



BSI Standards Publication

Drilling and foundation equipment — Safety

Part 1: Common requirements

National foreword

This British Standard is the UK implementation of EN 16228-1:2014+A1:2021. It supersedes BS EN 16228-1:2014, which is withdrawn.

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The UK participation in its preparation was entrusted to Technical Committee B/513/-/10, Drilling and piling machines - Safety.

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European foreword

This document (EN 16228-1:2014+A1:2021) has been prepared by Technical Committee CEN/TC 151 “Construction equipment and building material machines - Safety”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2022 and conflicting national standards shall be withdrawn at the latest by June 2022.

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

This document supersedes A1 EN 16228-1:2014 A1.

This document includes Amendment 1 approved by CEN on 22 November 2021.

The start and finish of text introduced or altered by amendment is indicated in the text by tags A1 A1.

This document has been prepared under a Standardization Request given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s) / Regulation(s).

For relationship with EU Directive(s) / Regulation(s), see informative Annex ZA, which is an integral part of this document.

This European Standard is divided into several parts and covers drilling and foundation equipment.

Part 1 contains requirements that are/may be common to all drilling and foundation equipment. Other parts contain additional requirements for specific machines that supplement or modify the requirements of part 1. Compliance with the clauses of part 1 together with those of a relevant specific part of this standard giving requirements for a particular machine provides one means of conforming with the essential health and safety requirements of the Directive concerned.

When a relevant specific part does not exist, part 1 can help to establish the requirements for the machine, but will not by itself provide a means of conforming to the relevant essential health and safety requirements of the Directive.

This European Standard, EN 16228, *Drilling and foundation equipment – Safety*, consists of the following parts:

- *Part 1: Common requirements*
- A1 *Part 2: Mobile drill rigs for civil and geotechnical engineering in soil or soil and rock mixture* A1
- *Part 3: Horizontal directional drilling equipment (HDD)*
- *Part 4: Foundation equipment*
- *Part 5: Diaphragm walling equipment*
- *Part 6: Jetting, grouting and injection equipment*

— *Part 7: Interchangeable auxiliary equipment*

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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

Introduction

This European Standard is a type C standard as stated in EN ISO 12100.

The machinery concerned and the extent to which hazards are covered are indicated in the scope of this standard.

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

1 Scope

This European Standard specifies the common safety requirements for drilling and foundation equipment.

Part 1 of this European Standard deals with the significant hazards common to drilling and foundation equipment (see Annex A), when they are used as intended and under the conditions of misuse which are reasonably foreseeable by the manufacturer associated with the whole life time of the machine (transport, assembly, dismantling, equipment in service and out of service, maintenance, moving on site, storage, disabling and scrapping).

NOTE 1 The requirements specified in this part of the standard are common to two or more families of drilling and foundation equipment.

This document gives safety requirements for all types of drilling and foundation equipment and is intended to be used in conjunction with one of parts 2 to 7. These machine specific parts do not repeat the requirements from part 1 but supplement or modify the requirements for the type of drilling and foundation equipment in question.

For multipurpose machinery, the parts of the standard that cover the specific functions and applications are used, e.g. a drilling machine also used as a piling machine will use the relevant requirements of EN 16228-1, EN 16228-2, and EN 16228-4.

The following machines are excluded from the scope of this standard:

- tunnelling machines, unshielded tunnel boring machines and rodless shaft boring machines for rock according to [A1](#) EN 16191 [A1](#);
- raise boring machines;
- drill rigs used in oil and gas industry [A1](#) ;
- specialized mining machinery and equipment for opencast mining (e.g. rock drill rigs, blast hole drills) (under the scope of CEN/TC 196);
- all underground mining machinery and equipment for the extraction of solid mineral substances (e.g. rock drill rigs, raise boring machines, shaft boring machines, mining auger boring machines, jumbos) as well as machinery and equipment for underground mine development (under the scope of CEN/TC 196);
- core drilling machines on stand (covered by EN 12348);
- hand-held machines (in particular machines covered by ISO 11148-5). [A1](#)

NOTE 2 Specific requirements for offshore applications are not covered by this European Standard.

Where a drilling or foundation equipment of fixed configuration that is not intended to be separated is assembled using a carrier based on earth-moving equipment, agricultural equipment, or a crane, then the completed assembly is [A1](#) covered by this [A1](#) standard.

Drilling and foundation equipment within the scope of EN 16228 parts 1 to 6 may include interchangeable auxiliary equipment within the scope of EN 16228-7, either as an integral part of its construction or as interchangeably fitted equipment.

[A1](#) If drilling and foundation equipment is intended to be used in a potentially explosive atmosphere, or in case of lightning risk, additional requirements will need to be met which are not covered by this document.

This document is not applicable to drilling and foundation equipment manufactured before the date of its publication. ^{A1}

2 Normative references

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

EN 474-1:2006+A4:2013, *Earth-moving machinery — Safety — Part 1: General requirements*

EN 474-5:2006+A3:2013, *Earth-moving machinery — Safety — Part 5: Requirements for hydraulic excavators*

^{A1} EN 614-1:2006+A1:2009, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles* ^{A1}

^{A1} EN 795:2016 ^{A1}, *Personal fall protection equipment — Anchor devices*

^{A1} *deleted text* ^{A1}

EN 1037:1995+A1:2008, *Safety of machinery — Prevention of unexpected start-up*

^{A1} *deleted text* ^{A1}

EN 13411-6:2004+A1:2008, *Terminations for steel wire ropes — Safety — Part 6: Asymmetric wedge socket*

EN 13411-7:2006+A1:2008, *Terminations for steel wire ropes — Safety — Part 7: Symmetric wedge socket*

^{A1} *deleted text* ^{A1}

^{A1} EN 13531:2001+A1:2008, *Earth-moving machinery — Tip-over protection structure (TOPS) for compact excavators — Laboratory tests and performance requirements (ISO 12117:1997, modified)* ^{A1}

^{A1} EN 60204-1:2018, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2016, modified)* ^{A1}

EN ISO 2860:2008, *Earth-moving machinery — Minimum access dimensions (ISO 2860:1992)*

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

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

EN ISO 3449:2008, *Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements (ISO 3449:2005)*

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

EN ISO 3457:2008, *Earth-moving machinery — Guards — Definitions and requirements (ISO 3457:2003)*

^{A1} EN ISO 3471:2008, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements (ISO 3741:2008)* ^{A1}

EN ISO 3744:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane (ISO 3744:2010)*

EN ISO 3747:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use in situ in a reverberant environment (ISO 3747:2010)*

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

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

EN ISO 4871:2009, *Acoustics — Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)*

EN ISO 6682:2008, *Earth-moving machinery — Zones of comfort and reach for controls (ISO 6682:1986, including Amd 1:1989)*

A1 deleted text **A1**

EN ISO 7096:2008, *Earth-moving machinery — Laboratory evaluation of operator seat vibration (ISO 7096:2000)*

EN ISO 9614-2:1996, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning (ISO 9614-2:1996)*

EN 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 11201:2010)*

EN ISO 11203:2009, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level (ISO 11203:1995)*

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

EN ISO 13732-1:2008, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces (ISO 13732-1:2006)*

A1 EN 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 13766-1:2018)*

EN 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 13766-2:2018)*

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

EN ISO 13850:2015, *Safety of machinery — Emergency stop function — Principles for design (ISO 13850:2015)*

EN ISO 13855:2010, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body (ISO 13855:2010)* 

EN ISO 13856-1:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors (ISO 13856-1:2013)*

EN ISO 13856-2:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars (ISO 13856-2:2013)*

EN ISO 13856-3:2013, *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 13856-3:2013)*

 EN ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2019)* 

 deleted text 

 EN ISO 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards (ISO 14120:2015)* 

EN ISO 14122-4:2010, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2004)*¹⁾

 EN IEC 61000-6-2:2019, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity standard for industrial environments (IEC 61000-6-2:2016)*

EN IEC 61000-6-4:2019, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Immunity standard for industrial environments (IEC 61000-6-4:2018)*

EN IEC 61496-1:2020, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests (IEC 61496-1:2020)* 

ISO 2631-1:1997, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*²⁾

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

ISO 4302:1981, *Cranes — Wind load assessment*

ISO 4309:2010, *Cranes — Wire ropes — Care and maintenance, inspection and discard*

ISO 5006:2006, *Earth-moving machinery — Operator's field of view — Test method and performance criteria*

 deleted text 

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

¹⁾ This document is impacted by stand-alone Amendment 1 published in 2010.

²⁾ This document is impacted by stand-alone Amendment 1 published in 2010.

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

ISO 7000:2012, *Graphical symbols for use on equipment — Registered symbols*

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

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

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

ISO 10567:2007, *Earth-moving machinery — Hydraulic excavators — Lift capacity*

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

 ISO 10968:2020 , *Earth-moving machinery — Operator's controls*

ISO 12117-2:2008, *Earth-moving machinery — Laboratory tests and performance requirements for protective structures of excavators — Part 2: Roll-over protective structures (ROPS) for excavators of over 6 t*

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

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* 

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN ISO 12100:2010 and the following apply.

3.1

drilling and foundation equipment

integrated machine, interchangeable equipment and machine equipped with interchangeable equipment designed for one or more of the following applications:

- preparing holes into soil and rock, for construction, exploration, water wells, soil investigation, or
- preparing, installing or retracting of longitudinal elements for foundations, retaining-walls, slurry-walls, soil improvement, or
- preparing and installing contiguous panels for retaining-walls and cut-off walls, or
- installing elements for ground improvement as drainage or injection, or
- installing elements for soil or rock nailing

Note 1 to entry: If drilling and foundation equipment will be used for different applications, it may consist of an assembly of machines and components (see Annex A and EN 16228 parts 2 to 7).

3.2**drill rig**

machine for drilling in soil or rock utilising either percussive, rotary or vibration principles (or a combination of principles) which may involve the addition of drill rods, tubes, casings or augers etc, normally threaded, as the hole extends

3.3**percussive drill rig**

drill rig using percussive drilling methods

3.4**non-percussive drill rig**

drill rig using non-percussive drilling methods

3.5**carrier machine**

machine providing mobility for and supporting the weight of the drilling and foundation equipment, together with the accessories and the load (e.g. pile, excavated soil)

Note 1 to entry: The carrier is part of the drilling and foundation equipment in integrated machines.

Note 2 to entry: A carrier machine may also accommodate the necessary power source and controls of the drilling and foundation equipment. Apart from stationary carrier machines, wheel, crawler or rail mounted, together with fixed or movable floating carrier machines can be considered.

3.6**horizontal directional drilling****HDD**

steerable system for the installation of pipes, conduits and cables in shallow arc using a surface or pit launched drilling rig

Note 1 to entry: Traditionally the term applies to large scale crossings in which a fluid filled pilot bore is drilled by rotating the drill string and this is then enlarged by a wash-over pipe and back reamer to the size required for the product pipe.

3.7**piling rig**

carrier machine complete with leader attachment and leader but without pile installation and other equipment

3.8**piling equipment**

assembly of machines and components used for installation or extraction of pile elements

3.9**diaphragm walling rig**

carrier machine and cutting tools to cut panels for diaphragm walls

3.10**jetting, grouting and injection equipment**

machine for mixing, pumping or injecting grout, cement, concrete and drilling fluids

3.11

interchangeable auxiliary equipment

separate equipment that can be attached to a carrier machine to allow it to be used for drilling and foundation operations

3.12

kelly bar

transmission part constituted with a specific steel bar or tube designed for transferring torques and forces onto the drilling tool

Note 1 to entry: A kelly bar may be telescopic with an interlockable function. Tools are attached to the lower end of the Kelly.

3.13

mast/leader

structure mounted to the carrier machine guiding the installation and extracting equipment

3.14

boom

structure for positioning of the mast, leader, feed beam or working platform or directly supporting an excavating tool

3.15

working platform for lifting personnel

platform used for raising or lowering personnel and materials, independently guided by the mast/leader to enable operational work or maintenance to be carried out

3.16

movable platform

platform attached to leader guided parts of drilling and foundation equipment, e.g. drill head, to enable operational work or maintenance to be carried out

Note 1 to entry: The platform can be a temporary or permanent attachment.

Note 2 to entry: Persons may enter and stay on the platform only when it is stationary.

3.17

assistant

person who assists with the drilling or foundation operation but is not responsible for control of the drilling or foundation equipment



Note 1 to entry: The assistant could be exposed to moving parts involved in the drilling process without having the control on the said moving parts. 

3.18

driver (for transport movement)

person controlling and moving drilling and foundation equipment while operating

3.19

operator

person controlling the drilling and foundation equipment while operating

Note 1 to entry: The operator may also be the driver of the rig.



Note 2 to entry: The operator can also be the maintenance technician of the rig.

3.20

user

person or company who brings the drilling and foundation equipment into operation for the application of drilling and foundation techniques

deleted text

3.21

working area

area near a machine in which its tools are moved in order to carry out work

3.22

danger zone

any zone within and/or around drilling and foundation equipment in which a person is exposed to risk of injury or damage to health

Note 1 to entry: For drilling and foundation equipment this means the area in which a person can be reached by an operational movement of the drilling and foundation equipment, by any part involved in the process by swinging or falling parts, pile elements and evacuated spoil or by ejected material.

3.23

pile element

foundation element installed in the soil made of concrete (precast or cast in situ), steel (tubes, beams or sheet piles), wood or plastic material

Note 1 to entry: Piles may have an interlocking feature to enable adjacent elements to be joined together.

3.24

hook load

actual load carried by the hook of the bottom block, including the weight of the bottom block and of the running ropes

3.25

rope/chain safety factor

ratio between the guaranteed minimum breaking and maximum pulling load

3.26

slewing

rotation of the upper structure of drilling and foundation equipment in relation to a fixed reference frame on the ground

3.27

stability angle

minimum among tipping angles relative to all tipping lines within a load case and position, to be found for all load cases, positions and all foreseen combinations of loads

3.28

required stability angle

minimum required value for stability angle (α_{SR})

Note 1 to entry: Different values may be required for different load cases (e.g. travelling, working) and types of machine.

3.29

tipping angle

angle a machine can be tilted before it becomes unstable while the machine is subjected to a system of loads (own weight, wind, accelerations, working loads)

Note 1 to entry: In case travelling and operating on slopes is allowed, tilting starts from the maximum allowed operating slope.

3.30

tipping line

line about which drilling and foundation equipment on various mountings may tip and which are used to calculate the stability

Note 1 to entry: Tipping lines for drilling and foundation equipment, crawler and wheel mounted:

- a) in the direction of travel, the lines connecting the lowest support points of contact of the idlers, rollers or the drives of the tracks or the front wheels;
- b) in sideward direction (perpendicular to the direction of travel), the lines passing through the centres of the support contact areas on each side of the chassis.

Tipping lines for drilling and foundation equipment on support legs:

- c) the lines passing through the outer edges of the support contact areas on each side of the chassis.

3.31

tramming

moving of drilling and foundation equipment in operating condition on site

3.32

travelling

moving of drilling and foundation equipment in non-operating condition specified by the manufacturer

3.33

vibration drilling ("resonance" or "sonic" drilling)

method with or without rotation by which the hole is formed by transmission of high frequency continuous compression waves through the drill rods which fluidise the ground immediately adjacent to the drill bit

3.34

percussive drilling

method by which the hole is produced by crushing the ground or rock at the bottom of the drill-hole by striking it with the drilling tool and removing the cuttings out of the borehole

3.35

rotary drilling

method in which the drilling tool at the bottom of the borehole is rotated and at the same time, a feed force is applied by a feed system or drill collar

Note 1 to entry: The ground or rock at the bottom of the borehole is crushed or cut by pressure, shear or tensile stress produced by the different drilling tools. The cuttings are periodically or continuously removed out of the bore hole.

3.36**rotary percussive drilling**

method in which a piston striking directly on the bit (down the hole hammer drills) or by percussive energy transmitted via a drill string to the bit is used

Note 1 to entry: The piston is typically powered by either hydraulic fluid or compressed air. At the same time the drill bit is rotated either continuously or intermittently.

Note 2 to entry: The cuttings can be continuously removed out of the borehole by a flushing medium, which is carried to the drilling tool.

3.37**stabiliser**

device and system used to stabilise the machine by supporting and/or levelling of the complete structure

Note 1 to entry: E.g. jacks, suspension locking devices, extending axles.

3.38**line pull**

pulling force to the rope by the winch at the outer diameter of the drum/outer layer of the rope

** 3.39****geometric protection zone**

volume within which, in case of a rolling-over or tilting-over of the rig, the cabin is located to be safe from major deformations

Note 1 to entry: Figure 5 (subclause 5.14.1) illustrates geometric protection zone.

3.40**supplementary trip device**

sensitive protective equipment intended to detect the touch of a person or body part of a person (mechanically or electro sensitive activated trip) and which can also act as impeding device

Note 1 to entry: This device is aimed at reducing severity of the accident, in addition to the other protective devices intended to reduce the occurrences of accidents.

3.41**clamp**

mechanical gripping device 

4 List of significant hazards

This clause contains hazards (hazardous situations and events) dealt with in this standard, identified by risk assessments as significant for this type of machinery and which require action to eliminate or reduce risk.

Cross references from hazards are given to the clauses that specify the action that needs to be taken to reduce the risk.

Hazards generally occur under the following conditions:

- in transportation to and from the work site;
- in rigging and dismantling on the work site;

- in service on the work site;
- when moving on the work site;
- out of service on the work site;
- in storage at the plant depot or on the work site;
- during maintenance.

Table 1 — List of significant hazards and associated requirements

No.	Hazard	Relevant clause(s) in this document
1	Mechanical hazards	
1.1	Generated by machine parts or work pieces, e.g. by:	
1.1.1	Shape	5.11, 5.12, 5.14, 5.22
1.1.2	Mass and stability	5.2.1, 5.2.3, 5.10.1, 5.10.2, Annex F
1.1.3	Mass and velocity	5.2.1, 5.2.3.4
1.1.4	Inadequacy of mechanical strength	5.2.2
1.2	Accumulation of energy inside the machinery, e.g. by:	
1.2.1	Fluids under pressure	5.4.1, 5.4.2, 5.4.3, 7.3.2
1.2.2	Live parts under voltage	5.3, 5.21, 7.3.2
1.3	Elementary forms of mechanical hazards	
1.3.1	Crushing	5.7, 5.8, 5.9, 5.12, 5.23, 7.2.2, 7.2.3
1.3.2	Shearing	5.7, 5.8, 5.9, 5.12, 5.23, 7.2.2, 7.2.3
1.3.3	Cutting or severing	5.8, 5.9, 5.12, 5.23, 7.2.2, 7.2.3
1.3.4	Entanglement hazard	5.9, 5.23
1.3.5	Drawing-in or trapping hazard moving transmission parts	5.23 5.23.3
1.3.6	Stabbing or puncture hazard	5.20
1.3.7	High pressure fluid injection or ejection hazard	5.4.1, 5.4.3
2	Electrical hazards due to:	
2.1	Contact of persons with live parts (direct contact)	5.3.1
2.2	Contact of persons with parts which have become live under faulty conditions (indirect contact)	5.3.1
2.3	Approach to live parts under high voltage	5.3.1

No.	Hazard	Relevant clause(s) in this document
2.4	Thermal radiation or other phenomena such as the projection of molten particles and chemical effects from short-circuits, overloads, etc.	5.3.2
3	Thermal hazards, resulting in:	
3.1	Burns and scalds, by possible contact of persons with objects or materials with an extreme temperature, by flames, by radiation, etc.	5.22
3.2	Hot or cold working environment	5.14.1
4	Hazards generated by noise, resulting in:	
4.1	Hearing losses and physiological disorders	5.14.1, 5.27, Annex B
4.2	Accidents due to interference with speech communication and warning signals	5.27, Annex B
5	Hazards generated by vibration	
5.1	Whole-body vibration, particularly when combined with poor postures	5.14.1, 5.27.3, Annex C
6	Processed materials and substances, used materials, fuels	
6.1	Hazards from contact with harmful fluids, gases, mists, fumes and dusts	5.3.2, 5.14, 5.28
6.2	Fire or explosion hazard	5.3.2, 5.26
7	Neglected ergonomic principles in machine design e.g. hazards from:	
7.1	Unhealthy postures or excessive efforts	5.11, 5.14.1
7.2	Inadequate consideration of hand-arm or foot-leg anatomy	5.14
7.3	Neglected use of personal protection equipment	5.11, 5.13, 5.14
7.4	Inadequate local lighting	5.25
7.5	Mental overload or underload, stress	5.11, 5.14.1
7.6	Human errors, human behaviour	5.11, 5.14.1
7.7	Inadequate design, location or identification of manual controls	5.11, 5.14.1
7.8	Inadequate design or location of visual display units	5.11, 5.14.1
8	Combination of hazards	5.18, 5.23.2.2, 5.23.5, 5.23.6, 5.29, 7.2.2
9	Unexpected start-up, unexpected overrun/overspeed (or any similar malfunction) from:	
9.1	Failure/disorder of control system	5.15, 5.17, 5.18
9.2	Restoration of energy supply after an interruption	5.5, 5.15

No.	Hazard	Relevant clause(s) in this document
9.3	External influences on electrical equipment	5.3.1
9.4	Other external influences (gravity, wind, etc.)	5.2
9.5	Errors in the software	5.15
9.6	Errors made by the operator (due to mismatch of machinery with human characteristics and abilities)	5.14.1
9.7	Electromagnetic disturbances	5.3.3
10	Impossibility of stopping the device in the best possible conditions	5.5, 5.6, 5.15
10.1	Control that can accidentally initiate dangerous movements	5.15.4, 5.16, 5.17, 5.18
11	Failure of the power supply	5.5, 5.6
12	Failure of the control circuit	5.15
13	Errors of fitting	5.9, 7.3
14	Break-up during operation	5.2, 7.3
15	Falling or ejected object or fluid	5.4.3, 5.14.1, 5.24
16	Loss of stability/overturning of machinery	5.2.3
17	Slip, trip and falling of persons (related to machinery)	5.12
18	Electromagnetic radiation	5.3.3
Additional hazards, hazardous situations and hazardous events due to mobility		
19	Relating to the travelling function	
19.1	Uncontrolled movement of machine when starting the engine	5.6
19.2	Movement without an operator at the driving position	5.15, 5.16.1
19.3	Insufficient ability of machinery to be slowed down, stopped and immobilised	5.6, 5.7
20	Linked to the work position (including driving station) on the machine	
20.1	Fall of persons during access to (or at/from) the work position	5.12
20.2	Exhaust gases/lack of oxygen at the work position	5.14.1, 5.28
20.3	Fire (flammability of the cab, lack of extinguishing means)	5.26
20.4	Mechanical hazards at the work position contact with the wheels/crawlers; fall of objects, penetration by object.	5.14.1, 5.23 5.24
20.5	Insufficient visibility from the working position	5.14.2
20.6	Inadequate lighting	5.25

No.	Hazard	Relevant clause(s) in this document
20.7	Inadequate seating	5.14.1
20.8	Noise at the driving position	5.14.1, 5.27.2, Annex B
20.9	Vibration at the driving position	5.14.1, 5.27.3, Annex C
20.10	Insufficient means of evacuation/emergency exit	5.14.1
21	Due to the control system	
21.1	Inadequate location of controls/control devices	5.16
21.2	Inadequate design of the actuation mode and/or action mode of controls	5.15, 5.16
22	From handling the machine (lack of stability)	5.2, 5.19, 7.3
23	Due to the power source and to the transmission of power	
23.1	Hazards from the engine and the batteries	5.3.2, 5.15, 5.23.3
23.2	Hazards from coupling and towing	5.19
24	From/to third persons	
24.1	Unauthorized start	5.13.3, 5.15.3
24.2	Drift of a part, away from its stopping position	5.4.1, 5.5, 5.6, 5.7, 5.8
24.3	Lack or inadequacy of visual or acoustic warning means	5.30
25	Insufficient instructions for the driver/operator	7.3.2
Additional hazards, hazardous situations and hazardous events due to lifting		
26	Mechanical hazards and events	
26.1	From load falls, collision, machine tipping caused by:	
26.1.1	Lack of stability	5.2.3, 5.8.2, 5.10, 7.3.2
26.1.2	Uncontrolled loading; overloading; overturning moment exceeded	5.6, 5.8.2, 5.9, 5.10, 7.3.2
26.1.3	Uncontrolled amplitude of movements	5.5, 5.6, 5.8.2, 5.10, 7.3.2
26.1.4	Unexpected/unintended movement of loads	5.5, 5.6, 5.8.2, 7.3.2
26.1.5	Inadequate holding devices/accessories	5.8.2, 5.9, 7.3.2, 7.3.3
26.1.6	Collision of more than one machine	5.7
26.2	From access of persons to load support	7.3.2
26.3	From insufficient mechanical strength of parts	5.2, 5.9
26.4	From inadequate design of pulleys, drums	5.8.2, 5.8.3
26.5	From inadequate selection/integration into the machine of chains, ropes, lifting accessories	5.8.3, 5.8.4, 5.8.5, Annex E
26.6	From lowering of the load by friction brake	5.8.2

No.	Hazard	Relevant clause(s) in this document
26.7	From abnormal conditions of assembly/testing/use/maintenance	6.1, 6.2, 7.3.3
26.8	Load-person interference (impact by load)	7.3.2
27	Electrical hazards	5.3, 5.5
28	Hazards generated by neglecting ergonomic principles	
28.1	Insufficient visibility from the driving position	5.14.2
Additional hazards, hazardous situations and hazardous events due to lifting of persons		
29	Mechanical hazards and hazardous events due to:	
29.1	Inadequate working coefficients	5.13.2, 5.13.3
29.2	Failing of load control	5.8.2, 5.13.2
29.3	Failing of controls at working platform for lifting personnel (function, priority)	5.13.2
29.4	Overspeed of working platform for lifting personnel	5.13.2
30	Falling of person from the working platform for lifting personnel	5.13.2
31	From derailment of the working platform for lifting personnel	5.13.2

A1

5 Safety requirements and/or protective measures

5.1 General

Drilling and foundation equipment shall comply with the safety requirements and/or protective measures of this clause. In addition, the drilling and foundation equipment shall be designed according to the principles of EN ISO 12100:2010 for relevant but not significant hazards, which are not dealt with by this document.

5.2 Requirements for strength and stability

5.2.1 Loads

5.2.1.1 Introduction

The loads acting on drilling and foundation equipment are divided into the categories of regular, occasional and exceptional as given in 5.2.1.2, 5.2.1.3 and 5.2.1.4. For the calculation of means of access, loads only acting locally are given in EN ISO 2867:2011.

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

5.2.1.2 Regular loads

Regular loads comprise for example the following:

- a) lifting and gravity effects acting on the mass of the drilling and foundation equipment;

- b) inertial and gravity effects 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 and foundation operation.

Regular loads occur frequently under normal operation.

5.2.1.3 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.

5.2.1.4 Exceptional loads

Exception 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.

5.2.2 Structural calculations

5.2.2.1 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.

5.2.2.2 Calculation methods

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

For example the EN 13001 series may be used.

The elastic deformations of slender components and geometrical non-linear effects shall be taken into account when necessary for accomplishing a safe and suitable structure.

EN 1993-1-1:2005, 5.2, may be used.

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

5.2.2.3 Analysis

5.2.2.3.1 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.

5.2.2.3.2 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.

5.2.2.3.3 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.

5.2.3 Rigid body stability

5.2.3.1 General

This subclause contains requirements for the calculation of stability of drilling and foundation equipment.

Drilling and foundation equipment shall be so designed and constructed that it is sufficiently stable under the intended operating conditions, e.g. transport, rigging, tramping, parking and working, and that there is no risk of overturning.

The above mentioned operating conditions shall be the same described as intended use in the operator's manual.

Foreseeable misuse shall also be taken into consideration.

The rigid body stability shall be verified by calculation.

5.2.3.2 Stability criteria

The following stability criteria and calculations refer to mobile and stationary equipment:

- a) 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.
- b) The calculation is based on the algebraic sum of all moments which simultaneously occur (see 5.2.3.4).
- c) 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.
- d) The stability shall be proven according to 5.2.3.5. The stability criterion is: the stability angle shall not be less than the required stability angle.
- e) As an alternative to indent c) and d): for rigging and de-rigging calculations, the stabilising moments of parts behind the tipping line shall exceed the tipping moments of parts in front of the tipping line by at least 10 %.
- f) Calculation of ground pressure shall be in accordance with 5.2.3.7.

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.

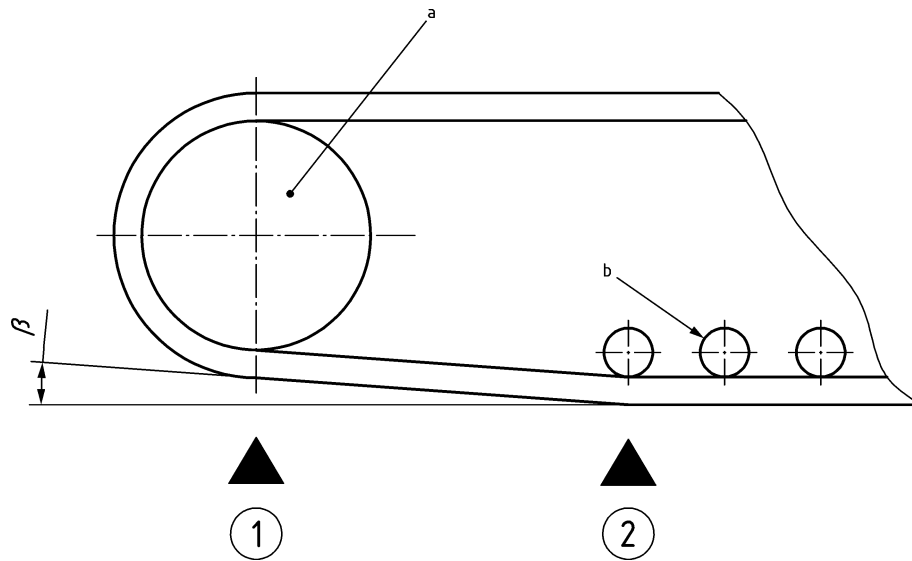
5.2.3.3 Tipping lines

5.2.3.3.1 General

Tipping lines shall be taken from ISO 10567:2007, 4.1.3 and 4.1.4.

5.2.3.3.2 Tipping lines for crawler machines

For crawler machines the tipping line definition given in Figure 1 shall be used.



Key

a drive or idler

b roller

Choose 1 if β is lower than or equal to 2°

Choose 2 if β is more than 2°

Figure 1 — Tipping line for tipping in direction of travel

5.2.3.3.3 Additional support

Examples of tipping lines in case of additional support by outrigger or leader are given in Figure 2:

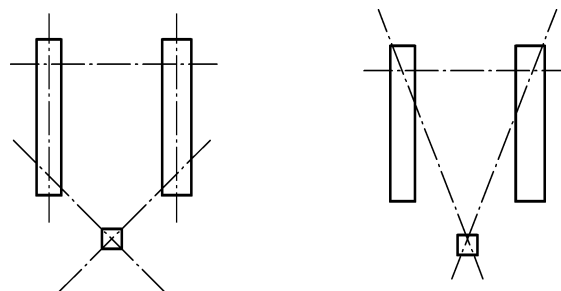


Figure 2 — Tipping lines

5.2.3.4 System of loads

5.2.3.4.1 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).

5.2.3.4.2 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.

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

5.2.3.4.3 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.

5.2.3.4.4 Wind load

The calculation shall be made according to ISO 4302:1981 for a wind pressure

— for in-service load cases:

$$p = 0,25 \text{ kPa (250 N/m}^2\text{);}$$

— for erected out-of-service:

$$p = 0,8 \text{ kPa (800 N/m}^2\text{), surfaces lower than 20 m from the ground;}$$

$$p = 1,1 \text{ kPa (1100 N/m}^2\text{), surfaces higher than 20 m from the ground;}$$

$$p = 1,65 \text{ kPa (1650 N/m}^2\text{) for offshore applications.}$$

Ⓐ — for all other operating conditions:

$$p = 0,25 \text{ kPa (250 N / m}^2\text{)}$$

Ⓐ

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

5.2.3.4.5 Dynamic loads

The effect of dynamic loads which are caused by movement of the equipment or suddenly released loads shall also be considered.

Examples are: accelerations of lifted load, travel accelerations, slewing accelerations, adjustment of leader position, etc.

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

The dynamic effect of sudden release of suspended load is an upward load Ⓐ that shall be calculated considering the application and the structure of the equipment Ⓐ such as drop hammer, diesel hammer ram, chisel, hammer grab, rope grab, etc. Ⓐ or on the basis of a default value of 30 % of the released mass. Ⓐ

When available, measured accelerations/deceleration values shall be used for the calculation.

Such measurement shall be made by operating the controls in the most abrupt way in order to define the highest real acceleration/deceleration, both when starting and when stopping the movement to/from the maximum speed.

In the absence of measured values of acceleration/deceleration, approximate values (a_{appr} , $\dot{\omega}_{\text{appr}}$) may be used in the calculations.

a_{appr} and $\dot{\omega}_{\text{appr}}$ are obtained as follows:

$$a_{\text{appr}} = \frac{k \cdot v_{\text{max}}^2}{(2 \cdot \Delta s)} = \frac{k \cdot v_{\text{max}}}{\Delta t}$$

where

v_{max} is the max speed of the movement;

Δs is the measured distance (starting/braking distance) required for acceleration to/deceleration from v_{max} ;

Δt is the minimum between starting and stopping time;

$\boxed{A1}$ k is an amplification factor. $\boxed{A1}$

$$\dot{\omega}_{\text{appr}} = \frac{k \cdot \varpi_{\text{max}}^2}{(2 \cdot \Delta \theta)} = \frac{k \cdot \varpi_{\text{max}}}{\Delta t}$$

where

ω_{max} is the max speed of the angular movement;

$\Delta \theta$ is the measured angle in radians required for acceleration to / deceleration from ω_{max} ;

Δt is the minimum between starting and stopping time;

k is an amplification factor.

The following values of k shall be applied:

- $k = 1$ for centrifugal forces;
- $1 \leq k \leq 1,5$ for movements with no backlash or in cases where existing backlash does not affect the dynamic forces and with smooth change of forces;
- $1,5 \leq k \leq 2$ for movements with no backlash or in cases where existing backlash does not affect the dynamic forces and with sudden change of forces;
- $k = 3$ for movements with considerable backlash, if not estimated more accurate by using a spring-mass-model.

Finally, in the absence of both direct (a_{test} , $\dot{\omega}_{\text{test}}$) and indirect (Δs , $\Delta \theta$, Δt) measurements, default acceleration/deceleration values may be used. These values are listed in Table 2 hereafter.

The manufacturer ensures that these values are not exceeded.

Table 2 also provides a summary of the methods explained above.

Table 2 — Values for acceleration/deceleration

MOVEMENT		ACCELERATION/DECELERATION		
		Method 1 by direct measurement	Method 2 by approximation	Method 3 by default values
Load lifting		a_{test}	a_{appr}	1 m/s ²
Travel	crawler mounted – hydraulic traction drive	a_{test}	a_{appr}	0,4 m/s ²
	crawler mounted – mechanical traction drive	a_{test}	a_{appr}	0,6 m/s ²
	wheel mounted	a_{test}	a_{appr}	2,5 m/s ²
Slewing	hydraulic drive	ω_{test}	ω_{appr}	0,25 rad/s ²
	mechanical drive	ω_{test}	ω_{appr}	0,35 rad/s ²
Adjustment of leader		a_{test}	a_{appr}	0,6 m/s ² at the outermost part of the leader

5.2.3.4.6 Horizontal load from unguided lifted load

The design shall take account of horizontal loads arising from the lifting of items on the hoist in a non-vertical manner. The manufacturer shall give in the operator's manual the limit admitted in the pulling of the rope in inclined direction for lifting unguided parts involved in the working process.

Although lifting may be foreseen vertically only, in practice it cannot be prevented that under normal operating circumstances some rope pulling on the slant occurs. In this case the effect of this slanting rope pull is taken into account by a horizontal load as follows.

for $L \leq 10$ t: $0,1 \cdot L \cdot g$ kN

for $L > 10$ t: $(5 + 0,05 \cdot L \cdot g)$ kN

with a maximum of 50 kN,

where

- L is the hoisted load, in t
- g is the gravitational acceleration, to be put at 10 m/s^2

The direction of this load shall be chosen in such a way that the overturning moments are as unfavourable as possible.

It is not necessary to consider a combination of this horizontal load and slewing.

NOTE Already at an angle between the hoisting cable and the vertical axis of only 6° , the horizontal component of the rope pull is equal to 0,1 of the vertical component.

The horizontal load is considered to be applied to its suspension point on the structure.

5.2.3.4.7 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 a backward overturning. A1 The maximum permissible values shall be given in the operator's manual, see 7.3.2.2.3. A1

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 drill rig 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.

5.2.3.5 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, travelling and erection/dismantling conditions shall be examined, according to the relevant instructions given in the operator's manual. The stability angle for all above load cases shall be determined.

Stability angle shall be not less than the required value as specified in parts 2 to 7 of this standard (EN 16228).

These parts may prescribe calculations relating to specific situations.

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.

NOTE Figure 3 is a schematic explanation of the method used for the stability calculation (see also 5.2.3.6.6).

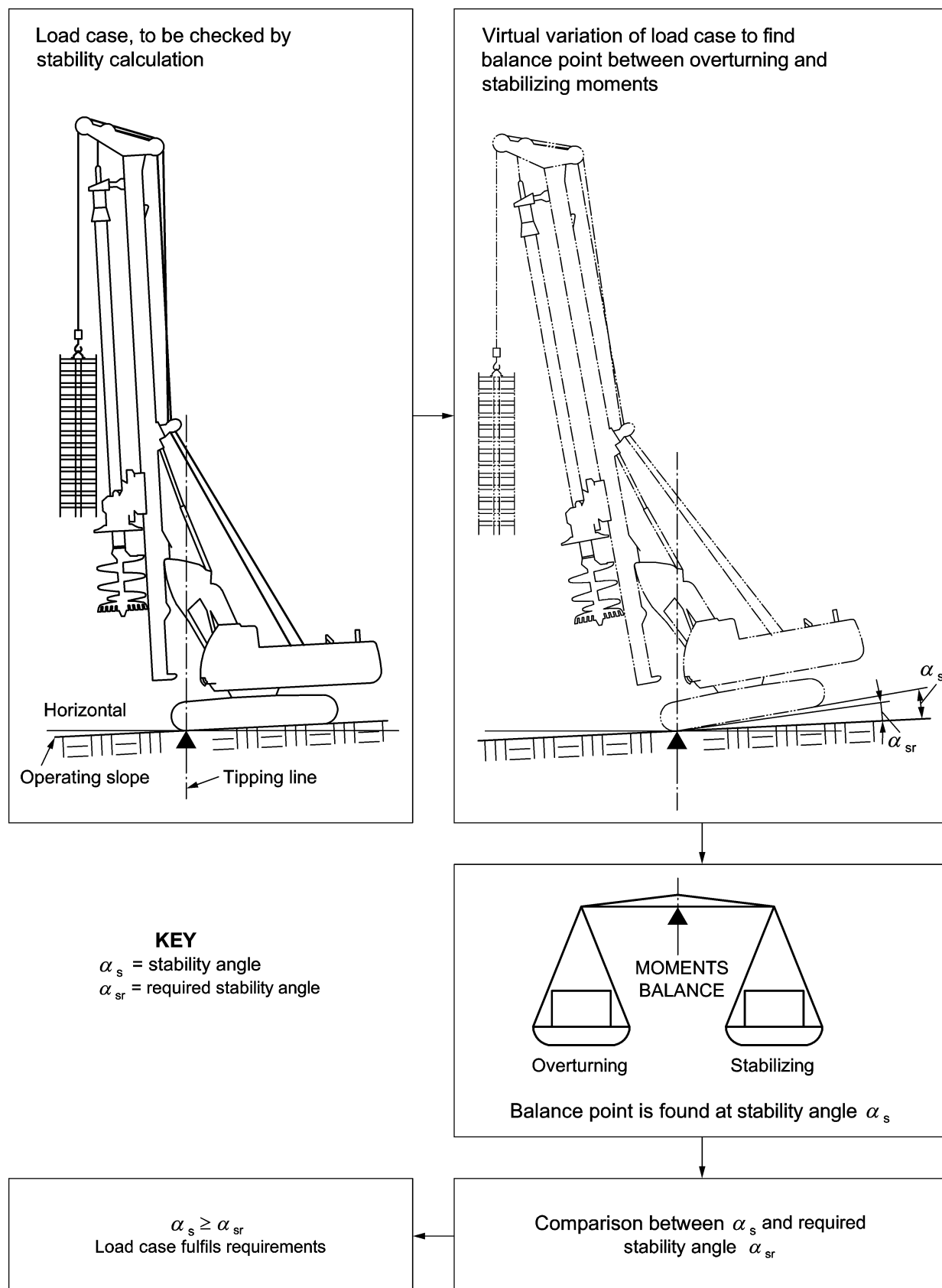


Figure 3 — Schematic explanation of stability calculation

5.2.3.6 Operating conditions

5.2.3.6.1 General

The calculation shall consider the most unfavourable conditions which may occur at the same time, including the following conditions, as specified in the operator's manual.

Examples are given in following subclauses.

5.2.3.6.2 In service – during operation

Examples of generally critical conditions are listed below.

- a) the most unfavourable position and maximum forward, backward or sideways inclination of the leader;
- b) moveable loads in the most unfavourable position;
- c) most unfavourable tipping line;
- d) for a slewing superstructure, centrifugal load due to maximum slewing speed and loads due to relevant accelerations;
- e) loads caused by adjustment to leader position;
- f) dynamic effects of raising or suddenly releasing loads;
- g) maximum extracting or pull-down load;
- h) inclined rope pull of unguided loads;
- i) wind in the most unfavourable direction.

5.2.3.6.3 Tramming

For tramming between working positions, parameters listed in 5.2.3.6.2 shall be considered where appropriate.

In addition, the acceleration loads caused by the tractive functions of the carrier machine shall be considered.

Possible restrictions to geometry and loads when tramming shall be defined in the operator's manual.

5.2.3.6.4 Out of service – erected leader

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

5.2.3.6.5 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.

5.2.3.6.6 Travelling and operating on slopes

The calculation of the stability angle shall start from an initial position of parts of the machine and equipment suitable for the relevant slope angle, as allowed and prescribed in the operator's manual. For example, when working on a slope with mast rendered vertical, the angle between the machine and the mast feature a different configuration of geometry and loads position in respect to the work on horizontal ground. This initial configuration is the one that shall be tilted to search the stability angle.

5.2.3.6.7 Equipment mounted on truck or trailer

In addition to the above mentioned criteria, the following shall be considered:

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 shall be given to the elastic effect of vehicle suspensions.

5.2.3.6.8 Leader support foot

Special consideration shall be given to equipment provided with a support foot at the base of leader (telescopic mast foot, sliding leader or similar), see Figure 2.

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.

5.2.3.7 Ground pressure

The ground pressure of crawler mounted drilling and foundation equipment shall be calculated in accordance with Annex F.

5.2.4 Floating ship, barge or pontoon

When calculating strength and stability of drilling and foundation equipment that is operating on a floating ship, barge or pontoon, the expected deviations by trim and list shall be considered. The resulting angle due to trim and list during handling and drilling or piling shall be maximum 2,5°. When lifting pile elements and/or changing position of the equipment on the pontoon, the maximum allowed angle due to trim and list is 5°.

5.3 Electrotechnical systems

5.3.1 General

Electrical components and conductors shall be installed in such a way as to avoid damage from exposure to environmental conditions (corresponding to the intended use of the machine) which can cause deterioration. Lead-through, e.g. through frames and bulkheads, shall be protected from abrasion.

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

The electric installation of drilling and foundation equipment shall comply with the requirements of [A1](#) EN 60204-1:2018 [A1](#).

NOTE Clauses of [A1](#) EN 60204-1:2018 [A1](#) of particular relevance are Clauses 4, 5, 6, 13, 14, and 15.

When the ambient temperature limits set in [A1](#) EN 60204-1:2018 [A1](#) are exceeded, the appropriate means, such as heating or cooling, shall be used.

5.3.2 Battery installation

Batteries shall be firmly attached in a ventilated space. The batteries shall be provided with handles and/or grips to allow their easy removal ^{A1} in order to avoid dangerous concentration of gases, e.g. hydrogen, acid vapours ^{A1}.

Batteries and/or battery locations shall be designed and built or covered to minimise any hazard to the operator and maintenance personnel caused by battery acid or acid vapours in the event of overturning of the machine, recharging the batteries and during maintenance activities.

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

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

It shall be possible to disconnect batteries easily, e.g. by a quick coupling or an accessible isolator switch. The symbol according to ISO 7000:2012, symbol 2063, shall be used for identification.

5.3.3 ^{A1} Electromagnetic compatibility (EMC)

The electrical equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, the electrical equipment shall have a sufficient level of immunity to electromagnetic disturbances so that it can function in its intended environment.

Machines connected to an external electrical power source shall comply with EN IEC 61000-6-2:2019 and EN IEC 61000-6-4:2019 with regard to electromagnetic compatibility (EMC) immunity and emission limits.

Machines powered by internal combustion engines shall comply with EN ISO 13766-1:2018 and EN ISO 13766-2:2018.

NOTE Tests are carried out either on the complete machines or on the safety-relevant ESA (Electrical/electronic subassemblies) as specified in EN ISO 13766 series. ^{A1}

5.4 Hydraulic and pneumatic systems

5.4.1 Hydraulic systems

The hydraulic systems shall comply with the requirements of EN ISO 12100:2010, 6.2.10 and EN ISO 4413:2010.

Hydraulic cylinders used for erection and lifting shall be fitted with load-sustaining devices which shall be self-bleeding or fitted with an air bleed point at the highest point. ^{A1} *deleted text* ^{A1}

^{A1} *deleted text* ^{A1}

^{A1} 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. They 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. ^{A1}

Flexible hydraulic hoses intended for pressures higher than 15 MPa shall be fitted with swaged fittings.

Hydraulic hoses and pipes shall be separated from electric power wiring (except signal cables) and be guarded against hot surfaces and sharp edges ^{A1}, in accordance with EN 60204-1:2018, 13.5.1 and 13.5.7 ^{A1}.

Pipes and hoses, which have to be disconnected frequently, shall be fitted with self-sealing couplings with built-in check valves. Couplings shall be marked to ensure correct reconnection.

The tanks for hydraulic fluid shall be fitted with level indicators and a low level sensor or cut out switch to prevent damage to the hydraulic system and loss of hydraulic power, which gives a warning signal. The filling point of the tank shall be so designed that overflow is prevented when working on any gradient for which the drilling and foundation equipment is designed.

A temperature gauge or a monitor, which gives a warning signal (at least visual) shall be fitted in order to detect an excess of the allowed temperature.

5.4.2 Pneumatic systems

Pneumatic installations shall comply with the requirements of EN ISO 12100:2010, 6.2.10 and EN ISO 4414:2010.

5.4.3 Hoses, pipes and fittings under pressure

Pipes, hoses and fittings shall be able to withstand the stresses from the pressure. The requirements of EN ISO 4413:2010 and EN ISO 4414:2010 shall be complied with.

^{A1} Hoses and pipes at the operator's position shall be shielded to prevent a hazard due to a rupture of hose or pipe or a high velocity jet or pressurized release of oil from a hose or pipe, e.g. as shown in Figure 4.

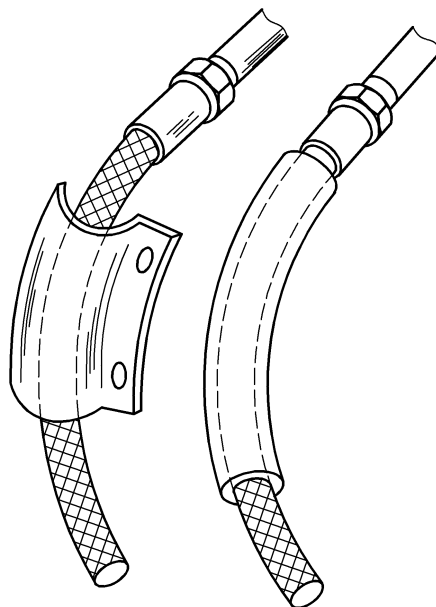


Figure 4 — Example of shielding [source: ISO 3457:1986] ^{A1}

^{A1} Hoses and pipes ^{A1} for materials such as air, water, mud, concrete, grout etc., shall be secured in case of disconnection or breakage, by means of adequate restraints.

5.5 Failure of the power supply

An interruption of the power supply and a re-establishment after an interruption shall not lead to a dangerous situation in particular:

- it shall only be possible to restart drilling and foundation equipment as described in 5.15.3;
- the drilling and foundation equipment shall not be prevented from stopping if the stop command has been given;
- no part of the machine or a tool shall fall or be ejected;
- stopping, automatic or manual, of moving parts shall be unimpeded;
- guards and other protective devices shall remain effective.

A power failure or a hydraulic or pneumatic pressure drop shall not cause any dangerous movements or actions. Such failures shall not stop the emergency stop systems from functioning.

5.6 Uncontrolled motion

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

5.7 Brakes of the carrier machine

5.7.1 Brakes for travelling

Brakes for travelling of the carrier machine shall comply with the requirements of EN ISO 3450:2011 (wheeled machines) **A1** or **A1** ISO 10265:2008 **A1** (crawler machines).

5.7.2 Brakes for slewing

Drilling and foundation equipment capable of slewing shall meet the requirements of EN 474-5:2006+A3:2013, Annex C.

5.8 Winches, draw-works and ropes

5.8.1 General

Winches, ropes and pulleys, which are integral parts of the drilling and foundation equipment and directly involved in the drilling or foundation process shall fulfil the requirements stated in 5.8.3 and 5.8.4.

NOTE Such systems are:

- systems running drill rods, chisels, kelly bars, hammer grabs, free fall hammers, piling hammers and other impact tools, by free fall, controlled free fall or powered lowering;
- systems running drill rods, casings, tools, tremie pipes and other accessories in and out of the bore hole;
- systems handling vibrators, pile elements, sheet piles, reinforcement elements, to and from the drilling and foundation equipment;
- systems assisting assembling, replacing and dismantling of equipment and tools;
- cable feed systems;

— any other system using winches, ropes and sheaves for any purpose other than lifting goods and personnel.

For requirements on winches, ropes and pulleys for working platforms for lifting personnel and movable platforms, see 5.13.2 and 5.13.3.

5.8.2 Winches and pulleys

Winches shall be equipped with:

- a service brake system;
- a holding brake system.

Both systems shall act independently.

The holding brake systems shall act automatically and prevent an unintentional running back of the load if the winch control levers are not actuated or in the case of failure of the energy supply.

NOTE 1 The brake systems may use common components. The load lowering valves of hydraulically powered winches or lowering devices are considered to be service brake systems.

Both brake systems shall each hold a minimum of 1,3 times the maximum allowed line pull. The service brake shall enable the operator to retard and stop a descending load smoothly.

If the service brake is coupled to the winch or draw-work by means of a disengageable clutch, a device shall be installed which is visible to the operator and indicates whether the clutch is engaged or not.

If an electrical eddy-current brake or a fluid fly-wheel brake is fitted as the service brake, all information necessary for the operation, for example rotational speed, temperature, water flow rate, operating voltage, shall be indicated within the view of the winch operator.

Winches or draw-works used for external loads to the equipment, having a negative influence on stability shall have a measuring system indicating the line pull of the rope or the hook load. Alternatively, there shall be a line pull limiter (e.g. a restriction of drive torque) to the winch. A capacity table visible to the operator shall show the allowed line pull.

A1 Winches or draw-works shall have a limiting device stopping any movement that reduces the distance to the end position before the end position is reached. For winches with a capacity equal to or less than 20 kN, a mechanical limit stopping device without influence on the winch control is sufficient. **A1**

Activation of the free fall function of the winch shall only be possible by actuation of two independent controls simultaneously. Both controls shall be of the hold-to-run type.

NOTE 2 After the initial activation of the free fall function it may be possible to further activate an automatic cycle mode.

When a winch is designed for several functions, including a free fall function, a key enabled mode selector shall be fitted, which allows the free fall function to be operated.

Flanges on drums shall be designed to extend at least 1,5 rope diameters beyond the outer layer of rope in all operating conditions.

There shall always remain at least three revolutions of rope on the winch drum. The rope fastening on the drum shall be such that the fastening strength is at least 70 % of the maximum allowed rope load.

5.8.3 Pulley and drum diameters

Pully and drum diameters shall meet the following minimum requirements:

- winch drum pitch = $14,0 d$,
- pulley pitch = $16,0 d$,
- compensation pulley pitch = $12,5 d$,
- pulley pitch in the feed system = $12,5 d$,

where d is the diameter of the rope.

All pulley assemblies shall be provided with devices preventing the rope from disengaging.

5.8.4 Ropes and rope end terminations

The following minimum safety requirements shall be met:

A1 Rope safety factors composed of intrinseque safety factor of the rope and the loss factor of the rope terminations (e.g. for the rope safety factor of 3,0 and if the rope termination loss factor is 0,8, a rope intrinseque safety factor of 3,75 is required): **A1**

- for running ropes = 3,0,
- running ropes for boom or leader during erection and dismantling = 3,0,
- stationary ropes in service or out of service = 3,0,
- stationary ropes during erection and dismantling = 2,5,
- free fall drop hammer or chisel = 3,0,
- for feed and pulling down ropes = 3,0,
- cable tool percussion drilling = 5,0.

NOTE For cable tool percussion drilling, the safety factor 5,0 is the ratio between minimal breaking load and the static weight of the drilling tool and excludes the weight of the content of the bucket.

Permanent rope end terminations shall consist of pressed, swaged or spelter poured sockets.

Detachable rope end terminations that consist of wedge type sockets shall be in accordance with EN 13411-6:2004+A1:2008 or EN 13411-7:2006+A1:2008.

Rope end connections using wire rope clamps are only permitted for free fall applications and they shall comply with Annex E.

5.8.5 Roller and leaf chains

Roller and leaf chains, which may be an integral part of the feed system of a drilling and foundation equipment and are directly involved in the pull-down and pull-up operation, shall fulfil the following requirements:

- they shall be selected with a safety factor, i.e. minimum breaking load in relation to maximum load, of 3,5;
- an adequate and safe means of tensioning shall be provided;

- where possible, chains shall wrap 180° around sprockets or guide pulleys.

5.9 Masts, derricks and feed beams

Mechanically raised masts, derricks and feed beams shall be equipped with a protective device designed to engage automatically in the event of failure of the lifting mechanism to prevent the mast from falling.

Locking pins or other removable devices for holding erected masts and feed beams in place shall be secured against unintentional loosening.

NOTE Pins or securing devices may be captive and attached at the locking point using a chain or similar.

Due consideration shall be given to stresses caused by the asymmetrical racking of drill rods or rod magazines. When guy ropes are necessary for masts and derricks, the pre-tensioning shall be laid down in a tension diagram. It shall be possible to control tension forces.

The rated load (normal load or pull-up force) of masts, derricks and feed beams shall be clearly displayed at the operator's position.

5.10 Indicating/limiting devices for inclination

5.10.1 Inclination of leader, mast or boom

Where the position of a leader, mast or boom can affect stability of the machine, an indicating device for the angle (angle between leader/mast/boom and vertical/horizontal) shall be installed so that it is clearly visible to the operator. This requirement does not apply to drilling and foundation equipment with more than 3 kinematic degrees of freedom of the boom/mast/leader.

Drilling and foundation equipment with more than 3 kinematic degrees of freedom of the boom/mast/leader combination shall:

- display instructions on stability and any restrictions, e.g. locking of oscillating tracks, in simple diagrammatic form at the driver's and operator's position and in the instruction manual;
- be designed in order that the operator/driver can check stability with the gradient angle indicator of the carrier only.

5.10.2 Inclination of the carrier

A system for indication of inclination of the carrier shall be provided at the operator's position.

5.10.3 Stroke limiting devices

Stroke limiting devices shall be fitted to stop the movement of the boom, mast or leader during operation, in order to prevent structural damage to the machine. A1

NOTE Stroke limiting devices do not prevent tipping or overloading of the machine. A1

The limiting devices shall only stop the movement of the boom, mast or leader. They shall not stop the engine. When activated, the operator shall be able to recover the boom, mast or leader back to its normal working position. Where necessary, a hold-to-run override switch shall be fitted to permit the erection and dismantling of the foundation equipment.

5.11 Ergonomics A1 *deleted text* A1

5.11.1 A1 General

The machine shall be designed according to the principles of EN 614-1:2006+A1:2009.

5.11.2 Control stations and servicing points ^{A1}

The drilling and foundation equipment shall be designed according to ergonomic principles to reduce the fatigue and stress on the operator and maintenance personnel. Consideration shall be given to the fact that operators and maintenance personnel may wear ^{A1} personal protective equipment, e.g. ^{A1} heavy gloves ^{A1} and ^{A1} footwear ^{A1} *deleted text* ^{A1}. For guidance, see EN ISO 3411:2007 and EN ISO 6682:2008.

5.12 Access to operating positions, intervention and servicing points

Access systems shall comply with ^{A1} EN ISO 2860:2008 ^{A1} and EN ISO 2867:2011.

Access systems shall be provided to ensure safe access to:

- the operator's position with the machine whilst in service on site;

NOTE 1 “In service” includes:

- in any operational position;
- on jacks or stabilisers;
- elevated cab or other operator's position.
- the operator's position and the tie-down points during loading and off-loading the machine from transportation vehicles when moving the machine between sites;
- the positions for assembly/dismantling of elements assembled on the site;
- areas where maintenance and inspections have to be performed, and which are not accessible from ground level, in accordance with the maintenance schedule as detailed in the maintenance and service manual;
- ropes to be replaced safely, at both the winch and the mast/boom or leader, or a mechanical system shall be provided that eliminates the need to access the mast/boom or leader.

Entrance gates to platforms shall meet the requirements of EN ISO 14122-4:2010, 4.7.3.2.

Access through platforms by means of trap doors shall meet the requirements of EN ISO 14122-4:2010, 4.7.3.3.

Where it is not possible to lower the mast on a rig for maintenance purposes and access to maintenance points is by ladder, harness anchor points shall be provided at maintenance positions along the mast. The instruction manual shall contain information on the testing and inspection of the anchor points in accordance with ^{A1} EN 795:2016 ^{A1}.

NOTE 2 For masts/leaders higher than 20 m working platforms for lifting personnel are preferred.

5.13 Platforms on masts and leaders

5.13.1 General

Platforms shall comply with EN ISO 2867:2011.

5.13.2 Working platform for lifting personnel

For definition of working platform for lifting personnel see 3.15. The platform shall be designed and located so that the ^{A1} personnel ^{A1} on the platform will not be hit by any part of the machine during operation of the machine as intended by the manufacturer.

The platform shall be guided by a guide frame secured to the mast/leader.

The hoist and lowering speed of the platform shall not exceed 0,75 m/s. Entrance doors shall be self-closing and be fitted with a self-closing locking device, see 5.12.

The manufacturer shall specify the maximum permitted weight of materials and the maximum number of personnel to be carried. A weight of 100 kg per person and a minimum overall weight of 500 kg shall apply. To determine the design load for the platform the maximum permitted load shall be multiplied by 1,25.

Working platforms shall be moved by systems of either steel wire rope, chain, tooth rack and pinion, or hydraulic cylinder(s).

A protective device shall be provided which shall operate when the nominal speed of the platform is exceeded by more than 40 %. This protective device shall arrest or limit the speed to maximum 1,4 times the nominal speed.

The protective device may consist of a stopping or gripping device which acts on the guide rails, or a safety rope or chain, fixed between the highest and lowest position of the platform.

Where a rope or chain is used for suspension of the platform, two independent ropes or chains each with its own anchorage or comparable redundant solution shall be used and the safety factor of each suspension rope shall be at least 10 and chains shall be at least 8.

The second rope or chain may be a fixed safety rope or chain with a stopping or gripping device acting on this rope or chain.

For systems suspended by steel wire ropes, the following shall apply in addition:

- an anti-slack line protection device shall be provided on each rope;
- the hoisting steel wire rope shall have a diameter of at least 8 mm. The rope, rope end terminations and anchoring points shall have a safety factor of at least 10;
- the diameter of the sheaves and the winch drum shall be at least 26 times the diameter of the steel wire rope;
- the winch shall meet the requirements of 5.8.2 and 5.8.3. Free fall winches shall not be used.

In case of cylinder suspension the load carrying side of the cylinder(s) shall be fitted with a directly mounted load-sustaining device.

Platforms shall be equipped with a limiting device for the highest and lowest position.

Platforms shall be designed and constructed so that personnel on the platform have means of controlling the movement of the platform and the following requirements shall be fulfilled:

- in operation, control devices shall override any other devices controlling the same movement with the exception of emergency stop devices;
- control devices for movement shall be hold-to-run;
- the operator in the cab shall have a full overview of the travel zone;
- a recovery system in case of emergency controlled by the operator in the cab shall be added.

Platforms shall be provided with a recovery system to bring the platform safely to ground level in case of an emergency.

Platforms shall be provided with a sufficient number of anchor points for the number of permissible persons on the platform. Removable anchor points shall meet the requirements of EN 795:2012.

5.13.3 Movable platform

For definition of movable platform, see 3.16. The platform shall be designed and located so that it will not be hit during operation of the machine as intended by the manufacturer.

Persons may enter and stay on the platform only when it is stationary.

The manufacturer shall specify the maximum permitted weight of materials and the maximum number of personnel allowed on the platform. A weight of 100 kg per person and a minimum overall weight of 500 kg shall apply. To determine the design load for the platform the maximum permitted load shall be multiplied by 1,25. The manufacturer shall give consideration to the dynamic effects.

The platform shall be moved by the moving system of the parts of the drilling and foundation equipment. This system consists of steel wire rope, chain, tooth rack and pinion, or hydraulic cylinder(s).

Platforms shall be designed and constructed in such a way that personnel on the platform have means of audible or visible communication with the operator.

Entrance doors shall be fitted with an automatically closing and locking device, see 5.12.

Platforms shall be provided with a sufficient number of anchor points for the number of permissible persons on the platform. Removable anchor points shall meet the requirements of EN 795:2012.

5.14 Operating position(s)

5.14.1 General

The ~~A1~~ *deleted text* ^{A1} tramming, travelling and operating position(s) shall be designed and constructed so that all manoeuvres necessary for moving and operation of the drilling and foundation equipment can be performed by the operator without risk to himself or to other persons in the vicinity of the rig.

^{A1} For the tramming and travelling of drilling and foundation equipment, where there is a risk of tipping-over, at least one of the measures a), b) or c) shall be taken:

- a) providing an alternative operator's position outside the tipping zone (e.g. by a remote control);
- b) providing tip-over protective structure (TOPS):
 - for machinery up to 6 t: TOPS shall comply with EN 13531:2001+A1:2008;
 - for machinery over 6 t and up to 50 t, installing a tip-over protective structure (TOPS) in accordance with EN 474-5:2006+A3:2013, 5.3.2.2.3;

For evaluation of the performance of the TOPS installed on machines having a mass less than or equal to 50 t, ISO 12117-2 shall be used in respect of lateral loading only and with the following lateral load energy:

- Lateral load energy U_s (J) = $6\,500 \times (M/10\,000)^{1,25}$
- TOPS shall be labelled in accordance with ISO 12117-2:2008, Clause 9, except that the standard referred to shall be EN 16228-1:2014+A1:2021;

NOTE There is no standard existing for testing TOPS for fixed cabins on machines over 6 t.

c) providing a geometric protection zone as defined in 3.39. ^{A1}

For the ^{A1} ~~text~~ ^{A1} tramping and travelling of drilling and foundation equipment, where there is a risk of roll-over, ^{A1} one of the following measures shall be taken:

- installing a roll-over protective structure (ROPS) in accordance with ISO 12117-2:2008 or EN ISO 3471:2008;
- providing an alternative driver's position (e.g. by a remote control);
- providing the geometric protection zone as defined in 3.39.

When a ROPS or TOPS is provided, a seat belt shall be provided and shall be designed according to ISO 6683:2005. ^{A1}

Drilling and foundation equipment with a cab shall be fitted with falling object protective structure (FOPS) level I of EN ISO 3449:2008.

All drilling and foundation equipment specified for use in applications where there is a risk of rock fall, shall be fitted with FOPS level II according to EN ISO 3449:2008.

Specific requirements for ROPS, TOPS and FOPS are given in parts 2 to 7 of this standard (EN 16228).

NOTE 1 The scope of EN ISO 3449:2008 excludes drilling and foundation equipment. However for drilling and foundation equipment the requirements of EN ISO 3449:2008 are equally applicable as for earth-moving equipment.

^{A1} The geometric protection zone shall be verified by drawing, which shows that the cabin is distant from even ground in the cases of rolling-over or tilting-over. The distance between ground and cabin shall be verified by a straight line, which connects the relevant tipping line with the firm outmost part of the equipment in the cases of tilting-over or rolling-over as shown in Figure 5.

Seat belt complying with ISO 6683:2005 shall be provided in the cabin.