



DPC: 25/30474748 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 22 January 2025

Origin: European

Latest date for receipt of comments: 17 March 2025

Project No. 2023/01148

Responsible committee: MRE/1 Mining mechanical equipment and machinery

Interested committees:

Title: Draft BS EN ISO 18758 BS EN ISO 18758 Mining and earth-moving machinery — Rock drill rigs and rock reinforcement rigs — Safety requirements.

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD. THIS DRAFT IS NOT CURRENT BEYOND 17 March 2025

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <https://standardsdevelopment.bsigroup.com/>.

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 18758

Mining and earth-moving machinery — Rock drill rigs and rock reinforcement rigs — Safety requirements

*Engins d'exploitation minière et de terrassement — Appareils de
forage et de renfort de roches — Exigences de sécurité*

ICS: 53.100; 73.100.30

ISO/TC 82

Secretariat: **DIN**

Voting begins on:
2025-01-22

Voting terminates on:
2025-04-16

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENTS AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

Reference number
ISO/DIS 18758:2025(en)

Full document details: 25/30474748 DC

© ISO 2025  **Documents**
Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO 2025

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	vi
Introduction	viii
1 Scope	1
2 Normative references	1
3 Terms and definitions	4
4 Safety requirements	4
4.1 General requirements	4
4.1.1 General	4
4.1.2 Handling of the machine and its parts	4
4.1.3 Access to operating positions and servicing points	6
4.1.4 Electrical equipment	6
4.1.5 Electromagnetic compatibility (EMC)	6
4.1.6 Lighting	6
4.2 On-board operator stations	7
4.2.1 General	7
4.2.2 General requirements for an operator station	7
4.2.3 Enclosed operator station	8
4.2.4 Specific types of operator stations	10
4.3 Control system	12
4.3.1 Safety-related parts of control system	12
4.3.2 Operator control devices	13
4.3.3 Prevention of unexpected start-up	14
4.3.4 Diagnostic system	14
4.3.5 Laser equipment	14
4.4 Fluid power systems	14
4.4.1 General	14
4.4.2 Hoses, pipes and fittings under pressure	15
4.4.3 Load holding cylinders for feeders, masts, jacks, and elevating operator stations	15
4.5 Strength	15
4.5.1 Loads	15
4.5.2 Structural calculations	16
4.6 Rigid body stability	17
4.6.1 General	17
4.6.2 Stability criteria	17
4.6.3 Tipping lines	18
4.6.4 Stability calculation – Tipping angle	22
4.6.5 Operating conditions	22
4.7 Steering	23
4.8 Carrier brakes	24
4.8.1 General	24
4.8.2 References	24
4.8.3 Symbols	24
4.8.4 Requirements for wheel-mounted underground machines	24
4.8.5 Test conditions for wheel-mounted underground machines	27
4.8.6 Performance tests for wheel-mounted underground machines	28
4.8.7 Test report for wheel-mounted underground machines	30
4.9 Winches	30
4.9.1 Dual braking system	30
4.9.2 Wraps	31
4.9.3 Flanges on drum	31
4.9.4 Dimensions	31
4.9.5 Tramming winch	31
4.9.6 Service winch and main winch	32
4.9.7 Survey winch	32

4.9.8	Wireline winch.....	32
4.10	Roller chains, leaf chains and wire ropes for feed system.....	32
4.11	Moving and rotating parts involved in the drilling process.....	32
4.11.1	General.....	32
4.11.2	Choice of protection methods.....	33
4.11.3	Drill string guards.....	33
4.11.4	Person detection systems for underground machines.....	34
4.11.5	Restricted drill string handling mode (RDM).....	36
4.11.6	Handling of drilling tools.....	36
4.11.7	Drill movement disabling switches on underground machines.....	37
4.11.8	Two hand control for remote controlled underground machines.....	37
4.12	Noise and vibration.....	38
4.12.1	General.....	38
4.12.2	Noise.....	38
4.12.3	Vibration.....	38
4.13	Energy supply.....	38
4.13.1	Propulsion battery systems.....	38
4.13.2	Diesel engine.....	39
4.14	Fire protection.....	40
4.14.1	General.....	40
4.14.2	Locations for portable fire extinguishers.....	41
4.14.3	Fire suppression system.....	41
4.14.4	Electrical cables.....	41
4.15	Dust suppression.....	41
5	Verification of safety requirements.....	42
6	Information for use.....	48
6.1	Nature of information for use.....	48
6.2	Signals and warning devices.....	49
6.2.1	General.....	49
6.2.2	Audible alert signal.....	49
6.2.3	Reversing signal.....	49
6.2.4	Remotely controlled or unmanned, automatically operating machine warning.....	49
6.2.5	Stability indication.....	50
6.2.6	Indication lights for person detection systems for underground machines.....	50
6.2.7	Signalling and marking lights for tramming and traveling.....	50
6.2.8	Seat belt reminder.....	50
6.3	Safety signs and labels.....	50
6.4	Graphical symbols for operator controls and other displays.....	51
6.5	Marking.....	51
6.5.1	Machine identification plate.....	51
6.5.2	Data plate of boom-mounted working platform.....	51
6.5.3	Marking of the machine and machine parts.....	52
6.5.4	Marking of winch.....	52
6.6	Instruction handbook.....	52
6.6.1	Types of instructions.....	52
6.6.2	Identification of instruction handbook.....	53
6.6.3	Information about the machine.....	53
6.6.4	Instructions for the use of the machine.....	53
6.6.5	Reasonably foreseeable misuse and prohibited use.....	53
6.6.6	Working environment.....	54
6.6.7	Personal protection.....	54
6.6.8	Protection against moving parts.....	54
6.6.9	Training required.....	55
6.6.10	Setting up.....	55
6.6.11	Tramming, travelling and operating position.....	55
6.6.12	Controls, functions, systems and devices.....	56
6.6.13	Stability of the machine.....	56
6.6.14	Electrical installations.....	56

ISO/DIS 18758:2025(en)

6.6.15	Machines powered by diesel engine	56
6.6.16	Noise and vibration	56
6.6.17	Winches and ropes	57
6.6.18	Machines for underground operation	57
6.6.19	Instructions for two-person operation	57
6.6.20	Information for emergency situations	58
6.6.21	Transport instructions	58
6.6.22	Assembly instructions	58
6.6.23	Maintenance instructions	58
6.6.24	Instructions for maintenance by two service technicians	59
6.6.25	Spare parts list	60
6.6.26	Disassembling, disabling and scrapping	60
6.6.27	Vocabulary for the instruction handbook	60
Annex A	(normative) Noise test code	61
Annex B	(normative) Whole-body and hand-arm vibration test	68
Annex C	(informative) List of significant hazards	70
Annex ZA	(informative) Relationship between this European Standard and the essential requirements of Directive 2006/42/EC aimed to be covered	72
Annex ZB	(informative) Relationship between this European Standard and the essential requirements of Regulation (EU) 2023/1230 aimed to be covered	89
Bibliography		101

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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 82, *Mining*, in cooperation with Technical Committee ISO/TC 127, *Earth-moving machinery*.

This edition of ISO 18758 cancels and replaces ISO 18758-1:2018 and ISO 18758-2:2018.

In addition to several editorial changes, the main revisions with respect to the previous edition (ISO 18758-2:2018) are as follows:

- a) This document has been revised under the Vienna agreement in cooperation with CEN/TC 196;
- b) The short-form term *rig* in this document has been replaced with the term *machine* to provide consistency with other machinery safety standards;
- c) The scope exclusions have been simplified and clarified. Most of the machines excluded are within the scope of the ISO 20770 series;
- d) The vocabulary of ISO 18758-1:2018 has been moved to ISO 22932-5, which has been revised to include new vocabulary;
- e) Internal references within this document have been updated, including [Annex C](#) on significant hazards;
- f) Repeated requirements have been deleted;
- g) Requirements for laser equipment have been added;
- h) Requirements for propulsion batteries have been added;
- i) Requirements for strength and stability have been revised;
- j) The carrier brake requirements have been revised to align more closely with ISO 3450;
- k) Winch and rope requirements have been revised;
- l) Revised requirements on the protection of moving parts.

- m) The requirements for the location for mounting fire extinguishers have been clarified;
- n) A verification table has been added to [Clause 5](#);
- o) The content of [clause 6](#) has been adapted from ISO 12100:2010, 6.4 and expanded to apply to rock drill rigs.
- p) The requirements on signals and warning devices have been adapted from ISO 12100:2010, 6.4.3.
- q) [Annex ZA](#) has been added to the CEN version, complying with CEN guide 414:2017, Option C;
- r) [Annex ZB](#) has been added to the CEN version to harmonise with the European Machinery regulation.
- s) The bibliography has been restructured under headings corresponding to the topics covered, often relating to the names of the TCs that drafted them;

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.

European foreword

This document has been prepared under a standardisation request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

For the relationship with EU Legislation, see informative [Annex ZA](#) and [ZB](#), which is an integral part of this document.

Introduction

This document is a type C standard as stated in ISO 12100:2010.

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

- machine manufacturers;
- mining companies;
- health and safety bodies (regulators, accident prevention organisations, market surveillance, etc.).

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

- machine operators;
- service providers, e.g. for maintenance;
- third party system and technology providers.

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.

The vocabulary of ISO 22932-5 is essential for the understanding of the safety requirements 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 rock drill rigs and rock reinforcement drills that have been designed and built according to the requirements of this type C standard.

The following assumptions were made in writing this document:

- a) the operators of the machines are well trained professionals and aware of potential risks of using the machine in the working environment, including the hazards of reasonably foreseeable misuse (See ISO/IEC GUIDE 51:2014, 6.1 a), b));
- b) the machines are operated and maintained according to the instructions given by the manufacturer, such as operator's instructions (See ISO/IEC GUIDE 51:2014, 7.4.2.2);
- c) that administrative controls are in place for preventing unauthorized entry of persons to the area where machines are working (See ISO/IEC GUIDE 51:2014, 6.2.2 and note).

For increased readability of this document, rock drill rigs and rock reinforcement rigs are called machines from [clause 4](#) onwards unless the specific term is needed for emphasis or clarity.

Mining and earth-moving machinery — Rock drill rigs and rock reinforcement rigs — Safety requirements

1 Scope

This document specifies the safety requirements for rock drill rigs and rock reinforcement rigs designed for the following underground or surface operations:

- a) blast hole drilling;
- b) rock reinforcement and consolidation (injection holes, pipe roofing, netting, bolting);
- c) drilling for secondary breaking;
- d) dimensional stone drilling;
- e) mineral prospecting, e.g. utilizing core drilling or reverse circulation drilling;
- f) water and methane drainage drilling;
- g) raise boring;

when used by a well-trained operator in accordance with the information for use and where sufficient measures have been taken to prevent unauthorized entry of persons to the area where machines are working.

NOTE Machines can be designed for more than one of the operations above. See ISO 22932-4 and ISO 22932-5 for vocabulary.

This document is also applicable to rock drill rigs and rock reinforcement rigs based on earth-moving machinery (EMM) as defined in ISO 6165.

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

This document is not applicable to the following machines: drill rigs for soil and rock mixture, Kelly drill rigs and casing drivers, cable tool drill rigs, pre-armouring machines, sonic drill rigs; shaft sinking drill rigs, crane attached drill rigs, drill rigs on derricks, scaling machines.

This document does not cover machines on railway tracks, artificial intelligence, autonomous systems, self-evolving systems, cyber security, lightning, protection against corruption, malicious attempts from third parties, or potentially explosive atmospheres.

This document deals with the relevant and significant hazards, hazardous situations, or hazardous events, as listed in [Annex C](#), when the machine is used as intended and under the conditions of misuse which are reasonably foreseeable by the manufacturer.

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 2631-1, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

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

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

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 3450:2011, *Earth-moving machinery — Wheeled or high-speed rubber-tracked machines — Performance requirements and test procedures for brake systems*

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

ISO 3471, *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 (all parts), *Graphical symbols — Safety colours and safety signs*

ISO 4302, *Cranes — Wind load assessment*

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

ISO 4414, *Pneumatic 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 — Wheeled machines — Steering requirements*

ISO 6405 (all parts), *Earth-moving machinery — Symbols for operator controls and other displays*

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

ISO 7000, *Graphical symbols for use on equipment — Registered symbols*

ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 7731, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

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

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

ISO 11201:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections*

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

ISO 12509, *Earth-moving machinery and rough-terrain trucks — Lighting, signalling and marking lights, and reflex reflectors*

ISO 13766-1, *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, *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, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

ISO 13850, *Safety of machinery — Emergency stop function — Principles for design*

ISO 13851, *Safety of machinery — Two-hand control devices — Principles for design and selection*

ISO 13856-2, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars*

ISO 13856-3, *Safety of machinery — Pressure-sensitive protective devices — Part 3: General principles for design and testing of pressure-sensitive bumpers, plates, wires and similar devices*

ISO 14118, *Safety of machinery — Prevention of unexpected start-up*

ISO 14119, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 14120, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

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 16368, *Mobile elevating work platforms — Design, calculations, safety requirements and test methods*

ISO 22932-5, *Mining — Vocabulary — Part 5: Drilling and blasting*

ISO 23875, *Mining — Air quality control systems for operator enclosures — Performance requirements and test methods*

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

IEC 60204-11, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

IEC 60825-1, *Safety of laser products — Part 1: Equipment classification and requirements*

IEC 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

IEC 61310-2, *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*

IEC 61851-1, *Electric vehicle conductive charging system — Part 1: General requirements*

IEC 62196 (all parts), *Plugs, socket-outlets, vehicle connectors and vehicle inlets — Conductive charging of electric vehicles*

IEC 62485-6, *Safety requirements for secondary batteries and battery installations — Part 6: Safe operation of lithium-ion batteries in traction applications*

IEC 62619, *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

IEC 62620, *Secondary cells and batteries containing alkaline or other nonacid electrolytes — Secondary lithium cells and batteries for use in industrial applications*

IEC 62745, *Safety of machinery — Requirements for cableless control systems of machinery*

EN 14492-2:2019, *Cranes — Power driven winches and hoists — Part 2: Power driven hoists*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in IEC 60204-1, ISO 2631-1, ISO 3450, ISO 4871, ISO 11201, ISO 12100, ISO 14120, and ISO 22932-5.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Safety requirements

4.1 General requirements

4.1.1 General

Machinery shall meet the safety requirements of this document. In addition, the machine shall be designed according to the principles of ISO 12100 for hazards which are not dealt with by this document.

4.1.2 Handling of the machine and its parts

4.1.2.1 Manual handling

For components which require to be manually handled during operation with a mass of 25 kg and higher, there shall be provisions for lifting.

For components which require to be manually handled during operation with a mass less than 25 kg, the geometry shall facilitate manual handling.

4.1.2.2 Attachment points

The machine shall have the attachment points for:

- lifting the whole machine, or parts of it
- anchoring the machine on the means of transport

The attachment points shall meet the requirements of ISO 15818.

4.1.2.3 Retrieval points

Retrieval points (hooks, ears, etc.) shall be provided on the machine. They shall be designed for the forces applicable to the working conditions and meet the requirements of ISO 10532.

The retrieval points may also be used for holding and securing the machine during transport.

4.1.2.4 Articulation frame lock

On articulated carriers there shall be a mechanical locking device for locking the articulation joint during maintenance, lifting and transport. The articulation frame lock shall meet the requirements of ISO 10570.

4.1.2.5 Mechanical support device for maintenance on an elevating operator station

A mechanical support device for maintenance work on an elevating operator station shall meet the following requirements (Adapted from ISO 13333:1994):

- a) It shall withstand the static load imposed by the lowering force, i.e. 1,2 times the working circuit pressure, plus a force which corresponds to the mass of the operator station, and the mass of any attachments, arms and linkage acting on the support device and/or the mechanically support device shall withstand a force which corresponds to twice the mass of the empty operator station depending on which method giving the highest requirement;
- b) For systems that do not have a lowering force other than gravity, the mechanical support device shall withstand a force which corresponds to twice the mass of the empty operator station;
- c) The support device(s) shall withstand the lifting force applied to the operator station without dislocation. It shall also retain its safety function whenever the operator station is returned to the original position;
- d) The support device shall be installed within the machine structure so that no unintended dislodging or disengagement of the support device will happen;
- e) The device shall be independent from all other systems used under normal operation and maintenance;
- f) When the support device is installed for its safety function, it shall only be possible to disengage it by a voluntary action of the operator;
- g) The support device should be capable of being installed and handled by one person;
- h) The support device and its required parts shall be stored permanently on the machine in a safe manner;
- i) The support device, excluding the attaching parts, shall be red on all machines except where the machine colour is red or the device is a cable or cables, in which case the support device shall be yellow.

4.1.2.6 Booms, stabilizers, outriggers, jacks, and moveable devices

Stabilizers, outriggers, jacks, and other moveable devices that may cause a hazard during transportation if moved out of position shall be lockable in their transport position.

Booms, stabilizers, outriggers, jacks, and other moveable devices shall have distinctive mechanical end stops that provide visual confirmation that they are in transport position.

4.1.2.7 Specific equipment

If the safe adjustment, maintenance, or use of the machine requires the use of equipment or accessories that are specific to machinery concerned, such equipment or accessories shall be made available by the machinery manufacturer with the machine.

4.1.2.8 Guards

Guards and other means of protecting personnel from mechanical, fluid, or thermal hazards associated with the operation and routine maintenance of the carrier machine shall meet the requirements of ISO 3457.

The engine compartment shall be guarded against unauthorised access by one of the following means:

- a) a locking device;
- b) a barrier to entry that requires the use of a tool or key;
- c) a guard latch control inside a lockable compartment (e.g. operator enclosure).

4.1.3 Access to operating positions and servicing points

Access systems shall be provided to operator stations, operating positions and to routine maintenance points.

Access systems and emergency exits shall meet the requirements of ISO 2867.

Minimum access dimensions shall meet the requirements of ISO 2860.

Consideration shall be given to that operators can wear heavy gloves, footwear, and other personal protective equipment.

4.1.4 Electrical equipment

The electrical equipment of the machine shall meet the requirements of

- a) IEC 60204-1 for nominal supply voltages not exceeding 1 000 V for alternating current (AC) and not exceeding 1 500 V for direct current (DC), and with nominal supply frequencies not exceeding 200 Hz and;
- b) IEC 60204-11 for nominal voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV AC or DC with nominal frequencies not exceeding 60 Hz.

4.1.5 Electromagnetic compatibility (EMC)

Machines shall meet the EMC requirements of:

- ISO 13766-1 and ISO 13766-2
- or
- IEC 61000-6-2 and IEC 61000-6-4. See also IEC 61000-6-7.

Electrical components and sub-systems used should meet the EMC standards relevant to the component type, sub-system, or the industry they are sourced from.

4.1.6 Lighting

4.1.6.1 Working light

For manned machines specified to work in darkness and non-lit conditions, the machine shall be fitted with working light illuminating the area around the typical drilling operation of the application. It shall give a minimum illumination of 100 lux at the typical working area apart from natural shadows from feeds and booms.

Internal parts requiring inspection, adjustment and/or maintenance shall have built in internal lighting, be equipped with a socket for plugging in a lamp or have a fixed rechargeable handheld flashlight at the operator station.

4.1.6.2 Illumination for tramming

For self-propelled machines tramming in darkness, lighting shall be provided;

- a) giving an illumination of at least 10 lux,
- b) 7 m in front and behind the machine when all positioning units are in their transport position. The 7 m shall be measured from the most fore and rear part of the machine.

Measurement shall be carried out 1 m from ground level and as wide as the body of the machine.

4.1.6.3 Internal operator station lighting and access lighting

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

Access illumination shall be provided in accordance with ISO 2867.

NOTE This includes lighting up the ladder, pathway on the machine and the ground next to the machine.

4.2 On-board operator stations

4.2.1 General

The operator stations shall be designed so that all manoeuvres necessary for moving and operating the machine can be performed by the operator, minimising risk to himself or to other persons.

To protect the operator from noise, dust and environmental conditions, self-propelled machines with an on-board operator station shall be provided with an operator enclosure, except when dimensional restrictions exist, such as:

- a) a small size of the machine, e.g. for restricted access applications (low seam, narrow vein);
- b) the size or layout of the machine prevents an operator enclosure from being mounted on the machine in a position from which the operator can view the operations;
- c) the controls for tramming and travelling can be located in a different position than the drilling controls;
- d) the presence of an operator enclosure impairs the functionality of the machine, e.g. machine for use on rock slopes

An on-board operator station is not required on:

- a) remote controlled or automated machines;
- b) non-self-propelled machines, for example on skids, trailer or truck mounted.

4.2.2 General requirements for an operator station

4.2.2.1 Falling object protection system (FOPS)

On-board operator stations on machines operating in environments where there is a risk of rock fall shall be fitted with FOPS level II according to ISO 3449.

4.2.2.2 Interior space

The minimum space available to the operator at the operator station shall be as defined in ISO 3411:2007 except the following amendments:

- a) the minimum space envelope height (dimension R1 in ISO 3411:2007, Table 1), may be reduced to 920 mm for compact machines and 1 000 mm for all other machines;
- b) for compact and narrow vein machines the minimum space envelope width at the operator station (dimension 920 mm in ISO 3411:2007, Figure 4) may be reduced to 650 mm.
- c) for low-profile machines, the interior height of the operator station shall be sufficient for a reclining operator's seat.

NOTE Adapted from EN 474-1:2022, 4.3.1.2

4.2.2.3 Seat

Unless the operator has to work in a standing position, a seat shall be provided. When a seat is provided, it shall provide the operator with a stable working position and shall be easily adaptable to operators of different weight and height.

4.2.2.4 Seatbelt

If there are seats for travelling, they shall be provided with seatbelts in accordance with ISO 6683. The performance requirements of ISO 6683 shall be verified by calculation or simulation.

Seats only for the stationary drilling operation of the machine do not require seat belts.

4.2.2.5 Operator's field of view

Machines shall be designed so that the operator has visibility from the operator station and driver's position to see the travel and work areas of the machine which are necessary for the intended use of the machine. Testing shall be in accordance with ISO 5006. See ISO 22932-5 for figures of the rectangular boundary of rock drill rigs.

Where necessary, optical aids or other means shall be provided.

When there is a need for an operator or a helper to work on the rig in the working area or near a hazard zone as a two-person operation and this involves activation of one or several machine functions, there shall be direct visibility from the operator station, or other means (e.g. CCTV) shall be provided, for the operator to ensure the helper is clear of hazards created by operator actions.

4.2.2.6 Flame-retardant material

Operator station interior, upholstery and insulation materials shall be made of flame-retardant material. The maximum linear velocity of flame propagation shall be 250 mm/min when tested in accordance with ISO 3795.

4.2.3 Enclosed operator station

4.2.3.1 Application

If the operator station is enclosed, the following applies in addition to the provisions for the general operator station:

4.2.3.2 Roll over protection (ROPS)

Surface machines with enclosed operator station shall have roll over protection (ROPS) as specified in [table 1](#):

Table 1 — Roll over protection (ROPS) criteria

Surface machine type	Shall have ROPS if:
Platform rock drill rig	Mass $\leq$ 25 000 kg
Other types	Mass $\leq$ 50 000 kg

Roll over protection (ROPS) shall meet the requirements of ISO 3471.

4.2.3.3 Windows and glazing

Windows shall be made of safety glass or other material that provides similar safety performance. EN 356:1999, P8B is recommended.

4.2.3.4 Window cleaning devices

There shall be window cleaning devices for each window essential for visibility during operations.

4.2.3.5 Defrosting system

Surface machines intended for cold climate shall provide facilities to defrost the front and rear window(s), for example by means of a heating system or a particular defrosting device.

4.2.3.6 Heating system

Surface machine operator enclosures shall be equipped with a heating system. It shall have the capability of increasing the temperature of the air inside the operator enclosure and maintain a temperature of +18 °C within 60 minutes at the expected ambient temperature that the machine is intended for.

4.2.3.7 Cooling system

Surface machines operator enclosures shall be equipped with a cooling system. It shall have the capability of decreasing the temperature of the air around the operator to a maximum of +25 °C within 60 minutes and maintain that temperature at the expected ambient temperature that the machine is intended for.

4.2.3.8 Ventilation system

The operator enclosure shall be equipped with a ventilation system. It shall be capable of providing the enclosed operator station with filtered breathing air at the minimum of 43 m³/h.

4.2.3.9 Operator air quality system

The operator enclosure shall be fitted with an operator air quality system meeting the requirements of ISO 23875.

4.2.3.10 Pressurization system

The operator enclosure shall have an air pressurisation system that provide an interior relative pressure of at least ≥ 20 Pa, to prevent dust from entering. This system shall be active when the electrical system of the operator enclosure is turned on.

The air pressurisation system shall provide an interior relative pressure of at least ≥ 50 Pa at high blower speed.

4.2.4 Specific types of operator stations

4.2.4.1 Elevating operator station

In addition to the provisions for general operator station, the following applies to elevating operator stations:

- a) The lift and descent speed of the operator station shall not exceed 0,6 m/s under normal operating conditions or 0,4 m/s in case of hydraulic line rupture;
- b) The elevating control shall be clearly marked and protected against unintentional activation;
- c) 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 station to the lowest position (irrespective of the actual position) or to leave the station safely, e.g. by steps or stairs;
- d) Load holding cylinders shall be provided to prevent the station from falling;
- e) A mechanical support device in accordance with [4.1.2.5](#) shall be provided to hold the elevating operators station in place when doing maintenance and repair.

NOTE Adapted from ISO 20474-1:2017, annex B.

4.2.4.2 Tilting operator station

In addition to the requirements for elevating operator station, the following applies to tilting operator stations:

- a) If the operator station front, when tilted, becomes a part of the falling-object protective structure (FOPS), it shall meet the requirements of ISO 3449, Level II;
- b) If a slewing seat is used, it should be adapted to the tilting conditions, for example by damping seat slew;
- c) Operator controls shall be adapted as appropriate;
- d) Emergency exit in tilting position shall be provided.

4.2.4.3 Trimming stand

Where a ride-on operator station is provided on the machine for the purposes of trimming the machine, it shall be provided with:

- a) A handrail for the operator stability when riding and;
- b) Slip-resistant surface, and;
- c) Exit routes in at least two directions.

4.2.4.4 Boom mounted working platforms for underground machines

4.2.4.4.1 Falling-object protective structure (FOPS)

A falling-object protective structure (FOPS) shall be provided. The FOPS shall allow for working access to the tunnel roof and shall therefore not cover the entire platform.

The FOPS may be adjustable taking into account the various functions to be performed from the platform.

The FOPS shall meet the requirements of ISO 3449, Level II.

4.2.4.4.2 Application of the safety standard for mobile elevating work platforms

Machines equipped with boom-mounted working platforms shall meet the requirements of ISO 16368 but are exempted from the following requirements of ISO 16368:

- a) Wind loads, because underground machines are considered for indoor use only;
- b) Providing a device that prevents driving of the machine when the boom-mounted platform is not in its transport position;
- c) A device that gives an easily identifiable visual or acoustic signal to indicate that the inclination of the chassis has reached the limits permitted by the manufacturer;
- d) Providing a device that prevents movement of the platform while the stabilizers are not set;
- e) Providing a device that prevents adjustment of the stabilizers while the boom-mounted platform is not in its transport position;
- f) Providing a device, located in the operator station, that indicates that the boom-mounted platform is not in its transport position;
- g) Providing a load sensing system;
- h) Providing a moment sensing system;
- i) Brake requirements (already covered by this document);
- j) Noise determination and declaration (already covered by this document);
- k) Providing an adjustment for uneven ground for base plates on stabilizing jacks.
- l) Dynamic fall arrest anchorage test

NOTE The exemptions are justified for the following reasons:

- 1) The primary function of the stabilizers is for use during drilling;
- 2) The need to manoeuvre in narrow tunnels;
- 3) Risk of rock fall;
- 4) Overturning of a machine for underground use and equipped with a boom-mounted working platform, due to overload of the platform, is not considered a significant hazard due to the size and weight of the machine.

The boom-mounted working platform shall be operable from both the platform and the operator's station. Only one control position shall be active at a time except for stop controls and emergency stop. In case of emergency, for example rock fall, it shall be possible to override the controls of the platform by the control at the operator station.

Overload of the boom and platform shall be prevented by restricting the platform size according to ISO 16368, or by mechanical, hydraulic or electronic protection systems. The platform shall be subject to a static load test according to ISO 16368.

Any overload prevention system fitted shall not prevent the platform from being lowered.

4.2.4.5 Temporary roof support (TRS) systems for underground machines

Persons shall work or travel between the support device of the TRS system and another support, and the distance between the support device of the TRS system and support to the left, right or beyond the TRS system, shall not exceed 1,5 m.

Each TRS system shall meet each of the following:

- a) The TRS system shall elastically support a deadweight load measured in kN of at least 22 times each square meter of roof intended to be supported, but in no case less than 56 kN/m²;
- b) The controls that position and set the TRS system shall be:
 - i. operable from under permanently supported roof; or
 - ii. located in a compartment, which includes a deck, that provides the equipment operator with overhead and lateral protection, and has the structural capacity to elastically support a deadweight load of at least 80 kN.
- c) All jacks affecting the capacity of the TRS system and compartment shall have check valves or equivalent devices that will prevent rapid collapse in the event of a system failure.
- d) Except for the main tram controls, tram controls for positioning the equipment to set the TRS system shall limit the speed of the equipment to a maximum of 0,4 m/s.

The support capacity of each TRS system and the structural capacity of each compartment shall be verified as meeting the applicable requirements of this clause.

NOTE The requirements of this clause correspond to the USA MSHA regulation 30 CFR Ch. I (7–1–15 Edition) § 75.209 Automated Temporary Roof Support (ATRS) systems, paragraph (d) through (f).

4.3 Control system

4.3.1 Safety-related parts of control system

Safety-related parts of the control system that realize the safety functions shall meet the requirements of ISO 13849-1 and ISO 13849-2. Requirements for safety functions are detailed in [Table 2](#). The list is not exhaustive.

Table 2 — Requirements for safety functions

Clause of ISO 18758	Description of safety function	Required performance level according to ISO 13849-1
4.3.2.4	Start and stop devices: Prevention of uncontrolled movements	C
4.3.2.7	Emergency stop: Stop rotation and feed	C
4.3.3	Prevention of unexpected start-up	C
4.4.3	Jacks: Ability to hold and stop movements	C
4.8.1	Machine stop function realized by carrier brakes	C
4.11.3	Drill string guard interlock: Stop drill rotation and feed	C
4.11.2 4.11.4	Stop of rotation and feed on detection by person detection systems	C
4.11.5	Restricted drill string handling mode: Limitation of the rotation and feed speed	C
4.11.8	Two hand control for remote controlled underground machines: Stop rotation and feed	C

Verification: ISO 13849-1 and ISO 13849-2.

4.3.2 Operator control devices

4.3.2.1 Operator controls

Operator controls shall meet the requirements of ISO 10968.

Accidental actuation of the controls shall be prevented when such actuation can cause a hazard.

4.3.2.2 Operator control location

Where there is more than one operator location for controlling the drilling process, the machine shall be provided with a lockable mode selector to intentionally select the location which shall be used.

4.3.2.3 On-board operator control devices

The on-board operator control devices on the operator station shall be located so that the operator cannot reach the rotating parts, or a two-hand control device shall be used.

When a control is designed and constructed to carry out several functions, e.g. keyboard control, the activated operation shall be clearly identified.

4.3.2.4 Start and stop devices

Starting of the machine's main power source shall only be possible by an intentional actuation of the starting control device.

The machine shall be fitted with a stopping device by which drilling or other operating functions are brought safely to a complete stop.

4.3.2.5 Remote control

Remote control systems shall meet the requirements of IEC 62745 and ISO 15817.

4.3.2.6 Two-hand control devices

Two-hand control devices shall meet the requirements of ISO 13851.

4.3.2.7 Emergency stop

There shall be an emergency stop at every operating or driving position placed within easy reach of the operator.

Additional emergency stops shall be fitted on the machine. These emergency stops shall be safely and easily accessible from outside of the machine.

The emergency stops shall comply with ISO 13850.

The Stop category per rock drilling technology shall be in accordance with [table 3](#).

Table 3 — ISO 13850 emergency stop categories as per rock drilling technology

ISO 13850 emergency stop category 0
Rotary-percussive drilling, top hammer
Rotary-percussive drilling, DTH
Rotary drilling, rod
Rotary drilling, auger
ISO 13850 emergency stop category 1

Table 3 (continued)

Raise boring, boxhole boring
Core drilling
Reversed circulation drilling

The emergency stops shall stop drill string rotation, feed, boom, mast movements, tramming and travelling movements.

Guards and other protective devices shall remain effective.

4.3.2.8 Pressure-sensitive protective devices

Pressure-sensitive protective devices shall meet the requirements of ISO 13856-2 or ISO 13856-3, depending on its type.

The pressure-sensitive protective devices shall stop drill string rotation, feed, boom, and mast movements.

4.3.3 Prevention of unexpected start-up

Prevention of unexpected start-up shall be in accordance with ISO 14118.

4.3.4 Diagnostic system

An unmanned, automatically operated machine's control system shall be designed with an integrated diagnostic system that shuts down the operation when a fault or an abnormal operational behaviour is detected by the system.

The system shall provide fault finding capabilities to access sensor data and event log via built in display or connection with an external device.

4.3.5 Laser equipment

The following requirements apply to lasers mounted on the machine:

- Laser equipment shall meet the requirements of and be classified according to IEC 60825-1.
- When a laser has to be positioned in the immediate direction of eyes of any operator or by-stander, the primarily laser equipment shall be of class 1, 1M, 2 or 2M.
- Laser equipment of class 1C can be used for specific cases, but a class 1C laser shall not emit radiation. Use IEC 60825-1 for guidance.
- Laser equipment of class 3R may be used when the control of the laser or the location of the laser or the direction of the radiation limits the risk of any operator or by-stander.
- Laser equipment of class 3B and class 4 should be avoided but may be used when the location of the laser equipment and the direction of the radiation prevents and limits any risk to any operator or by-stander.

4.4 Fluid power systems

4.4.1 General

Hydraulic systems shall meet the requirements of ISO 4413, and of this clause.

Pneumatic systems shall meet the requirements of ISO 4414, and of this clause.

4.4.2 Hoses, pipes and fittings under pressure

Hoses meant to have an open end (e.g. air, grout and mud) shall have means to be restrained against freeing themselves when they are not in use.

If the machine is powered by an external compressor, a main line valve shall be provided on the machine.

Hydraulic fluid lines shall be routed away from high temperature components or shielding shall be provided to prevent spray in the event of rupture or leak.

4.4.3 Load holding cylinders for feeders, masts, jacks, and elevating operator stations

Hydraulic cylinders used for erection and lifting feed beams, masts, jacks, and elevating operator stations shall be fitted with load-sustaining devices which shall be self-bleeding or fitted with an air bleed point at the highest point.

Alternatively, bleeding can also be obtained by moving the piston between full stroke movements.

Load holding cylinders (e.g. mast lifting cylinders, feed cylinders) shall be fitted with a load holding device to prevent unintended movement caused by failure of an external pipe or hose [excluding those pipes indicated in c)]. The load holding device shall only release the overpressure caused by an external force or by an internal force due to, e.g. thermal expansion inside the cylinder. The setting of the internal relief-valve shall be at a pressure which does not allow movements causing unsafe conditions.

The load-holding valve shall be either:

- a) integral with the cylinder; or
- b) directly and rigidly flange-mounted; or
- c) placed close to the cylinder and connected to it by means of rigid pipes, having welded or flanged connections and being calculated in the same way as the cylinder.

4.5 Strength

4.5.1 Loads

4.5.1.1 Introduction

The loads acting on drilling equipment are categorized as regular, occasional, and exceptional. For the calculation of means of access, loads only acting locally are given in ISO 2867.

These loads shall be considered in proof against failure by uncontrolled movement, yielding, elastic instability and, where applicable, against fatigue.

4.5.1.2 Regular loads

Regular loads comprise for example the following:

- a) lifting and gravity forces acting on the mass of the drilling equipment;
- b) inertial and gravity forces acting on the lifted load;
- c) loads caused by travelling on uneven surface;
- d) loads caused by acceleration of all drives;
- e) loads induced by displacements;
- f) loads induced by drilling operation;
- g) loads induced by bolting and meshing operation;

h) loads caused by scaling.

Regular loads occur frequently under normal operation.

4.5.1.3 Occasional loads

Occasional loads comprise for example the following:

- a) loads due to in-service wind;
- b) snow and ice loads;
- c) loads due to temperature variation;
- d) loads caused by erection and dismantling.

Occasional loads occur infrequently; therefore, fatigue assessment is not mandatory.

4.5.1.4 Exceptional loads

Exceptional loads comprise for example the following:

- a) loads caused by rescue lifting or pulling under exceptional circumstances;
- b) loads due to out-of-service wind;
- c) test loads;
- d) loads caused by emergency cut-out.

Exceptional loads occur infrequently; therefore, fatigue assessment is not mandatory.

4.5.2 Structural calculations

4.5.2.1 General

The calculations shall conform to the laws and principles of applied mechanics and strength of materials. If special formulae are used, the sources shall be given, if they are generally available. Otherwise, the formulae shall be developed from first principles, so that their validity can be checked.

The individual loads shall be taken to act in the positions, directions and combinations which produce the most unfavourable conditions under all intended operating conditions. For all critical load-bearing components and joints, the required information on stresses or safety factors shall be included in calculations in a clear and easily verifiable form. If necessary, for checking the calculations, details of the main dimensions, cross-sections and materials for the individual components and joints shall be given.

The analysis shall be made for the worst-case load combinations. The calculated safety factors shall not fall below the required values. The permissible values and the required values of safety factors depend on the material, the load combination and the calculation method.

The method of calculation shall follow any one of the recognised international or national design standards, or any one of the recognised international or national design guidelines, which includes fatigue-stress calculation methods.

4.5.2.2 General stress analysis

The general stress analysis is the proof against failure by yielding or fracturing. This analysis shall be made for all load-bearing components and joints which are critical to failure. Finite element analysis (FEA) modelling may be used to meet this requirement. The FEA model shall be specified and include an explanation of the loading areas, load types, constraint areas and constraint types.

4.5.2.3 Elastic stability analysis

Elastic stability analysis is the proof against failure by elastic instability (e.g. buckling). This analysis shall be made for all critical load-bearing components subjected to compressive loads and defined as those whose failure represents a hazard to the entire structure. Any initial residual stresses and geometrical imperfections of those components shall be taken into account for analysis.

EN 1993-1-1:2005, 5.3, may be used.

4.5.2.4 Fatigue-stress analysis

Fatigue-stress analysis is the proof against failure by fatigue due to stress fluctuations. This analysis shall be made for all load-bearing components and joints which are critical to fatigue, taking into account the construction details, the degree of stress fluctuation and the number of stress cycles.

4.6 Rigid body stability

4.6.1 General

The stability of the machine shall be in accordance with this clause.

The operating conditions shall be the same described as intended use in the instruction handbook.

The rigid body stability of the whole machine shall be verified by calculation.

NOTE The centre of gravity of the machine and the stability of a given tipping line can be verified on a tilting platform.

4.6.2 Stability criteria

Machines shall be stable under the intended operating conditions, e.g. transport, tramping, travelling, parking and drilling and that there is no risk of overturning and falling. The stability shall be verified by calculation.

The calculation shall assume that the equipment is standing on firm ground. The maximum allowed operating slope, if any, shall be considered in the calculation.

The calculation is based on the algebraic sum of all moments which simultaneously occur.

The parameter assumed for assessing stability is the stability angle, representing the residual angle by which the equipment, subjected to a system of loads including dynamic ones, can be tilted before tipping over.

The stability shall be proven according to [4.6.4](#). The stability criterion is: the stability angle shall not be less than the required stability angle.

The stability angles, α , shall not be less than 10° in any directions when tramping or traveling and be not less than 5° under any other conditions.

When the machine is intended to work, tram, travel or be parked on a plane deviating from the horizontal, the verification of stability shall include the maximum allowed slope angle under the most unfavourable conditions as specified and stated in the operator's instructions. The stability angle shall meet the limits, i.e. the safety margin of 10° and 5° respectively shall be added to the specified operational slope angle.

The stability angle of 10° also includes a margin for the effects of the dynamic forces from acceleration and braking of the total machine.

These criteria are not applicable to equipment fixed to the ground, floating pontoons or a foundation. For those rigs, the moments from weights and loads shall be taken into account when calculating and designing the anchoring of the rig.

4.6.3 Tipping lines

4.6.3.1 Tipping lines for crawler machines

For crawler machines, the tipping line definition given in [Figure 1](#) shall be used.

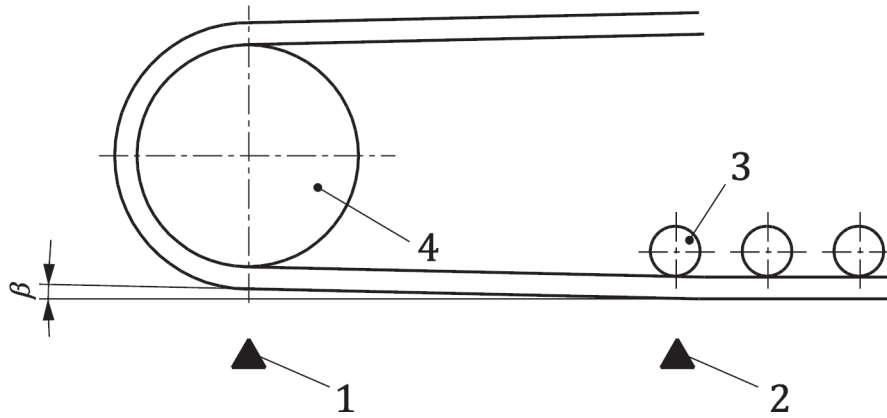


Figure 1 — Tipping lines for crawlers, partial side view

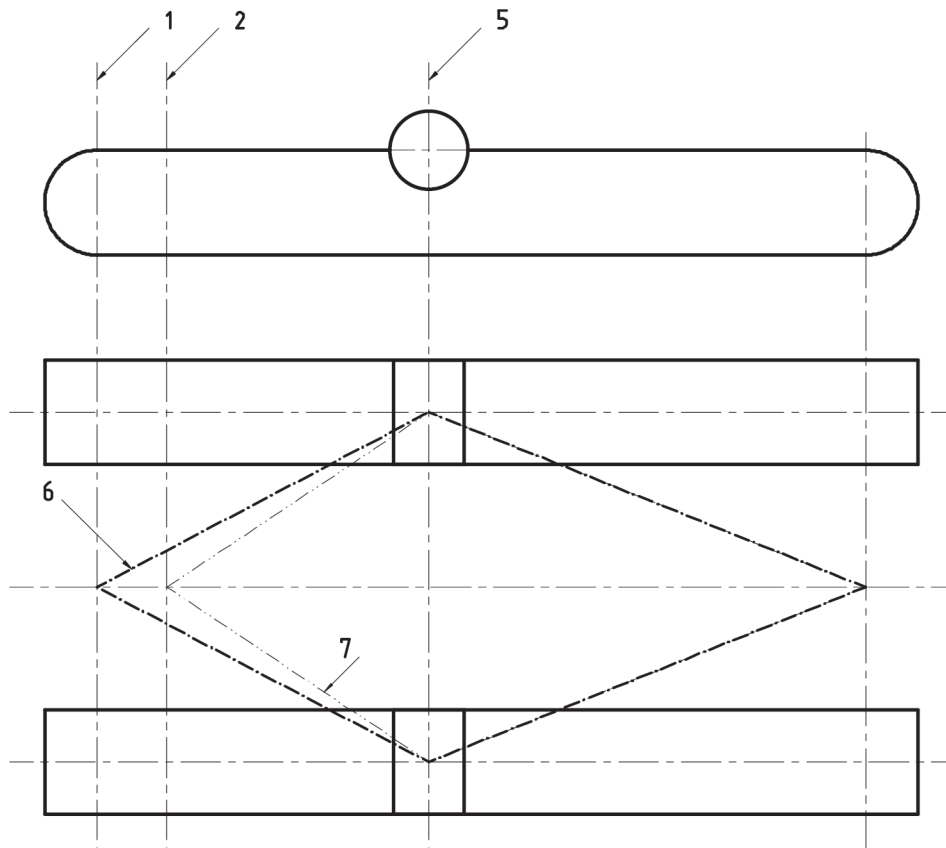


Figure 2 — Tipping lines for crawlers, top view

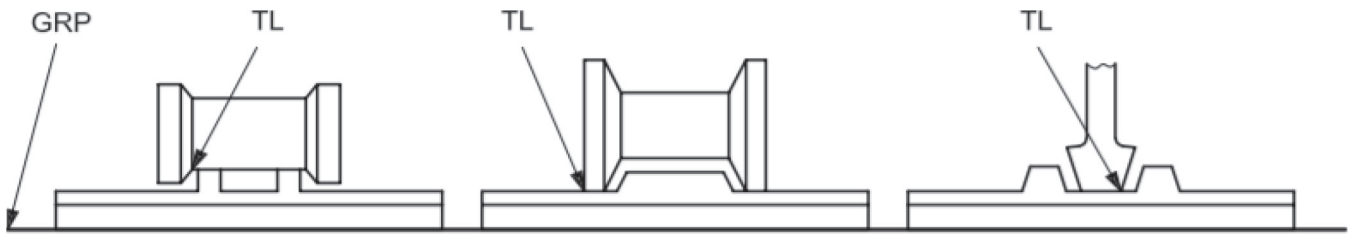


Figure 3 — Tipping lines for crawlers, front view

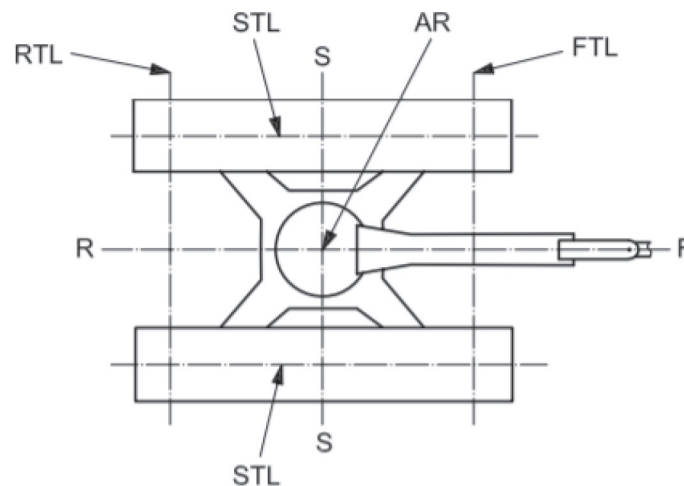
Key to figures 1 through 3

- 1 choose 1 if β is lower than or equal to 2 degrees
- 2 choose 2 if β is greater than 2 degrees
- 3 roller
- 4 drive or idler
- 5 oscillation axis
- 6 stable area if $\beta \leq 2^\circ$
- 7 stable area if $\beta > 2^\circ$
- β angle as shown in top figure
- GRP ground reference plane
- TL tipping line (located on side of machine nearest load line)

4.6.3.2 Closed oscillation

The tipping line used for closed oscillation stability calculations over the front/rear of machines with crawler undercarriage shall be a line connecting the centreline of support idlers or sprockets.

The tipping line used for closed oscillation side-tipping stability calculations on machines with crawler undercarriages shall be defined by the pivot points between support rollers and track elements (such as links or guides) as shown in Figure 1 and Figure 2.

**Key**

- F front
- R rear
- S side
- AR axis of rotation

FTL front tipping line
 RTL rear tipping line
 STL side tipping line

Figure 4 — Tipping conditions for crawler undercarriage

4.6.3.3 Open oscillation

The tipping line used for open oscillation stability calculation with crawler undercarriages shall be a line connecting a point in the oscillation axis above the left/right side tipping line and a point at an intersection of front/rear tipping line and the machine centreline as shown in [Figure 5](#).

NOTE These tipping lines apply only to a machine with a parallel oscillation cylinder connection i.e. the left track oscillation cylinder A chamber is connected to the right track oscillation cylinder A chamber.

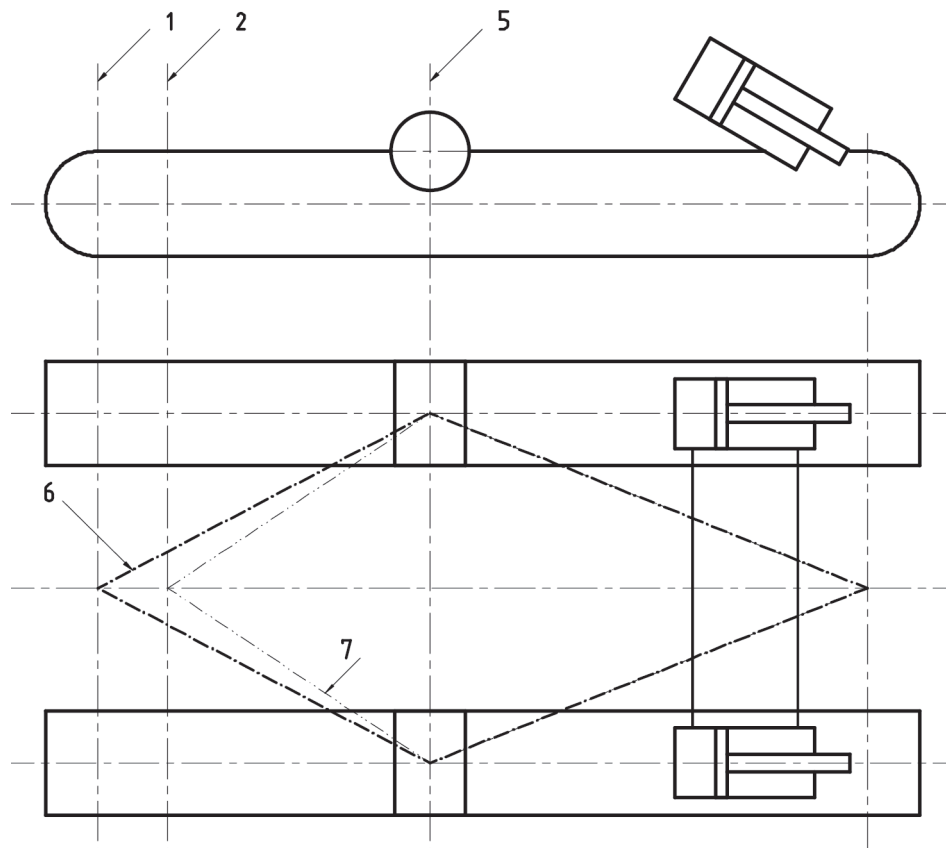


Figure 5 — Tipping lines with a parallel oscillation cylinder connection

For legend see [4.6.3.1](#) Tipping lines for crawler machines.

4.6.3.4 Tipping lines for wheel mounted carrier when tramming

An example of tipping lines for a rock drill rig with dual tires is given in ISO 22932-5.

In the case of an oscillation axle, the tipping line goes through the axis of the pivot point.

4.6.3.5 Additional support

Examples of tipping lines in case of additional support by outrigger or leader are given in ISO 22932-5.

For tipping lines of machines supported on jacks see ISO 22932-5.

4.6.3.6 System of loads

4.6.3.6.1 General

Loads acting on the equipment are external loads (pulling-pushing working loads or lifting loads), mass loads (due to gravitational, centrifugal, inertial accelerations), and surface loads (mainly due to wind).

4.6.3.6.2 Weights and moments of inertia

Weights, positions of centres of gravity and moments of inertia of single parts of the equipment, including the base machine, which have a significant effect on the stability and which are input data for the stability calculation, shall be verified by weighing as far as possible and/or by calculation.

The position of the total centre of gravity and the total weight shall be measured by testing or calculated using the centres of gravity and weights of all parts of the equipment. See also ISO 5005.

This calculation shall be made to search the most unfavourable combination of masses, their positions and configuration of the equipment.

4.6.3.6.3 Centrifugal load

For equipment with a slewing superstructure, the calculation shall consider the effect of centrifugal load which acts at the centre of gravity of the rotating masses, including the mass of superstructure and working loads.

For any working loads (e.g. swinging leader, lifted load) whose radial position is not fixed relative to the axis of rotation, its centrifugal load is considered to be applied to its suspension point on the structure.

An overspeed limiting device shall be used to limit the slewing speed to the value used for calculation.

4.6.3.6.4 Wind load

The calculation of wind load shall be made according to ISO 4302 for a wind pressure:

- for in-service load cases:
 - $p = 0,25 \text{ kPa}$ (250 N/m^2);
- for erected out-of-service:
 - $p = 0,8 \text{ kPa}$ (800 N/m^2), surfaces lower than 20 m from the ground;
 - $p = 1,1 \text{ kPa}$ ($1\,100 \text{ N/m}^2$), surfaces higher than 20 m from the ground;
 - $p = 1,65 \text{ kPa}$ ($1\,650 \text{ N/m}^2$) for offshore applications.

The direction of the wind load shall be considered as acting in the most unfavourable combination with other loads.

This clause only applies to surface machines because underground machines are not affected by wind.

4.6.3.6.5 Working loads

Other working loads that can influence the stability shall be taken into account when calculating the stability:

- the winch force between drill mast and drilling tool in the bore hole. The drill string and tool shall not be regarded as a support when only a rope is being used for pulling up the drilling tool;
- pulling or extraction load;
- pushing or feed load that may cause an overturning.

In the case of drilling down, the drill string shall not be considered as a support.

In the case of upwards drilling, it shall be checked that the available feed forces do not make the rear part of the machine lift.

The manufacturer shall give in the operator's manual the limit angle admitted for the use of service rope in inclined direction for lifting unguided parts involved in the working process. The stability calculation shall give consideration to this inclined load in the most unfavourable combination.

4.6.4 Stability calculation – Tipping angle

For each tipping line the algebraic sum of moments which simultaneously occur shall be calculated, considering the most unfavourable combination of loads, their position and equipment geometry.

The moment calculation shall be repeated for a tilted position of the equipment around the tipping line, taking into account that some loads (e.g. feed load, centrifugal and inertial loads) rotate together with the equipment, while other loads are fixed in direction (e.g. weight and wind loads, swinging loads).

The tilt angle will be increased until the sum of moments results to be nil. The final tilt angle is assumed as tipping angle relative to this tipping line.

The minimum among the tipping angles relative to all the tipping lines is the stability angle of the equipment in the considered load case and position.

All operating, tramming, travelling and erection/dismantling conditions shall be examined, according to the relevant instructions given in the instruction handbook. The stability angle for all above load cases shall be determined.

Stability angle shall be not less than the required value as specified in [4.6.2](#).

Deformations and displacements under load shall be taken into account where the design calculation or the practice show that they may significantly affect the stability of the equipment.

4.6.5 Operating conditions

4.6.5.1 General

The calculation shall consider the most unfavourable conditions which may occur at the same time, including the following conditions, as specified in the instruction handbook.

4.6.5.2 In service – during operation

Examples of generally critical conditions are:

- a) booms, service platforms and feed extension in advanced positions and turned to the limit of the working area. Moveable loads in the most unfavourable position. The rated load shall be applied to the service platform;
- b) mast at the utmost front upward position and maximum forward mast inclination;
- c) steering turned in the extreme and most unfavourable position (articulated carrier);
- d) attachments at their highest position;
- e) maximum pulling force on the rope suspended tool in the bore hole
- f) most unfavourable tipping line;
- g) for a slewing superstructure, centrifugal load due to maximum slewing speed and loads due to relevant accelerations;
- h) loads caused by adjustment to leader position;

- i) dynamic effects of raising or suddenly releasing loads;
- j) maximum extracting or pull-down load;
- k) inclined rope pull of unguided loads;
- l) wind in the most unfavourable direction.

4.6.5.3 Trimming

For trimming between working positions, parameters listed in [4.6.5.2](#) shall be considered where appropriate.

Stability in trimming shall be calculated for the conditions specified in the operator's manual, taking into account the most unfavourable case.

Possible restrictions to geometry and loads when trimming shall be defined in the instruction handbook. For example, when cornering, the boom and feed beam may be in special positions defined in the instruction handbook.

4.6.5.4 Out of service – erected leader

The calculation shall be based on the equipment weights and wind pressure in the foreseen configuration.

4.6.5.5 Out of service – lowered leader, during rigging and stowed condition during transport

The calculation shall be based on the equipment weights and wind pressure in the foreseen configuration.

4.6.5.6 Travelling and operating on slopes

Stability in travelling shall be calculated for the conditions specified in the operator's manual, taking into account the most unfavourable case.

The stability calculations shall be done for the most unfavourable combinations of gradient and load condition as specified in the operator's manual.

4.6.5.7 Machine mounted on truck or trailer

When equipment is mounted on a truck or trailer chassis, the weight distribution, the axle, and tyre loading shall be within the limits specified by the vehicle manufacturer.

Consideration should be given to the elastic effect of vehicle suspensions.

4.6.5.8 Leader support foot

Consideration shall be given to machines provided with a support foot at the base of leader (telescopic mast foot, sliding leader or similar).

NOTE If the foot is capable of lifting the front side of crawlers, thus excluding some previous support point and limiting the area surrounded by the tipping lines, an additional risk is generated. On the contrary, if the foot is not in contact with the ground (e.g. due to ground collapse), some tilt angle is allowed before the efficiency of the foot is restored.

Consideration shall be given to the fact that both cases may drastically reduce the intended effect of such device.

When the foot is in working position, it shall be designed to withstand the foreseen support reaction.

4.7 Steering

Self-propelled machines shall have a steering system.

The steering system of wheeled machines with rubber tyres shall meet the requirements of ISO 5010.

Testing on a steering test course in accordance with ISO 5010 is not required if the maximum machine speed is less than 20 km/h.

A secondary steering system is not required if the maximum machine speed is less than 20 km/h.

4.8 Carrier brakes

4.8.1 General

If the maximum machine speed is limited by design to less than 6 km/h, the requirement can be fulfilled by any of the braking systems that can bring the machine to a stop within the brake stopping distances.

Braking systems for crawler-mounted machines shall meet the requirements of ISO 10265.

Braking systems for wheel-mounted surface machines shall meet the requirements of ISO 3450.

Braking systems for wheel-mounted underground machines shall meet the requirements of ISO 3450:2011 as modified by [4.8.2](#) through 4.8.8.

4.8.2 References

This clause is following the numbering of ISO 3450:2011 as closely as possible for easy reference.

4.8.3 Symbols

M	is the maximum mass of the machine, in kg;
g	is the acceleration due to gravity, in m/s^2 ;
S	is the maximum gradient on which the machine is designed to operate, expressed as a percentage;
p	is the residual pressure as a percentage;
$p1$	is the brake application pressure during the first brake application;
$p2$	is the lowest brake application pressure measured during subsequent brake applications;
$S1$	is the stopping distance, service braking, in metres;
$S2$	is the stopping distance, secondary braking, in metres;
a	is the deceleration, in m/s^2 ;
t	is the system response time, in seconds;
v	is the initial speed, in km/h.
b	is the brake efficiency ($b=a/g$).

4.8.4 Requirements for wheel-mounted underground machines

4.8.4.1 Required brake systems

ISO 3450:2011, 4.1 and the following applies:

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.