:

— Annex G, Annex H and Annex I have been added to include state-of-the-art technologies.

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Introduction

This document outlines test procedures and sets criteria for the development of object detection systems (ODSs) and visibility aids (VAs) which indicate to the operator the presence of objects which are within the detection zone of these systems.

Proper job-site organization, operator training and the application of relevant vision standards (ISO 5006 and ISO 14401) address the safety of people on job sites. In some cases, vision of the working area cannot be achieved either by the operator's direct view or indirect view using mirrors. In such cases, operator awareness can be improved by the use of ODSs and VAs.

ODSs and VAs provide information to the operator as to whether a person or object is in the path of the machine, primarily during rearward movement.

It is essential to note that ODSs and VAs have both advantages and disadvantages. There is no device that works perfectly in all situations. It is especially important that the shortcomings of ODSs and VAs be recognized and known to system users. The advantages and disadvantages of selected devices are summarized in Annex A.

The use of a haptic signal (signal that stimulates the operator's sense of touch, vibration, force and motion) as an alternative to the use of visual and audible signals in ODS warning devices was discussed during the revision of this document, as haptic warnings are now being used in the automotive industry. While this document does not currently allow warning devices that only use haptic signals, they can be incorporated into the warning device to supplement the visual and audible signal. More study is needed to determine the effectiveness of a haptic signal in various earth-moving machinery applications.

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Earth-moving machinery — Object detection systems and visibility aids — Performance requirements and tests

1 Scope

This document specifies general requirements and describes methods for evaluating and testing the performance of object detection systems (ODSs) and visibility aids (VAs) used on earth-moving machines. It covers the following aspects:

— detection or visibility or both of objects including people in the detection zone;

— visual, audible, or both warnings to the operator and if appropriate to the persons in the detection zone;

— operational reliability of the system;

— compatibility and environmental specifications of the system.

It is applicable to machines as defined in ISO 6165. An ODS, VA or both can be used to augment the operator's direct vision (see ISO 5006) or indirect vision using mirrors (see ISO 14401). In addition, an ODS, VA or both can be used to provide additional means of object detection or view, for example, where ergonomic considerations limit the effectiveness of direct vision and to avoid repeated turning of the head and upper body.

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 6394, *Earth-moving machinery — Determination of emission sound pressure level at operator's position — Stationary test conditions*

ISO 9533, *Earth-moving machinery — Machine-mounted audible travel alarms and forward horns — Test methods and performance criteria*

ISO 13766, *Earth-moving machinery — Electromagnetic compatibility*

ISO 15998, *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests for functional safety*

EN 50132-7:1996, *Alarm systems — CCTV surveillance systems for use in security applications — Application guidelines*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

3.1
object detection system
ODS
system that detects objects, including people, that are in the *detection zone* (3.3) and warns the operator

Note 1 to entry: The system generally includes a *sensing device* (3.1.1), *warning device* (3.1.2) and *evaluation device* (3.1.3).

Note 2 to entry: An ODS which operates by detection of a visual image is a *visual* object detection system.

Note 3 to entry: The system can also warn the person on the ground.

3.1.1
sensing device
ODS (3.1) component that detects a *test body* (3.4) in the *detection zone* (3.3)

3.1.2
warning device
ODS (3.1) component that transmits information to the operator or to persons in the *detection zone* (3.3) by visual or audible or both signals

3.1.3
evaluation device
ODS (3.1) component or components that analyse the signals and information transmitted from the sensing device and transform the corresponding signal to the *warning device* (3.1.2)

3.2
visibility aid
VA
system that provides indirect visibility without a *warning device* (3.1.2)

Note 1 to entry: The system generally includes one or more *monitors* (3.2.1) and *cameras* (3.2.2).

3.2.1
monitor
VA (3.2) component that provides a visual image of the *detection zone* (3.3) on a screen

3.2.2
camera
VA (3.2) component that transmits to the monitor an image of the *detection zone* (3.3)

3.3
detection zone
zone within which a *test body* (3.4) is detected by an *ODS* (3.1) or is shown by a *VA* (3.2)

3.4
test body
person or a standard measuring unit representative of a person, used to test the geometry and size of the *detection zone* (3.3)

Note 1 to entry: Depending on the system used, test bodies can be varied (see Annexes B to I).

3.5
self-checking
capability of the system to self-check continuously and immediately to inform the operator, audibly, visually, or both, of a failure

3.6
detection time
time required for an object detection system to detect the *test body* (3.4) in the *detection zone* (3.3) and activate the signal output

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

3.7
stand-by
operation mode whereby the object detection and visibility aid systems are active, but no information is transmitted by the *warning device* (3.1.2) or *monitor* (3.2.1)

3.8
job-site organization
rules and procedures for managing the working together of machines and people at a job site

EXAMPLE Safety instructions, traffic patterns, restricted areas, operator training, machine and vehicle markings, communications systems.

3.9
warning range
range within the *detection zone* (3.3) in which a distinctive warning is provided to indicate the range between the machine and the object being detected

4 Performance requirements and tests

4.1 General requirements

4.1.1 Test to determine the detection zone boundary

The test shall be performed on a system that is either fitted to the machine or to a representative configuration in accordance with the appropriate annex (see Annexes B to Annex I).

4.1.2 Test body requirements

The test body requirements are specified in Annex B to Annex I.

4.1.3 Evaluation of test results

4.1.3.1 Detection

Detection shall take place unambiguously with an uninterrupted sequence of the signal or information appropriate to the detection zone. For further details, see Annex B to Annex I.

It is possible to combine ODSs and VAs to cover the necessary detection zone in the case where a single system cannot cover the zone.

EXAMPLE A surround view system can be combined with another object detection system, whose detection zone covers the area where the image size achieved by the surround view system is less than required.

4.1.3.2 Evaluation of false signals

False signals, such as the following, should be minimized:

— from objects outside the detection zone;

— from weather conditions of fog, snow, rain, wind, dust, etc.

4.2 Location and fixing of ODS and VA components

Components shall be located and arranged on the machine in accordance with the specification of the component manufacturer so that

— the component does not restrict any function or operation of the machine,

— the component is protected against external damage,

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

— the component is affixed to the machine so as to deter unauthorized disablement or removal,

— the component is mounted so as to limit exposure to, or amplification of, dynamic loads, temperature, shock or vibration that could prematurely damage the device,

— the attachment and fixings of ODSs and VAs component do not affect the integrity of the protective structures, e.g. rollover protective structures (ROPS).

4.3 Operator station components

4.3.1 Location and images of monitor

The monitor shall be located such that it is in the 180° arc centred in front of the operator.

The image on the monitor should be displayed in the most intuitively logical way for the application, as in the following examples.

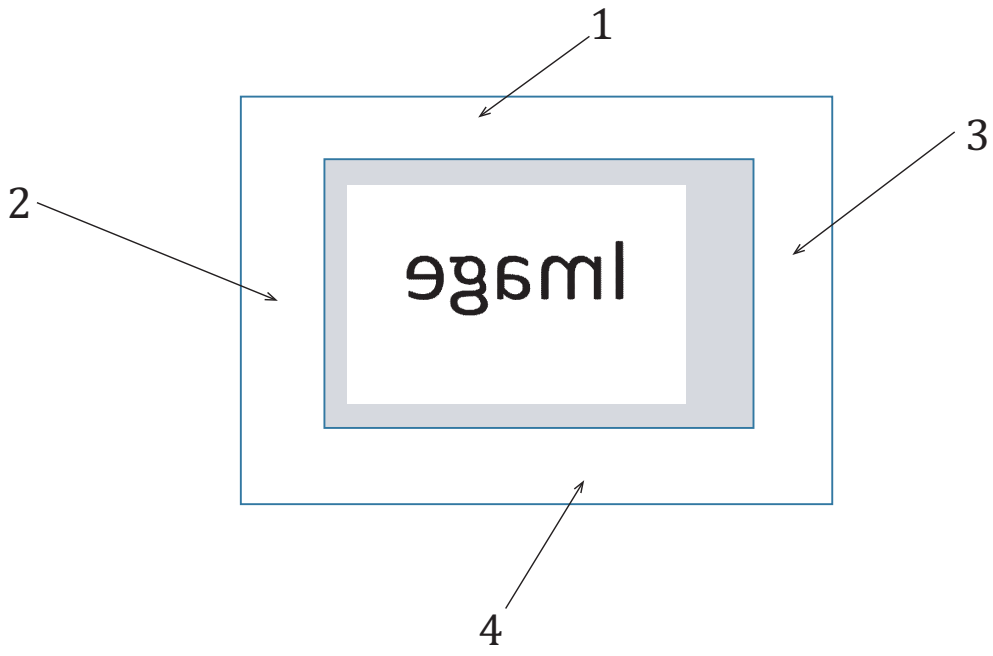
— The image of a rear view camera is commonly displayed as a mirror image (see Figure 1).

— The image of a front view camera is commonly displayed as a “normal” image.

— The image from a side-mounted camera looking downwards is commonly displayed as “normal” image.

— The image from a side-mounted camera looking rearwards could be displayed either as a “normal” or “mirror” image.

— A 360° “surround view” image is commonly displayed as a “normal” image (see Figure 2).

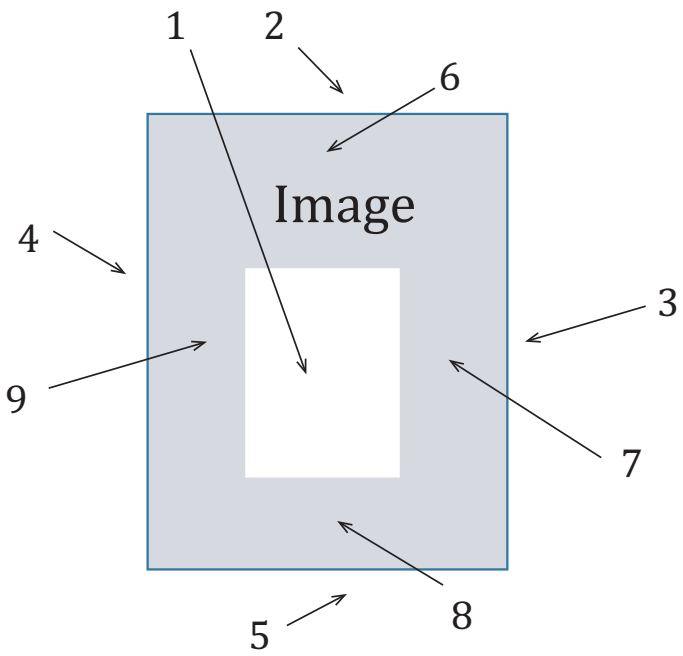


Key

1 top of monitor
2 left side of monitor
3 right side of monitor
4 bottom of monitor

Figure 1 — Example of a mirror image on the monitor covering the area behind the machine

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017



Key

1 mock surround view of machine
2 top of monitor
3 right side of monitor
4 left side of monitor
5 bottom of monitor
6 ground in front of machine
7 ground to right
8 ground in rear of machine
9 ground to left

Figure 2 — Example of a normal image on the monitor showing the surround view around the machine

The monitor should be within 1,2 m of the operator's eye point. If the monitor location is more than 1,2 m of operator's eye point, the displayed images shall be proportionally enlarged according to the monitor. The test requirements shall be according to B.8.2, G.4 and G.5. The monitor shall be positioned so as to minimize the glare caused by direct sunlight.

NOTE Factors that influence an operator's ability to detect a person on the monitor are the position of the monitor within the cab, the distance of the operator from the monitor, the size and resolution of monitor, the ambient lighting, the lens on the camera and the distance of the object from the lens.

4.3.2 Warning devices for ODS

Both audible and visual warning devices are required for an ODS. These devices shall provide indications to the operator and may provide indications to workers and other persons present at the work site.

4.3.2.1 Audible devices

Operator station warning devices shall be set at, or shall automatically adjust to, a level at least 3 dB higher than the ambient noise level as measured at maximum governed speed under no load.

All in-cab warnings should be selected so that they are clearly audible at the operator station. The warning signal should be in the frequency range 500 Hz to 3 400 Hz.

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

In-cab alarms shall be distinguishable from other sounds (for example, warnings or machinery noise) in the operator's station.

NOTE Distinctiveness of the alarm can be achieved by varying the spectral characteristics and the temporal distribution of the signals (see ISO 9533).

4.3.2.2 Visual devices

A green system-status light shall inform the operator that the system is powered and functional. The status light may be continuous or may turn off after the function check is completed.

The warning signals in the cab shall be located such that it is in the 120° arc centred in front of the operator and shall be bright enough to be viewed under sunlight operating conditions. Appropriate shielding may be used to reduce the effect of direct sunlight onto the visual display unit.

The warning signals shall be distinguishable from other instrument panel warnings; the most severe warning shall be a flashing red light.

4.3.2.3 External machine-mounted warning devices

If an external machine-mounted audible warning device is fitted as part of the ODS to alert workers and other persons at the worksite, then the external alarms shall comply with ISO 9533.

External machine-mounted visual warning devices, when fitted, shall be visible to people in the detection zone.

4.4 System activation and initial check

4.4.1 System activation on engine start

The system shall activate automatically on engine start or power-on, shall perform an initial system check, and shall give a proper function indication.

NOTE For a visibility aid, displaying the image from a camera on the monitor fulfils this requirement.

In the case of an ODS malfunction, a warning shall be given to the operator.

4.4.2 System activation from stand-by mode

The system may remain in stand-by mode unless the relevant machine movement mode is selected.

If stand-by mode is provided, the system shall wake up and provide information from the camera or sensor about the direction of the machine motion when the machine moves.

If multiple cameras or sensors are fitted, the system shall provide the camera view or sensor signal appropriate to the direction of travel or other machine movement, for example:

— by using multiple monitors or multiple indicators, each of which provides information about its corresponding camera or sensor;

— by using a single monitor or indicator which sequentially provides information about multiple cameras or sensors;

— by using a single monitor or indicator which simultaneously provides information about multiple cameras or sensors.

4.5 ODS detection time

After the introduction of an object to be detected, the ODS detection time shall not exceed 300 ms.

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

4.6 Continuous self-checking

The availability of an image of the detection zone on the monitor is sufficient as a monitoring function for a VA.

An ODS shall have a permanent monitoring function including at least the following:

a) an operating indication light (green);

b) if stand-by mode is provided, a stand-by indication light (flashing amber or flashing green) (see 4.3.2.2);

c) a visual or audible or both failure signal if the operation of the system is impaired, including monitoring of each link on the ODS, which includes the monitoring of all machine signals used for system operation, for example:

— wire break,

— short-circuit,

— time management (if applicable),

— signal output and signal input, and

— checking of the system.

4.7 Warning device disablement for ODS

The ODS warning device shall not have a means to allow it to be deactivated by a single action. It may be deactivated by two or more separate and distinct actions by the operator.

The activation of the warning device shall be so designed and installed that its operation cannot easily be altered by the operator.

Any exceptions shall be specified in accordance with Annex B to Annex I.

4.8 Electromagnetic compatibility and physical environment operating conditions

The electromagnetic compatibility (EMC) of ODSs and VAs shall comply with ISO 13766.

The physical environmental conditions in which the ODSs and VAs are used shall be according to ISO 15998.

NOTE ISO 19014-3 can be used as an alternative to ISO 15998.

5 Marking and identification

Each major component (e.g. camera, sensor, monitor and controller) shall bear legibly and indelibly the following information:

— manufacturer;

— type and model;

— product serial number;

— regulatory markings, as required.

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

6 Operator's manual

6.1 Operator's manual

An operator's manual complying with ISO 6750 shall be provided. The manual may be integrated into the appropriate manual for the base machine and shall contain the following, if applicable:

— description of systems function;

— detection area shape and size, and variances according to operational and external factors (e.g. interference, weather, presence of other systems);

— information for job-site organization as it related to the use of ODSs and VAs, as required;

— weather limitations;

— topography limitations, as required;

— instructions for routine maintenance, including necessary countermeasures against environmental conditions that could impair the system's sensitivity or its ability to discriminate objects;

— instructions for activation;

— description of controls;

— instructions concerning safe operation;

— instructions on action in the event of malfunction;

— regulatory certifications (such as RF conformity test certifications required by the regional regulatory body), if required;

— countries for which type approval has been achieved, if required;

— recommended routine for regular performance checks of the ODSs and VAs by the user, as required;

6.2 Other information documents

For ODSs and VAs systems if separately placed on the market shall have additional instructions covering the following:

— detailed description of performance and operating limits, in particular, the effect of different mounting heights and angles;

— instructions for installation and assembly, including mounting location, if required;

— instructions for performance verification;

— information for connection with other components, if required;

— regulatory certifications (such as RF conformity test certifications required by the regional regulatory body);

— electrical supply requirements, as required.

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Annex A
(informative)

Selection of ODSs and VAs

A.1 Overview

ODSs and VAs can be used to supplement the direct and indirect vision of the operator. In selecting an ODS or VA, consideration should be given to the operator's information needs and to the operator's ability to respond to the information provided. The operator experiences many demands for attention. When selecting, careful consideration should also be given to the form of information, visual or audible, that is of most use to the operator when an object entering occurs.

It is essential to take into account that ODSs and VAs have both advantages and disadvantages. There is no device that works perfectly to cover the desired detection zone in all situations. There is always a risk that visual information passes unnoticed. Audible information can catch the operator's attention, but can be ignored if too many unwanted warnings are provided. It is especially important that the shortcomings of ODSs and VAs be recognized and known to system users. Some of these shortcomings can be offset by combining two or more technologies. The advantages and disadvantages of some techniques are summarized in Table A.1.

NOTE The basic technologies are being continuously improved. Therefore, some of the shortcomings could be addressed by future developments.

A.2 Consideration of the functional aspects of ODSs and VAs

A.2.1 General

The following machine functions, and operational and environmental aspects, of the ODSs and VAs should be considered.

A.2.2 Operator needs and ability to interface and use the system

These needs are, for example:

— tolerance of false alarm signals;

— signal-to-noise ratio;

— time and frequency of observation for visual systems;

— potential for information overload where multiple ODSs and VAs are used;

— human factors, (e.g. reaction time);

— training and instruction;

— type of warning required by the operator or person in detection zone.

A.2.3 Operating environment

The operating environment can be influenced by, for example:

— open, congested or restricted site;

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

— topography of the site;

— site conditions (for example, dust, water, light, contrast);

— weather;

— sources of interference (for example, other machines, stronger reflectors or emitters).

A.2.4 Machine functions

These functions can be, for example:

— object entering zones to be covered;

— analysis of machine movement and application at the job site;

— available mounting positions;

— anticipated speed of movement;

— turning circle;

— articulation effects;

— stopping distance.

A.3 Selection of ODSs and VAs

The system should be selected considering the following characteristics:

— visual or sensor detection;

— active or passive response;

NOTE For example, Annex C, Annex D and Annex F type 1 systems are based on active response; on the other hand, Annex B and Annex F type 2 systems are based on passive response. There also exists a combined system such as Annex E, one that is based on passive response triggered by active input.

— visual or audible warning or both;

— response time;

— detection zone;

— operational integrity;

— mounting security;

— overriding, muting and disablement requirements;

— unwanted alarms;

— maintenance, servicing and cleaning requirements;

— performance checking requirements, e.g. periodic detection zone verification;

— ability to distinguish persons (pedestrians) from other obstacles;.

— ability to perform in inclement weather;

— ability to perform in harsh conditions.

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Table A.1 — Some advantages and disadvantages of ODSs and VAs

Technology	Description	Advantages	Disadvantages	Range
Fresnel lens	A thin, flat lens using concentric circular grooves in its surface. The grooves act like prisms to bend and focus light.	Allows the driver to see objects below the normal driving position line of sight.	Image can distort near envelope edges. External light can cause lens to be "flooded" with light. External light source needed. Interpretation of image and judging distances can be difficult.	Horizontal: >90°. Vertical: typically 2 m. Depends on mounting position.
Mirror	A reflective surface that provides indirect vision.	Low maintenance and simple to use.	Requires good light conditions. Mounting can affect performance. Can be prone to mechanical damage.	Potentially long, depending upon optical characteristics.
Discriminating external alarm	An alarm system that uses a sensor to trigger an audible warning signal.	Activated when machine movement is selected. Warns only when object is detected.	Relies on pedestrians in the path of the machine to take evasive action. Can be difficult to determine where the direction of sound originates. Potential for confusion if more than one machine is operating in close proximity.	Varies according to decibel output, frequency, mounting position and environmental characteristics.
Ultrasonic	A system that uses reflecting sound waves to detect the presence and measure the distance of an object.	Accurate indication of target distance; both LED and audio signals to operator.	Time delay restricts usage to slow vehicles; limited to operating at reverse speeds of up to 10 km/h. Performance can be affected by adverse weather. Multiple sensors required to cover the entire back area of the machine. Does not discriminate between people and other objects. Limited mounting height above ground.	Horizontal: 6 m max.

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Table A.1 *(continued)*

Technology	Description	Advantages	Disadvantages	Range
Fixed-frequency Doppler radar	A system that uses microwave radiation that is emitted and reflected from a moving object; frequency difference indicates motion.	Low cost. Reflects well from most objects. Ignores any dirt on the radar surface and is not affected by snow, wind, rain, etc. Can be designed to detect speed and direction of object.	Difficulty sensing stationary objects; distance can only be inferred from strength of reflected signal. Therefore, at a given sensitivity, the system-responds equally to larger objects farther away from the sensor and to smaller objects closer to the sensor. Not fail safe. Can sense objects outside the vehicle's path. Does not discriminate between people and other objects. Can only detect moving objects.	Range unlimited (but see under "Disadvantages"). Spans up to 160° by design.
Switched-frequency Doppler radar	See description for "Fixed frequency Doppler radar", except that the transmitted frequency is stepped between two or more frequencies.	Can measure range. Reflects well from most objects. Ignores any dirt on the radar surface and is not affected by snow, wind, rain, etc. Can be designed to detect speed and direction of object.	Range measured is the weighted average range of all targets. Therefore, small targets close to the sensor can be masked by larger targets farther away from the sensor. Not fail safe. Does not discriminate between people and other objects. Can sense objects outside the vehicle's path.	Range unlimited, but see under "Dis-advantages". Spans up to 160° by design.
Pulse radar	A system that uses reflecting pulses to detect the presence and measure the distance of an object.	Can identify the ranges of multiple targets.	Can sense objects outside the vehicle's path. Does not discriminate between people and other objects.	Range can be limited. Spans up to 160° by design.
Frequency modulated continuous wave (FMCW)	See above, except the transmitted frequency is swept from low to high and back again.	Can identify the ranges of multiple targets. Can be designed to detect speed and direction of object.	Can sense objects outside the vehicle's path. Does not discriminate between people and other objects.	Unlimited. Spans up to 160° by design.

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Table A.1 *(continued)*

Technology	Description	Advantages	Disadvantages	Range
Closed circuit television (CCTV)	A device that uses wide-angle lens cameras with a monitor in the cab.	Scratch, dirt and water resistant. Works in low-light conditions.	Distortion makes distances hard to judge. Direct light into the camera causes visibility problems. Direct sun on monitor blocks the image. Objects in shadows are difficult to distinguish. Mud and dust on camera lens can distort the image. Mud and dust can be removed by built-in wash/wipe systems.	Horizontal: up to 127°. Vertical: up to 115°.
Passive infrared (PIR)	A device that senses changes in infrared (IR) emissions from objects.	Ideally detects the difference between a person and the background.	Sensitive to dirt, water and vibration. Cannot measure distance. Cannot distinguish a nearby person from a hot engine afar.	Can be limited in this application; see under "Disadvantages".
Active infrared (IR)	A device that uses infrared (IR) emissions from objects to detect its presence and measure its distance from the machine.	Unknown.	Unknown.	Unknown.
Contact	Uses brakes that are activated after a switch is triggered by a pivoted bumper.	Simple and relatively inexpensive.	Not suitable for all machines. No advance detection of object or pedestrian. Not considered safe for pedestrian protection. Suitable only for very low-speed applications.	Determined by the dimensions of the device.
Electro-magnetic (radio frequency) signal transponder	System that uses electromagnetic signals or radio waves to communicate between a machine-mounted transceiver and an electronic tag worn by workers or mounted on other obstacles to signal close proximity or collision.	Mutual warnings to both parties. Monitors every direction.	Does not monitor anything without a tag. Radiated power is too weak to pass through the human body and to cover all the detection zone. Directional, like the ultrasonic transponder (see E.4.1). Can detect a person outside the required detection area and requires a judicious choice of the radio frequencies.	Adjustable to 20 m in every direction.

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Table A.1 *(continued)*

Technology	Description	Advantages	Disadvantages	Range
Laser	Software-programmable system that uses a pulsed laser and a revolving mirror.	Detection zone can be precisely configured. Different functions can be given to different zones (e.g. apply brakes, sound horn, etc.).	Can suffer from interference from direct sunlight. Heavy steam or plumes of smoke could act as a barrier. Another laser operating on the same wavelength could also signal an alarm. Lens requires frequent cleaning. Diode has limited life (approx. 5 years).	Maximum practical range of 8 m and scan angle of 180°, beam thickness of up to 50 mm.
Ultrasonic transponder	System that uses dual ultrasonic wave to communicate between a "detecting device" installed on the machine and a "responder" worn by the workers to signal close proximity or collision.	Can be adjustable for the detection range required. Sends an alarm directly to both the vehicle operator and the worker. Generates visual and audible warning to the operator and audible warning to the workers.	Does not detect anything without a responder.	Maximum detection range is 12 m, which can be set in 1 m increments. Detection range depends on the choice of a transducer, which is available in 20°, 30°, 40° and 60° directivity.
Colour recognition CCTV	System that analyses CCTV images to detect specific colour tags worn by workers.	Mutual warnings to both parties. Monitors within camera's field of view.	Does not monitor anything without a colour tag.	Detection range is 10 m to 15 m, depending upon camera lens angle.

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Table A.1 *(continued)*

Technology	Description	Advantages	Disadvantages	Range
Moving object visual ODS	System that detects objects by analysing visual image of moving objects from the CCTV, then warns the operator (and the person on the ground, if appropriate).	More than one object can be distinguished based on the images provided by the camera. Theoretically, it is possible to add velocity measurement and direction detection to the system's functions.	Difficult to detect stationary objects; can fail to detect object when the machine itself is travelling. Does not discriminate between moving people and other moving objects. Direct light onto the camera causes visibility problems. Objects in shadows are difficult to distinguish. Snow, rain, mist, dust, etc. can cause difficulty in distinguishing objects. Raindrops on the camera can cause distortion on the image and cause it difficult to distinguish the object. If a person does not move (walk), it can be difficult to distinguish the person from static objects such as rocks.	According to manufacturer's specifications
Visual system and morpho-logical recognition	Visual system that uses camera and video analysis algorithms to detect obstacles and their classification according to their appearance.	Obstacle detection with the capability to differentiate pedestrians from hazards and objects to avoid unnecessary triggering of alarms. VA and ODS functionalities are integrated by design; easy installation. Detection zone can be precisely configured.	Cameras shall have direct visibility on the surveil-lance area. Might not detect a person with "unnatural appearance", i.e. unusual posture or clothing, or incor-rect angle from the system's cameras, making identifica-tion difficult. Above a certain level, dirt on lenses can lead to degraded detection/ recognition performances.	Maximum range from 6 m up to 15 m

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Table A.1 *(continued)*

Technology	Description	Advantages	Disadvantages	Range
Light Detection and Ranging (LIDAR)	An optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the object with pulsed light. It is a scanning laser rangefinder that generates a 3D point cloud of its environment. Similar to a radar in principle and operation but using laser light instead of radio waves, it is capable of detecting particles and varying physical conditions in the atmosphere.	Can be used close to or at some distance from the machine. No electronic emissions. Good field of detection.	Needs to be evaluated relative to heavy dust and heavy rain conditions.	Detection range is from 1,5 m (min.) to 120 m (max.) Vertical field of detection >20°, with most biased below the horizontal. Horizontal field of detection >250°

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

Annex B
(normative)

Test procedure for closed-circuit television (CCTV) systems — Additional performance requirements and tests

B.1 Overview and purpose of tests

The tests are designed to measure the performance of CCTV systems intended for use on earth-moving machinery. Aspects of the performance to be determined are

a) overall quality of the image presented in terms of TV lines resolved or equivalent, based on the scale on the test body (see B.2) reading that can be resolved (see B.9.1),

b) limit of operational light levels to maintain minimum proposed resolution (see B.9.2),

c) vertical and horizontal fields of vision for the system (see B.6 and B.7),

d) detection distance (see 4.3.1 and B.8),

e) masking due to direct exposure to high intensity light (see B.9.5), and

f) time taken for the system to respond fully to rapid changes in light levels (see B.9.6).

The tests are not designed to measure aspects of performance due to the camera's height. The performance criteria laid down in these tests assume operating conditions of at least 50 lx average and 20 lx minimum measured illuminance.

B.2 Test body

The Rotakin test body described in EN 50132-7:1996, Annex A shall be used.

B.3 Test areas

For internal tests: 5 m × 5 m level floor area. For external tests: 30 m × 8 m level area.

B.4 Test environment

The test environment shall be evenly lit, free from shaded areas and reflections in field of view.

B.5 Mounting and set-up

B.5.1 Assembly

The CCTV system shall be assembled according to the manufacturer's instructions.

B.5.2 Positioning and alignment

B.5.2.1 Camera

The camera shall be aligned vertically and horizontally to the test body.

© ISO 2017 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017

B.5.2.2 Test body

The test body shall be vertical and shall face the camera at the centre of the field of view, and at 90° to the optical axis of the lens.

Unless otherwise stated, the image of the test body shall occupy the entire vertical field of view of the monitor.

B.5.2.3 Monitor

The monitor shall be mounted, positioned and aligned so that it is normal to the observer's face, at a comfortable height, and shall be free from glare and reflections.

B.6 Horizontal test

B.6.1 Light levels

Light levels shall be greater than 50 lx and less than 50 000 lx.

B.6.2 Test procedure

Position the test body away from the camera so that the image occupies 25 % of the vertical height at the centre of the monitor screen. Measure and record the distance from the camera to the test body. Move the test body along an arc to the point where the vertical centre line of the image of the test body is at the edge of vision in the monitor screen. Mark the point.

Similarly, establish and mark the point at the opposite side of the monitor screen. Measure and record the distance between the two marks and calculate by trigonometry the horizontal field of view.

B.7 Vertical test

B.7.1 Light levels

Light levels shall be greater than 50 lx and less than 50 000 lx.

B.7.2 Test procedure

Rotate the camera through 90°. Position the test body away from the camera so that the image occupies 25 % of the vertical height at the centre of the monitor screen.

Measure and record the distance from the camera to the test body.

Move the test body along an arc to the point where the vertical centre line of the image of the test body is at the edge of vision in the monitor screen. Mark the point. Similarly establish and mark the point at the opposite side of the monitor screen.

Measure and record the distance between the two marks and calculate by trigonometry the vertical field of view.

B.8 Range

B.8.1 Light levels

Light levels shall be greater than 50 lx and less than 50 000 lx.

© ISO 2017 – All rights reserved
Documents
Document Sharing Hub
Full document details: BS EN ISO 16001:2017