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Earth-moving machinery — Hazard detection systems and visual aids — Performance requirements and tests

Engins de terrassement — Dispositifs de détection des risques et d'aide visuelle — Exigences de performances et essais

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Foreword

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

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

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

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

ISO 16001 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

Introduction

This International Standard outlines test procedures and sets criteria for the development of hazard detection systems (HDS) and visual aids (VA) for detecting people.

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 HDS and VA.

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

Earth-moving machinery — Hazard detection systems and visual aids — Performance requirements and tests

1 Scope

This International Standard specifies general requirements and describes methods for evaluating and testing the performance of hazard detection systems (HDS) and visual aids (VA) used on earth-moving machines. It covers the following aspects:

— detection of people in the detection zone;

— visual and/or audible warning(s) to the operator and/or 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. HDS and/or VA can be used to augment the operator's direct vision (see ISO 5006) or indirect vision using mirrors (see ISO 14401) or to provide additional means of hazard detection, for example, where ergonomic considerations limit the effectiveness of direct vision, e.g. to avoid repeated turning of the head and upper body.

2 Normative references

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

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

ISO 6394, *Earth-moving machinery — Determination of emission sound pressure level at operator's position — Stationary test conditions* [1)]

ISO 9533, *Earth-moving machinery — Machine-mounted forward and reverse audible warning alarm — Sound test method*

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

ISO 15998 [2)], *Earth-moving machinery — Machine-control systems (MCS) using electronic components — Performance criteria and tests for functional safety*

1) To be published. (Revision of ISO 6394:1998)

2) To be published.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
hazard detection system
HDS
system that both detects hazards and warns the operator and/or the person on the ground

NOTE The system generally includes a sensing device, warning device and evaluation device.

3.1.1
sensing device
HDS component that detects a test body in the detection zone

3.1.2
warning device
HDS component that transmits information to the operator and/or to persons in the detection zone by visual and/or audible signals

3.1.3
evaluation device
HDS component or components that analyse the signals and information transmitted from the sensing device and transform the corresponding signal to the warning device

3.2
visual aid
VA
system that provides visual information without warning

NOTE The system generally includes a monitor and camera.

3.2.1
monitor
VA component that provides a visual image of the detection zone on a screen

3.2.2
camera
VA component that transmits to the monitor an image of the detection zone

3.3
detection zone
zone within which a test body is detected by an HDS or is shown by a VA

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

NOTE Depending on the system used, test bodies can be varied (see Annexes B to F).

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

3.6
detection time
time required for a hazard detection system to detect the test body in the detection zone and activate the signal output

3.7
stand-by
operation mode whereby the hazard detection and visual aid systems are active, but no information is transmitted by the warning device or monitor

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.

4 Performance requirements and tests

4.1 General requirements

4.1.1 Test of detection zone

The test method shall be performed on a system that is either fitted to the machine or to a representative configuration in accordance with Annexes B to F.

4.1.2 Test body requirements

The test body requirements are specified in Annexes B to F.

4.1.3 Environmental conditions

The test shall be undertaken under the following environmental conditions:

— temperature (23 °C ± 5 °C);

— relative humidity (60 % ± 25 %).

The test shall not be affected by reflections from surrounding walls, auxiliary test equipment or other objects. For further details, see Annexes B to F.

4.1.4 Evaluation of test results

4.1.4.1 Detection

Detection shall take place unambiguously with an uninterrupted sequence of the signal or information appropriate to the warning range. For further details, see Annexes B to F.

4.1.4.2 Evaluation of false signals

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

— when a machine approaches a ramp;

— from objects outside the detection zone;

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

4.2 Location and fixing of HDS and VA devices

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

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

— the device is protected against external damage,

— the device is affixed to the machine so as to deter unauthorized disablement and/or removal,

— the device 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 HDS and VA devices do not affect the integrity of the protective structures, e.g. rollover protective structures (ROPS), and

— the device is designed and mounted to permit routine service access from the ground or from a service platform so that the intended performance is maintained.

4.3 Operator station devices

4.3.1 Location of monitor

The monitor shall be located within the operator's view. Restriction of the operator's view of the working area or of the machine working equipment shall be minimized.

When the monitor is used to cover the area behind the machine, the system shall be configured to provide a reverse image on the monitor.

In order to see a person at the maximum distance of the detection zone, the monitor shall display the height of a fifth percentile person (see ISO 3411) such that the image is 7 mm on the monitor. The monitor should be within 1,2 m of the operator's eye point. 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 of monitor, the ambient lighting, the lens on the camera and the distance of the object from the lens.

4.3.2 Warning devices

Both audible and visual warning devices are required for an HDS. 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 2 500 Hz.

In-cab alarms shall be distinguishable by the operator from other sounds (i.e. warnings or machinery noise) in the operator's station.

NOTE This 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 light may be continuous or turn off after the function check is completed.

The warning signals in the cab shall be mounted in direct view of the operator and be visible in direct sunlight. 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 warning devices

If an external warning device is fitted as part of the HDS, then the external alarms shall comply with ISO 9533.

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

4.4 System activation and initial check

The system shall activate automatically on engine start, perform an initial system check and give a proper function indication. For visual aid systems, the indication of proper function shall be by a clear image of the detection zone on the monitor.

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

The system may enter stand-by mode until the relevant machine movement mode is selected.

If multiple cameras or sensors are fitted, the system shall automatically select the camera or sensor appropriate to the direction of travel.

4.5 HDS detection and response time

HDS detection and response time shall not exceed 300 ms after activation of the system or after waking from stand-by. The system detection and response time is the time from which the operator selects the relevant machine movement mode until the system is able to detect a person.

4.6 Operational integrity

4.6.1 General

The operational integrity of the HDS and VA shall comply with ISO 15998 and ISO 13766.

4.6.2 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 HDS shall have a permanent monitoring function including at least the following:

a) an operating indication light (green);

b) a stand-by indication light (flashing amber or green) (see 4.3.2.2);

c) a visual and/or audible failure signal if the operation of the system is impaired, including monitoring of each link on the HDS, which includes the monitoring of all machine signals used for system operation, i.e.

   — wire break,

   — short-circuit,

   — time management (if applicable),

— signal output and signal input, and

— checking of the system.

4.7 System disablement

It shall not be possible to disable the warning device simply by switching it off. The activation of the warning device shall be so designed and installed that its reliable operation cannot easily be altered by the operator. Any exceptions shall be specified in accordance with Annexes B to F.

4.8 Physical environment and operating conditions

The HDS and VA shall comply with ISO 15998 in respect of the physical environment and operating conditions with the following exceptions:

— temperature: −30 °C to +60 °C;

— vibration: −10 g over 5 Hz to 100 Hz (4,5 g for in-cab components);

— shock: −10 g for exterior components (4,5 g for in-cab components).

NOTE The objective is to achieve, as the state-of-the-art progresses, the temperature, vibration and shock requirements of ISO 15998.

5 Marking and identification

Each device shall bear legibly and indelibly the following information:

— manufacturer;

— type/model;

— product/serial number;

— regulatory markings, as required.

6 Operator's manual

HDS and VA shall be supplied with an operator's manual containing installation, technical and safety instructions for the intended use of such systems, as follows:

— description of systems function;

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

— information for job-site organization;

— weather limitations;

— topography limitations;

— instructions for maintenance;

— instructions for installation and assembly, including mounting location;

— instructions for activation;

— description of controls;

— instructions concerning safe operation;

— instructions for performance verification;

— instructions on action in the event of malfunction;

— information for connection with other components (if required);

— regulatory certifications, e.g. EMC and RF conformity test certifications (if required by the regional regulatory body);

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

— recommended routine for regular performance checks of the HDS and VA by the user;

— electrical supply requirements.

Annex A
(informative)

Selection of HDS and VA

A.1 Introduction

HDS and VA may be used to supplement the direct and indirect vision of the operator. In selecting HDS and VA, consideration should be given to the operator's information needs and his ability to respond to them. The operator has many demands on his attention and when selecting HDS and VA, careful consideration should be given to the form of information, visual or audible, that will be of most use to the operator when a hazard occurs. There is always a risk that visual information will pass unnoticed. Audible information will catch the attention of the operator but will be ignored if too many unwanted warnings are provided.

It is essential to note that HDS and VA have both advantages and disadvantages. There is no device that works perfectly to cover the desired detection zone in all situations. It is especially important that the shortcomings of HDS and VA be recognized and known to system users. However some of these may be offset by combining two or more technologies. The advantages and disadvantages of some techniques are summarized in Table A.1.

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 HDS and VA

A.2.1 General

The following machine functions, and operational and environmental aspects, of the HDS and VA 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,

— time and frequency of observation for visual systems,

— potential for information overload where multiple HDS and VA are used,

— human factors, e.g. reaction time,

— training and instruction, and

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

A.2.3 Operating environment

The operating environment can be, or be influenced by, for example,

— an open, congested or restricted site,

— the topography,

— site conditions, e.g. dust, water, light, contrast,

— weather, or

— sources of interference such as other machines, stronger reflectors or emitters.

A.2.4 Machine functions

These functions can be, for example,

— hazard zones to be covered,

— analysis of machine movement and application at job site,

— available mounting positions,

— anticipated movement speed,

— turning circle,

— articulation effects, or

— stopping distance.

A.3 Selection of HDS and VA

The system should be selected considering the following characteristics:

— visual or sensor detection;

— active or passive response;

— 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.