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ISO 20474-1

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Earth-moving machinery — Safety —

Part 1: General requirements

Engins de terrassement — Sécurité —

Partie 1: Sécurité

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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.

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 2, *Safety, ergonomics and general requirements*.

This second edition cancels and replaces the first edition (ISO 20474-1:2008), which has been technically revised with the following changes:

— normative references have been updated;

— references to national and regional provisions in the withdrawn ISO/TS 20474-14 have been deleted;

— new safety requirements and protective measures have been added, including the normative annexes, requirements for elevating operator's stations, for lifting devices used in object handling and for earth-moving machinery used underground in non-explosive atmospheres.

It is intended to be used in conjunction with the other parts of ISO 20474.

A list of all parts in the ISO 20474 series, published under the general title, *Earth-moving machinery — Safety,* can be found on the ISO website.

Introduction

This document is a type-C standard as stated in ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

ISO 20474 provides acceptable safety requirements for earth-moving machinery. This standard does not necessarily provide requirements to meet all national and regional regulatory provisions, e.g. Japan does not allow object handling with earth-moving machinery.

Earth-moving machinery — Safety —

Part 1: General requirements

1 Scope

This document specifies the general safety requirements for earth-moving machinery as defined in ISO 6165, each of these requirements being common to two or more earth-moving machine families. It is also applicable to machine attachments, and to derivative machinery designed primarily for equipment used to excavate, load, transport, drill, spread, compact or trench earth, rock, and other materials.

It is intended to be used in conjunction with the other parts of ISO 20474, which give the provisions that are specific to particular machine families. Those specific requirements take precedence over the requirements of this document for the machines concerned. For multi-purpose machinery, all of those parts of ISO 20474 whose requirements cover the functions and applications of such machines are applicable.

EXAMPLE For a compact loader also used as a trencher, the relevant requirements of ISO 20474-1, ISO 20474-3 and ISO 20474-10 are applicable.

This document deals with all significant hazards, hazardous situations and events relevant to the earth-moving machinery within its scope (see Annex A) when used as intended or under conditions of misuse reasonably foreseeable by the manufacturer. It specifies the appropriate technical measures for eliminating or reducing risks arising from relevant hazards, hazardous situations or events during commissioning, operation and maintenance.

Specific requirements related to autonomous machines are covered in ISO 17757.

This document is not applicable to machines manufactured before the date of its publication.

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 2860, *Earth-moving machinery — Minimum access dimensions*

ISO 2867, *Earth-moving machinery — Access systems*

ISO 3164, *Earth-moving machinery — Laboratory evaluations of protective structures — Specifications for deflection-limiting volume*

ISO 3411:2007, *Earth-moving machinery — Physical dimensions of operators and minimum operator space envelope*

ISO 3449, *Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements*

ISO 3450, *Earth-moving machinery — Wheeled or high-speed rubber-tracked machines — Performance requirements and test procedures for brake systems*

ISO 3457:2003, *Earth-moving machinery — Guards — Definitions and requirements*

ISO 3471:2008, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements*

ISO 3795, *Road vehicles, and tractors and machinery for agriculture and forestry — Determination of burning behaviour of interior materials*

ISO 3864-1, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 3864-2, *Graphical symbols — Safety colours and safety signs — Part 2: Design principles for product safety labels*

ISO 4250-3, *Earth-mover tyres and rims — Part 3: Rims*

ISO 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4871, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 5006, *Earth-moving machinery — Operator's field of view — Test method and performance criteria*

ISO 5010, *Earth-moving machinery — Rubber-tyred machines — Steering requirements*

ISO 6011, *Earth-moving machinery — Visual display of machine operation*

ISO 6014, *Earth-moving machinery — Determination of ground speed*

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

ISO 6395, *Earth-moving machinery — Determination of sound power level — Dynamic test conditions*

ISO 6396, *Earth-moving machinery — Determination of emission sound pressure level at operator's position — Dynamic test conditions*

ISO 6405-1, *Earth-moving machinery — Symbols for operator controls and other displays — Part 1: Common symbols*

ISO 6405-2, *Earth-moving machinery — Symbols for operator controls and other displays — Part 2: Specific symbols for machines, equipment and accessories*

ISO 6682, *Earth-moving machinery — Zones of comfort and reach for controls*

ISO 6683, *Earth-moving machinery — Seat belts and seat belt anchorages — Performance requirements and tests*

ISO 6750, *Earth-moving machinery — Operator's manual — Content and format*

ISO 7096:2000, *Earth-moving machinery — Laboratory evaluation of operator seat vibration*

ISO 8643, *Earth-moving machinery — Hydraulic excavator and backhoe loader boom-lowering control device — Requirements and tests*

ISO 9244, *Earth-moving machinery — Machine safety labels — General principles*

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

ISO 10263-2, *Earth-moving machinery — Operator enclosure environment — Part 2: Air filter element test method*

ISO 10263-3, *Earth-moving machinery — Operator enclosure environment — Part 3: Pressurization test method*

ISO 10263-4:2009, *Earth-moving machinery — Operator enclosure environment — Part 4: Heating, ventilating and air conditioning (HVAC) test method and performance*

ISO 10264, *Earth-moving machinery — Key-locked starting systems*

ISO 10265, *Earth-moving machinery — Crawler machines — Performance requirements and test procedures for braking systems*

ISO 10532, *Earth-moving machinery — Machine-mounted retrieval device — Performance requirements*

ISO 10533, *Earth-moving machinery — Lift-arm support devices*

ISO 10570, *Earth-moving machinery — Articulated frame lock — Performance requirements*

ISO 10968, *Earth-moving machinery — Operator's controls*

ISO 11112:1995, *Earth-moving machinery — Operator's seat — Dimensions and requirements*

ISO 11862, *Earth-moving machinery — Auxiliary starting aid electrical connector*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 12508, *Earth-moving machinery — Operator station and maintenance areas — Bluntness of edges*

ISO 12509, *Earth-moving machinery — Lighting, signalling and marking lights, and reflex-reflector devices*

ISO 12509:2004, *Earth-moving machinery — Lighting, signalling and marking lights, and reflex-reflector devices*

ISO 13031, *Earth-moving machinery — Quick couplers — Safety*

ISO 13333, *Earth-moving machinery — Dumper body support and operator's cab tilt support devices*

ISO 13459, *Earth-moving machinery — Trainer seat — Deflection limiting volume, space envelope and performance requirements*

ISO 13766 (all parts), *Earth-moving machinery — Electromagnetic compatibility*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13857, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14401-1, *Earth-moving machinery — Field of vision of surveillance and rear-view mirrors — Part 1: Test methods*

ISO 14401-2, *Earth-moving machinery — Field of vision of surveillance and rear-view mirrors — Part 2: Performance criteria*

ISO 14990-1, *Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems — Part 1: General requirements*

ISO 14990-2, *Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems — Part 2: Particular requirements for externally-powered machines*

ISO 14990-3, *Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems — Part 3: Particular requirements for self-powered machines*

ISO 15817, *Earth-moving machinery — Safety requirements for remote operator control systems*

ISO 15818, *Earth-moving machinery — Lifting and tying-down attachment points — Performance requirements*

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

ISO 16001, *Earth-moving machinery — Object detection systems and visibility aids – Performance requirements and tests*

ISO 16528-1, *Boilers and pressure vessels — Part 1: Performance requirements*

ISO 16528-2, *Boilers and pressure vessels — Part 2: Procedures for fulfilling the requirements of ISO 16528-1*

ISO 17063, *Earth-moving machinery — Braking systems of pedestrian-controlled machines — Performance requirements and test procedures*

ISO 19014-1[1)], *Earth-moving machinery — Safety — Part 1: Methodology to determine safety-related parts of the control system and performance requirements*

ISO 19014-3[1)], *Earth-moving machinery — Safety — Part 3: Environmental performance and test requirements of electronic and electrical components used in safety-related parts of the control system*

ISO 21507, *Earth-moving machinery — Performance requirements for non-metallic fuel tanks*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

EN 1677-2:2000+A1:2008, *Components for slings — Safety — Part 2: Forged steel lifting hooks with latch, Grade 8*

EN 1679-1, *Reciprocating internal combustion engines — Safety — Part 1: Compression ignition engines*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and 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
earth-moving machinery
self-propelled or towed machine on wheels, crawlers or legs, having *equipment* (3.3) or *attachment* (3.2), or both, primarily designed to perform excavation, loading, transportation, drilling, spreading, compacting or trenching of earth, rock and other materials

Note 1 to entry: Earth-moving machinery can be of a type either directly controlled by an operator riding or not riding on the machine, or can be remotely controlled by wired or wireless means with or without direct view on the working area

[SOURCE: ISO 6165:2012, 3.1]

3.1.1
compact machine
earth-moving machinery (3.1), except for compact excavators and compact loaders, having an *operating mass* (3.8) of 4 500 kg or less

[SOURCE: ISO 6165:2012, 3.1.1]

1) Under preparation.

3.1.2
derivative earth-moving machinery
earth-moving machinery (3.1) that is a combination of features from other earth-moving machine families, creating a different configuration or arrangement

EXAMPLE Machine having the front-mounted equipment of a loader and a non-self-loading, rear-mounted dumper body.

[SOURCE: ISO 6165:2012, 3.11.1]

3.2
attachment
working tool
assembly of components that can be mounted onto the *base machine* (3.15) or *equipment* (3.3) for specific use

[SOURCE: ISO 6746-2:2003, 3.5]

3.3
equipment
set of components mounted onto the *base machine* (3.15) that allows an *attachment* (3.2) to perform the primary design function of the machine

[SOURCE: ISO 6746-2:2003, 3.4]

3.4
quick coupler
quick hitch
attachment bracket
device mounted on the *earth-moving machinery* (3.1) to allow the quick interchange of *attachments* (3.2)

[SOURCE: ISO 13031:2016, 3.1]

3.5
object handling
application of *earth-moving machinery* (3.1) comprising lifting, lowering and transporting of a load by use of lifting accessories, whereby the assistance of a person or the operator of the machine is required for hooking, unhooking or stabilizing (while transporting) the load

Note 1 to entry: If the load is picked up by a self-acting device and no assistance of a person is required for hooking, unhooking and stabilizing the load, this work is considered as a usual earth-moving application.

Note 2 to entry: Lifting accessories include wire ropes, chains or textile straps; loads in object handling applications include pipes and vessels; examples of self-acting devices are grabs, clamshell buckets, log clamps, vacuum lifting devices, magnetic plates and forks.

3.6
maximum rated operating capacity
maximum rated lift capacity
<object handling> maximum load which can be lifted in at least one position of the working range as specified by the manufacturer (e.g. on the rated object handling capacity table) in the most stable configuration (such as with outriggers down)

Note 1 to entry: A definition of *rated operating capacity* for loaders given in ISO 14397-1 is used in ISO 20474-3 and ISO 20474-4.

Note 2 to entry: *Rated lift capacity* forms the subject of ISO 10567 and is the term used in ISO 20474-5.

3.7
routine maintenance
maintenance that is specified in the periodic maintenance schedule of the operator's manual for performing scheduled daily/weekly/monthly maintenance on the machine

3.8
operating mass
mass of the *base machine* (3.15), with *equipment* (3.3) and empty *attachment* (3.2) in the most usual configuration as specified by the manufacturer, and with the operator (75 kg), full fuel tank and all fluid systems (i.e. hydraulic oil, transmission oil, engine oil, engine coolant) at the levels specified by the manufacturer and, when applicable, with sprinkler water tank(s) half full

[SOURCE: ISO 6016:2008, 3.2.1, modified — Notes to the definition have not been included.]

3.9
relevant hazard
hazard which is identified as being present at, or associated with, the machine

[SOURCE: ISO 12100:2010, 3.7]

3.10
significant hazard
hazard which has been identified as relevant and which requires specific action by the designer to eliminate or to reduce the risk according to the risk assessment

[SOURCE: ISO 12100:2010, 3.8]

3.11
lifting device
device fixed or incorporated to the *attachment/working tool* (3.2) or *equipment* (3.3) of the *earth-moving machinery* (3.1) used for object handling, excluding *attachable hook* (3.14)

3.12
sling
assembly of slinging components, e.g. chain, wire rope or textile material, joined to upper or lower terminals suitable for attaching loads to the lifting point

3.13
rated lifting load
RLL
maximum mass for which the *lifting device* (3.11) is designed

Note 1 to entry: The RLL can be different from the rated operating capacity/lift capacity of the machine.

3.14
attachable hook
component intended to be fixed to the *attachment* (3.2) (working tool) or the *equipment* (3.3) of the *earth-moving machinery* (3.1), either welded or bolted

3.15
base machine
earth-moving machinery (3.1) with a cab or canopy and operator protective structures if required, without *equipment* (3.3) or *attachments* (3.2) but possessing the necessary mountings for such *equipment* (3.3) and *attachments* (3.2)

[SOURCE: ISO 6016:2008, 3.1.1]

4 Safety requirements and protective measures

4.1 General

Machinery shall comply with the safety requirements of this clause, in as far as those are not modified by the specific requirements of another part of ISO 20474.

In addition, the machine shall be designed according to the principles of ISO 12100.

4.2 Access systems

4.2.1 General requirements

Access systems shall be provided to the operator's station and to routine maintenance points. Access systems shall comply with ISO 2867.

4.2.2 Access to articulated machines

On machines with articulated frames and in the fully articulated steering position, a minimum clearance of 150 mm shall be provided between firm structures and components with relative movement in the path of the access systems to the operator's station, as illustrated in Figure 1.

Dimension in millimetres

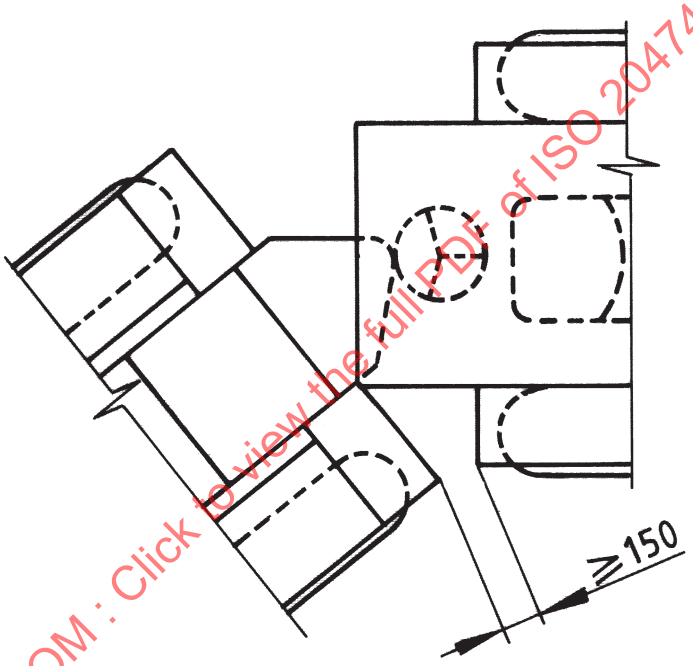


Figure 1 — Minimum clearance for access to operator's station on machines with articulated steering

4.3 Operator's station

4.3.1 General requirements

4.3.1.1 Machinery equipment

The operator's station of ride-on machines should be fitted with a cab.

Machines with an operating mass greater than 1 500 kg and a seated operator shall have the possibility of being fitted with a cab. A cab is not required for machines with a mass of less than 1 500 kg.

Earth-moving machinery shall be designed so that adequate protection can be fitted when they are intended to be used for applications (e.g. operation with a hydraulic- or demolition-hammer) where there is a risk of projection of fractured materials

4.3.1.2 Minimum space

The minimum space available to the operator shall be as defined in ISO 3411.

The minimum space and location of the controls at the operator's station shall meet the requirements of ISO 6682.

4.3.1.3 Moving parts

Measures shall be taken to avoid accidental contact from the operating position with moving parts (e.g. wheels, tracks or working equipment or attachments) in accordance with the relevant subclauses of 4.14.

4.3.1.4 Engine exhaust

The engine exhaust system shall release the exhaust gas away from the operator and the air inlet of the cab.

4.3.1.5 Instruction storage

A space intended for the safekeeping of the operator's manual and other instructions shall be provided near the operator's station. The space shall be lockable, unless the space is inside the operator's station, and the operator's station can be locked.

4.3.1.6 Sharp edges

The operator's working space within the operator's station (e.g. ceiling, inner walls, instrument panels and access to the operator's station) shall not present any sharp exposed edges or acute angles/corners. The radius of corners and the bluntness of edges shall comply with ISO 12508, in order to avoid sharp edges (see also 4.14.6).

4.3.2 Operator's station equipped with a cab

4.3.2.1 Climatic conditions

The cab shall protect the operator against foreseeable adverse climatic conditions. Provisions shall be made to install a ventilation system, an adjustable heating system and a system for defrosting windows. For details, see 4.3.2.5 to 4.3.2.7.

4.3.2.2 Pipes and hoses

Pipes and hoses that contain fluids at pressures exceeding 5 MPa or temperatures above 60 °C located inside the cab shall be guarded in accordance with ISO 3457:2003, Clause 9. See also 4.17.3.

Parts or components placed between pipes or hoses and the operator, which divert a hazardous spray of fluid, can be considered as a sufficient protection device.

4.3.2.3 Primary opening

A primary access opening shall be provided. The dimensions shall be in accordance with ISO 2867.

4.3.2.4 Alternative opening

An alternative opening shall be provided on a side other than that of the primary opening. The dimensions shall be in accordance with ISO 2867. A window panel or another door is acceptable if they are easy to open or remove without the use of keys or tools. Latches may be used if they can be opened from the inside without the use of keys or tools. The breaking of a suitable size of glass pane is considered to represent a suitable alternative opening, provided that the necessary pane hammer, immediately accessible to the operator, is provided and stored in the cab.

When the window panel is used as an emergency exit, it shall bear an appropriate marking (see, for example, ISO 7010:2011, Figure E001).

4.3.2.5 Heating system

A heating system shall comply with ISO 10263-4:2009. If the cab is not equipped with a pressurization system then ISO 10263-4:2009, 6.1.1 is not applicable.

4.3.2.6 Ventilation system

The ventilation system shall be capable of providing the cab with filtered fresh air at the minimum of 43 m^3/h. The filter shall be tested according to ISO 10263-2.

4.3.2.7 Defrosting system

A defrosting system shall provide facilities for defrosting the front and rear windows, for example, by means of a heating system or a particular defrosting device.

NOTE A test method for windscreen defrosting systems is given in ISO 10263-5.

4.3.2.8 Pressurization system

Where a cab is provided with a pressurization system, it shall be tested according to ISO 10263-3 and shall provide an interior relative pressure of at least 50 Pa.

4.3.2.9 Doors and windows

Doors, windows and flaps shall be securely held in their intended operating positions. Doors shall be retained at their intended operating positions by a positive engagement device. A primary opening that is designed to be held securely open as an intended operating position shall be releasable from the operator's station or the entry platform to the operator's station.

Windows shall be made of safety glass or other material that provides similar safety performance (for example, ECE R43).

The front window shall be fitted with motorized windscreen wipers and washers.

The tank of the window washers shall be easily accessible.

4.3.2.10 Inner lighting

The cab shall be fitted with a fixed inner lighting system and shall be able to function with the engine stopped, so that it is possible to illuminate the operator's station such that the operator's manual can be read.

4.3.3 Operator-protective structures

4.3.3.1 General

Earth-moving machinery with a seated operator shall be equipped with a roll-over protective structure (ROPS). The ROPS shall comply with ISO 3471.

4.3.3.2 ROPS for derivative machinery

For derivative machinery, the ROPS shall be designed taking into account the operating mass of the derivative machinery in the heaviest configuration as specified by the manufacturer.

4.3.4 Falling-object protective structures (FOPS)

Earth-moving machinery, apart from exceptions as specified in ISO 3449, shall be so designed that a FOPS can be fitted, when they are intended for applications where there is a risk of falling objects.

The fitted FOPS shall be in accordance with ISO 3449.

4.3.5 Elevating operator's station

See Annex B.

4.3.6 Replacement of operator protective structure

Machines shall be designed such that operator protective structures (e.g. ROPS, TOPS, FOPS) can be replaced, according to the manufacturer's specification. The manufacturer shall instruct the end-user to replace the protective structure if the structure experiences plastic deformation or rupture that has impact on its integrity, it. See 6.2.

4.4 Seats

4.4.1 Operator's seat

4.4.1.1 General requirements

Machinery with provision for a seated operator shall be fitted with an adjustable seat that supports the operator in a position that allows the operator to control the machine under the intended operating conditions.

4.4.1.2 Dimensions

The seat dimensions shall be in accordance with ISO 11112.

4.4.1.3 Adjustment

All adjustments to accommodate the operator's size shall comply with ISO 11112. Adjustment shall be possible without the use of any tool.

4.4.1.4 Vibration

If provided, suspended operator's seats shall meet the requirements of ISO 7096 with regard to its ability to reduce the vibration transmitted to the operator.

NOTE Comparative data for whole body vibration can be found in ISO/TR 25398.

4.4.1.5 Restraint system

Machines fitted with ROPS or TOPS shall have an operator restraint system in accordance with ISO 6683.

4.4.2 Additional seat

4.4.2.1 Trainer seat

If an additional seat for a trainer is installed in the operator's station, it shall be padded and shall provide adequate space for the trainer. The trainer shall also have available a conveniently placed handhold.

If a trainer seat is installed it shall be in accordance with ISO 13459.

4.4.2.2 Second operator's seat

If a second operator's seat is provided to fully operate the machine, this seat shall fulfil all the requirements for seats given in 4.4, as well as those for operator protective structures, 4.3.3 and 4.3.4.

Separate operator seats on attachments, from which only the attachment and not the machine or equipment is intended to be operated, do not need to meet the above requirement.

4.5 Operator's controls and indicators

4.5.1 General

The controls (hand levers, joysticks, pedals, switches, etc.) of the machine, equipment and attachment, shall be chosen, designed, constructed and arranged in accordance with ISO 10968, and the following requirements:

— the normal engine stop device is within the zone of reach as defined by ISO 6682;

— when a control such as a keyboard or joystick control is designed and constructed to carry out several functions, the activated functions are clearly identified;

— for the safety-related functions of control systems, the principles outlined in ISO 13849-1 or ISO 19014-1 and ISO 19014-3 apply.

4.5.2 Starting and stopping system

Earth-moving machinery shall be equipped with a starting and stopping device (e.g. key). The starting system shall comply with ISO 10264 or have similar protection against unauthorized use.

Earth-moving machines shall be so designed that movement of the machine, working equipment and attachment, shall not be possible, while starting or stopping the engine, without activating the controls.

4.5.3 Inadvertent activation

Controls that can cause a hazard due to inadvertent activation shall be so arranged, deactivated or guarded as to minimize the risk — particularly while the operator is getting into or out of the operator's station. The deactivation device shall either be self-acting or shall act by compulsory actuation of the relevant device.

4.5.4 Pedals

Pedals shall be of an appropriate size, shape and shall be adequately spaced. They shall have a slip-resistant surface and be easy to clean.

If the pedals of an earth-moving machine have the same function (clutch, brake, and accelerator) as on a motor vehicle, they shall be arranged in the same manner to avoid the risk of confusion.

4.5.5 Emergency attachment lowering

If the engine is stopped it shall be possible to

— lower the equipment/attachment to the ground/frame,

— see the equipment/attachment lowering from the operator actuating position of the lowering control,

— release the residual pressure in each hydraulic and pneumatic equipment/attachment lowing circuit which can cause a risk.

The means to lower the attachment and the device to release the residual pressure may be located outside the operator's station and shall be described in the operation manual.

4.5.6 Uncontrolled motion

Machine and equipment/attachment movement from the holding position — other than by actuation of the controls by the operator — due to drift or creep (e.g. by leaking) or when power supply stops, shall be limited to the extent that it cannot create a risk to exposed persons.

4.5.7 Remote control

Remote operator controlled earth-moving machinery shall be in accordance with ISO 15817, unless otherwise specified in a machine-specific part of ISO 20474.

4.5.8 Visual displays/control panels, indicators and symbols

4.5.8.1 Visual displays/control panels

The operator shall be able to see from the operator's station, in either daylight or darkness, the necessary indicators allowing a check of the proper function of the machine. Glare shall be minimized.

4.5.8.2 Operating instrumentation

Control indicators for the safe and proper operation of the machine shall be in accordance with ISO 6011 with respect to the use of colours and related aspects.

4.5.8.3 Symbols

Symbols used on visual displays/controls on earth-moving machinery shall, if available, follow, ISO 6405-1 or ISO 6405-2.

4.5.9 Ride-on machine controls accessible from ground level

Ride-on machine controls that are not intended to be operated from the ground, shall have means to minimize the possibility of actuating the controls from the ground.

EXAMPLE Protection by door/guard locking or interlocking systems.

4.5.10 Non-riding machine controls

Non-riding machines shall be equipped with a hold-to-run device to stop machine travel and hazardous tool movement if the operator releases the operator's controls. Design of the controls shall take into account the hazards from inadvertent movement of the machine towards the operator.

4.6 Steering systems

4.6.1 General

The steering system shall be such that the movement of the steering control corresponds to the intended direction of steering according to ISO 10968.

4.6.2 Wheeled machines

The steering system of wheeled machines having a forward/reverse travel speed greater than 20 km/h shall be in accordance with ISO 5010.

4.6.3 Crawler machines

The steering system of crawler machines with a forward/reverse travel speed greater than 20 km/h shall be gradual.

4.7 Brake systems

Earth-moving machines shall be equipped with a service brake system, a secondary brake system and a parking brake system, with all three systems being effective under all conditions of service, load, speed, terrain and slope, according to the intended use of the machine.

Ride-on earth-moving machines shall have a brake system in accordance with ISO 3450 except for crawler machines with a travel speed less than 20 km/h. These shall have a brake system in accordance with ISO 10265.

Non-riding earth-moving machines shall have a brake system in accordance with ISO 17063.

4.8 Visibility

4.8.1 Operator's field of view

Earth-moving machines shall be designed so that the operator has sufficient visibility from the operator's station in relation to the travel and work areas of the machine necessary for its intended use. The performance criteria shall be in accordance with ISO 5006.

NOTE 1 The travel mode according to ISO 5006 is considered to be representative for testing visibility in both travel and operating modes.

Earth-moving machines shall be equipped with rear view mirrors in accordance with ISO 14401-1 and ISO 14401-2. Alternatively, systems that provide visibility aids giving similar performance to mirrors may be used where ISO 14401-1 and ISO 14401-2 give requirements.

If the earth-moving machine is equipped with an object detection system or visibility aid ISO 16001 shall apply.

If equipped with a front windscreen and, if relevant, rear window (e.g. backhoe loader), adjustable sun visors shall be fitted to minimize glare to the operator unless other parts of the operator's station (e.g. roof profile, cab members) provide sufficient protection or where the fitting of a sun visor is not practicable (e.g. on compact machines due to space constraints).

4.8.2 Lighting, signalling and marking lights, and reflex-reflector devices

Work lamps and reflex-reflector devices shall be provided in accordance with ISO 12509. Lighting, signalling and marking lights, if provided, shall comply with the appropriate clauses of ISO 12509.

4.9 Warning devices and safety signs

The earth-moving machinery shall be equipped with

a) an audible warning device (horn) controlled from the operator's station and tested to compliance with ISO 9533, and

b) safety signs and hazard pictorials in accordance with ISO 9244.

The requirement for an audible warning device is not applicable to non-riding machines with an operating mass ≤ 1 500 kg.

4.10 Tyres and rims

Wheeled earth-moving machinery with rubber tyres shall have tyre and rim load performance adapted to the machine's purpose and application.

Rims shall have clear identification in accordance with ISO 4250-3.

4.11 Stability

Earth-moving machines with equipment and attachments, including optional equipment, shall be designed and constructed so that stability is provided under all intended operating conditions including maintenance, assembling, dismantling, and transportation, as specified by the manufacturer in the operation manual.

Devices (e.g. outriggers, oscillating axle locking) intended to increase the stability of earth-moving machines in working mode shall be fitted with interlocking devices or check valves which keep them in position in case of hose failure or in case of oil leakage.

4.12 Object handling

4.12.1 Lifting devices for object handling

Lifting devices may be either fixed or removable, and may be located on a bucket, an arm or on any other part of the machine, or may be a separate device. Lifting devices shall be

— so located and designed that the risk of damage to them during normal earth moving operations is minimized, and

— designed so that the hooking device prevents unintentional unhooking of the load.

Lifting devices shall meet the requirements of Annex C.

4.12.2 Lowering control device

Machines used in object handling applications (see the other, machine-specific, parts of ISO 20474), which require a lowering control device, shall be in accordance with ISO 8643.

4.13 Noise

4.13.1 Requirements for noise reduction

When designing machinery, the available information and technical measures to control noise at source shall be taken into account.

NOTE Recommended practice for the design of low-noise machinery is given in ISO/TR 11688-1, while ISO/TR 11688-2 gives useful information on noise generation mechanisms in machinery.

4.13.2 Noise emission measurement

4.13.2.1 Sound power level

The sound power level for the different types of earth-moving machinery shall be measured according to ISO 6395 unless otherwise stated in the machine-specific parts of ISO 20474.

4.13.2.2 Emission sound pressure level at the operator's station

The emission sound pressure level at the operator's station for the different types of earth-moving machinery shall be measured according to ISO 6396 unless otherwise stated in the machine-specific

parts of ISO 20474. The A-weighted emission sound pressure level at the operator's station shall be noted in the operators manual if it exceeds an A-weighted value of 80 dB.

4.14 Protective measures and devices

4.14.1 Contaminated area

If an earth-moving machine is intended to be used in a contaminated environment, an appropriate protection system shall be added, in cooperation with the machine user and the provider of the protection system.

4.14.2 Hot parts

Parts which become hot in operation shall be designed, constructed, positioned or provided with a thermal guard to minimize the risk of contact with hot parts or hot surfaces in close proximity to the primary opening, operating position and maintenance area, in accordance with ISO 3457.

For ergonomic data that can be used to establish temperature limit values for hot surfaces, see ISO 13732-1.

4.14.3 Moving parts

All moving parts that create a hazard shall be designed, positioned or provided with protection to minimize the risk of crushing, shearing and cutting. ISO 13857 shall be used.

Tempered glass does not fulfil the requirements of a protective device where a risk of crushing, shearing and cutting exist.

4.14.4 Guards

Guards shall be in accordance with ISO 3457.

Engine compartment panels are regarded as guards.

Movable guards shall be provided with means to remain in an open position up to a wind speed of 8 m/s.

Fixed guards that are to be removed as a part of routine maintenance procedures described in the operator's manual shall be fixed by systems that can be opened or removed only with tools. These guard-fixing systems shall remain attached to the guards or to the machinery when the guards are removed.

Where possible, fixed guards shall be unable to remain in place without their fixings.

4.14.5 Articulated frame lock

Articulated machines shall be equipped with an articulated frame lock according to ISO 10570.

4.14.6 Sharp edges and acute angles

Sharp edges and acute angles shall be in accordance with ISO 12508 in those areas that can be accessed during operation and routine maintenance, except for the area of the attachment necessary for the attachment to provide its function (e.g. trencher chain, snow blower). See also 4.3.1.6.

4.14.7 Fenders

Earth-moving machinery with a design speed according to ISO 6014 greater than 25 km/h shall be provided with fenders in accordance with ISO 3457.

Earth-moving machinery with a design speed according to ISO 6014 equal to or less than 25 km/h shall be provided with fenders if required according to ISO 3457.

4.15 Retrieval, transportation, lifting and towing

4.15.1 Common use

Points for retrieval, tying-down, lifting and towing may be the same if allowed by the configuration of the machine.

4.15.2 Retrieval

Retrieval points shall be provided at the front or rear of the earth-moving machines in accordance with ISO 10532.

4.15.3 Tying-down

Tying-down attachment points shall be in accordance with ISO 15818.

4.15.4 Lifting

Lifting attachment points shall be in accordance with ISO 15818.

4.15.5 Off-road towing

A towing point (e.g. hook, ear), if provided on the machine, shall be in accordance with ISO 10532. The location, the permissible forces and the correct use when towing another object (e.g. scraper, disc, trailer), as well as the maximum towing speed and distance shall be clearly specified in the operator's manual.

These requirements do not apply to non-riding machines.

4.15.6 Transportation

Stabilizers, outriggers or other moveable devices that can cause a hazard during transportation or travelling shall have a means to be secured in their transport position.

Instructions for secure locking shall be provided in the operator's manual.

4.16 Electrical and electronic systems

4.16.1 General

Electrical components and conductors shall be installed in such a way as to avoid damage from exposure to environmental conditions (corresponding to the intended use of the machine) that can cause deterioration.

Electrical component insulation shall have flame-retardant properties. Lead-through (e.g. through frames and bulkheads) shall be protected from abrasion.

Electrical wires/cables not protected by over-current devices shall not be strapped in direct contact with pipes or hoses containing fuel.

Earth-moving machines shall comply with the EMC requirements given in ISO 13766.

Machine utilizing on-board voltages in the ranges of 50 V–36 KV AC r.m.s. and 75 V–36 KV DC shall be in accordance with ISO 14990-1, ISO 14990-2 and ISO 14990-3.

4.16.2 Degree of protection

Depending on the location/installation of electrical and electronic components, the following degrees of protection are required:

a) all components installed exterior to the machine or directly exposed to the environment shall have a minimum degree of protection corresponding to according IEC 60529, IP 55;

b) all components installed in the operator's cab or protected against the environment, the protection shall be designed and executed to safeguard a correct function under expected and intended conditions.

Electronic controls, connectors in control circuits, multi-pin connectors and control switches external to the cab, shall have a minimum protection of IP 55.

4.16.3 Electrical connections

In order to avoid incorrect connections, electrical wires and cables used to connect components in electric circuits shall be marked and identified. ISO 9247 should be used as guidance.

This requirement does not apply to the electrical circuits of anti-theft systems.

4.16.4 Over-current protective devices

Unless specifically designed to be unfused (e.g. starter motor, alternator, pre-heater), the fusing for the electrical equipment shall be as close as practical to the source. The protecting device for the load centre (e.g. fuse box, relay box) shall be near or adjacent to the battery. Protection devices should be sized to protect the wire sizes attached to them. If a harness is split (separated into multiple wires), then the protection device shall also be placed immediately after the point of the split, unless protection device amperage rating prior to the split is sufficiently low to protect the wire sizes after the split.

4.16.5 Batteries

The battery location should have easy access. Batteries should be easily removable.

Batteries shall be firmly attached in a ventilated space. The batteries shall be provided with measures for safe handling.

Batteries and battery locations shall be designed and built or covered to minimize any hazard to the operator caused by battery acid or acid vapours in the event of a machine overturn.

Live parts (not connected to the frame) and connectors shall be covered with insulation material.

4.16.6 Battery disconnection

It shall be possible to disconnect batteries easily (e.g. quick coupling, accessible isolator switch). The symbol ISO 7000-2063 (see ISO 6405-1) shall be used for identification.

The disconnection system shall be capable of being locked (e.g. padlock) if reconnection could endanger persons.

4.16.7 Electrical connectors for auxiliary starting aids

If electrical connectors for auxiliary starting aids or power supply are mounted on the machine, the connectors shall be in accordance with ISO 11862.

4.16.8 Electric sockets for lighting

An electric socket intended for the connection of a lighting device for maintenance use shall be provided on the machine and shall be easily accessible.

Voltage of electrical socket shall be marked.

The design of the sockets shall prevent incorrect connection.

The requirement for electric socket for lighting is not applicable to non-riding machines with an operating mass ≤ 1 500 kg.

4.17 Pressurized systems

4.17.1 General requirements

Pressurized equipment shall be designed in accordance with ISO 4413 or ISO 4414 as appropriate.

4.17.2 Hydraulic lines

Hydraulic lines (e.g. pipes, hoses and fittings) shall be located and, if necessary, restrained so as to minimize deterioration such as through contact with hot surfaces, sharp edges and other damage causing sources. Visual inspection of hydraulic lines, other than those located inside frames, shall be possible.

4.17.3 Hydraulic hose assemblies

Hydraulic hose assemblies containing fluid at a pressure of more than 5 MPa (50 bar) or at a temperature of more than 60 °C, and which are located within 1,0 m from any surface of DLV (deflection limiting volume, as defined in ISO 3164), shall be guarded in accordance with ISO 3457 (see also 4.3.2.2).

Any part or component that diverts a possible jet of fluid may be regarded as providing sufficient protection.

Hydraulic hose assemblies intended to withstand a pressure of more than 15 MPa (150 bar) shall not be fitted with reusable fittings, unless they require the use of dedicated tooling (such as a press) and are parts authorized by the manufacturer of the earth-moving machine.

Hydraulic hose assemblies shall be in accordance with ISO 4413.

Steering system hydraulic hose assemblies shall be in accordance with ISO 5010.

4.17.4 Air pressure vessels

Simple pressure vessels shall be designed and tested according to ISO 16528-1 and ISO 16528-2.

4.18 Fuel tanks, diesel emission fluid tanks and hydraulic oil tanks

4.18.1 General requirements

Fuel, diesel emission and hydraulic oil tanks shall be provided with a fluid level indicator. Pressure in the tanks exceeding the specified pressure shall be automatically compensated by a suitable device (vent, safety valve, etc.).

4.18.2 Filler openings

Filler openings of tanks (except window washer tanks) shall

a) be easily accessible for filling,

b) have provisions for lockable filler caps except for filler caps located inside lockable compartments (e.g. engine compartment) or caps that can only be opened with a special tool, except for machines with an operating mass ≤ 1 500 kg, and

c) be located outside the cab, with the exception of the hydraulic oil tank on compact machines.

4.18.3 Fuel tanks

Non-metallic fuel tanks shall meet the requirements of ISO 21507.

Metallic fuel tanks shall meet the strength test, including the elevated pressure and temperature test if required, and the inversion test according to ISO 21507.

4.19 Fire protection

4.19.1 Fire resistance

The interior, upholstery and insulation of the cab and other parts of the machine where insulation materials are used shall be made of flame-retardant materials. The burning rate shall not exceed 200 mm/min, tested in accordance with ISO 3795.

4.19.2 Fire extinguisher

Earth-moving machinery with an operating mass greater than 1 500 kg shall have space for the installation of a fire extinguisher or extinguishers, easily accessible to the operator, or shall have a built-in extinguishing system to permit the operator safe exit from the machine.

4.20 Attachments

4.20.1 General

The machine manufacturer shall define the range of attachments intended to be used with the machine and establish the criteria for the safe fitting and use of the attachment.

4.20.2 Identification

The attachment shall be permanently marked with the following information:

— manufacturer's name and address;

— type denomination (e.g. part number);

— mass, expressed in kilograms (kg);

— working circuit pressure, expressed in Pascals (Pa), if relevant;

— capacity of attachment, e.g. expressed in cubic metres (m^3), if relevant.

4.20.3 Instructions

The attachment manufacturer shall provide instructions concerning mounting and use of the attachment.

4.20.4 Quick couplers

Quick couplers shall be in accordance with ISO 13031.

4.20.5 Lifting devices

Requirements for lifting devices used for object handling are given in Annex C.

4.21 Maintenance

4.21.1 General

Machines shall be designed and built so that routine lubrication and maintenance operations can be carried out safely, whenever possible with the engine stopped. Where it is only possible to undertake checks or maintenance with the engine running, the safe procedure shall be described in the operator's manual.

Openings intended for maintenance purposes shall comply with ISO 2860.

If practical, the design of the machine shall permit lubrication and filling of tanks from the ground.

4.21.2 Routine maintenance

Components that require routine maintenance shall be easily accessible for checking and changing.

A lockable storage box shall be provided on the machine for tools and accessories as recommended by the manufacturer.

4.21.3 Support devices

Machines which require the equipment to be held in the elevated position for maintenance shall be provided with a device in accordance with ISO 10533.

If support device or devices are required for routine maintenance, they shall be permanently affixed to the machine or shall be stored in a secure place on the machine.

Engine access panels shall be provided with a device to hold them in the open position.

4.21.4 Access to the engine compartment

The engine compartment shall have provisions to guard against unauthorized access by one of the following means:

— a locking device;

— an installation that requires the use of a tool or key;

— a guard latch control inside a lockable compartment (e.g. cab).

4.21.5 Tiltable cab support device

If the operator's cab has an integral tilt system for maintenance, servicing or other non-operational purpose, an automatic means shall be provided to keep the cab in the raised position (e.g. mechanical latch, over centre design).

If a mechanical support device is provided, it shall meet the requirements of ISO 13333.

When a cab is tilted, a control locking system shall be available to avoid unintended movement of the machine and equipment/attachment actuated by the controls located in the cab.

An automatic locking device (in closed position) is required if daily maintenance is needed below a tilted cab.

4.22 Underground operation in non-explosive atmosphere

The requirements regarding use of earth-moving machinery in underground operations in non-explosive atmosphere are given in Annex D.

4.23 Rear-mounted winch

4.23.1 Mounting

The means for securing a winch, if provided, to the machine structure shall be designed to withstand a force of twice the maximum line-pull that can be exerted by the rope without permanent deformation. ISO 19472 should be used as guidance for design of the mounting system.

4.23.2 Controls

The winch controls shall be located at the operator's station and shall be in accordance with ISO 10968.

4.23.3 Protection

Where a rear-mounted winch is fitted, provision shall be made to allow for protection.

Earth-moving machinery equipped with a rear winch shall be equipped with an adequately sized protective screen or screens of a steel wire of minimum diameter 6 mm woven wire mesh and maximum opening of 45 mm × 45 mm, or equivalent protection, between the operator and the winch.

ISO 8084 should be used as guidance for design.

The screen width and height shall cover at least

— the rear window, for machines fitted with a cab;

— the rear of the minimum space envelope as specified in ISO 3411:2007, Figure 4, for machines without a cab.

4.24 Speed limit for non-riding machines

The maximum travel speed of non-riding earth-moving machinery shall be limited to 6 km/h. If the controls are located at the rear of the machine, the reverse speed shall be limited to 2,5 km/h.

When operating downhill at the maximum gradeability, the travel speed of the machine shall not increase more than 2 m/min with the speed selector in its pre-set position.

5 Verification of safety requirements and protective measures

It is necessary to verify that the requirements of this document have been incorporated in the design and manufacture of the earth-moving machinery. Either one or a combination of the following shall achieve this:

a) measurement;

b) visual examination;

c) as appropriate, test items with special requirements using methods prescribed in cited standards;

d) assessment of the contents of the required documentation kept by the manufacturer (e.g. evidence for bought-in components, such as windscreens) have been manufactured according to standard requirements.

6 Information for use

6.1 Safety labels

Safety labels shall be affixed to the machines when the machinery or its attachments present residual risks for the operator and for nearby persons.

Safety labels shall meet the requirements of ISO 9244.

6.2 Operator's manual

The operator's manual shall be in accordance with ISO 6750.

The manufacturer shall provide information on the following:

— the procedure for emergency attachment lowering and release of residual pressure;

— the use of retrieval, lifting and tying-down points;

— the use of towing point, if fitted, including location, permissible forces, maximum towing speed and distance;

— instructions for secure locking of stabilizers, outriggers and movable devices, if fitted;

— a statement to the effect that no alterations or repairs to a protective structure such a ROPS, TOPS or FOPS, if fitted, are permitted except where authorized by the manufacturer;

— the operation and safe use of winches, if fitted;

— a marking of the maximum pull force of the winch, if fitted;

— the A-weighted emission sound pressure level at the operator's station or stations (see 4.13.2.2) where this level exceeds 80 dB; or, where this level is not greater than 70 dB, an indication that it is not; with the declaration of this value having the format of a single number declaration as defined in ISO 4871.

6.3 Machine marking

Each machine shall, as a minimum, bear the following minimal information in a legible and indelible condition:

a) name and address of the manufacturer;

b) mandatory marking, if any;

c) designation of series or type;

d) the serial number, e.g. PIN according to ISO 10261.

Annex A
(informative)

List of significant hazards

NOTE Table A.1 contains all the significant hazards, hazardous situations and events, as far as they are dealt with in this document, identified by risk assessment as common to two or more machine families and which require action to eliminate or reduce the risk.

Table A.1 — List of significant hazards

No.	Hazard	Relevant sections of this document
	Hazards, hazardous situations and hazardous events	
1	**Mechanical hazards** due to machine parts and workpieces, (e.g. shape, location, mass and stability, mass and velocity, mechanical strength) or due to accumulation of energy inside the machine (e.g. elastic elements such as springs, liquids and gases under pressure, effect of vacuum).	4.3.1.3, 4.3.2.2, 4.3.2.8, 4.5.3, 4.5.6, 4.17
1.1	Crushing hazard	4.2.2, 4.3.1.2, 4.3.1.3, 4.3.3, 4.3.4, 4.3.5, 4.4.1.5, 4.4.2, 4.5.3, 4.5.6, 4.5.9, 4.5.10, 4.14.3, 4.14.5, 4.21.3,4.21.5, B.1 to B.6
1.2	Shearing hazard	4.14.4, 4.14.6
1.3	Cutting or severing hazard	4.3.1.6, 4.14.3
1.4	Drawing-in or trapping hazard	4.3.3, 4.3.4, 4.14.3, 4.14.4
1.5	Impact hazard	4.3.4
1.6	Stabbing or puncture hazard	4.3.1.3, 4.14.3, 4.14.4
1.7	Friction or abrasion hazard	4.3.1.3, 4.3.1.6, 4.14.3, 4.14.4
1.8	High pressure fluid injection or ejection hazard	4.3.2.2, 4.17
2	**Electrical hazards** due to:	
2.1	Contact of persons with live parts (direct contact)	4.16.2, to 4.16.7
2.2	Electrostatic phenomena	4.16
2.3	Thermal radiation or other phenomena such as the projection of molten particles and chemical effects from short circuits, overloads, etc.	4.16.1 to 4.16.4
3	**Thermal hazards**, resulting in:	
3.1	Burns, scalds and other injuries by a possible contact of persons with objects or materials with an extreme high or low temperature, by flames or explosions and also by radiation of heat sources	4.3.2.2, 4.14.2, 4.17.3
3.2	Damage to health by hot or cold working environment	4.3.2.1, 4.3.2.5, 4.3.2.6
4	Hazards generated by noise, resulting in:	
4.1	Hearing loss (deafness), other physiological disorders (e.g. loss of balance, loss of awareness)	4.13
4.2	Interference with speech communication, acoustic, signals etc.	4.9
5	**Hazards generated by vibration**	4.4.1.4
6	**Hazards generated by radiation**	
6.1	Low frequency, radio frequency radiation, micro waves	4.16.1

Table A.1 *(continued)*

No.	Hazard	Relevant sections of this document
6.2	Infrared, visible and ultraviolet light	4.8.2
7	**Hazards generated by materials and substances, processed or used by the machinery**	
7.1	Hazards from contact with/or inhalation of harmful fluids, gases, mists, fumes and dusts	4.3.1.1, 4.3.2.6, 4.3.2.7, 4.3.2.8, 4.14.1
7.2	Fire or explosion hazard	4.19
8	**Hazards generated by neglecting ergonomic principles in machinery design**, e.g. hazards from:	
8.1	Unhealthy postures or excessive effort	4.3.1.1, 4.3.2, 4.4.1.2, 4.4.1.3
8.2	Inadequate consideration of hand-arm or foot-leg anatomy	4.1, 4.2, 4.3.2, 4.4.1, 4.4.2, 4.5.1, 4.5.4
8.3	Neglected use of personal protection equipment	6.2
8.4	Inadequate local lighting	4.3.2.10, 4.8.2
8.5	Mental overload and underload, stress	4.3.1, 4.3.2.6, 4.3.2.7, 4.8
8.6	Human error, human behaviour	4.3.1.3, 4.4 to 4.9, 4.12 to 4.17, 4.18, 4.19, 4.20
8.7	Inadequate design, location or identification of manual controls	4.5, 4.6, 4.7
8.8	Inadequate design or location of visual display units	4.5.8
8.9	Neglecting principles of safety integration	4.2, 4.3, 4.4, 4.5
8.10	Inadequate guards and protection devices	4.14
8.11	Inadequate operating position	4.4.1
8.12	Inadequate design of adjustment, service and maintenance places and access to these places	4.21
9	**Combination of hazards**	4.17, Annex B
10	**Unexpected start-up, unexpected overrun/ overspeed (or similar malfunction)** from:	
10.1	Failure/disorder of control system	4.5
10.2	Restoration of energy supply after an interruption	4.5.5
10.3	External influences on electrical equipment	4.16.1, 4.16.2
10.4	Other external influences (gravity, wind etc.)	4.14.4
10.5	Errors in the software	4.5.1, 4.16.1
10.6	Errors made by the operator (due to mismatch of machinery with human characteristics and abilities, see 8.7)	4.4 to 4.10, 4.12, 4.14 to 4.17, 4.18.2, 4.20
11	**Impossibility of stopping the machine in the best possible conditions**	4.5, 4.6, 4.7
12	**Failure of the power/energy supply**	4.5.5, 4.5.6, 4.5.7, 4.6.2, 4.7, 4.16.5
13	**Failure of the control circuit**	4.6, 4.7, 4.16
14	**Errors of fitting**	4.17, 4.20
15	**Falling or ejected objects or fluids**	4.3.2.9, 4.3.4, 4.14.7, 4.17, 4.18
16	**Loss of stability/overturning of machinery**	4.3.3, 4.11
17	**Slip, trip and fall of persons** (related to machinery)	4.1, 4.2, 4.21, Annex B
	Additional hazards, hazardous situations and hazardous events due to mobility	
18	**Relating to travelling function**	
18.1	Movement when starting the engine	4.5.1 to 4.5.3

Table A.1 *(continued)*

No.	Hazard	Relevant sections of this document
18.2	Movement without a driver at the driving position	4.5.7, 4.16
18.3	Movement without all parts in a safe position	4.5.6, 4.11, 4.15.3
18.4	Travelling function	4.5.7, 4.6, 4.7
18.5	Excessive oscillation when moving	4.5.6
18.6	Insufficient ability of machinery to be slowed down, stopped and immobilised	4.7
18.7	Remote control	4.5.7
19	**Linked to the work position** (including operator's station) on the machine	
19.1	Fall of persons during access to (or at/from) the work positions	4.2, 4.3.2.9, 4.21, B.5
19.2	Exhaust gases/lack of oxygen at the work position	4.3.1, 4.3.2.6
19.3	Fire (flammability of the cab, lack of extinguishing means)	4.19
19.4	Mechanical hazards at the work position:	
	– contact with the wheels;	4.3.1.2, 4.3.1.3, 4.14.7
	– rollover;	4.3.3
	– fall of objects, penetration by objects.	4.3.4
19.5	Insufficient visibility from the operator's/work positions	4.3.1.1, 4.3.2.7, 4.3.2.9, 4.5.8, 4.8
19.6	Inadequate work/drive lighting	4.3.2.10, 4.8.2, 4.16.8
19.7	Inadequate seating	4.4.1, 4.4.2
19.8	Noise at the work position	4.13
19.9	Vibration at the drive/work positions	4.4.1.4
19.10	Insufficient means for evacuation/emergency exit	4.3.2.3, 4.3.2.4
20	**Due to control system**	
20.1	Inadequate design of energy/control circuits	4.6, 4.7, 4.17
20.2	Inadequate location of manual controls	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.7
20.3	Inadequate design of manual controls and their mode of operation	4.5, 4.6, 4.7
21	**From handling the machine** (lack of stability)	4.11, 4.12, 4.15, 6.2
22	**Due to the power source and to the transmission of power**	
22.1	Hazards from the engine and the batteries	4.3.1.3, 4.16.5, 4.16.6, 4.21.4
22.2	Hazards from transmission of power between machines	4.14.3
22.3	Hazards from retrieval, transportation, lifting and towing	4.15
23	**From/to third persons**	
23.1	Unauthorised start-up/use	4.5.2
23.2	Drift of a part away from its stopping position	4.5.6, 4.7, 4.11
23.3	Lack or inadequacy of visual or acoustic warning means	4.5.8, 4.9, 6.1
24	**Insufficient instructions for the driver/operator** (operation manual, signs, warnings, and markings)	4.3.1.5, 4.5.1, 4.5.8.2, 4.5.8.3, 4.9, 4.13.2.2, 4.15.5, B.7, C.5
	Additional hazards, hazardous situations and hazardous events due to lifting	
25	**Mechanical hazards and hazardous events:**	
25.1	From load falls, collision, machine tipping caused by:	4.12, 4.15.4, Annex C
25.1.1	lack of stability	4.10, 4.11, 4.15.4, 4.1

Table A.1 *(continued)*

No.	Hazard	Relevant sections of this document
25.1.3	inadequate holding devices/accessories	4.12.1
25.2	From insufficient mechanical strength of parts	4.12.2, C.2, C.4
25.3	From inadequate selection of chain, ropes, lifting attachments and their inadequate integration into the machine	C.3, C.4
	Additional hazards, hazardous situations and hazardous events due to underground works	
26	**Mechanical hazards and hazardous events** due to:	
26.1	Operator's station	4.3, 4.4, Annex B

Annex B
(normative)

Requirements for elevating operator's stations

B.1 General

Machines with an elevating operator's station, regardless of the elevation height, shall comply with the requirements of 4.3, 4.4 and 4.5. With the operator's station in the lowest position, the access shall comply with 4.2.

The lift and descent speed of the operator's station shall not exceed 0,6 m/s under normal operating conditions and in case of hydraulic line rupture 0,4 m/s.

The operator's station shall not exceed ± 5° on horizontal tilting.

If service or maintenance work has to be done with a raised operator's station, a mechanical support device shall be provided. The device shall withstand a force of twice the mass of the operator's station.

B.2 Elevating control

The elevating control shall be clearly marked and protected against unintentional activation.

B.3 Emergency descent

In case of failure of the source of energy, engine stop or hydraulic system failure, it shall be possible for the operator to lower the operator's station to the lowest position (irrespective of the actual position) or to leave the operator's station safely, e.g. by steps or stairs. It shall be possible for a person outside the operator's station to lower the operator's station safely.

The control for the emergency lowering shall be marked red as a safety device.

B.4 Crushing hazards

The hazardous area between the machine main frame and the bottom of the elevated operator's station shall be marked with alternating yellow and black stripes in accordance with ISO 3864-1 and ISO 3864-2 and warning signs according to ISO 9244. If the operator does not have a direct view of the hazardous area between the operator's station and the frame, visibility aids (e.g. mirrors, CCTV) shall be installed to allow the operator to observe the hazardous area when lowering the operator's station.

B.5 Falling down protection for the operator

When the machine is intended for use with an elevating operator's station and the risk of falling down from this operator's station exists, the side door shall be designed and constructed in such a way as to prevent inadvertent opening and shall open in a direction that obviates any risk of falling, should it open unexpectedly, or a device which fulfils these requirements (e.g. bar, armrest) shall be used. If a bar is used, it shall be so designed that it is adjusted in the closed position 700 mm above the operator's station floor.

B.6 Roll-over protective structures (ROPS) for elevating operator's station

On machines where a ROPS is required (e.g. trenchers), ISO 3471 applies with the following exceptions:

— the ROPS for the operator's station shall be regarded as a separate independent ROPS (ROPS not connected to the machine frame);

— only the vertical load test of ISO 3471:2008, 6.3, shall be applied in all planes;

— in the case of symmetrical design of the structure in one or more directions front/rear, left/right, top/bottom) only one test is required in applicable directions;

— ISO 3471:2008, Clause 8, h), does not apply.

B.7 Operator's manual

The operator's manual shall contain safety instructions for elevating operator's stations, for example:

— the use of seat belts;

— operator's station position when travelling;

— emergency instructions;

— the use of mechanical support device for maintenance.

B.8 Marking

The carrier shall be marked by the following:

— the number of persons permitted on the carrier;

— the maximum working load.

Annex C
(normative)

Requirements for lifting devices used in object handling

C.1 General

Annex C specifies requirements for lifting devices on earth-moving machines used in object handling operations with regard to strength, assembly and operation.

The tests as defined in this annex may be replaced by calculation.

C.2 Safety requirements

C.2.1 Mounting and fixing

C.2.1.1 The lifting devices shall be positioned on the attachment or the other parts of the earth-moving machine so that unintentional unhooking of the sling is avoided (for the test, see C.3.2.)

C.2.1.2 The location at the attachment or the equipment shall provide best visibility between the operator and the slinger (operator to attach the sling to the lifting devices).

C.2.1.3 The fixing position of the lifting devices shall avoid that the sling is deflected from its vertical load by other machine parts, except when the sling is guided over the back-wall of the bucket (see Figure C.1) or over the rounded shape of sufficient diameter.

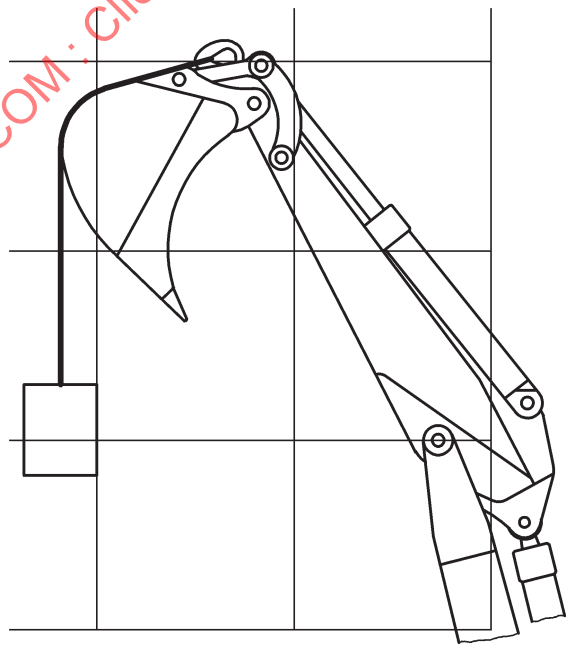


Figure C.1 — Sling guidance over back-wall of bucket

C.2.1.4 The lifting devices shall be so placed and of such a shape as to avoid the risk of unintentional displacement of the sling.

C.2.1.5 There shall be no damage to the sling by other parts of the earth-moving machine, e.g. sharp edges.

C.2.1.6 The lifting devices shall be fixed in such a way as to avoid any hazardous area (e.g. squeezing/shearing or rotating parts) for the slinger.

C.2.1.7 The lifting devices shall be so located, that hooking and unhooking is easily possible.

C.2.1.8 The lifting devices shall be so positioned that there is no restriction (e.g. catching) at normal operation of the earth-moving machine, nor at object handling operation.

C.2.2 Design and strength of lifting devices

C.2.2.1 Lifting devices provided by the machine manufacturer

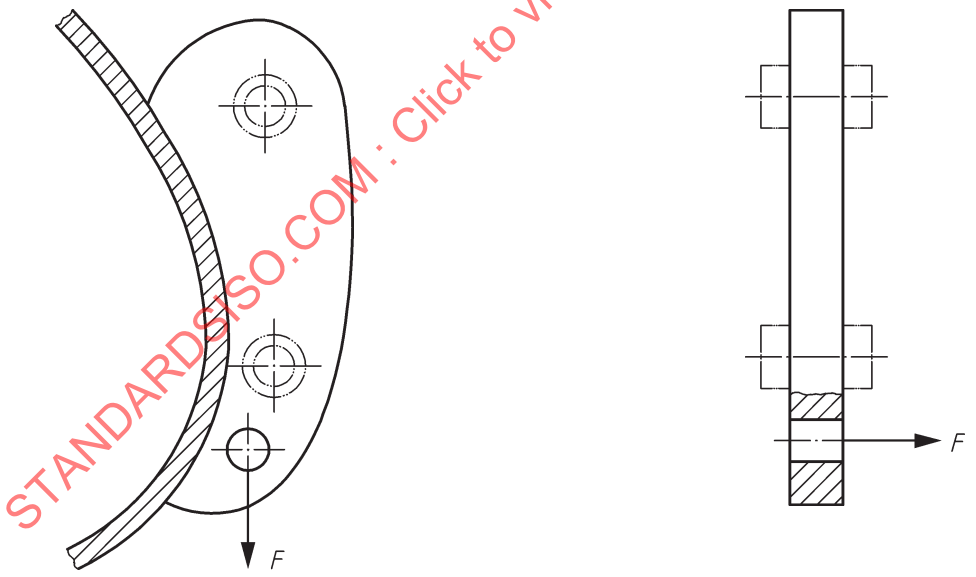
The lifting devices shall be designed to withstand the load that can be applied at any position of the attachment or parts of the boom. This includes a side load or pull, which may occur in practice.

C.2.2.2 Lifting devices provided by the attachment (working tool) manufacturer

The lifting devices shall have the following capacity:

— 2,5 times the RLL in the direction of the vertical load [see Figure C.2 a)] without a visible deformation after completion of the test;

— 1,5 times the RLL in side-load [see Figure C.2 b)] without visible deformation after completion of the test.



a) Direction of vertical load **b) Direction of side load**

Figure C.2 — Load direction