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Mining — Mobile machines working underground — Machine safety

Exploitation minière — Engins mobiles d'exploitation souterraine — Sécurité des machines

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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 of 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 82, *Mining*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

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

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance etc.)

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

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.

The following assumptions were made in writing this standard:

a) the operators of the machines are well trained professionals and aware of potential risks of the working environment;

b) the machines are operated according to the instructions given by the manufacturer in the operating instructions;

c) administrative controls are in place for preventing unauthorized entry of persons to the area where machines are working;

d) components are:

   1) designed in accordance with the good engineering practice and calculation codes, taking account of shocks and vibration, including all failure modes;

   2) made of materials with adequate strength and of suitable quality; and

   3) free of defects;

e) harmful materials, such as asbestos are not used;

f) components are kept in good repair and working order, so that the required dimensions remain fulfilled despite wear.

Mining — Mobile machines working underground — Machine safety

1 Scope

This document specifies the safety requirements for self-propelled mobile machines used in underground mining, as defined in 3.1.

This document deals with hazards, hazardous situations and hazardous events (see Annex B) relevant to these machines when they are used as intended or under conditions of misuse reasonably foreseeable by the manufacturer.

For utility/service/support machines, this document only includes provisions to address the risks associated with the mobility (movement of the whole machine from one location to another). Risks for the additional functions (e.g. scaling, concrete spraying, bolting, charging, drilling, attachments) are not covered in this document.

This document specifies the appropriate technical measures for eliminating or sufficiently reducing risks arising from hazards, hazardous situations or hazardous events during commissioning, operation and maintenance.

This document does not address:

— the additional risks for machines operating in potentially explosive atmospheres;

— air quality and engine emissions.

This document is not applicable to:

— machines constrained to operate by rails;

— continuous miners, roadheaders, drill rigs, conveyors, long wall production equipment, tunnel boring machines (TBM), and mobile crushers.

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 2860:1992, *Earth-moving machinery — Minimum access dimensions*

ISO 2867:2011, *Earth-moving machinery — Access systems*

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

ISO 3449:2005, *Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements*

ISO 3450:2011, *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 3795:1989, *Road vehicles, and tractors and machinery for agriculture and forestry — Determination of burning behaviour of interior materials*

ISO 3864-3:2012, *Graphical symbols — Safety colours and safety signs — Part 3: Design principles for graphical symbols for use in safety signs*

ISO 4250-3:2011, *Earth-mover tyres and rims — Part 3: Rims*

ISO 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 5006:2017, *Earth-moving machinery — Operator's field of view — Test method and performance criteria*

ISO 5010:—[1)], *Earth-moving machinery — Rubber-tyred machines — Steering requirements*

ISO 5349-1:2001, *Mechanical vibration — Measurement and evaluation of human exposure to hand-transmitted vibration — Part 1: General requirements*

ISO 6011:2003, *Earth-moving machinery — Visual display of machine operation*

ISO 6014:1986, *Earth-moving machinery — Determination of ground speed*

ISO 6016:2008, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components*

ISO 6395:2008, *Earth-moving machinery — Determination of sound power level — Dynamic test conditions*

ISO 6396:2008, *Earth-moving machinery — Determination of emission sound pressure level at operator's position — Dynamic test conditions*

ISO 6405-1:2017, *Earth-moving machinery — Symbols for operator controls and other displays — Part 1: Common symbols*

ISO 6405-2:2017, *Earth-moving machinery — Symbols for operator controls and other displays — Part 2: Symbols for specific machines, equipment and accessories*

ISO 6483:1980, *Earth-moving machinery — Dumper bodies — Volumetric rating*

ISO 6682:1986, *Earth-moving machinery — Zones of comfort and reach for controls*

ISO 6683:2005, *Earth-moving machinery — Seat belts and seat belt anchorages — Performance requirements and tests*

ISO 6750:2005, *Earth-moving machinery — Operator's manual — Content and format*

ISO 6805:1994, *Rubber hoses and hose assemblies for underground mining — Wire-reinforced hydraulic types for coal mining — Specification*

ISO 7130:2013, *Earth-moving machinery — Operator training — Content and methods*

ISO 7546:1983, *Earth-moving machinery — Loader and front loading excavator buckets — Volumetric ratings*

ISO 8030:2014, *Rubber and plastics hoses — Method of test for flammability*

1) Under preparation (revision of ISO 5010:2007). Stage at the time of publication: ISO/DIS 5010:2018.

ISO 8084:2003, *Machinery for forestry — Operator protective structures — Laboratory tests and performance requirements*

ISO 8152:1984, *Earth-moving machinery — Operation and maintenance — Training of mechanics*

ISO 9244:2008, *Earth-moving machinery — Machine safety labels — General principles*

ISO 9533:2010, *Earth-moving machinery — Machine-mounted audible travel alarms and forward horns — Test methods and performance criteria*

ISO 10262:1998, *Earth-moving machinery — Hydraulic excavators — Laboratory tests and performance requirements for operator protective guards*

ISO 10263-2:2009, *Earth-moving machinery — Operator enclosure environment — Part 2: Air filter element test method*

ISO 10263-3:2009, *Earth-moving machinery — Operator enclosure environment — Part 3: Pressurization test method*

ISO 10264:1990, *Earth-moving machinery — Key-locked starting systems*

ISO 10265:2008, *Earth-moving machinery — Crawler machines — Performance requirements and test procedures for braking systems*

ISO 10268:1993, *Earth-moving machinery — Retarders for dumpers and tractor-scrapers — Performance tests*

ISO 10532:1995, *Earth-moving machinery — Machine-mounted retrieval device — Performance requirements*

ISO 10533:1993, *Earth-moving machinery — Lift-arm support devices*

ISO 10570:2004, *Earth-moving machinery — Articulated frame lock — Performance requirements*

ISO 10968:2004, *Earth-moving machinery — Operator's controls*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 12508:1994, *Earth-moving machinery — Operator station and maintenance areas — Bluntness of edges*

ISO 13031:2016, *Earth-moving machinery — Quick couplers — Safety*

ISO 13333:1994, *Earth-moving machinery — Dumper body support and operator's cab tilt support devices*

ISO 13766-1:2018, *Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply — Part 1: General EMC requirements under typical electromagnetic environmental conditions*

ISO 13766-2:2018, *Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply — Part 2: Additional EMC requirements for functional safety*

ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 14397-1:2007, *Earth-moving machinery — Loaders and backhoe loaders — Part 1: Calculation of rated operating capacity and test method for verifying calculated tipping load*

ISO 14990-1:2016, *Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems — Part 1: General requirements*

ISO 14990-2:2016, *Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems — Part 2: Particular requirements for externally-powered machines*

ISO 14990-3:2016, *Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems — Part 3: Particular requirements for self-powered machines*

ISO 15817:2012, *Earth-moving machinery — Safety requirements for remote operator control systems*

ISO 15818:2017, *Earth-moving machinery — Lifting and tying-down attachment points — Performance requirements*

ISO 20474-1:2017, *Earth-moving machinery — Safety — Part 1: General requirements*

ISO 21507:2010, *Earth-moving machinery — Performance requirements for non-metallic fuel tanks*

ISO 22448:2010, *Earth-moving machinery — Anti-theft systems — Classification and performance*

IEC 60204-1:2016, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100, ISO 3450 and the following apply.

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

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

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

3.1
underground mobile machine
self-propelled machine designed to operate underground for carrying persons or material, for lifting or loading materials, or to work with attached equipment

Note 1 to entry: These machines are designed to operate in locations which have restricted widths and heights: therefore the machines are generally compact.

3.1.1
load haul dump
LHD
machine whose primary purpose is for loading, hauling and dumping material but can be extended to other applications by utilizing attachments in place of the bucket

Note 1 to entry: See Figure 1.

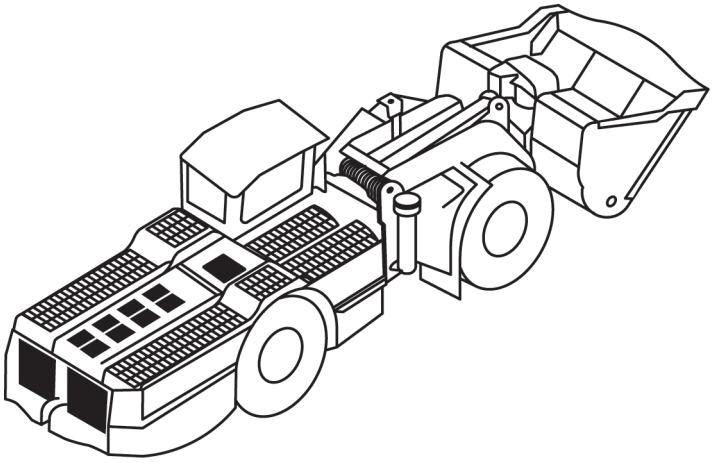

Figure 1 — Load haul dump

3.1.2
underground dumper hauler
rigid frame or articulated machine with an open body, for hauling and dumping materials, without the capability for self loading

Note 1 to entry: See Figure 2.

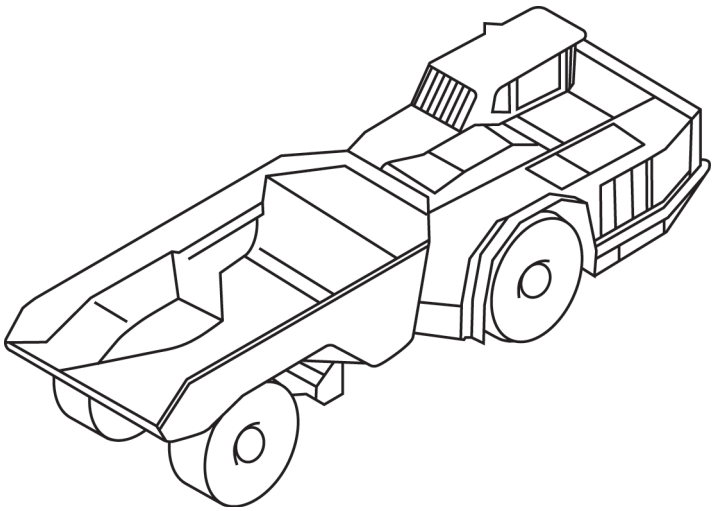

Figure 2 — Dumper hauler

3.1.3
underground dozer
self-propelled crawler or wheeled machine designed or modified to be used underground with equipment having either a dozing attachment which cuts, moves and grades material through forward motion of the machine or a mounted attachment used to exert a push or a pull force

3.1.4
underground utility/service/support machine
mobile machine that supports the primary production of the underground process, e.g. concrete spraying, charging, lifting and installation, servicing, scaling, transporting material

Note 1 to entry: See Figure 3 through Figure 6.

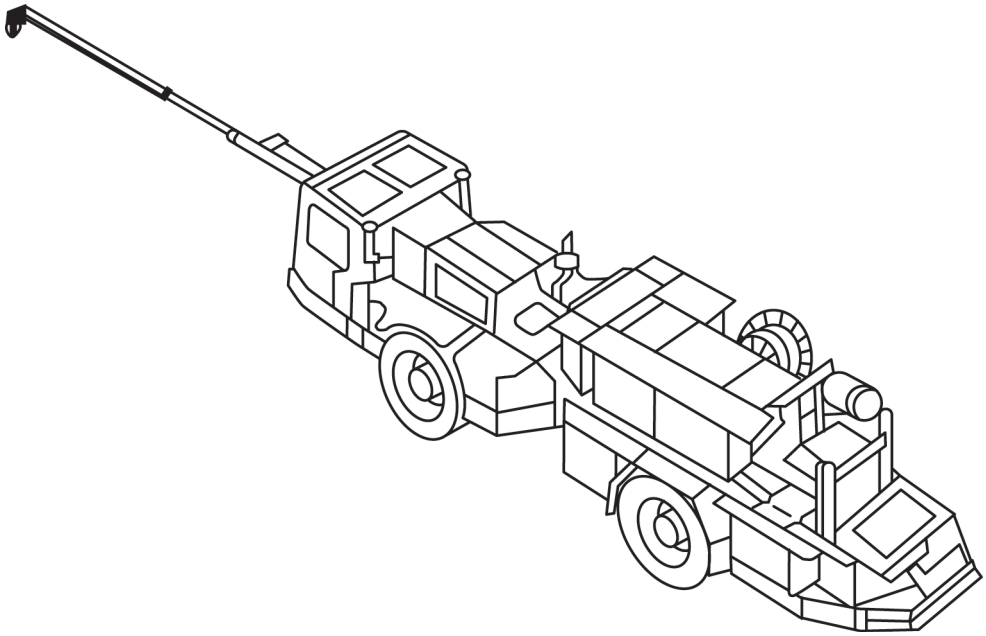

Figure 3 — Concrete spraying machine

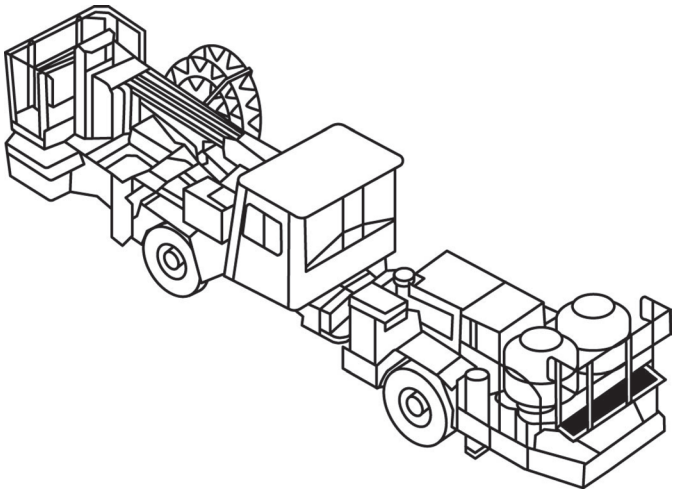

Figure 4 — Charging machine

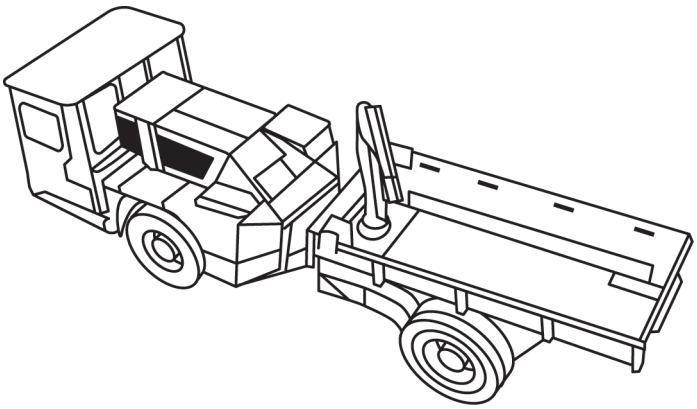

Figure 5 — Utility and service machine

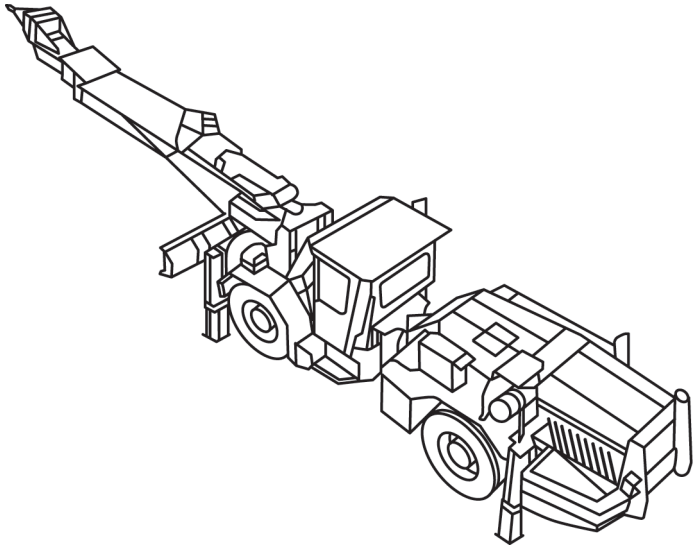

Figure 6 — Scaling machine

3.1.5
underground personnel transporter
machine whose primary function is to transport people at the mine site

Note 1 to entry: See Figure 7.

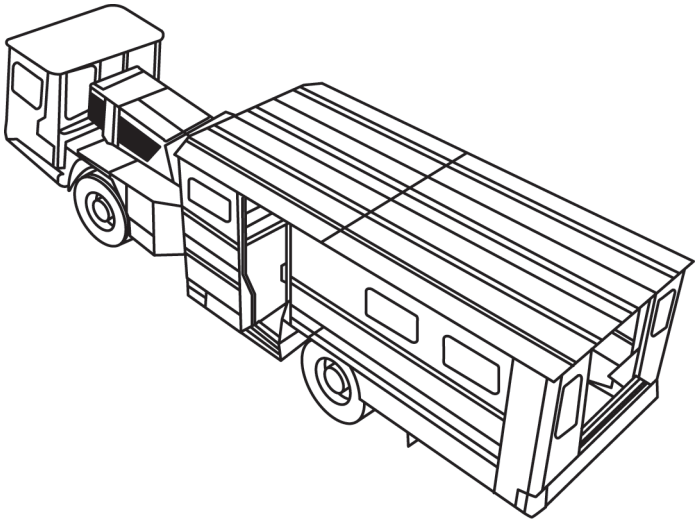

Figure 7 — Personnel transporter

3.1.6
continuous loader
machine equipped with digging arms or buckets that feed a conveyer transporting the material to the back of the machine for loading dumpers, conveyors, etc.

Note 1 to entry: See Figure 8.

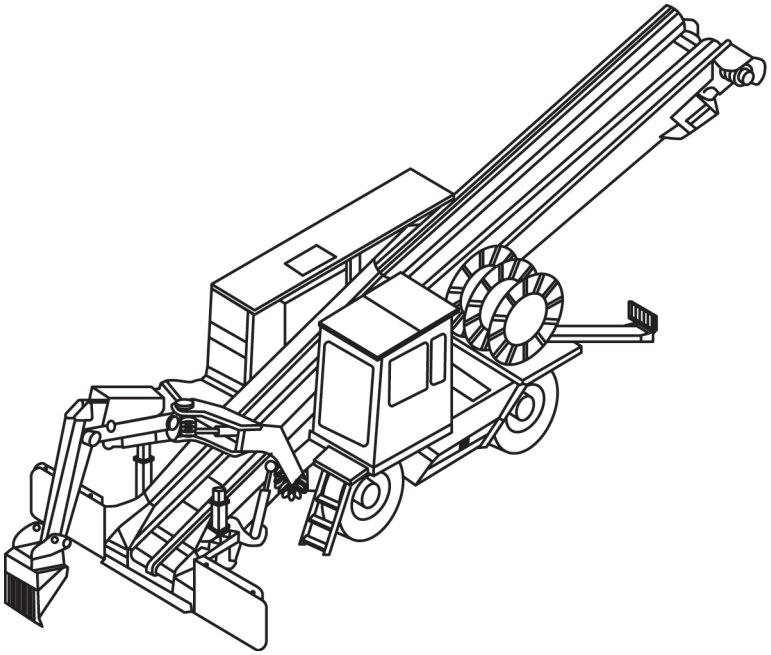

Figure 8 — Continuous loader

3.1.7
shuttle car
self-propelled wheeled haulage vehicle for transporting mined material between a mining machine and a feeder breaker

Note 1 to entry: See Figure 9.

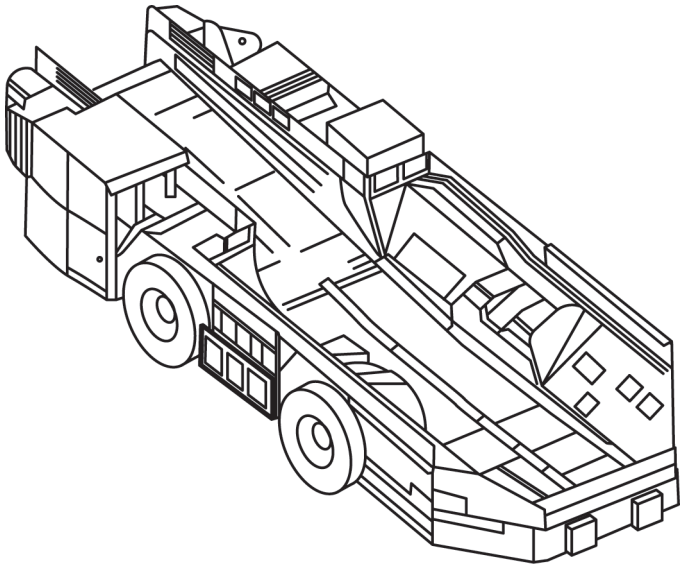

Figure 9 — Shuttle car

3.2
operator
designated, competent person, suitably trained and qualified by knowledge and practical experience and provided with the necessary instructions to ensure safe use of the machine for all operations it is designed for and within the limits of safe operation of the machine

3.3
brake system
all components which combine together to stop or hold the machine, including the brake control, brake actuation system, the brakes themselves and, if the machine is so equipped, the retarder

3.3.1
service brake system
primary system used for stopping and holding the machine

3.3.2
secondary brake system
system used to stop the machine in the event of any single failure in the *service brake system* (3.3.1)

3.3.3
parking brake system
system used to hold a stopped machine in a stationary position

3.4
maximum speed
speed the machine has been designed by the manufacturer to achieve on level ground per ISO 6014

3.5
gross machine mass
maximum machine mass as approved by the manufacturer, which combines the operating mass of the machine with the heaviest combination of equipment and attachments, the heaviest combination of optional equipment, the rated payload (mass that can be carried by the machine, as specified by the manufacturer), and the rated ballast mass (maximum mass of ballast that can be added to the machine, as specified by the manufacturer)

3.6
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

[SOURCE: ISO 2867:2011, 3.1.3 - Modified.]

4 Safety requirements and/or protective/risk reduction measures

4.1 General requirements

4.1.1 General

Machines shall comply with the safety requirements and/or protective/risk reduction measures of this clause. In addition, the machine shall be designed according to the principles of ISO 12100:2010 for relevant but not significant hazards which are not dealt with by this document. The manufacturer shall undertake a process of risk assessment for the design and functions of the machine. The manufacturer shall include a process of risk assessment for typical operations over the machine life cycle. Risk assessment processes shall be in accordance with ISO 12100.

4.1.2 Moving parts

All moving parts that create a hazard of crushing, shearing or cutting shall be designed, constructed, positioned or provided with guards or protective devices that minimize the risk. Guards shall comply with ISO 3457. Fixed guards that are to be removed as a part of routine maintenance, described in the operator's manual, shall be fixed by systems that can be opened or removed only with tools. Fixed guards that are removable for routine maintenance shall have a means of fastening that shall remain attached to the guards or to the machinery when the guards are removed.

4.1.3 Equipment carrier restraints

Machines intended to carry equipment other than bulk materials shall be provided with facilities for the attachment of load restraint devices to secure loose equipment. The load restraint system shall as a minimum be able to withstand the following:

a) 0,8 times the force of gravity in each direction of travel;

b) 0,5 times the force of gravity in lateral directions;

c) 0,2 times the force of gravity in a vertical direction where the load is not contained by adequate height sides.

This requirement does not apply when the machine has a forklift attachment fitted.

4.1.4 Starting system

The starting system of machines shall be provided with a starting device (e.g. a key) and shall comply with ISO 10264 or have similar protection.

If anti-theft systems are provided, they shall comply with ISO 22448.

4.1.5 Unintended movement

Mobile machinery shall be so designed that unintended movement of the machine or its working equipment or attachment shall not occur by starting the engine or energizing the machine under normal operating condition.

4.2 Lifting and transportation

Lifting and tie down points shall be in accordance with ISO 15818 and shall be clearly identified on the machine.

Articulated steered machines shall be fitted with an articulated frame lock conforming to ISO 10570.

4.3 Towing and retrieval

All machinery designed to tow or to be towed by other machines shall be fitted with towing or coupling devices designed, constructed and arranged in such a way as to ensure easy and secure connection and disconnection and to prevent accidental disconnection during use.

If the machine is equipped with towing devices (hooks, ears, etc.), the manufacturer shall provide information regarding the maximum permitted gross trailer mass which can be towed for braked and unbraked trailers and the relevant roadway conditions.

The gross trailer mass shall be based on the static friction characteristics for the intended roadway conditions with the machine unloaded. The manufacturer shall specify any ballast requirements where necessary.

The towing devices on the machine shall have a breaking strength not less than 2,5 times the gross trailer mass.

Retrieval devices shall be provided and they shall comply with ISO 10532.

Operator and other personnel stations shall be equipped with guards that comply with ISO 8084 if the machine is equipped with a winch that has wire rope cable.

4.4 Fluid power systems

4.4.1 Hydraulic systems

4.4.1.1 General

Hydraulic systems shall be designed and installed to conform to ISO 4413.

Hydraulic systems shall be designed to enable the use of fluids that minimize risks to health.

The systems shall be designed to enable fire-resistant fluids to minimise fire hazards (see ISO 7745 for guidance).

As an alternative to fire-resistant fluids the following precautions shall be taken for all systems:

a) all hydraulic lines shall be separated from any electrical cable and equipment and prevent rubbing of moving parts;

b) all hydraulic lines shall be separated from any part of the machine which can reach 80 % of the flashpoint temperature of the hydraulic fluid for which the system has been designed;

c) hydraulic lines shall be covered or protected to prevent flammable fluid under pressure from being ejected during a leak or a burst onto a hot surface as defined in paragraph a) and b) above;

d) hydraulic hose temperature capability shall be compatible with the operating temperature environment.

4.4.1.2 Fluid tanks

Hydraulic fluid tanks shall be protected against corrosion and be secured to the machine and incorporated in such a way (e.g. inside the rigid structure of the machine) that they are protected against mechanical damage. Alternatively, the tank shall be sufficiently robust to withstand damage from normal operation without leakage of fluid.

4.4.1.3 Tank filling

The filling apertures of hydraulic fluid tanks shall be easily accessible. If the aperture is not reachable when standing on the ground, then facilities or equipment shall be provided to allow easy access. The filling aperture shall be designed and positioned in such a way that any overflow or escape of hydraulic fluid is prevented on any gradient for which the machine is designed.

Any cap fitted shall be secured to prevent unintended loosening in service and shall require an intentional action to release it. The cap shall remain permanently attached to the machine in open position.

The location and marking of the filling point of any hydraulic system shall be so designed to avoid inadvertent introduction of other substances (e.g. fuel, water, sand).

4.4.1.4 Tank drainage

Hydraulic tanks shall be provided with a drainage device at their lowest point. Provision shall be made for free flow and safe catchment of fluid without coming into the proximity of hot parts or electrical equipment. The design intent shall be to prevent any fluid residues collecting in parts of the machine outside the hydraulic system.

Pressure in the tanks exceeding the specified pressure shall be automatically compensated by a suitable device (vent, safety valve, etc.).

4.4.1.5 Relief valves

Hydraulic pressure relief valves shall discharge the fluid back into the system only.

4.4.1.6 Pressure lines

Hydraulic pressure lines shall be designed as rigid metal lines or as flexible hoses. Hydraulic lines and hoses shall meet the following requirements:

a) materials for hydraulic hoses and their components shall be fire resistant so that the materials self-extinguish within 30 s of removal of the flame in accordance with ISO 8030;

b) safety factor of the hose assembly (complete with end fittings) shall be a minimum of 4 times operating pressure before failure. If hoses of different pressure rating are used, provisions to reduce the risk of using the wrong hose pressure capability, e.g. different diameters, hose markings, shall be incorporated;

c) hydraulic lines shall be designed to take into account the twisting or movement of the machine and attachments or equipment. Hydraulics lines shall be supported along their length to prevent damage due to vibration, abrasion, and chafing;

d) hydraulic hoses containing fluid with a pressure exceeding 5 MPa (50 bar) or a temperature exceeding 60 °C and which are located within 1 m of the operator shall be guarded in accordance with ISO 3457. Parts or components may be considered as guards;

e) for coal applications, materials for hydraulic hoses and their components shall be in accordance with ISO 6805.

4.4.1.7 Tank level indicator

Hydraulic fluid tanks shall be fitted with a mechanically protected fluid level indicator showing at least the maximum and minimum operating levels.

4.4.1.8 Fluid temperature

Means shall be provided to monitor hydraulic fluid temperature and to warn the operator when the fluid temperature approaches the maximum temperature specified by the manufacturer.

4.4.1.9 Manufacturer's instructions

The hydraulic system, under intended operating conditions and when maintained according to the manufacturer's instructions, shall be designed such that overheating of the fluid beyond the fluid and component rated temperature specified by the manufacturer does not occur.

4.4.2 Pneumatic systems

a) Pneumatic systems shall be designed and installed in accordance with ISO 4414.

b) Compressors shall either be designed to operate on a lubricant which is resistant against carbonization (e.g. synthetic oils), or fitted with temperature monitoring systems and a manual or automatic shutdown systems.

c) A filter shall be incorporated in every compressor air intake system to prevent the ingress of foreign material.

d) Simple air pressure vessels shall meet the requirements of ISO 4414 for air reservoirs.

4.5 Electrical equipment

4.5.1 General

Electrical equipment shall be designed, manufactured and installed in accordance with ISO 14990-1, ISO 14990-2, and ISO 14990-3 for electrical systems 50 V and over AC or 75 V and over DC. ISO 20474-1:2017 Clause 4.16 and IEC 60204-1 shall apply for electrical systems less than 50 V AC or less than 75 V DC.

4.5.2 Electromagnetic compatibility (EMC)

Underground mobile machines shall comply with the requirements of electromagnetic compatibility as specified in ISO 13766-1 and ISO 13766-2.

4.5.3 Batteries

Where batteries are fitted for starting purposes or for feeding other power circuits, the following shall apply:

a) batteries shall be positioned and secured to prevent mechanical damage. Spillage of liquid shall not be possible on components of the machine;

b) non-sealed batteries shall be housed in a ventilated space and contain a drain path for fluids to escape;

c) the finish of internal surfaces of battery containers shall be resistant to the chemical effects of the electrolyte;

d) the individual battery terminals shall be protected against contact, e.g. by insulating covers or shrouds;

e) a switch disconnect shall be fitted close to the battery. A starter isolator shall be provided when live testing or system diagnostics are required;

f) the battery housing shall be designed and constructed in such a way as to prevent the electrolyte being ejected on to the operator in the event of rollover or tip over and to avoid the accumulation of vapours in places occupied by operators.

4.6 Machines powered by diesel engine

4.6.1 Fuel and exhaust

Diesel engines shall use a fuel which has a flash point exceeding 55 °C.

The engine exhaust system shall release the exhaust gas away from the operator and the air inlet of the cab and other personnel stations on the machine. The exhaust gas shall not be discharged directly upwards to avoid thermal stresses on the roof.

Exhaust systems which can be reached and touched during operation, access or maintenance shall be guarded in accordance with ISO 3457 considering touchable surface temperatures defined in ISO 13732-1.

4.6.2 Exhaust pipes

In addition, exhaust pipes shall be so directed that the risk of personnel in the close proximity during operation is minimized.

4.6.3 Engine cooling system

A means to release the engine cooling system pressure shall be provided, that address the risk of human exposure to hot water or steam.

4.7 Fuel systems

4.7.1 Fuel tanks

Fuel tanks shall be protected against corrosion, be fixed to the machine and be incorporated in such a way that they are protected against mechanical damage (e.g. by placing the fuel tank within the rigid structure of the machine). Non-metallic fuel tanks shall comply with ISO 21507. Metallic fuel tanks shall comply with the pressurization and spill requirements of ISO 21507.

4.7.2 Fuel tank filler inlet

The filler inlets of fuel tanks shall be easily accessible for filling. The filling aperture shall be designed and positioned in such a way that any overflow or escape of fuel is prevented on any gradient for which the machine is designed. Fuel caps shall be secured to prevent unintended loosening in service and shall require an intentional action to release it. When released it shall remain permanently attached to the machine in open position.

4.7.3 Fuel tank vent system

Fuel tanks shall have a vent system to control pressure within the tank during filling. Fuel tanks shall be vented to maintain atmospheric pressure within the tank by use of a breather filter rated not greater than 125 µm during operation. Fuel tanks shall prevent the ingress of foreign material by use of a tank filler filter rated not greater than 250 µm.

4.7.4 Fuel tank drainage device

Fuel tanks shall be fitted with drainage devices.

4.7.5 Fuel shut-off system

The purpose of this system is to provide the means of removing the fuel from a fuel fire and another means of stopping an engine if all other methods fail.

Fuel tanks shall have provisions to stop fuel flow from the tank.

Manual fuel shut-off valves:

a) shall be connected into the fuel system after all supply (lift) pumps and filters, to minimize the time required to shut down the engine system after operation of the valve;

b) shall be accessible from the outside of the machine;

c) shall be clearly identified and labelled including operating instructions. The label shall be as close as practical to the valve;

d) for mechanical fuel injection pumps, the valve shall close both the supply and return lines from the injection pump.

Electrically controlled valves shall be automatically closed when the machine is shut down.

4.7.6 Fuel lines

Fuel lines on the machine shall be:

a) made of metal piping or fire and wear resistant hoses. Hoses that comply with ISO 7840 fulfil this requirement;

b) installed taking into account the effects of mechanical vibration, corrosion and heat, chafing, and abrasion; in addition:

   1) line joints shall remain visible;

   2) line connections shall be minimised in number and be designed to provide reliable protection against leaks during operation;

c) routed to avoid potential for fuel to contact surface temperatures above the ignition point of the fuel as far as practical.

4.8 Light intensity and quantity

4.8.1 General

Lighting systems within and on the machine should be designed and installed using ISO 12509 as a guide.

4.8.2 Head lights

Machines shall be equipped at the front with a minimum of two head lights, for travelling. They shall have provision for both low and high beam operation, if the maximum speed of the machine does not allow illumination of the stopping distance, or if the maximum speed of the machine is more than 10 km/h.

4.8.3 Tail lights

Machines shall be equipped at the rear with two red tail lights. In addition, the rear of machines shall be fitted with one of the following:

a) two red reflectors, each of at least 20 cm^2 area;

b) two red triangular reflectors of 0,15 m side length;

c) reflecting film of at least equivalent area and of the same form and colour.

4.8.4 Reversing lights

Machines shall be equipped with a minimum of two reversing lights except for machines normally operating in both directions.

4.8.5 Stop lamps

Machines shall be equipped with two stop lamps at the rear for machines that travel faster than 12 km/h. Machines that comply with 4.8.6 do not need stop lamps.

4.8.6 Both direction lights

Machines normally operating in both directions (e.g. load haul dump or similar machines) shall have head lights for travelling in both directions.

4.8.7 Protective systems

Protective systems for the lenses of lights and reflectors shall allow easy cleaning.

NOTE Machines can be equipped with additional independent working lamps, illuminating specific parts of the machine or the working area during operation.

4.9 Warning devices and safety signs

a) there shall be a manually operated, audible warning signal to warn personnel in the working area of impending danger. Audible warnings shall conform to ISO 9533. The A-weighted sound pressure level shall be >93 dB(A), measured according to ISO 9533. It shall be possible to operate audible warnings from each driving position;

b) an automatic audible or visual signal shall be provided for reversing to warn bystanders, where the machine is not bi-directional;

c) safety signs shall be provided in accordance with ISO 9244 or ISO 3864-3.

4.10 Braking

4.10.1 General requirements

Machines shall be fitted with service, secondary and parking brakes. The brakes on rubber-tyred wheeled machines shall fulfil the requirements in Annex A of this document (modified from ISO 3450:2011, Annex A). Crawler machines shall fulfil the requirements of ISO 10265.

4.10.1.1 Retarder

Underground dumper haulers shall have provisions to be equipped with a retarder system, which meets the requirements of ISO 10268.

4.10.1.2 Wheel chocks

A storage location shall be provided on the machine in an accessible location for wheel chocks.

4.11 Control systems and devices

4.11.1 General

For safety-related functions of control system(s), the principles outlined in ISO 13849-1:2015 shall be used or methods giving similar protection. Examples of performance levels (PL_r) for safety-related functions are detailed in Annex D.

4.11.2 Control devices

Control devices shall be arranged and located based on ISO 6682 and ISO 10968 so that the control devices can be operated easily and safely. The location of the control zones may be moved to accommodate different seat cushion angles. Emergency controls (e.g. horn manually operated audible warning signal) should be located in the zone of comfort.

a) Controls which can cause a hazard due to inadvertent activation shall be so arranged or deactivated or guarded as to minimize the risk, e.g. when the operator gets into or out of the operator's station and also when the operator is seated at the controls. The deactivation device shall either be self-acting or by compulsory actuation of the relevant device.

b) On machines with more than one operating position, the layout of the control devices shall be similar at each position. This does not apply to auxiliary work stations, e.g. working platforms, remote control.

c) The control devices shall only be controlled from one operating position at a time. Means shall be provided to ensure that the use of other control positions is prevented. This shall not apply to the secondary or parking brake control devices and to the fire extinguishing systems.

d) Remote controls for mining machines working underground shall be in accordance with ISO 15817.

4.11.3 Steering systems

Steering systems on wheeled machines shall comply with ISO 5010.

Steering systems on crawler machines with a forward/reverse travel speed greater than 20 km/h shall be gradual.

4.11.4 Displays

Displays shall follow the general guidance of ISO 6011.

4.11.4.1 Display information

The following display information shall be provided at each driving position, where appropriate to the particular type of machine:

a) speed;

b) pressure of pneumatic or hydraulic brake systems;

c) parking brake applied.

4.11.4.2 Additional information

In addition, for example, the following can be provided:

a) fuel level or battery charge;

b) hydraulic reservoir level;

c) engine oil pressure;

d) temperature of oil-immersed brakes;

e) pressure in hydrostatic drives if service braking is hydrostatic;

f) cooling water temperature;

g) hydraulic transmission temperature;

h) running time or distance travelled meter;

i) service hour meter;

j) fire suppression system operating pressures;

k) hydraulic oil temperature;

l) transmission oil pressure;

m) system voltage;

n) engine oil temperature;

o) brake circuit charging pressure;

p) hydraulic oil pressure;

q) slope indicator.

Each display shall be marked by clear symbols in accordance with ISO 6405-1 and ISO 6405-2. The limits of normal operation shall be clearly identified.

NOTE Additional operator symbols are found in ISO 7000 and IEC 60417.

4.11.4.3 Multiple positions

On machines with more than one driving position, the arrangement of display equipment required for operation shall be similar at each driving position.

4.12 Operator and passenger's position

4.12.1 Protection

a) The seats shall be so located to minimise the likelihood of injuries, e.g. from accidental contact with the roof or sides of the roadway and moving parts of the machine (e.g. wheels). For applications where there is a risk of injury due to objects entering the cab, protection shall be provided. The impact of visibility shall be evaluated when installing such protection.

b) A risk assessment shall be used to evaluate the need for FOPS (falling objects protective structure). The risk assessment shall take into account, but shall not be limited to, the risk of falling objects due to the intended use of the machine in the mine as well as the functional requirements to the entire machine especially when working in narrow envelopes. If FOPS is required, it shall comply with ISO 3449. Excavator FOPS shall comply with ISO 10262.

c) A risk assessment shall be used to evaluate the need for ROPS (roll over protective structure). If ROPS is required, it shall comply with ISO 3471.

d) Where possible, pipes and hoses shall be routed outside the operator's and/or passenger's position.

e) Where this is not possible, pipes and hoses shall be guarded in accordance with ISO 3457.

4.12.2 Access systems

a) Access systems that comply with ISO 2867 shall be provided to the operator station and to areas where routine maintenance is performed by the operator as described in the operator's manual except for machines with restrictions. Machines with restrictions that cannot comply with ISO 2867 require risk assessments (see 4.1.1) and instructions to be provided in the operator's manual.

b) An emergency exit shall be provided on a different side from the normal exit according to ISO 2867. Machines with restrictions that cannot comply with ISO 2867 require risk assessments (see 4.1.1) and instructions to be provided in the operator's manual. The emergency exit shall be able to be opened from both the inside and outside of the machine.

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

d) Door latches shall be operable from inside and outside the operator station. A means shall be provided to prevent inadvertent opening.

4.12.3 Visibility

a) 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. The operator's visibility shall be measured

according to ISO 5006. If the direct view is restricted and where hazards due to restricted visibility exist, the risks shall be addressed with visibility aids, e.g. mirrors, closed circuit TV (CCTV), reverse cameras or detection systems.

NOTE The CCTV does not need to have a recording function.

b) Glazing shall be made of safety glass, or of other material which provides at least equal safety.

c) Windscreen wipers, washers, demisters, etc., shall be provided if the conditions under which the machine is to be used make these necessary.

4.12.4 Interior space, dimensions, and seats

a) The operator's position shall be based on the requirements specified in ISO 3411. The horizontal seating surface height (see ISO 3411:2007, Table 1) and the dimension R1 may be reduced following the guidance in ISO 3411 where the available height is restricted. For low-profile machines, the operator's space envelope shall be based on a risk assessment.

b) The interior shall be free from sharp edges and corners, which might cause personal injuries, and shall comply with ISO 12508.

c) The dimensions of operator seats should comply with the requirements of ISO 11112. Seats should accommodate the wearing of essential personal protective equipment. Every seat shall offer a stable position. ISO 11112 does not apply to low-profile and narrow vein underground mining machines. A risk assessment should be performed for low-profile underground mining machines to determine acceptable seating.

d) Settings for adjusting seats to the size of the operator should comply with the requirements of ISO 11112. Settings should be changeable without the use of tools.

e) All machines equipped with ROPS shall have a suitable restraining system according to ISO 6683. All seats shall have provisions to add seat belts, even without ROPS.

f) A space intended for the safekeeping of the operator's manual and other instructions shall be provided near the operator's station.

g) Machines should have facilities that are easily accessible for secure storage of personal protection equipment (e.g. cap lamp, filter self-rescuer). Provision shall be provided to secure any equipment in the operator station so it cannot cause a hazard due to movement of the machine.

h) The ventilation system for machines with enclosed operator cabs should 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.

i) When 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.

4.13 Fire protection

a) An evaluation of fire hazards shall be performed. Components such as fuel tanks, fuel lines, cables, battery container, the hydraulic system including associated lines, and other similar items that can ignite due to operating heat of the machine shall be arranged and guarded to avoid fire.

b) A means shall be provided to prevent the spray from ruptured hydraulic or lubricating oil lines from being ignited by contact with engine exhaust system components.

c) If an enclosed operator station is installed on the machine, its interior, upholstery and insulation and other parts of the machine where insulation materials are used shall be made of flame-retardant materials. The burn rate shall not exceed 200 mm/min, tested in accordance with ISO 3795.

NOTE Insulation or water jacketing of hot components, conduit over lines to block sprays, separate compartments for hot engine components and lines, fire-resistant fluid, etc. can be effective.

d) Exhaust systems shall be so designed or located so that they minimize the risk of damage or ignition of the fuel system, hydraulic system or machine tyres.

e) Brake systems shall be so designed to prevent sparks and installed that the emitted heat cannot ignite the fuel system, hydraulic system or tyres. Hot engine and brake system components shall be designed to minimize the accumulation of combustible material.

f) Machine suspension systems shall be so designed, that in the event of failure, the tyres do not abrade on the machine body.

g) Provision shall be made for fitting portable fire extinguishers suitable in type and size for the fire type and load, protected against heat and mechanical shock and vibration.

h) Space provisions should be provided for fire suppression systems on all machines. If all surface temperatures are below 150 °C, then provision for fire suppression systems might not be required subject to local requirements.

NOTE The above requirement does not mean that the machine is already prepared to accept certain fire suppression systems.

i) A fire risk assessment shall be conducted to determine the need for a fire suppression system. If needed, a suppression system shall cover the high risk areas identified and be possible to initiate the system from the cab.

j) The engine and all power sources shall be shut down automatically in the event of actuation of any on-board fire suppression system, possibly subject to a time delay according to the agreement with the manufacturer of the fire suppression system.

k) Where single conductor cables are used, they shall be designed and installed so as to avoid any hazard arising from induced current from magnetising fields, for example by causing dangerous levels of eddy currents to flow in adjacent metalwork, resulting in dangerous heating in the metallic frame of the machine.

l) In the case of machines operating in coal mines, the pneumatic systems should incorporate a device to give the operator warning if the temperature of the air being discharged from the air compressor exceeds 150 °C.

4.14 Noise

4.14.1 Noise reduction at source at the design stage

a) Machinery shall be so designed and constructed that risks resulting from noise emission are reduced to a reasonable level taking account of technical progress, machine constraints and the availability of means of reducing noise.

NOTE Guidelines for the design of cabs and enclosures can be found in ISO 15667.

b) When designing machinery, the available information and technical measures to control noise at source shall be taken into account. Guidelines for the design of low-noise machinery are given in ISO/TR 11688-1.

4.14.2 Information on noise emission

Information on noise emission shall be given by the manufacturer in the operator's manual (see 6.1).

4.14.2.1 A-weighted sound power level

Measurement to determine the A-weighted sound power level shall be made according to ISO 6395, using the loader cycle for LHDs and the dumper cycle for hauling trucks. For utility/service/support machines the test cycle shall be weighted 30% forward, 30% reverse, 40% high idle for machines that travel in both directions and 60% forward and 40% high idle for machines that normally travel forward. The test cycle used shall be indicated with the A-weighted sound power level reported, see Clause 6.

4.14.2.2 A-weighted emission sound pressure level at the operator's position

The A-weighted emission sound pressure level at the operator's position shall be measured according to ISO 6396, using the cycles defined in 4.14.2.1. The test cycle used shall be indicated with the A-weighted emission sound pressure level reported, see Clause 6.

4.15 Vibrations

a) Machinery should be designed and constructed in such a way that risks resulting from vibrations produced by the machinery are reduced to reasonable levels, taking account of technical progress in the mining industry and the availability of means of reducing vibrations. ISO 2631-1 provides techniques for measuring whole-body vibrations.

b) The driver's hand-arm vibration measurements shall be evaluated according to ISO 5349-1. ISO/TR 25398 provides information for evaluating whole-body vibrations.

c) Whole-body vibrations are dependent upon the application, the terrain conditions and operator techniques. Whole-body vibration levels can be minimized by recommending the following:

   1) train operators to run machines smoothly;

   2) maintain the surface where machines operate to minimize bumps, holes, ditches;

   3) operate machines at the appropriate speed for the terrain conditions.

4.16 Radiation health risks

Where laser equipment is used, the following shall be taken into account:

a) laser equipment on machinery shall be designed and constructed in such a way as to prevent any accidental radiation;

b) laser equipment on machinery shall be protected in such a way that effective radiation, radiation produced by reflection or diffusion and secondary radiation do not damage health;

c) optical equipment for the observation or adjustment of laser equipment on machinery shall be such that no health risk is created by laser radiation.

4.17 Tyres and rims

a) Rubber tyred mobile machinery working underground shall have tyre and rim load performance adapted to the machine's purpose and application.

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

c) To ensure safety of machines working underground follow use and maintenance instructions recommended by the tyre and rim manufacturers.

d) The machine manufacturer should provide maintenance and safety information on tires and rims as recommended by the tire and rim manufacturers.

4.18 Stability

a) Mobile machines with working equipment or attachments and 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 instruction manuals.

b) Devices intended to increase the stability of machines in working mode (e.g. outriggers, oscillating axle locking) shall be fitted with locking devices, e.g. check valve which keeps the device in position in case of hose failure or oil leakage.

c) Stabilizer or similar devices shall be retained in their retracted positions for travelling and the operator should be able to verify the travelling position.

d) Means, e.g. inclinometer, should be provided at the operator's station to indicate the slope of the machine.

4.19 Load haul dump capacity

The rated operating capacity shall be determined according to ISO 14397-1.

The volumetric rating of bucket shall be determined according to ISO 7546.

NOTE The mass, volumetric rating of bucket and density of the material are factors to take into account when the bucket capacity is selected for a specific application.

The volumetric capacity of the dumper body shall be determined according to ISO 6483.

4.20 Maintenance

4.20.1 General

Machines shall be designed and built so that the 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 instruction manual. Machine maintenance should be in accordance with ISO 12510.

Openings intended for maintenance purposes shall comply with ISO 2860.

The design of the machine should permit lubrication and filling of tanks from the ground.

4.20.2 Frequent maintenance

Components (batteries, lubrication fittings, filters, etc.) which require frequent maintenance should be easily accessible for checking and changing from ground level. See ISO 2867.

A lockable storage box shall be provided on the machine for tools and accessories if such tools are recommended by the manufacturer for frequent maintenance.

4.20.3 Support devices

On machines where routine maintenance can only be performed with equipment (e.g. bucket or truck body), in a raised position, such equipment shall be mechanically secured with a device according to ISO 10533 or ISO 13333.

If a support device is required for routine maintenance, it should be permanently fixed to the machine or be stored on a safe place on the machine. Support device instructions shall be provided in the operator's manual.

Engine access panels shall be provided with a support device to secure the panel in the open position.

Instructions for raising and supporting of the machine off the ground in order to perform maintenance shall be provided.

4.20.4 Tiltable cab support device

If the operator's cab has an integral tilt system for maintenance, servicing or other non-operational purpose, the cab or system shall be equipped with a support device to hold the cab in the fully raised or tilted position.

This system shall meet the requirements of ISO 13333.

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

4.21 Quick coupler systems

Quick coupler systems and quick coupler control systems to allow the quick interchange of attachments shall meet the requirements of ISO 13031.

5 Verification of safety requirements and/or protective/risk reduction measures

Safety requirements and/or protective measures of Clauses 4 and 6 of this document shall be verified according to Annex C.

6 Information for use

6.1 Operator's manual

6.1.1 General

The manufacturer of the machine shall provide, at the time of delivery, one or more operator's manuals containing information for the safe operation and maintenance of the machine.

The operator's manual shall be in an official language of the country for which the machine is placed on the market, and if relevant, in a language specified by the customer.

The operator's manual shall be in accordance with ISO 6750 with the following additional information:

a) the cleaning requirements in order to avoid hazardous accumulation of material;

b) instructions on the capacity and type of fire extinguisher to be used;

c) instructions for operation of fire extinguishing and fire suppression equipment;

d) information identifying risks from specific fire hazards and specific information to reduce the hazards;

e) a checklist for the operator to use before starting the machine;

f) advice about the possible hazards that can occur by leaning out of the machine;

g) information on operator’s visibility and instructions for safe operation shall be provided;

h) jacking points;

i) instructions for maintenance and replenishment of fire extinguishing and suppression equipment in accordance with manufacturers recommendations;

j) safety precautions information for charging, changing, and maintenance of traction batteries where appropriate;

k) machine disposal instructions;

l) data for verification of the brake systems, methods of testing and adjustment;

m) inspection and instructions for replacement of machine safety messages and instructions if damaged or illegible;

n) instructions for energy isolation and achieving zero energy including the bleeding of pressurized lines and components without the loosening of fittings;

o) instructions for installing and removing wheel chocks;

p) instructions for machine maintenance, inspection and replacement of parts that wear;

q) information on the machine capability, (e.g. loads, slopes, speed);

r) instructions for the use of radiation equipment;

s) information on the use of equipment carrier restraints;

t) information for inspecting and replacing pressure containing components such as hoses and tyres that have internal structural wires, yarns, etc. that become exposed due to abrasion, ageing, etc.

6.1.2 Information on noise emission

The operator's manual shall provide the values of the sound power of the machine and the A-weighted emission sound pressure level at the operator's position together with the associated uncertainties. The uncertainties of these values shall be calculated in accordance with ISO 6395 for the A-weighted sound power level and in accordance of ISO 6396 for the A-weighted emission sound pressure level.

The method in ISO 4871 shall be used to determine noise emission values to be declared and to verify the declared values. The technical sales literature providing performance data of the machine shall give the same information on noise as that given in the operator's manual.

6.1.3 Information concerning hand-arm and whole-body vibration emission

6.1.3.1 General

The operator's manual shall include information on hand-arm and whole-body vibration transmitted by the machine:

a) the vibration total value to which the hand-arms are subjected, if it exceeds 2,5 m/s^2. Where this value does not exceed 2,5 m/s^2, this shall be mentioned;

b) the highest root mean square of weighted acceleration to which the whole-body is subjected, if it exceeds 0,5 m/s^2. Where this value does not exceed 0,5 m/s^2, this shall be mentioned.

6.1.3.2 Whole-body

The operation manual shall include the following information on the real intensity of exposure to whole-body vibration:

a) the vibration magnitude for a machine can be highly variable. Actual magnitude is influenced by factors such as: an operator and his driving style (e.g. aggressive, smooth), different operating conditions, ground conditions, machine speeds, or different materials. It is therefore not possible to obtain precise vibration exposure levels;

b) properly adjusting and maintaining machines, operating machines smoothly, and maintaining the terrain conditions can reduce whole-body vibrations. The following can help the users of machines to reduce whole-body vibration levels.

   i) using the right type and size of machine, equipment, and attachments;

   ii) maintaining machines according to the manufacturer's recommendations;

   iii) keeping the terrain where the machine is working and travelling in good condition by removing any large rocks or obstacles and filling any ditches and holes;

   iv) keeping the seat maintained and adjusted;

   v) smoothly steering, braking, accelerating, and shifting gears, and moving the attachments;

   vi) adjusting the machine speed and travel path to minimize the vibration level.

6.2 Marking

6.2.1 General

The machine shall be permanently fitted with a legible, easily visible plate marked (e.g. etched, engraved or stamped) with the following minimum information:

a) business name and address of the manufacturer and, where applicable, the authorised representative;

b) designation of the machine;

c) certification marking, as applicable;

d) designation of series or type;

e) product identification number, e.g. PIN according to ISO 10261;

f) the following additional information can be provided:

   1) year of construction, that is the year in which the manufacturing process is completed;

   2) nominal power, expressed in kilowatts (kW);

   3) operating voltage and frequency for electrically powered machines;

   4) mass of the most usual configuration, in kilograms (kg), per ISO 6016 operating mass;

   5) and, where appropriate:

      i) maximum drawbar pull provided for at the coupling hook, in newtons (N);

      ii) maximum vertical load provided for on the coupling hook, in newtons (N).

6.2.2 Attachment points

Attachment points for lifting, handling, transport, assembly and dismantling shall be marked.

6.2.3 Section or sub-assemblies

Where the machine is constructed in separate sections or sub-assemblies to facilitate handling and transport, the weight of each such section or sub-assembly and the position of lifting points shall be permanently and unambiguously marked on it.

6.3 Training manuals

The operator training manual shall be based on ISO 7130.

The manual for training of mechanics shall be based on ISO 8152.

Annex A
(normative)

Brake requirements for rubber tyred underground mining machines

A.1 General

The general requirements for braking, test conditions and performance tests of ISO 3450:2011 apply to rubber-tyred underground mining machines except as specified in this annex.

A.2 Normative references

The normative references cited in this annex are given in Clause 2. This clause is only given to align the clause numbers of this annex with ISO 3450:2011.

A.3 Terms and definitions

The terms and definitions required to implement this annex are given in Clause 3. This clause is only given to align the clause numbers of this annex with ISO 3450:2011.

A.4 General requirements

In addition to the requirements in the body of this document, the following additional requirements and modifications apply to specialized rubber-tyred underground mining machines.

No device that traps a column of fluid to hold the brake in the applied position shall be installed in any brake system, unless the trapped column of fluid is released when the equipment operator is no longer in contact with the brake activation device.

Specialized machines shall be tested at the gross machine mass.

A.4.1 Required brake systems

ISO 3450:2011, Clause 4.1 applies.

A.4.2 Common components

ISO 3450:2011, Clause 4.2 applies, except Table 3.

A.4.3 Brake control system

ISO 3450:2011, Clause 4.3 applies with the following additional requirement.

The parking brake control shall be considered a primary control as per ISO 10968. It should have a distinct shape and colour in relation to the other controls.

A.4.4 Service brake systems

ISO 3450:2011, Clause 4.4 applies with the following additions. The brake test to determine the stopping distance shall be run on level ground.

The service brake stopping distance, S, is given by Formula A.1:

$$S = \frac{vt}{3,6} + \frac{v^2}{26a} \quad \text{(A.1)}$$

where:

S is the service brake stopping distance, in m

v is the initial speed, in km/h

t is time, and has a value of 0,35 s

a is deceleration, in m/s^2 — use 0,28 g or 2,75 m/s^2

This represents 28 % brake efficiency [the standard requirement for machines used on gradients of up to 20 % (11,3°)]. If a brake efficiency of 20 % is used, this would be the standard requirement for machines used on gradients of up to 12,3 % (7°). The machine during the test shall demonstrate a minimum of 0,75 m/s^2 peak deceleration on the design slope.

If the machine is intended to be used on gradients of more than 20 %, the minimum brake capability shall be 8 % greater than the maximum slope.

The service brake shall hold the machine stationary (no creep) on the maximum design grade plus a 20 % factor safety.

A.4.5 Secondary brake systems

ISO 3450:2011, Clause 4.5 applies with the following additions and modifications.

The secondary brake stopping distance, S', is given by Formula A.2:

$$S' = \frac{vt}{3,6} + \frac{v^2}{26a} \quad \text{(A.2)}$$

where:

S' is the secondary brake stopping distance, in m;

v is the initial speed, in km/h;

t is time, and has a value of 1,0 s;

a is deceleration, in m/s^2 — use 1,77 m/s^2 or 0,18 g.

The machine during the test shall demonstrate a minimum of 0,45 m/s^2 peak deceleration on the design slope.

Hydrostatic brake systems shall not be used as the secondary brake.

Retarders are not to be applied during secondary brake system performance testing.

Secondary brakes on specialized underground mining equipment may be applied without modulation. Secondary brakes may be applied automatically with warning to the operator prior to application.

If automatic brakes are separate from the secondary brake system, their performance requirements shall be at least the same as the secondary brake performance.

A.4.6 Parking brake systems

ISO 3450:2011, Clause 4.6 applies with the following additions:

a) the parking brake shall be capable of holding the machine stationary on a 25 % grade with a 1,20 factor of safety or the maximum design slope with a 1,20 factor of safety if greater;

b) the parking brake shall automatically apply:

   — whenever the engine is stopped by the operator;

   — whenever the engine stops for any reason. (e.g. the operation of the automatic engine protection system). The automatic brake application with engine stoppage may be delayed, provided the operator is warned and the service brake system remains operational. The delay may last until the machine reaches a condition which minimizes the risk of a sudden parking brake apply, e.g. after the machine velocity is reduced to near zero;

   — in addition, the machine shall have provisions to apply the parking brake automatically when the operator exits the operator compartment;

c) for an engine stoppage, the response time of the parking brake should not exceed 2 s from the time the engine ceases rotation;

d) if the parking brake has been manually or automatically applied, it shall only be released by a specific action (e.g. parking brake release control, accelerating the engine) of the operator;

e) the machine shall have an interlock system fitted to prevent the machine from being driven with the parking brake applied. Procedures and systems that accommodate a daily test as covered by ISO 3450:2011, Clause 4.12.1, Item 3, are allowed. A means may be provided to move the machine in an emergency situation;

f) machine retrieval instructions need to be supplied in the occasion the parking brake has been applied automatically or otherwise;

g) automatic park brakes shall include a means in the machine operator's compartment to apply the brakes manually without shutting off the equipment;

h) if the brake is manually released, the brake shall automatically reapply when the machine is started. A means that prevents the machine from being restarted until the brake is manually applied also meets this section;

i) during parking brake testing, minimize the contribution from the hydrostatic drive train on the brake performance of the parking brake. The parking brake holding performance can be checked by performance on the actual slope or by achieving sufficient holding performance while being towed on level ground with the parking brake applied.

A.4.7 Hydrostatic brake systems

ISO 3450:2011, Clause 4.7 applies with the following addition.

For machines utilizing hydrostatic transmissions, back throttling shall not be used to meet the holding performance criteria.

A.4.8 Systems with combined brake and steer function

ISO 3450:2011, Clause 4.8 applies.

A.4.9 Performance and warning devices for stored energy sources

ISO 3450:2011, Clause 4.9 applies.

A.4.10 Brake systems with electronic MCS

ISO 3450:2011, Clause 4.10 applies.

A.4.11 Machines designed to tow trailers

ISO 3450:2011, Clause 4.11 applies with the additions shown in a) through f) below.

a) If the towing machine's brakes alone cannot meet the service, secondary, and parking brake requirements, as applicable, when tested at machine and trailer mass plus the total towing machine and trailer payload, then the towed trailer shall be equipped with brakes that act on each trailer wheel as part of these systems. If the trailer is designed with wheels that have an equally distributed load in all the conditions, then the brakes need only act on the wheels required to meet the stopping requirements.

b) The trailer brakes shall act on both sides of an axle.

c) The towing machine's parking brake control shall apply the parking brakes of the machine and of any towed trailers equipped with parking brakes.

d) Trailer parking brake systems shall be designed such that they are applied automatically whenever the trailer is disconnected from the tow machine.

e) If there are no parking brakes on the trailer and the trailer needs to be parked by itself, a means shall be provided on the trailer to hold it stationary. Chocks are not preferred.

f) Testing of machine/trailer combinations is required only in the forward direction.

A.4.12 Machine instructions and labels

ISO 3450:2011, Clause 4.12 applies.

A.4.13 Estimating brake slope capability

ISO 3450:2011, Clause 4.13 applies.

A.5 Test conditions

A.5.1 Overall test parameters

ISO 3450:2011, Clause 5.1 applies with the following addition.

Retarders shall not be used during service and secondary brake testing.

A.5.2 General test conditions

ISO 3450:2011, Clause 5.2 applies with the following addition:

All machines shall be tested on a level surface with a slope in the direction of travel that is no greater than 1 %.

A.5.3 Test course

ISO 3450:2011, Clause 5.3 applies, except that all machines shall be tested according to Clause A.5.2.

A.5.4 Machine test configuration

ISO 3450:2011, Clause 5.4 applies.

The machine mass shall be as stated in ISO 3450:2011, Clause 3.3, and shall include the maximum specified payload. There are exceptions noted below for testing with no payload after the loaded braking performance has been tested.

A.6 Performance tests

A.6.1 General

ISO 3450:2011, Clause 6.1 applies.

A.6.2 Brake system controls

ISO 3450:2011, Clause 6.2 applies.

A.6.3 Stored energy sources

A.6.3.1 Service brake system recovery capacity

ISO 3450:2011, Clause 6.3.1 applies.

A.6.3.2 Secondary brake system capacity

ISO 3450:2011, Clause 6.3.2 applies.

A.6.3.3 Test performance

ISO 3450:2011, Clause 6.3.3 applies.

A.6.4 Holding performance

ISO 3450:2011, Clause 6.4 applies.

A.6.4.1 General

ISO 3450:2011, Clause 6.4.1 applies.

A.6.4.2 Service and parking brakes

Service brakes holding performance is specified in A.4.4.

Parking brake holding performance is specified in A.4.6.

A.6.4.3 Brake holding performance tests

ISO 3450:2011, Clause 6.4.3 applies.

A.6.4.4 Durability test of parking brake when used as a secondary brake

ISO 3450:2011, Clause 6.4.4 applies.

A.6.5 Stopping performance

A.6.5.1 General

ISO 3450:2011, Clause 6.5.1 does not apply.

A.6.5.2 Service brake systems

Stopping performance shall be according to A.4.4 as follows.

For machines that travel as fast in reverse as they do in forward (e.g. LHD machines):

— 5 stops in Forward at maximum loaded mass as per A.5.4;

— 5 stops in Reverse at maximum loaded mass as per A.5.4;

— 2 stops in Forward with no payload;

— 2 stops in Reverse with no payload.

For machines that travel primarily in forward (e.g. dumpers, machines with trailers):

— 5 stops in Forward at maximum loaded mass as per A.5.4;

— 2 stops in Forward with no payload.

These tests shall be run at a minimum of 80 % of maximum speed. The stops shall be separated by a maximum of 10 min between stops. Peak deceleration shall be recorded.

A.6.5.3 Secondary brake systems

Stopping performance shall be according to 4.5.1 as follows:

— 3 stops in Forward at maximum loaded mass as per A.5.4;

— 3 stops in Forward with no payload.

These tests shall be run at maximum machine speed. If the maximum machine speed is greater than 25 km/h these tests shall be run at a minimum test speed of 25 km/h. The stops shall be separated by a maximum of 10 min between stops.

A.6.5.4 Heat fade test

Clauses 6.5.4. and 6.5.5 of ISO 3450:2011 do not apply.

Apply and release the service brakes to complete four consecutive stops at, or as near as possible to, the maximum deceleration of the machine without sliding of the tyres or tracks. After each stop, the machine test speed according to Clause 6.5.1 of ISO 3450:2011 shall be regained as quickly as possible using maximum machine acceleration. A fifth consecutive stop shall be measured which shall not exceed 125 % of the service brake stopping distance according to A.4.4.

A.6.6 General exceptions from ISO 3450:2011

ISO 3450:2011, Clause 6.6.1 does not apply.

ISO 3450:2011, Clause 6.6.2 applies.

A.7 Test report

ISO 3450:2011, Clause 7 applies

Annex B
(informative)

List of significant hazards, hazardous situations and hazardous events

Table B.1 lists the significant hazards, hazardous situations and hazardous events addressed in this document.

Table B.1 — List of significant hazards, hazardous situations and hazardous events with associated requirements

No.	Type or group	Examples of hazards		
		Cause[a]	Subclause of this document	Potential consequences[b]
1	Mechanical hazards	Acceleration, deceleration;	4.10	Being run over;
		Falling objects;	4.12.1) a)+b	Crushed;
		Fall from height;	4.12.2, 4.21	Drawn in or trapping;
		High pressure;	4.4.1.6, 4.12.1 d)-e)	Entanglement;
		Mass and stability;	4.1.3, 4.3, 4.18, 4.19, 4.20.3, 4.20.4	Impact; Slipping, tripping; Falling;
		Kinetic energy;	4.10	Collision.
		Potential energy, stored energy;	4.4.1.1, 4.4.1.6, 4.4.2, 4.10, 4.12.1 d)-e), 4.17 a), 4.20.3, 4.20.4, 4.21	
		Machinery mobility;	4.1.4, 4.1.5, 4.10, 4.11, 4.12.1 a), 4.12.3, 4.12.4	
		Rotating elements;	4.1.2, 4.12.1 a)	
		Rough, slippery surface;	4.12.2	
		Sharp edges;	4.1.2, 4.12.1, 4.12.4 b)	
		Inadequacy of mechanical strength;	Introduction, 4.1.3, 4.2, 4.3, 4.4.1.1, 4.4.1.2, 4.4.1.6, 4.4.2 a)+d), 4.7.1, 4.17 a), 4.18, 4.19, 4.20.3, 4.20.4, 4.21	

a) A single cause of a hazard can have several potential consequences.

b) For each type of hazard or group of hazards, some potential consequences can be related to several origins of hazard.

Table B.1 — *(continued)*

No.	Type or group	Examples of hazards		
		Cause[a]	Subclause of this document	Potential consequences[b]
1	Mechanical hazards	Unplanned activation of an equipment function;	4.1.4, 4.1.5, 4.11.1, 4.11.2	
		Pinch points;	4.1.2, 4.2, 4.12.1, 4.20.3, 4.20.4	
		Unexpected start-up, overrun, under-speed or similar malfunction;	4.1.4, 4.1.5, 4.11.1, 4.11.2	
		Inability for the equipment to be slowed, stopped and immobilised;	4.10, 4.11.1, 4.11.2 c)-d)	
		Rollover.	4.12.1 c), 4.12.4 e)	
2	Electrical hazards	Electrical arcing;	4.5.1, 4.5.3 d)-e), 4.13 a)	Burn; Chemical effects; Electrocution; Falling, being thrown; Fire; Shock.
		Electromagnetic phenomena;	4.5.2, 4.13 k), 4.11.2 d)	
		Live parts;	4.5.1, 4.5.3	
		Parts that have become live under fault conditions;	4.5.1, 4.5.2	
		Short circuit;	4.5.1, 4.5.3 d)-e)	
		Failure of control system;	4.5.1, 4.11.1, 4.11.2, 4.11.3	
		Failure of power circuit.	4.5.1	
3	Thermal hazards	Flame;	4.4.1.1, 4.4.1.4, 4.4.1.6 a)+e), 4.7.5, 4.7.6, 4.13, 6.1.1 b), c), d), i)	Burn; Injuries by the radiation of heat sources.
		Objects or materials with high or low temperature;	4.4.1.6 d), 4.6.1, 4.6.3, 4.12.1 a)+d)+e)	
		Radiation from heat sources.	4.6.1	

a) A single cause of a hazard can have several potential consequences.

b) For each type of hazard or group of hazards, some potential consequences can be related to several origins of hazard.

Table B.1 — *(continued)*

No.	Type or group	Examples of hazards		
		Cause[a]	Subclause of this document	Potential consequences[b]
4	Noise hazards	Exhausting system; Moving parts; Indicator alarms (i.e. reversing signal); Combustion engine and associated drive system.	4.14 4.14 4.9, 4.14, 4.14	Discomfort; Loss of awareness; Hearing degradation leading to hearing loss; Hearing loss; Stress, annoyance; Fatigue; Interference with speech communication or acoustic signals.
5	Vibration hazards	Misalignment of moving parts; Moving parts (i.e. bucket movement); Jerky movements; Combustion engine and associated drive system; Worn parts; Machine operating surface/s.	4.15 4.15 4.15 4.15 4.15 4.15	Discomfort; Low-back morbidity; Osteo-articular disorder; Shoulder, elbow, wrist, foot and leg disorders.
6	Radiation hazards	Optical radiation (infrared, visible spectrum and ultraviolet) including laser.	4.16	Damage to eyes and skin; Stress, annoyance; Headache, insomnia etc.
7	Material/ substance hazards	Combustible; Fibre; Flammable; Fluid; Gas.	4.4.1.1, 4.4.1.6, 4.4.2 b), 4.7.5, 4.7.6, 4.11.2 c), 4.12.4 i), 4.13, 6.1.1 a) 4.12.4 i) 4.4.1.1, 4.4.1.6, 4.7.5, 4.7.6, 4.12.4 i), 4.13, 6.1.1 a) 4.4.1.5, 4.12.4 i), 6.1.1 a), 4.4.1.7 4.6.1, 4.6.2, 4.12.4 i), 4.13 d), 4.5.3 b)	Breathing difficulties, suffocation; Cancer Fire.

a) A single cause of a hazard can have several potential consequences.

b) For each type of hazard or group of hazards, some potential consequences can be related to several origins of hazard.

Table B.1 — *(continued)*

No.	Type or group	Examples of hazards		
		Cause[a]	Subclause of this document	Potential consequences[b]
8	Ergonomic hazards	Access maintenance and operator;	4.4.1.3, 4.4.1.4, 4.12.2, 4.20.1, 4.20.2, 4.7.2	Discomfort; Fatigue; Musculoskeletal disorder; Stress; Any other (for example mechanical, electrical) as a consequence of human error; Entanglement; Collision; Roll over; Entrapment.
		Design or location of indicators and visual display units;	4.9, 4.11.2, 4.11.4, A.4.3	
		Effort;	4.11.2, 4.11.3, 4.12.2, 6.1.1 h), A.4.3, A.6.2	
		Local lighting;	4.8	
		Mental overload/underload;	4.11	
		Posture;	4.12.4	
		Visibility;	4.8, 4.12.3	
		Inadvertently activating or deactivating controls	4.1.4, 4.1.5, 4.11.2, 4.11.3, A.4.3	
		Human error;	4.11, 4.12.3, 6	
		Restricted visibility (operator and or pedestrian);	4.12.3	
		Inadequate visual and or acoustic warning to persons in the vicinity of the machine;	4.9, 4.12.4	
		Unhealthy postures and/or excessive effort;	4.12.4, 4.20	
		Inadequate maintenance practises;	Introduction f), 4.17 b)-d), 4.20	
		Inadequate operator practises;	Introduction a) to c), 4.11, 6	
		Neglecting principle of safety integration;	4.1.1	
		Inadequate lighting.	4.8	
9	Hazards associated with environment in which the machine is used	Dust;	4.4.2 c), 4.12.4	Suffocation/drowning; Uncontrolled movement of machine or parts of machine; Discomfort; Loss of awareness; Physical injury; Crushing; Collision; Roll over.
		Roughness/smoothness of travelling surface;	4.15, 6.1	
		Inclination of travelling surface (sloped and or cross sloped).	4.18, 4.19, 6.1.1 q)	

a) A single cause of a hazard can have several potential consequences.

b) For each type of hazard or group of hazards, some potential consequences can be related to several origins of hazard.

Annex C
(normative)

Verification table

Safety requirements and/or protective measures of Clauses 4 and 6 of this document shall be verified according to Table C.1. Table C.1 includes the following verification methods:

a) design check: to establish that the machine as designed complies with the requirements of this document;

b) calculation: to establish that the requirements of this document have been met;

c) visual verification: to establish that something is present (e.g. a guard, a marking, a document);

d) measurement: to show that the required numerical values have been met (e.g. geometric dimensions, safety distances, resistance of insulation of the electric circuits, results of physical tests);

e) functional tests: to show that the adequate signals intended to be forwarded to the main control system of the complete machine are available and comply with the requirements and with the technical documentation.

Table C.1 — Verification table

Clause number	Design check	Calculation	Visual verification	Measurement	Functional tests
4.1.1	X				
4.1.2	X		X	X	
4.1.3	X	X			
4.1.4, para 1	X		X		
4.1.4, para 2	X				
4.1.5	X				X
4.2, para 1	X	X	X	X	
4.2, para 2	X		X		
4.3, para 1	X		X		
4.3, para 2			X		
4.3, para 3	X				
4.3, para 4	X	X			
4.3, para 5	X		X		
4.3, para 6	X		X		
4.4.1.1, paras 1 to 3	X				
4.4.1.1, para 4	X		X		
4.4.1.2	X		X		
4.4.1.3	X		X		
4.4.1.4, para 1	X		X		
4.4.1.4, para 2	X				
4.4.1.5	X				
4.4.1.6	X		X (b, c and d only)	X (d)	

Table C.1 *(continued)*

Clause number	Design check	Calculation	Visual verification	Measurement	Functional tests
4.4.1.7	X		X		
4.4.1.8	X		X		
4.4.1.9	X				
4.4.2	X				
4.5.1	X				
4.5.2	X				
4.5.3	X		X (except c)		
4.6.1, para 1	X				
4.6.1, para 2	X		X		
4.6.1, para 3	X				
4.6.2			X		
4.6.3	X				
4.7.1	X				
4.7.2	X		X		
4.7.3	X				
4.7.4	X				
4.7.5, para 2 (para 1: no normative requirements)	X				
4.7.5, para 3	X		X (b and c only)		
4.7.5, para 4	X				
4.7.6	X		X (b1 and c only)		
4.8.1	X				
4.8.2	X				
4.8.3	X		X	X	
4.8.4	X				
4.8.5	X				
4.8.6	X				
4.8.7	X				X
4.9 a)	X			X	X
4.9 b)	X				X
4.9 c)	X		X		
4.10.1	X				
4.10.1.1	X				
4.10.1.2			X		
4.11.1	X				
4.11.2	X				
4.11.2 a)	X				
4.11.2 b)	X		X		
4.11.2 c)	X				
4.11.2 d)	X				
4.11.3	X				

Table C.1 *(continued)*

Clause number	Design check	Calculation	Visual verification	Measurement	Functional tests
4.11.4	X				
4.11.4.1	X		X		
4.11.4.2, para 2	X		X		
4.11.4.3	X		X		
4.12.1 a)	X				
4.12.1 b)	X				
4.12.1 c)	X				
4.12.1 d)	X		X		
4.12.1 e)	X				
4.12.2 a)	X				
4.12.2 b)	X		X		
4.12.2 c)	X		X		
4.12.2 d)	X				X
4.12.3 a)	X				
4.12.3 b)	X				
4.12.3 c)	X				
4.12.4 a)	X				
4.12.4 b)	X		X		
4.12.4 c)	X				
4.12.4 d)	X				X
4.12.4 e)	X				
4.12.4 f)			X		
4.12.4 g)	X				
4.12.4 h)	X			X	
4.12.4 i)	X			X	
4.13 a)	X				
4.13 b)	X		X		
4.13 c)	X				
4.13 d)	X				
4.13 e)	X		X		
4.13 f)	X				
4.13 g)	X				
4.13 h)	X				
4.13 i)	X				
4.13 j)	X				
4.13 k)	X				
4.13 l)	X				
4.14.1	X				
4.14.2			X		
4.14.2.1	X			X	
4.14.2.2	X			X	
4.15 a)	X				
4.15 b)	X				

Table C.1 *(continued)*

Clause number	Design check	Calculation	Visual verification	Measurement	Functional tests
4.15 d) no normative requirement					
4.16 a)	X				
4.16 b)	X				
4.16 c)	X				
4.17 a)	X				
4.17 b)	X		X		
4.17 c)	X				
4.17 d)			X		
4.18 a)	X				
4.18 b)	X				
4.18 c)	X		X		
4.18 d)			X		
4.19	X				
4.20.1, para 1	X		X		
4.20.1, para 2	X				
4.20.1, para 3	X		X		
4.20.2, para 1	X		X		
4.20.2, para 2			X		
4.20.3, para 1	X				
4.20.3, para 2	X		X		
4.20.3, para 3	X		X		
4.20.3, para 4			X		
4.20.4, para 1	X		X		
4.20.4, para 2	X				
4.20.4, para 3	X				
4.21	X				
Annex A					
A.1	X				
A.4	X				
A.4.1	X				
A.4.2	X				
A.4.3	X		X (2nd para only)		
A.4.4	X			X	
A.4.5	X			X	
A.4.6 a)	X			X	
A.4.6 b)	X				X
A.4.6 c)	X			X	
A.4.6 d)	X				X
A.4.6 e)	X				X
A.4.6 f)			X		
A.4.6 g)	X				X

Table C.1 *(continued)*

Clause number	Design check	Calculation	Visual verification	Measurement	Functional tests
A.4.6 h)	X				X
A.4.6 i)					Test planning
A.4.7	X				
A.4.8	X				
A.4.9	X				
A.4.10	X				
A.4.11	X				
A.4.11 a)	X				
A.4.11 b)	X				
A.4.11 c)	X				
A.4.11 d)	X				X
A.4.11 e)	X		X		X
A.4.11 f)					Test planning
A.4.12	X				
A.4.13	X				
A.5					Test planning
A.6.1	X				
A.6.2				X	
A.6.3				X	
A.6.4.1	X				
A.6.4.2				X	
A.6.4.3				X	
A.6.4.4				X	
A.6.5.1	X				
A.6.5.2				X	
A.6.5.3				X	
A.6.5.4				X	
A.6.6	X				
A.7			X		

Annex D
(informative)

Examples of performance levels for safety-related functions

Table D.1 provides examples of performance levels (PL_r) in accordance with ISO 13849-1:2015 for the outlined safety-related functions.

Table D.1 — Performance levels

Paragraph of this document	Required performance level according to ISO 13849-1:2015	Description of safety function
4.1.5	c	Unintended movement
4.4.2 b)	b	Automatic shutdown system for compressor to prevent overheating
4.10.1	c	Braking
4.11.2 a)	c	Deactivation of controls
4.11.2 c)	c	Interlocking of control positions
4.11.3	c	Steering
4.13 j)	c	Shut down of engine and power sources in the event of actuation of an on-board fire suppression system
4.18 b)	c	Stability in working mode
4.18 c)	b	Retracted travelling positions of stabilizers and similar devices

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