BS EN 16228-1:2014

BSI Standards Publication

Drilling and foundation equipment — Safety

Part 1: Common requirements

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/513, Construction equipment and plant and site safety.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2014

ISBN 978 0 580 73264 5
ICS 91.220; 93.020

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2014.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16228-1

May 2014

ICS 93.020

English Version

Drilling and foundation equipment - Safety - Part 1: Common requirements

Machines de forage et de fondation - Sécurité - Partie 1: Prescriptions communes

Geräte für Bohr- und Gründungsarbeiten - Sicherheit - Teil 1: Gemeinsame Anforderungen

This European Standard was approved by CEN on 6 March 2014.

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Ref. No. EN 16228-1:2014 E

Contents

Page

Foreword

This document (EN 16228-1:2014) 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of an identical text or by endorsement, at the latest by November 2014 and conflicting national standards shall be withdrawn at the latest by November 2014.

This document supersedes EN 791:1995+A1:2009, EN 996:1995+A3:2009.

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

For relationship with EU Directive(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*

— *Part 2: Mobile drill rigs for civil and geotechnical engineering, quarrying and mining*

— *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*

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, 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 prEN 16191;

— raise boring machines;

— drill rigs used in oil and gas industry.

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 will conform to the requirements specified in this drilling and foundation equipment 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.

If drilling and foundation equipment is intended to be used in a potentially explosive atmosphere, additional requirements will need to be met which are not covered by this standard.

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*

EN 795:2012, *Personal fall protection equipment — Anchor devices*

EN 953:1997+A1:2009, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

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

EN 13309:2010, *Construction machinery — Electromagnetic compatibility of machines with internal power supply*

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*

EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*[1)]

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)*

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)*

EN ISO 7731:2008, *Ergonomics — Danger signals for public and work areas — Auditory danger signals (ISO 7731:2003)*

[1)] This document is impacted by a Corrigendum issued in 2010.

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 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 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)*

EN ISO 13849-1:2008, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

EN ISO 13850:2008, *Safety of machinery — Emergency stop — Principles for design (ISO 13850:2006)*

EN ISO 13857:2008, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2008)*

EN ISO 14122-4:2010, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2004)*[2)]

ISO 2631-1:1997, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*[3)]

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*

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

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

ISO 6405-1:2004, *Earth-moving machinery — Symbols for operator controls and other displays — Part 1: Common symbols*[4)]

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 10968:2004, *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*

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

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[4)] This document is impacted by stand-alone Amendment 1, *Additional Symbols*, published in 2010.

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

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.

3.20
user
person or company who brings the drilling and foundation equipment into operation for the application of drilling and foundation techniques

Note 1 to entry: The user who is assembling different parts or changing the original configurations or functions of the equipment which departs from the manufacturer's instructions will be considered as the manufacturer according to the Machinery Directive.

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
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.

3.26
rope/chain safety factor
ratio between the guaranteed minimum breaking and maximum pulling load

3.27
slewing
rotation of the upper structure of drilling and foundation equipment in relation to a fixed reference frame on the ground

3.28
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

3.29
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

Note1 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

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 standard
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
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

No.	Hazard	Relevant clause(s) in this standard
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	5.26, 5.28, 5.3.2
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
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
10	Impossibility of stopping the machine 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

No.	Hazard	Relevant clause(s) in this standard
16	Loss of stability/overturning of machinery	5.2.3
17	Slip, trip and falling of persons (related to machinery)	5.12
Additional hazards, hazardous situations and hazardous events due to mobility		
18	Relating to the travelling function	
18.1	Uncontrolled movement of machine when starting the engine	5.6
18.2	Movement without an operator at the driving position	5.15, 5.16.1
18.3	Insufficient ability of machinery to be slowed down, stopped and immobilised	5.6, 5.7
19	Linked to the work position (including driving station) on the machine	
19.1	Fall of persons during access to (or at/from) the work position	5.12
19.2	Exhaust gases/lack of oxygen at the work position	5.14.1, 5.28
19.3	Fire (flammability of the cab, lack of extinguishing means)	5.26
19.4	Mechanical hazards at the work position contact with the wheels/crawlers;fall of objects, penetration by object.	5.14.1, 5.23 5.24
19.5	Insufficient visibility from the working position	5.14.2
19.6	Inadequate lighting	5.25
19.7	Inadequate seating	5.14.1
19.8	Noise at the driving position	5.14.1, 5.27.2, Annex B
19.9	Vibration at the driving position	5.14.1, 5.27.3, Annex C
19.10	Insufficient means of evacuation/emergency exit	5.14.1
20	Due to the control system	
20.1	Inadequate location of controls/control devices	5.16
20.2	Inadequate design of the actuation mode and/or action mode of controls	5.15, 5.16
21	From handling the machine (lack of stability)	5.2, 5.19, 7.3
22	Due to the power source and to the transmission of power	
22.1	Hazards from the engine and the batteries	5.3.2, 5.15, 5.23.3
22.2	Hazards from coupling and towing	5.19
23	From/to third persons	
23.1	Unauthorized start	5.13.3, 5.15.3
23.2	Drift of a part, away from its stopping position	5.4.1, 5.5, 5.6, 5.7, 5.8
23.3	Lack or inadequacy of visual or acoustic warning means	5.30
24	Insufficient instructions for the driver/operator	7.3.2
Additional hazards, hazardous situations and hazardous events due to lifting		
25	Mechanical hazards and events	
25.1	From load falls, collision, machine tipping caused by:	

No.	Hazard	Relevant clause(s) in this standard
25.1.1	Lack of stability	5.2.3, 5.8.2, 5.10, 7.3.2
25.1.2	Uncontrolled loading; overloading; overturning moment exceeded	5.6, 5.8.2, 5.9, 5.10, 7.3.2
25.1.3	Uncontrolled amplitude of movements	5.5, 5.6, 5.8.2, 5.10, 7.3.2
25.1.4	Unexpected/unintended movement of loads	5.5, 5.6, 5.8.2, 7.3.2
25.1.5	Inadequate holding devices/accessories	5.8.2, 5.9, 7.3.2, 7.3.3
25.1.6	Collision of more than one machine	5.7
25.2	From access of persons to load support	7.3.2
25.3	From insufficient mechanical strength of parts	5.2, 5.9
25.4	From inadequate design of pulleys, drums	5.8.2, 5.8.3
25.5	From inadequate selection/integration into the machine of chains, ropes, lifting accessories	5.8.3, 5.8.4, 5.8.5, Annex E
25.6	From lowering of the load by friction brake	5.8.2
25.7	From abnormal conditions of assembly/testing/use/maintenance	6.1, 6.2, 7.3.3
25.8	Load-person interference (impact by load)	7.3.2
26	Electrical hazards	5.3, 5.5
27	Hazards generated by neglecting ergonomic principles	
27.1	Insufficient visibility from the driving position	5.14.2
Additional hazards, hazardous situations and hazardous events due to lifting of persons		
28	Mechanical hazards and hazardous events due to:	
28.1	Inadequate working coefficients	5.13.2, 5.13.3
28.2	Failing of load control	5.8.2, 5.13.2
28.3	Failing of controls at working platform for lifting personnel (function, priority)	5.13.2
28.4	Overspeed of working platform for lifting personnel	5.13.2
29	Falling of person from the working platform for lifting personnel	5.13.2
30	From derailment of the working platform for lifting personnel	5.13.2

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, tramming, 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.

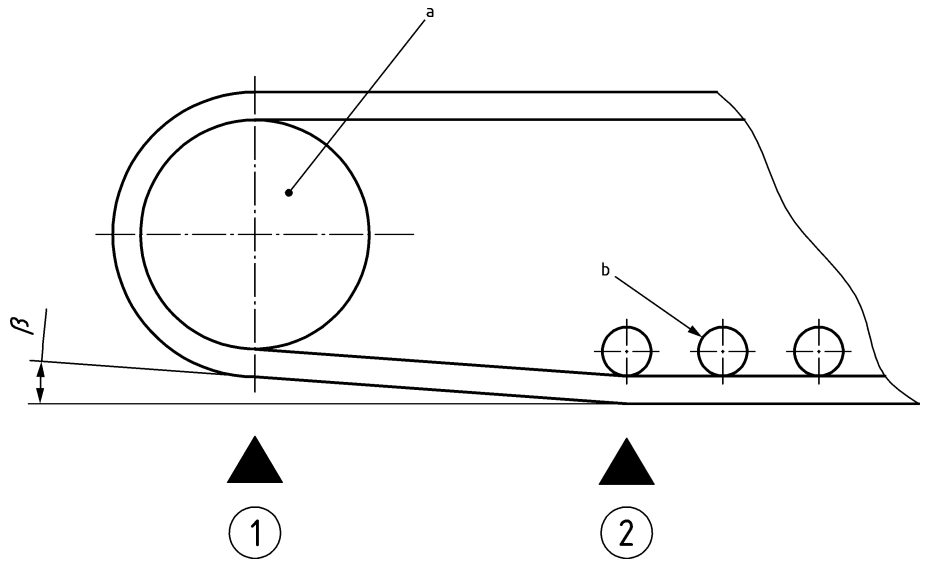
5.2.3.3 Tipping lines

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:

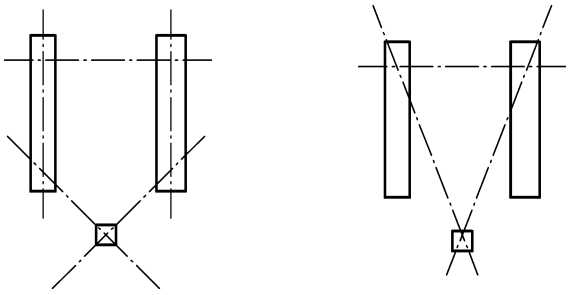


Figure 2 — Tipping lines

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 kPa (250 N/m^2);

— for erected out-of-service:

  — p = 0,8 kPa (800 N/m^2), surfaces lower than 20 m from the ground;

  — p = 1,1 kPa (1100 N/m^2), surfaces higher than 20 m from the ground;

  — p = 1,65 kPa (1650 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.

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 equal to the weight of the released mass. It is applicable to equipment such as drop hammer, diesel hammer ram, chisel, hammer grab, rope grab, etc.

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 ($\mathbf{a}_{appr}$, $\dot{\boldsymbol{\omega}}_{appr}$) may be used in the calculations.

$\mathbf{a}_{appr}$ and $\dot{\boldsymbol{\omega}}_{appr}$ are obtained as follows:

$$\mathbf{a}_{appr} = \frac{k \cdot v_{max}^{\,2}}{(2 \cdot \Delta s)} = \frac{k \cdot v_{max}}{\Delta t}$$

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;

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

where

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

$\Delta\theta$ is the measured angle in radiants 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 ($\mathbf{a}_{test}$, $\mathbf{\acute{\omega}}_{test}$) and indirect ($\Delta s$, $\Delta\theta$, 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		$\mathbf{a_{test}}$	$\mathbf{a_{appr}}$	1 m/s^2
Travel	crawler mounted – hydraulic traction drive	$\mathbf{a_{test}}$	$\mathbf{a_{appr}}$	0,4 m/s^2
	crawler mounted – mechanical traction drive	$\mathbf{a_{test}}$	$\mathbf{a_{appr}}$	0,6 m/s^2
	wheel mounted	$\mathbf{a_{test}}$	$\mathbf{a_{appr}}$	2,5 m/s^2
Slewing	hydraulic drive	$\acute{\omega}_{test}$	$\acute{\omega}_{appr}$	0,25 rad/s^2
	mechanical drive	$\acute{\omega}_{test}$	$\acute{\omega}_{appr}$	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 $L \cdot g$ kN

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

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).

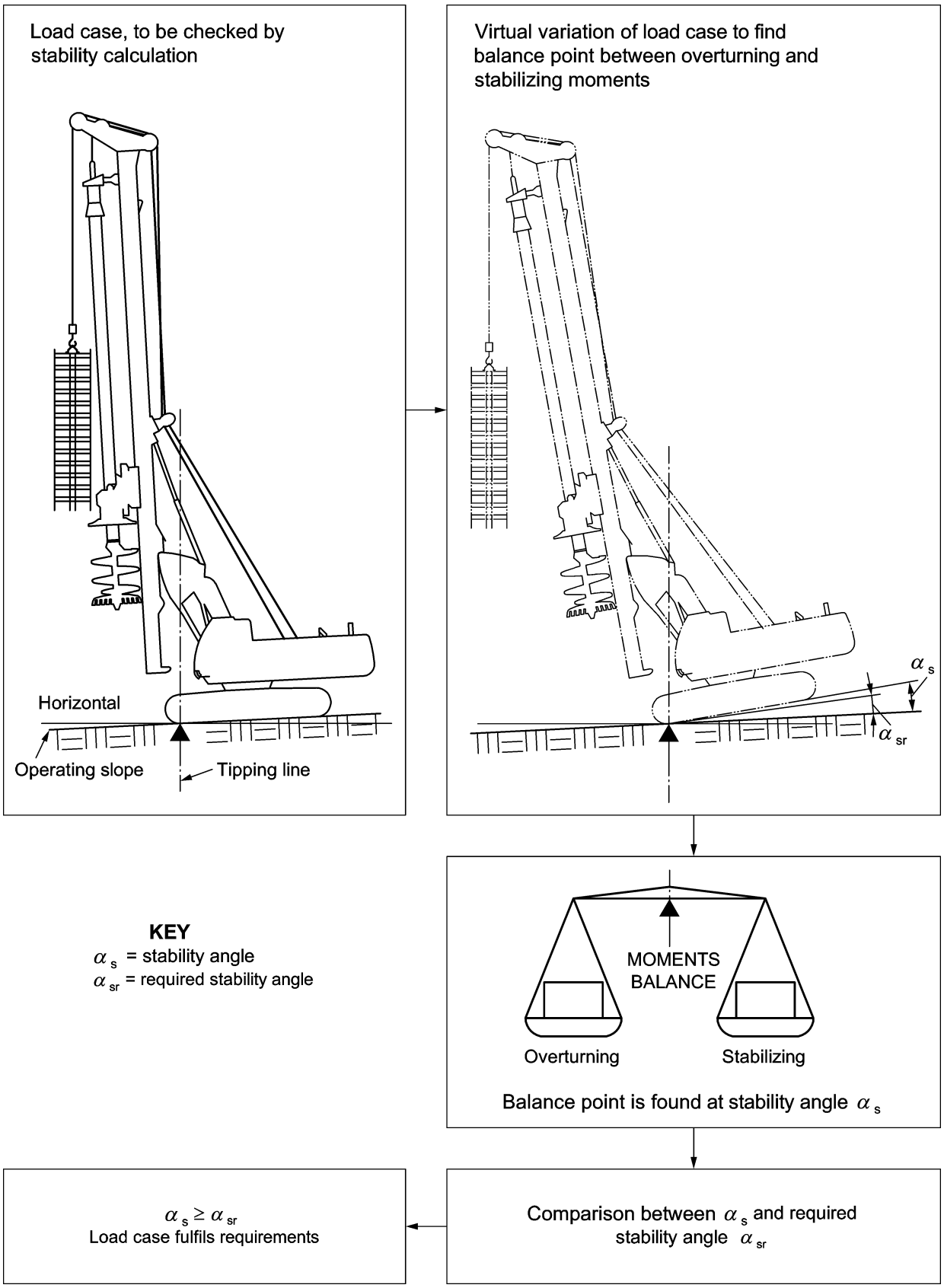


Figure 3 — Schematic explanation of stability calculation

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 EN 60204-1:2006.

NOTE Clauses of EN 60204-1:2006 of particular relevance are Clauses 4, 5, 6, 13, 14, and 15.

When the ambient temperature limits set in EN 60204-1:2006 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.

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.

5.4 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. These devices shall be placed inside or directly on the cylinder connected to the load side.

NOTE Bleeding can also be obtained by moving the piston between full stroke movements.

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.

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.

Where there is a risk that a rupture of a hose or pipe at the operator's position could cause hazard to the operator, the hoses and pipes in this area shall be provided with protective guards in accordance with EN ISO 3457:2008, Clause 9.

Hoses, pipes and nozzles 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) and ISO 10265 (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 disengable 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.

Winches or draw-works shall have a limiting device stopping the lifting movement by influencing the winch control, before the mechanical 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.

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:

Rope safety factors (including terminations):

— 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.

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 for control stations and servicing points

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 heavy gloves, footwear and other personal protection equipment. 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 EN ISO 2860 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 EN 795:2012.

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 personell 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 driving, 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.

For the driving, tramming and travelling of drilling and foundation equipment, where there is a risk of tipping-over, an alternative driver's position or a tip-over protective structure (TOPS) in accordance with EN 474-5:2006+A3:2013, 5.3.2.2.3, shall be provided. Alternatively, remote control shall be provided.

For the driving, tramming and travelling of drilling and foundation equipment, where there is a risk of roll-over, a roll-over protective structure (ROPS) in accordance with ISO 12117-2:2008 shall be provided. Alternatively, remote control shall be provided.

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.

Where there is a risk of horizontally ejected objects, an appropriate protection shall be provided, e.g. in the case of auger and pile driving.

ISO 10262:1998 may be used as a guideline.

Required space, leg space etc. shall be in accordance with EN ISO 3411:2007 and EN ISO 6682:2008.

NOTE 2 For requirements regarding the driver's position on truck and tractor mounted drilling and foundation equipment, see appropriate standards.

Drilling and foundation equipment shall be provided with a cab to protect the operator against noise, dust and adverse weather conditions.

The cab shall be fitted with the following:

— ventilation system with adequate dust filtration where necessary and where climate conditions require, heating and/or cooling, as defined in EN 474-1:2006+A4:2013, 5.3.2.1;

NOTE 3 For this requirement no verification is given.

— protection against noise, see 5.27.2;

— isolation against vibration of the floor, see 5.27.3;

— a means of rapid escape from the cab;

— an emergency exit on a different side of the cab from that where the normal exit is situated, e.g. in the form of knock-out windows or knock-out panels and/or provision of tools for breaking the window unless normal exit/entrance is for both sides of the machine;

— a seat, unless the operator is intended to work in a standing position. The seat shall provide the operator with a comfortable and stable working position and shall be easily adaptable to operators of different weight and height. The seat shall be designed to reduce vibrations transmitted to the operator to the lowest level that can be reasonably achieved, see 5.27.3;

— window cleaning devices for each window essential for overlooking the operations.

Windows and transparent panels shall be made of safety glass or other material which provides similar safety performance (see e.g. ECE R43).

The material of the interior of the cab shall be in accordance with the requirements of 5.26.1.

There are types of drilling and foundation equipment or operating conditions where it is not appropriate or possible to provide a cab. Examples may be:

— small size of the machine, e.g. for restricted access applications;

— the size or layout of the machine prevents a cab being mounted on the machine in a position from which the operator can view the operations;

— the controls for driving, tramming and travelling may be located in a different position than the drilling controls;

— the presence of a cab impairs the functionality of the machine, e.g. machine for use on rock slopes;

— for remote controlled machines.

Within the cab the A-weighted emission sound pressure level at the operator's position(s) (measured value plus uncertainty) should not exceed 80 dB(A) and shall not exceed 85 dB(A) when tested in accordance with Annex B.

Where a ride-on operator’s position is provided at the rear of the machine for the purposes of tramming the machine, it shall be provided with guard rails and safe access to prevent the operator from falling from the machine.

5.14.2 Visibility

Visibility from the driver's and/or operator's position shall be such that when driving, tramming or operating the driver or operator can operate the drilling and foundation equipment without causing danger to himself or to other persons. Where necessary, optical aids or other means shall be provided.

During slewing, if it is part of the working process like in Kelly drilling and grab excavation, the area around the machine shall be visible to the operator. If the size and shape of the machine and the position of the cab do not allow safe visibility, it shall be assured either by close circuit monitoring system, or mirrors, or other optical aids.

Drilling and foundation equipment shall be designed in accordance with ISO 5006:2006, 10.4 and Clause 12, so that the operator has sufficient visibility from the operator's 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.

NOTE The scope of ISO 5006 does not cover drilling and foundation equipment. However for drilling and foundation equipment the requirements of ISO 5006 are equally applicable as for earth-moving equipment.

5.15 Control systems

5.15.1 General

Requirements for control systems are described in Clauses 9, 10 and 11 of EN 60204-1:2006, EN ISO 4413:2010 and EN ISO 4414:2010.

5.15.2 Required performance levels for safety related parts of control systems

Protective measures as defined in EN ISO 12100:2010, 3.19, may include safety functions. The implementation of safety functions shall meet the requirements of EN ISO 13849-1. The performance level (PL) for safety functions shall meet the minimum required performance level (PL_r) as detailed in Table 3 below. For purely mechanical solutions that fulfil the required functions of Table 3, no specific performance level is required; for example a locking pin.

Table 3 — Required performance level

No. of safety function	Safety function requirements	Required Performance Level PL_r
	Travelling	
1	Ability to stop	**c**
	Tramming	
2	Ability to stop	**c**
	Slewing	
3	Ability to stop	**c**
	Lifting in the process	
4	Ability to stop	**c**
5	Keeping the load stationary	**c**
6	Limiters/over-hoist	**b**
	Winching (Pulling/anchoring)	
7	Ability to stop	**c**
8	Limiters/over-hoist	**b**
	Working platforms for lifting personnel	
9	Ability to stop	**c**
10	Limiters/over-hoist	**c**
	Machine stability jacks and ground anchor systems	
11	Ability to stop	**c**
12	Ability to hold	**c**
	Activation of Safeguards	
13	Stopping rotation/feed on activation of interlocked guards or protective devices	**c**
	Restricted Operating Mode	
14	Engagement and maintenance of slow rotation and feed speed	**c**
	Drill rotation/feed during special protective mode for specific circumstances	
15	Stopping rotation/feed on activation of pressure sensitive devices	**c**
	Clamping and breaking of tools	
16	Ability to hold	**b**
	Rod handling devices	

No. of safety function	Safety function requirements	Required Performance Level PL_r
17	Ability to stop the device	**c**
	Mast/boom/leader positioning system	
18	Ability to stop the mast/boom/leader	**c**
19	Ability to hold the mast/boom/leader in position	**c**

NOTE When drafting this table, the Performance Levels specified in Table 3 reflect what was feasible by the current state of the art. Based on experience gained in the application of EN ISO 13849-1, the Performance Level values will be re-assessed in the next revision of this standard.

5.15.3 Starting

Starting of the drilling and foundation equipment's main power source shall only be possible by an intentional actuation of the starting control device. This shall also apply after a stop from whatever cause.

Unauthorized starting shall be prevented by the provision of suitable safeguards, e.g. lockable cab, lockable starting switch or lockable electric isolator switch.

If the drilling and foundation equipment has several starting controls they shall be interlocked so that starting can only be carried out from one of the starting controls.

On pneumatically powered drilling and foundation equipment, a main line valve shall be provided on the machine, which either connects the machine to the air supply or in the closed position shuts off the air supply and releases the air pressure in the machine system.

5.15.4 Stopping

5.15.4.1 Normal stopping

The drilling and foundation equipment shall be fitted with a stopping device by which the operating function is brought to a complete stop.

5.15.4.2 Emergency stop

In order that an actual or impending danger is averted quickly, emergency stops shall be provided. They shall stop all relevant movements or functions as quickly as possible to prevent a dangerous situation developing without creating an additional hazard. The emergency stop devices shall be in accordance with EN ISO 13850.

There shall be an emergency stop at every operating or driving position.

For a truck or tractor mounted drilling and foundation equipment this requirement does not apply to the driver's position.

The emergency stop function shall be operational, regardless of the operating mode.

5.16 Control devices

5.16.1 General

Control devices shall be marked without ambiguity in accordance with relevant standards and positioned for safe, quick and comfortable operation. For marking, preference shall be given to pictograms. For guidance, see 6.2.8 of EN ISO 12100:2010, ISO 6405-1 and Annex D.

If the identification of the control device is made in writing, the information and warning shall be provided in the official language of languages of the Member States in which the machinery is placed on the market and/or put into service.

Control devices other than which control continuous or automated operations, e.g. drilling and casing operations, shall be of hold-to-run type. This requirement does not apply to non-operational controls for example light switches, etc.

Control devices shall:

— when they are of primary importance, be within comfortable reach;

— when they are of secondary importance, be within normal reach;

— where possible, be located outside the danger zone.

For definition of comfort and reach, see EN ISO 6682:2008.

Where there is more than one operator's position for primary functions, the drilling and foundation equipment shall be provided with a mode selector to intentionally select the operating position which shall be used. This requirement does not apply to any stop command or emergency stops.

For starting see 5.15.3.

The forces required to operate the controls shall comply with ISO 10968:2004, Table 1.

Controls shall be designed, constructed and arranged so that:

— their function is clearly identifiable;

— the movement to activate the controls corresponds as far as possible to the intended effect.

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

5.16.2 Inadvertent actuation of controls

Controls that can accidentally initiate dangerous movements shall be so arranged, deactivated or guarded that they cannot be activated inadvertently in particular when the operator enters or exits the operator's position.

5.16.3 Controls for extending the crawlers (tracks) of the carrier machine

Controls for extending the crawlers on a carrier machine shall be designed and located to eliminate the risk of injury to the person operating the controls. This may be achieved by use of a remote control unit, the requirements of which are detailed in 5.17.

Controls for extending the crawlers (tracks) shall not require the presence of a person underneath the machine.

5.17 Remotely controlled and automated drilling and foundation equipment

5.17.1 General

Remote operator control shall be designed according to ISO 15817:2012.

5.17.2 Operating position

Starting and stopping of operational movements of the drilling and foundation equipment shall only be possible from local controls on the drilling and foundation equipment or from a control position with a sufficient visibility over the operating area, e.g. by means of a closed circuit monitoring system (CCTV).

Drilling and foundation equipment, without an operator's position on it, shall be provided with at least an attachment for a remote control box, from which the drilling and foundation equipment can be controlled.

Drilling and foundation equipment able to be remote controlled, manned or unmanned or able to operate in automatic mode shall be provided with a visual warning light. It shall be automatically actuated before starting and when the equipment is working in remote control or automatic mode. This requirement is not valid for remotely controlled drilling and foundation equipment with the control panel situated in the vicinity of the equipment and where there is a direct visual contact between the operator and the equipment.

5.17.3 Emergency stop

Drilling and foundation equipment shall be fitted with an emergency stop located on the remote control panel in the control/monitoring position and additional emergency stops shall be fitted on the machine.

All emergency stops shall be easily accessible.

Cable-less remote control panel(s) shall be fitted with a stop device according to 9.2.7.3 of EN 60204-1:2006.

5.17.4 Control system

The control circuits of drilling and foundation equipment shall be so designed that the operations stop automatically in case of an interruption or break down of the control link between the control box and the equipment, or when the initiated sequence has been completed.

A failure shall not lead to a dangerous situation. The same safety requirements as stated in 5.5 shall be fulfilled.

Resetting, after a fault occurs in part of the system, shall not restart any automatic function. Restarting of the operation shall only be possible by an intentional action by the operator.

Electrical and electronic control systems shall conform to EN 13309:2010 with regard to electromagnetic compatibility.

5.18 Unmanned, automatically operated drilling and foundation equipment

A control system of unmanned, automatically operated drilling and foundation equipment shall be designed with an integrated diagnostic system that shuts down the operation when a fault relevant to the ongoing automatic function or task or an abnormal operational behaviour is detected by the system.

5.19 Retrieval, transportation, lifting and towing of the drilling and foundation equipment and its parts

5.19.1 Common use

The devices for retrieval, tie-down, lifting, and towing may be the same if allowed by the configuration of the machine.

NOTE ISO/DIS 15818 can be used as a guideline.

5.19.2 Retrieval/Towing

Retrieving points and/or towing device(s) (hooks, ears etc.) shall be provided on the machine. They shall comply with ISO 10532:1995. Their location, permissible forces, the correct use when towing as well as the maximum towing speed and distance shall be clearly specified in the operator's manual.

If a pin is part of the towing device, the pin shall be permanently attached to the device. The securing device for the pin shall not be detachable.

Attachment points for retrieving of the machine shall be described in the operation manual as well as permissible forces and correct use.

5.19.3 Tie-down

To transport drilling and foundation equipment safely, tie-down points to anchor the machine, e.g. on a trailer, shall be provided and clearly identified on the machine (see ISO 6405-1:2004, symbol 7.27). Instructions for their use shall be included in the operation manual.

5.19.4 Lifting points

Lifting points shall be provided and designed for the operating mass in the heaviest configuration and shall be clearly identified on machines or subassemblies that are to be lifted in one piece.

The method of lifting heavy attachments, components and machines shall be described in the operation manual (see 7.3).

For lifting symbol, see ISO 6405-1:2004, symbol 7.23.

5.19.5 Transportation

Stabilisers, outriggers or other moveable devices that can cause a hazard during transportation or travelling shall be secured lockable in their transport position.

Instructions for secure locking shall be provided in the operation manual.

5.20 Handling of drilling tools

Drilling tools shall be fitted with supports where the tools can be placed in the drill stem.

5.21 Isolation of energy sources

Drilling and foundation equipment supplied with external energy shall be fitted with means to isolate them from all energy sources. Such devices shall be clearly identified and it shall be possible to lock them if reconnection could endanger persons. The requirements in EN 1037:1995+A1:2008 and EN 60204-1:2006 shall be complied with. After the energy is shut off, it shall be possible to dissipate any energy remaining or stored in the circuits of the drilling and foundation equipment without risk to exposed persons.

As an exception from the above requirements, certain circuits may remain connected to their energy sources, e.g. to hold parts in position, to protect information, to provide interior lighting. These circuits shall be clearly identified in the instruction book. They shall have permanent warning labels.

5.22 Hot and cold surfaces and sharp edges

Where there is a risk of human contact with hot or cold surfaces, such surfaces shall be protected by guards or covers in accordance with Clause 8 of EN ISO 3457:2008 and EN ISO 13732-1:2008. Surfaces and edges shall fulfil the requirements of ISO 12508:1994.

5.23 Protection against moving parts

5.23.1 General

Drilling and foundation equipment shall be designed, constructed and equipped to ensure that the need for personnel to enter any danger zone during the working process is minimised.

Design and construction shall take into account the working environment in which drilling and piling is undertaken, likely loads on the equipment during the working process, and the need to operate the machine in restricted spaces and with the rotating parts involved in the drilling process at various inclinations and in various configurations if intended to do so by the manufacturer (see instruction book).

5.23.2 Moving parts involved in the process

5.23.2.1 General

Where access to moving parts directly involved in the drilling and piling process is foreseeable during normal operation of the machinery, safeguards shall be selected from the following:

— fixed guard or;

— interlocking movable guard with or without guard locking or;

— sensitive protective devices, e.g. electro-sensitive protective equipment or pressure sensitive devices or;

— a combination of the above.

NOTE 1 Positioning of leaders and booms and slewing of the turret etc. are not considered as moving parts directly involved in the drilling and piling process.

NOTE 2 It is anticipated that protective devices, adopted from other technologies, will emerge during the lifetime of the standard.

The machine shall be designed so that the operator at the control station is not able to reach the moving parts involved in the drilling process in any other situation than the restricted operating mode.

5.23.2.2 Guards and protective devices

5.23.2.2.1 General

The technical principles for guards and protective devices are described in EN ISO 12100:2010.

5.23.2.2.2 Guards

Fixed guards shall comply with EN 953:1997+A1:2009.

Interlocking movable guards shall comply with EN 953:1997+A1:2009 and prevent access to the danger zone, during any dangerous movement. Initiation of the dangerous movement shall be prevented while the guard is open.

When the interlocking movable guard is opened, the rotation and feed functions together with any associated moving parts identified with residual risks shall stop. Restarting with an open interlocking movable guard shall only be possible in restricted operating mode (see 5.23.2.2.4).

Interlocking guards without guard locking shall be placed in such a position that the operator does not have time to reach the danger zone before any dangerous movement has ceased.

For determination of safety distances through the guards, Table 4 of EN ISO 13857:2008 shall be applied. When there is no risk of crushing or shearing but only risk of entanglement, the following provisions shall be applied:

— for round and square openings smaller or equal to 20 mm, minimum safety distance shall be 20 mm;

— for round and square openings smaller or equal to 40 mm, minimum safety distance shall be 120 mm.

The open ends of the drill string guard are not considered as openings.

After the interlocking movable guard has been closed, restart of normal operating mode shall only be possible after a deliberate reset action. This deliberate action shall be by means of a reset which shall be in a fixed position outside the rotating parts danger zone with a clear view of the complete danger zone and not reachable from the inside of the rotating parts danger zone.

5.23.2.2.3 Sensitive protective devices

Sensitive protective devices shall be positioned in appropriate configurations for the range of applications and working conditions as specified by the manufacturer.

Sensitive protective devices shall detect foreseeable access to the rotating parts danger zone, during any dangerous movement. When the sensitive protective device is activated, the rotation and feed functions together with any moving parts identified with residual risks shall stop.

Following activation and for as long as the device remains triggered it shall only be possible to restart feed and/or rotation in restricted operating mode (ROM) as described in 5.23.2.2.4 by a separate, deliberate action.

After detection has ended, restart of normal operating mode shall only be possible after a deliberate reset action. This deliberate action may be by means of a reset which shall be in a fixed position outside the rotating parts danger zone with a clear view of the complete danger zone and outside the detection zone and not reachable from the inside of the rotating parts danger zone.

Where the detection zone is programmable, the program and setting of the detection zone shall only be accessible through a password or a key.

NOTE EN ISO 13855:2010 gives information about the positioning of sensitive protective devices.

5.23.2.2.4 Restricted operating mode (ROM)

Where it is necessary to operate in the danger zone with opened moveable guards or triggered protective devices, the restricted operating mode shall be used.

The restricted operating mode shall be activated by a lockable mode selector switch.

The restricted operating mode shall be applicable in the danger zone, where persons can reach moving parts up to a height of 2,5 m from ground level or from the level a person is standing.

This mode shall be maintained by the switch or until the interlocking movable guard has been closed and reset or the sensitive protective device is no longer triggered and has been reset.

This mode may be used during rigging, maintenance or special protective mode operations.

Normal machine operation may be initiated after the normal operating mode is selected, the interlocking movable guard has been closed and reset or the sensitive protective device is no longer triggered and has been reset, and the start control is actuated. Mode selection by itself shall not initiate machine operation.

Restricted operating mode shall comprise:

— a rotational speed of not more than 30 rpm or “inching mode” that is no more than half a revolution per activation in the danger zone;and

— a feed speed of not more than 15 m/min, or “inching mode” that is no more than10 cm feed stroke per activation, in the danger zone;and

— “hold-to-run” control for rotation function;and

— “hold-to-run” control for feed function;and

— an indicator informing the operator and crew that the restricted operating mode is on.

When hold to run controls for rotation are released the rotating parts shall stop in less than half a revolution.

5.23.2.2.5 Special protective mode for specific circumstances

Where circumstances are foreseen by the manufacturer that specific applications/positions/orientations where the use of safeguards (guards and protective devices) is not possible (e.g. confined spaces, limited working areas, work close to obstacles or structures), a special protective mode shall be installed to operate without guards (see 5.23.2.2.2) and sensitive protective devices (see 5.23.2.2.3) disabled.

Safeguards shall be designed to remain as far as possible fixed on to the machine e.g. adjustable, foldable, retractable, slideable.

This mode shall not be permitted if the operator at the control station or using a remote control has the possibility to reach the moving parts involved in the drilling process.

This mode shall be activated by a lockable mode selector switch.

In this mode:

— rotation and feed controls shall be hold-to-run;and

— rotation and feed can operate at normal speed;and

— a warning signal (visual and/or audible) shall be activated when the special protective mode is selected;and

— additional pressure sensitive devices shall be fitted (see 5.23.2.2.6).

During the use of the special protective mode for specific circumstances the reduction of the rotation and feed speed of the machine while adding or removing rods shall be achieved by activation of the ROM.

Sensor, e.g. on clamps, shall be fitted, activating by design a slow speed rotation according to 5.23.2.2.4 in order to avoid to add or remove tools at full speed.

5.23.2.2.6 Additional pressure sensitive devices

Additional pressure sensitive devices to be used in the special protective mode for specific circumstances shall be designed in accordance with EN ISO 13856-2:2013 and EN ISO 13856-3:2013, as relevant, together with the following requirements:

— be activated by contact with any part of a person;

— be activated by a force in accordance with EN ISO 13856 for pressure sensitive devices and from any foreseeable actuation direction;

— be activated by an actuating travel of less than 50 mm;

— an activation shall stop the moving parts identified with the residual risks as follows:

— special protective mode; rotating parts, feed movements and remaining moving parts shall stop as quickly as possible without creating additional hazards;

— restricted operating mode; rotating parts shall stop in less than half a revolution; feed movements and remaining moving parts shall stop as quickly as possible without creating additional hazards;

— be positioned and of sufficient number to cover any residual risks;

— be of design and construction together with its associated signal parts, connecting wiring etc. so as to prevent unauthorized or deliberate overriding of its function;

— be clearly visible and of a colour that contrasts with the standard machine, with red being the normal colour;

— be capable of being tested prior to each period of machine operation by the operator.

The stopping performances shall be verified according to the test code defined in Annex G.

5.23.3 Transmission parts

Transmission parts such as drive shafts, couplings, belt drives, which are within reach of personnel, shall be installed with guards to prevent contact. Guards shall comply with EN 953:1997+A1:2009, and shall be of robust construction and securely held in place. Fixed guards shall be installed when access is rarely necessary.

NOTE EN ISO 12100:2010 sets out the general principles for the guarding of moving parts.

The mechanical ventilation and the cooling ports shall be provided with grills or similar devices to prevent fingers and limbs from reaching the moving components, in accordance with EN ISO 13857:2008.

When frequent access is required for service or maintenance purposes, movable interlocking guards shall be fitted. They shall fulfil the following requirements:

— whenever possible they shall remain fixed to the machine when open;

— they shall be fitted with a system supporting them in the open position;

The support may be locking, latching or spring-loaded.

5.23.4 Drilling and foundation equipment using threaded drill string connections

A powered drill rod break out system shall be installed on drilling and foundation equipment using threaded drill rods.

NOTE The following designs are regarded as being valid parts of a powered drill rod break out system:

— on drilling and foundation equipment with top hammers, the percussive mechanism is regarded as being a part of the powered drill rod break out system;

— on rotary top drive drilling and foundation equipment, the controlled reverse rotation of the head drive, together with the use of a chuck device or equivalent lockable rotating connection is regarded as being a powered drill rod break out system;

— on rotary spindle drilling and foundation equipment, the controlled reverse rotation of the chuck or an equivalent lockable rotating connection and the rotation of the spindle is regarded as being a part of a powered drill rod break out system;

— bottom mounted break out clamp system.

5.23.5 Clamps and rod breaking clamps used in the drilling process

All mechanical or hydraulic rod clamps and rod breaking clamps shall be designed and equipped to protect against the hazards during operation and maintenance of:

— entrapment;

— shearing;

— crushing.

NOTE One example may be hold to run controls with full visibility of clamps etc. from control panel

5.23.6 Tools handling system

If the mass of a tool and the working process causes any person to handle more than 25 kg, the drilling and foundation equipment shall be provided with a mechanized tool handling system, e.g. carousel, magazine, robot arm etc.

If the application of drilling and foundation equipment does not allow the use of a mechanized rod or pipe handling system:

— the drilling and foundation equipment shall be fitted with a lifting device allowing safe transfer of the rods and/or pipes to the drill axis and vice versa. A pivoting rotary head with a chuck or a travelling block either with an elevator, lifting cap, pulling out flange, lifting sling or similar is considered as being sufficient;

or

— the manufacturer shall specify how handling of rods or pipes shall be done, e.g. with external equipment or second person.

All mechanized rod or pipe handing systems that incorporate storage of rods or pipes shall be designed and equipped to prevent the unintentional release or movement of the rods or pipes at any time, including maintenance tasks.

All tool handling systems shall be designed and equipped to protect against the hazards during operation and maintenance of:

— entrapment;

— shearing;

— crushing.

NOTE One example might be hold to run controls with full visibility of the system from control panel.

5.24 Falling or ejected objects

Drilling and foundation equipment shall be designed, constructed and equipped to prevent objects that could cause injury from falling or being ejected towards persons.

NOTE Falling or ejected objects include:

— air flush cuttings, excavated material, dust;

— machine parts/components or fragments of machine parts/components;

— tools or fragments of tools.

Drilling and foundation equipment using either compressed air or air mist as a flushing agent shall be fitted with a system to prevent injury to persons from ejected material or dust, e.g. dust collectors, diverters/deflectors etc. See also 5.28.2.

All drilling and foundation equipment that is capable of using a continuous flight auger greater than 350 mm outside diameter and with flights wider than 100 mm which can carry material to a height of 10 m or more above ground level shall be provided with an auger cleaning device or connections for an auger cleaning device or other measures to prevent spoil causing injury to personnel at ground level.

This auger cleaning device or other measures shall:

— be positioned or guarded to prevent injury to persons;

— discharge spoil without risks to persons, e.g. fitting a shroud or chute to direct material safely to ground level.

5.25 Lighting

5.25.1 Working light

If drilling and foundation equipment is specified to work in darkness and non-lit conditions, lighting shall be fitted giving an illumination of at least 100 lux of the area around the point of operation apart from natural shadows from the equipment.

All internal parts requiring frequent inspection and adjustment and maintenance areas, shall have appropriate lighting.

White light shall be used.

5.25.2 Illumination when tramming or slewing

For drilling and foundation equipment tramming, travelling or slewing in darkness, lighting shall be provided giving an illumination of at least 10 lux at a distance of 7 m from the drilling and foundation equipment in the direction of movement.

5.25.3 Lighting inside the cab

For machines fitted with a cab, lighting shall be provided.

Lighting shall be provided to facilitate access to the machine.

5.26 Fire prevention

5.26.1 General

Materials used in the construction of drilling and foundation equipment shall be fire resistant as far as possible. Cab interior upholstery shall be made of flame retardant material which has a linear velocity of flame propagation of maximum 250 mm/min when tested in accordance with ISO 3795:1989.

There shall be a physical barrier between hydraulic hoses and hot surfaces or a sufficiently large air gap to prevent damage to the hoses from heat. Any barrier shall not restrict the circulation of engine cooling air.

A fixed fire suppression system does not replace the requirements for fire extinguishers as described in 5.26.2.

5.26.2 Fire extinguishers

Drilling and foundation equipment with an operating mass of more than 1 500 kg shall have space for installation of fire extinguisher(s) easily accessible to the operator, or a built-in extinguishing system to permit the operator a safe exit of the machine.

5.26.3 Installation of fire extinguishers

The places for fire extinguishers shall be located in the immediate vicinity of the operator or, in case of remotely controlled drilling and foundation equipment, in another clearly visible and easily accessible place.

If there are more than one fire extinguisher on the drilling and foundation equipment, they shall be placed on different sides of the rig.

Fire extinguishers shall not be placed near areas with a high fire risk, e.g. power units, fuel tanks. The fire extinguishers shall be positioned between the operator and such an area.

5.26.4 Fire prevention for fuel and hydraulic circuits

All fuel and hydraulic circuits within the engine compartment shall comply with the following:

— where possible hydraulic components shall not be located where main ventilating air will cause leaking oil to be spread over the engine compartment;

— when using hydraulic driven fans then the fan hydraulics shall be suitably guarded to ensure that oil does not come in contact with ignition sources;

— all fuel tanks be fitted with non-leaking caps which are effective irrespective of the orientation of the equipment;

— all pipes/hoses shall be routed in a manner which will give them maximum mechanical protection against wear and mechanical and thermal damage;

— all fuel lines shall be metal or metal braided or equally wear resistant.

— the hydraulic system shall be adequately shielded in accordance with Clause 9 of EN ISO 3457:2008.

5.27 Noise and vibration

5.27.1 General

The significant emission of noise and vibration occurs during operation of drilling, pile driving or excavation (diaphragm walls). Travelling and tramming are negligible contributors. The noise and vibration levels during operation are heavily influenced by the operation process.

5.27.2 Noise

5.27.2.1 Noise reduction at the design stage

Drilling and foundation equipment shall be so designed and constructed that risks resulting from the emission of airborne noise are reduced to the lowest level taking account of technical progress and the availability of means of reducing noise, in particular at source.

When designing drilling and foundation equipment, the available information and technical measures to control noise at source shall be taken into account, e.g. EN ISO 11688-1:2009.

NOTE 1 EN ISO 11688-2:2000 gives useful information on noise generation mechanisms in machinery.

The following measures, where practicable, are suitable examples:

— use of low-noise components, like engines, fans, pumps and gears;

— a cab as specified in 5.14;

— enclosure of the engine(s);

— exhaust mufflers;

— vibration insulation mounting.

NOTE 2 Guidelines for the design of cabs and enclosures can be found in EN ISO 15667:2000.

Other measures with the same or better efficiency can be used.

5.27.2.2 Measurement of noise emission

The measurement of the sound power from the drilling and foundation equipment and the emission sound pressure level at the operator's position shall be carried out in accordance with Annex B and the results shall be stated in the operator’s manual according to 7.3.2.2.4.

5.27.3 Vibration

Drilling and foundation equipment shall be so designed and constructed that the risk to the operator resulting from vibration is reduced to the lowest level taking account of technical progress and the availability of means of reducing vibration, in particular at source. Vibrations affecting the operator, sitting or standing at the operator's position shall be measured at operating conditions as defined in Annex C and shall be stated in the operator’s manual according to 7.3.2.2.5.

NOTE Reduction of risk of vibrations: CEN/TR 15172-1 gives general technical information on widely recognized principles for the design of mobile machinery. A reference to CEN/TR 15172-1 will usually be appropriate.

For a seated operator's position, the seat used shall meet the requirements of EN ISO 7096, input spectral class EM 6 for crawler machines and EM 3 for wheeled machines with regard to its ability to reduce the vibration transmitted to the operator.

5.28 Exhaust gases and dust

5.28.1 Engine exhausts

Exhaust gases from internal combustion engines of drilling and foundation equipment shall be directed away from the operating position(s).

Exhaust gases from internal combustion engines of drilling and foundation equipment intended for use in underground workings shall not be discharged upwards.

5.28.2 Dust

Drilling and foundation equipment, which during the work process produces dust of any kind, shall be equipped with a device that provides the handling of dust, securing a significant reduction of dust emissions. The device shall be able to handle all working conditions and applications as specified by the manufacturer.

Acceptable methods for dust control are:

— use of water as flushing medium;

— adding an additive to the flushing air such as water or foam;

— use of any dust suppression/extraction method, e.g. cyclone, fraction device.

The dust control device shall be designed so that it is in operation when drilling is started.

5.29 Maintenance

Locations at which planned maintenance is required shall be readily accessible, preferably from ground level.

It shall be possible to carry out adjustment, maintenance, lubrication, repair, cleaning and service operations while the drilling and foundation equipment is shut down and the prime mover stopped.

If for technical reasons one or more of the above work items cannot be carried out under a shut down condition, precautions shall be taken so that the work can be carried out safely, see 7.3.3.

Winches and ropes are subject to frequent inspection because of the wear pattern. The manufacturer shall make due provision for safe access for the replacement of ropes.

For routine maintenance the manufacturer shall provide means to handle and instructions how to handle components over 25 kg in weight or which are otherwise awkward to handle.

Any component, for example filters, engines, hydraulic tanks, etc. (excluding hoses), containing fluid which can cause risk of pollution, personal contamination or slip hazard, shall be designed and located so that during service and maintenance the fluid can be directed under control into a suitable receiving container.

5.30 Warning devices

There shall be a manually operated, audible alert signal to warn personnel in the working area of impending danger. It shall be possible to operate the audible warning from each driving or operating position including (if applicable) a remotely situated monitoring position. The audible alert signal shall meet the requirements in EN ISO 7731:2008 (Sound pressure Level, 1/3 Octave or listening test). During the test the machine shall be operated at full engine speed. Alternative compliance could be confirmed by calculation.

Drilling and foundation equipment shall be provided with an automatic audible or visual alert signal to warn personnel in the working area during slewing/tramming/travelling.

If an audible reverse alarm is used it shall conform to ISO 9533:2010.

6 Verification of the safety requirements and/or protective measures

6.1 General

Safety requirements and/or protective measures of Clauses 5 and 7 of this European Standard shall be verified according to Table 4 below. It includes the following types of verification:

a) design check: the result of which being to establish that the design documents comply with the requirements of this European Standard;

b) calculation: the results of which being to establish that the requirements of this European Standard have been met;

c) visual verification: the result of which only being to establish that something is present (e.g. a guard, a marking, a document);

d) measurement: the result of which shows that the required numerical values have been met (e.g. geometric dimensions, safety distances, resistance of insulation of the electric circuits, noise, vibrations);

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

f) special verification: the procedure being given or in the referred clause.

Table 4 — Verification of safety requirements and/or protective measures

Clause number	Title	a) Design check	b) Calculation	c) Visual verification	d) Measurement	e) Functional test	f) Special verification (see at the end of this table)
5	Safety requirements and/or protective measures						2
5.1	General						2
5.2	Requirements for strength and stability						2
5.2.1	Loads						
5.2.1.1	Introduction	x					2
5.2.1.2	Regular loads	x	x				2
5.2.1.3	Occasional loads	x	x				
5.2.1.4	Exceptional loads	x	x				
5.2.2	Structural calculations	x					
5.2.2.1	General	x	x				
5.2.2.2	Calculation methods	x	x				2
5.2.2.3	Analysis	x					
5.2.2.3.1	General stress analysis	x	x				
5.2.2.3.2	Elastic stability analysis	x	x				
5.2.2.3.3	Fatigue-stress analysis	x	x				
5.2.3	Rigid body stability						
5.2.3.1	General	x					
5.2.3.2	Stability criteria	x	x				
5.2.3.3	Tipping lines						
5.2.3.3.1	General	x					2
5.2.3.3.2	Tipping lines for crawler machines	x	x				
5.2.3.3.3	Additional support	x	x				
5.2.3.4	System of loads						
5.2.3.4.2	Weights and moments of inertia	x	x			x	
5.2.3.4.3	Centrifugal load	x	x			x	
5.2.3.4.4	Wind load	x	x				
5.2.3.4.5	Dynamic loads	x	x			x	
5.2.3.4.6	Horizontal load from unguided lifted load	x	x				
5.2.3.4.7	Working loads	x					
5.2.3.5	Stability calculation – Tipping angle	x	x				
5.2.3.6	Operating conditions	x					
5.2.3.6.2	In service – during operation	x					

5.2.3.6.3	Tramming	x					
5.2.3.6.4	Out of service – erected leader	x	x				
5.2.3.6.5	Out of service – lowered leader, during rigging and stowed condition during transport	x	x				
5.2.3.6.6	Travelling and operating on slopes	x	x				
5.2.3.6.7	Equipment mounted on truck or trailer	x					
5.2.3.6.8	Leader support foot	x	x			x	
5.2.3.7	Ground pressure	x	x				
5.2.4	Floating ship, barge or pontoon	x	x				
5.3	Electrotechnical systems						
5.3.1	General	x		x			2
5.3.2	Battery installation	x		x			2
5.4	Hydraulic and pneumatic systems						
5.4.1	Hydraulic systems	x		x	x	x	2
5.4.2	Pneumatic systems	x		x	x	x	2
5.4.3	Hoses, pipes and fittings under pressure	x		x		x	1, 2
5.5	Failure of the power supply	x				x	
5.6	Uncontrolled motion	x				x	
5.7	Brakes of the carrier machine						
5.7.1	Brakes for travelling	x				x	2
5.7.2	Brakes for slewing	x				x	2
5.8	Winches, draw-works and ropes						
5.8.1	General	x					
5.8.2	Winches and pulleys	x	x			x	
5.8.3	Pulley and drum diameters shall meet the following minimum requirements:	x				x	
5.8.4	Ropes and rope end terminations	x		x			
5.8.5	Roller and leaf chains	x		x			
5.9	Masts, derricks and feed beams	x		x		x	
5.10	Indicating/limiting devices for inclination						
5.10.1	Inclination of leader, mast or boom	x		x		x	
5.10.2	Inclination of the carrier	x		x			
5.10.3	Stroke limiting devices	x				x	
5.11	Ergonomics for control stations and servicing points	x					2
5.12	Access to operating positions, intervention and servicing points	x					2
5.13	Platforms on mast, leaders, etc.						
5.13.1	General						2
5.13.2	Working platform for lifting personnel	x			x	x	2
5.13.3	Movable platform	x			x	x	2
5.14	Operating position(s)						

5.14.1	General	x			x	x	2
5.14.2	Visibility	x		x		x	2
5.15	Control systems						
5.15.1	General	x					2
5.15.2	Required performance levels for safety related parts of control systems	x	x			x	2
5.15.3	Starting	x				x	
5.15.4	Stopping						
5.15.4.1	Normal stopping	x				x	
5.15.4.2	Emergency stopping	x		x		x	2
5.16	Control devices						
5.16.1	General	x		x		x	2
5.16.2	Inadvertent actuation of controls	x				x	
5.16.3	Controls for extending the crawlers (tracks) of the carrier machine	x		x			
5.17	Remotely controlled and automated drilling and foundation equipment						
5.17.1	General	x				x	2
5.17.2	Operating position	x		x		x	
5.17.3	Emergency stop			x		x	2
5.17.4	Control system	x				x	2
5.18	Unmanned, automatically operated drilling and foundation equipment	x				x	
5.19	Retrieval, transportation, lifting and towing of the drilling and foundation equipment and its parts						
5.19.1	Common use	x					
5.19.2	Retrieval/Towing	x					2
5.19.3	Tie-down	x					2
5.19.4	Lifting points	x	x				2
5.19.5	Transportation	x		x			
5.20	Handling of drilling tools	x		x			
5.21	Isolation of energy sources	x				x	2
5.22	Hot and cold surfaces and sharp edges	x					2
5.23	Protection against moving parts						
5.23.1	General	x					
5.23.2	Moving parts involved in the process	x					
5.23.2.1	General						2
5.23.2.2	Guards and protective devices	x		x		x	2
5.23.2.2.1	General	x		x		x	2
5.23.2.2.2	Guards	x		x		x	2
5.23.2.2.3	Sensitive protective devices	x		x		x	
5.23.2.2.4	Restricted operating mode (ROM)	x		x		x	

5.23.2.2.5	Special protective mode for specific circumstances	x		x		x	
5.23.2.2.6	Additional pressure sensitive devices	x			x		
5.23.3	Transmission parts	x		x			2
5.23.4	Drilling and foundation equipment using threaded drill string connections	x					
5.23.5	Clamps and rod breaking clamps used in the drilling process	x		x			
5.23.6	Tools handling system	x		x		x	
5.24	Falling or ejected objects	x		x		x	
5.25	Lighting						
5.25.1	Working light	x			x		
5.25.2	Illumination when tramming or slewing	x			x		
5.25.3	Lighting inside the cab	x				x	
5.26	Fire prevention						
5.26.1	General	x		x			2
5.26.2	Fire extinguishers	x		x			
5.26.3	Installation of fire extinguishers	x		x			
5.26.4	Fire prevention for fuel and hydraulic circuits	x		x			2
5.27	Noise and vibration						
5.27.2	Noise						
5.27.2.1	Noise reduction at the design stage	x					2
5.27.2.2	Measurement of noise emission				x		
5.27.3	Vibration	x			x		2
5.28	Exhaust gases and dust						
5.28.1	Engine exhausts	x				x	
5.28.2	Dust	x				x	
5.29	Maintenance	x		x			
5.30	Warning devices	x				x	
7	Information for use						
7.1	Marking						
7.1.1	Data plate for drilling and foundation equipment			x			
7.1.2	Data plate for working platforms for lifting personnel and movable platforms			x			
7.2	Indicators						
7.2.1	Information indicators			x			
7.2.2	Warning signs for residual hazards			x			2
7.2.3	Warning devices			x		x	2
7.3	Instruction books for drilling and foundation equipment						
7.3.1	General			x			2
7.3.2	Operator's manual			x			
7.3.2.1	General information			x			

7.3.2.2	Safety information			x			
7.3.2.2.2	Warning signs			x			
7.3.2.2.3	Capacities and limitations			x			
7.3.2.2.4	Noise			x			
7.3.2.2.5	Vibrations			x			2
7.3.2.3	Technical information			x			2
7.3.2.4	Operating instructions			x			
7.3.2.5	Transportation and assembly instructions			x			
7.3.3	Maintenance instructions			x			2
7.3.4	Spare parts list			x			
1 Verification by reference to hose manufacturer documents. 2 Verification by reference to standard which is mentioned in the corresponding clause.							

6.2 Testing

6.2.1 General

Each drilling and foundation equipment shall be tested before being put into service to ensure that it is able to fulfil its specified functions safely. The test results shall be recorded.

The tests shall include

— functional tests according to 6.2.2.1; and

— load tests according to 6.2.2.2 and 6.2.2.3.

At the conclusion of testing, all limiters that may have been either disengaged or adjusted to facilitate such testing shall be reactivated and returned to their prescribed operational settings.

6.2.2 Tests

6.2.2.1 Functional test

All motions of the drilling and foundation equipment shall be operated throughout their range of movements, without load, up to their maximum operating speeds. Motion limiters and buffer positions shall initially be approached and contact made at slow speed prior to contact being made at maximum operational speed.

All functions of drilling and foundation equipment shall be tested in accordance to the safety requirements of Clause 5.

6.2.2.2 Static test

Drilling and foundation equipment fitted with hoisting/pulling abilities, e.g. winches, hydraulic cylinder, rack and pinion, chain feed, etc. shall be tested with a test load of:

— all loads guided by a mast/leader or guided to a boom 100 % of the rated capacity;

— all free suspended loads 125 % of the rated capacity; or the winch load multiplied by the factor that has been used in design calculations whichever is the greater.

Equipment tests will be performed using load combinations which are allowed for the use, selecting the most unfavourable ones.

Where drilling and foundation equipment is equipped with more than one hoisting/pulling mechanism that can be used separately, it shall be tested individually.

Drilling and foundation equipment that is equipped only with direct acting limiters, shall be tested in accordance with the above load values, or the direct acting limiter setting, whichever is the greater.

The test shall be carried out in the critical positions, so as to qualify overload and stability requirements.

The test load shall be positioned 100 mm to 200 mm above the ground and be applied for a minimum period of 5 min at each critical position.

Tests are considered successful, if no fractures, permanent deformations or damages affecting the function or safety of the drilling and foundation equipment are visible and if no connections have loosened or show signs of damage.

Minor permanent deformations such as settling are acceptable providing they do not affect the functioning of the drilling and foundation equipment.

6.2.2.3 Dynamic test

Dynamic tests shall be performed with a test load that is at least 100 % of the rated capacity.

The tests shall include repeated starting and stopping of each motion, including all combined movements as provided by the intended use over the whole sequence of the movements. During these tests the drilling and foundation equipment shall be continuously monitored to check for

— smooth operation of the drilling and foundation equipment,

— effective operation of the braking systems,

and unless previously checked, the effectiveness and accuracy of limiting and indicating devices.

The dynamic tests are considered successful if the components in question have fulfilled their function, the subsequent examination does not reveal any damage to the drive or supporting structure and if no connection has loosened or been damaged.

6.2.2.4 Fitness for purpose

Before being put into service, each working platform for lifting personnel that is moved by systems of either steel wire rope, chain, tooth rack and pinion or hydraulic cylinders shall be tested according to the requirements in 5.13.2 with a load of 125 % of the rated load.

7 Information for use

7.1 Marking

7.1.1 Data plate for drilling and foundation equipment

The data plates for drilling and foundation equipment shall give at least the following information:

a) business name and full address of the manufacturer and, where applicable, his authorized representative;

b) designation of the machinery;

c) type designation;

d) serial number and year of construction, that is the year in which the manufacturing process is completed;

e) installed power, in kilowatts;

f) rated voltage and frequency of the electrical installation;

g) mass of the most usual configuration, in kilograms (see also specific parts of this standard);

h) mandatory marking[5)].

7.1.2 Data plate for working platforms for lifting personnel and movable platforms

A working platform for lifting personnel or a movable platform shall have a data plate with the following information:

— the maximum number of persons permitted on the platform;

— the maximum working load.

7.2 Indicators

7.2.1 Information indicators

The information needed to control drilling and foundation equipment shall be presented in an unambiguous manner and so that it is easily understood. Pictograms are preferred, see Annex D.

7.2.2 Warning signs for residual hazards

Where hazards remain despite all measures adopted or in the case of potential hazards that are not evident, warnings shall be provided on the machine and mentioned in the operator's manual.

Such warnings shall preferably use readily understandable pictograms, see Annex D, and/or be drawn up in the languages as required in EN ISO 12100:2010, 6.4.4.

The drilling and foundation equipment shall be equipped with warning signs forbidding entry of unauthorized personnel into the danger zone of the machine.

A remotely controlled and/or unmanned, automatically operated drilling and foundation equipment shall be equipped with signs warning that the drilling and foundation equipment is remotely and/or automatically operated.

7.2.3 Warning devices

Warning devices such as signals (see 5.4, 5.17.2, 5.23.2.2.5, 5.23.2.2.6, 5.30), etc. shall be unambiguous and easily perceived. The operator shall have the facility to check the operation of all essential warning devices at all times.

7.3 Instruction books for drilling and foundation equipment

7.3.1 General

The instruction books shall be drawn up according to 6.4.5 of EN ISO 12100:2010.

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5) For machines and their related products intended to be put on the market in the EEA, CE-marking as defined in the applicable European Directive(s), e.g. Machinery.

The following documentation (separate or combined) shall be supplied with every drilling and foundation machine and interchangeable auxiliary equipment:

— operator's manual, which shall be available on the machine in a place specially intended for it. For interchangeable auxiliary equipment the operator´s manual should be located on the carrier base machine;

— maintenance instructions;

— instructions for inspections;

— spare parts list;

— transport and assembly instructions, where applicable;

— where appropriate, a test report detailing the static and dynamic tests carried out by or for the manufacturer or his authorized representative.

This European Standard specifies only safety-related matters in these instruction books.

The instruction books are part of the product and are important documents for the safe and proper operation, maintenance and service of the drilling and foundation equipment. The text shall be simple, adequate and complete. The wording shall be adapted to the people who are using the products. The information shall be comprehensive and explicit.

All information concerning personal safety shall be specially marked so as to be identified as information for personal safety.

NOTE For guidance, see ISO 6750:2005.

The need to give the operating and maintenance personnel practical training in the operation, maintenance and mounting/dismounting operations of the drilling and foundation equipment with special emphasis on the safety precautions and the content of this training shall be mentioned in the instruction books.

7.3.2 Operator's manual

7.3.2.1 General information

The operator's manual shall, on its first page and/or front cover, give the following information:

— manufacturer or his authorized representative;

— title of manual;

— type designation of drilling and foundation equipment concerned together with information on type, model and serial number if applicable;

— the same information as on the data plate;

— details of manufacturer and the sales companies, distributors or authorized agents including names, full addresses, and communication details.

All instructions that are important for the safe operation of the machine shall be included:

— a general view of the drilling and foundation equipment and its attachments;

— specification of the intended use of the machine;

— warning concerning any changes to the machine, and against reasonable foreseeable misuse;

— if a continuous flight auger greater than 350 mm outside diameter and with flights wider than 100 mm which can carry material to a height of 10 m is to be used, an auger cleaning device shall be used;

— necessary drawings, diagrams and illustrations of sufficient size to be quite clear showing the designation of major components, their functions, locations and relationships with the whole drilling and foundation equipment;

— explanation of symbols used;

— identity of single machinery parts, e.g. pile cap;

— a detailed description of each winch and its intended use;

— a warning stating that any other use of a winch (e.g. lifting goods in general) is forbidden and must be considered an improper use of the equipment;

— warnings against actions that can cause injuries to the operator or other personnel.

7.3.2.2 Safety information

7.3.2.2.1 General

The following safety related information shall be included:

— information of residual risks that remain and the prevention measures that shall be taken by the user;

— it shall be made fully clear to the operator where the major risks are and what measures need to be taken to make the operation safe;

— description of danger zone around the machine and advice that all unauthorized persons be kept outside the danger zone during operation;

— description of safety measures during necessary operations in the danger zone, e.g. area of spin-off when using auger tools;

— information about the required no access area for a remotely controlled and/or unmanned, automatically operated drilling and foundation equipment;

— information about the safe area from which the operator can control the machine with the remote control box, e.g. safety distance between the operator and the drilling and foundation equipment;

— information about the need for earth-fault protection system in worksite electric network or mobile power source for electrically powered drilling and foundation equipment;

— instructions of when and how to use safety harnesse or escape/recovery equipment;

— instructions for required personel protective equipment (PPE);

— safety precautions to be taken when transporting, assembling and dismantling the drilling and foundation equipment, parts and attachments with particular attention to the erection and securing of masts, leaders, derricks and feed beams;

— the location and use of fire extinguishers;

— instruction for operating drilling and foundation equipment in confined conditions so that the exhaust gases shall be directed in such a way that they do not return to the working area and create a hazard;

— instructions on the protective measures to be taken by the user;

— instructions about the use of the special protective mode;

— instructions on how the connection and disconnection of the drilling tools shall be carried out;

— instructions for how the handling of the pile elements shall be executed.

7.3.2.2.2 Warning signs

All warning signs used shall be described in the operator's manual.

7.3.2.2.3 Capacities and limitations

The operator's manual shall specify:

— the most unfavourable conditions which may occur at the same time;

— the nominal line pull for all winches and draw works (including admitted inclination if applicable, see 5.2.3.4.6 and 5.2.3.4.7);

— display instructions on stability and any restriction of the inclination of the boom/mast/leader or the carrier at the operator’s position;

— all operational capacities;

— a load/speed diagram for the winches and draw-works;

— instructions on stability and other essential restrictions of use which are of immediate importance shall be given on signs clearly visible at the driver’s and operator’s position, e.g. maximum allowed gradient angle for slopes when tramming, travelling and/or operating on slopes, complete with the corresponding prescribed configurations. Drawings illustrating these cases are recommended;

— if a compressor or power pack is included in the stability calculation as part of the counterbalance, details shall be stated;

— detailed instructions regarding the restrictions and special measures to be taken when working, tramming or parking shall be given;

— the position and allowed configuration of the equipment and loads when “out of service” shall be specified. Optional use of support points and guy ropes shall be given;

— the limit wind speed for this configuration;

— limitation of conditions for tramming shall be given.

7.3.2.2.4 Noise

The operation manual shall contain information on sound power level from drilling and foundation equipment and the emission sound pressure level at the operator's position(s) as follows:

— information as listed in B.7;

— instructions relating to installation and assembly of measures for reducing noise;

— a statement that the noise emission values were determined during a standard test cycle and may not be representative for all conditions in accordance with the intended use. The operating conditions such as the soil or rock the machine is operated on or the operating environment such as sound reflective surfaces nearby can cause the sound levels to be higher than the declared values.

7.3.2.2.5 Vibration

The operator's manual shall contain information on hand-arm and whole-body vibration caused by emission from the drilling and foundation equipment as follows:

— hand-arm vibration if this value exceed 2,5 m/s^2. Experience has shown that the magnitude of hand-arm vibration on the steering wheel or control levers of drilling and foundation equipment with a ride-on operator is in general significantly below 2,5 m/s^2. In this case it is sufficient to mention that the acceleration is below this limit. See also the equipment specific parts of EN 16228;

— the highest root mean square value of weighted acceleration to which the whole body is subjected, if this value exceeds 0,5 m/s^2. Where this value does not exceed 0,5 m/s^2, this shall be mentioned. The particular operating conditions of the equipment relevant for the determination of this single value shall be indicated;

— the uncertainty of measurement;

NOTE 1 This single whole-body vibration emission value was determined under particular operating and terrain conditions and is therefore not representative for the various conditions in accordance with the intended use of the equipment. Consequently this single whole-body vibration emission value declared by the manufacturer in accordance with this European Standard is not intended to determine the whole-body vibration exposure to the operator using this machine.

NOTE 2 As an alternative to the measurement of these vibration values by the manufacturer, these values can be determined on the basis of measurement taken for technically comparable machinery which is representative of the equipment to be produced.

NOTE 3 Information on the uncertainty of vibration measurements and the declaration and verification of vibration values is given in EN 12096:1997. For the estimation of the uncertainty values of 0,4 and 0,5 of the measured vibration value in dependency on the vibration level are indicated in Table D.1.

— if applicable, information on how to minimise vibration risk by limiting the operation modes of the machine, by controlling the method of operation or by limited duration of operation (for example: tramming).

7.3.2.3 Technical information

The operation manual shall contain the following technical information:

— mass of the machine;

— mass of all major sub-assemblies, e.g. leader, power pack;

— the values of ground pressure for all conditions shall be stated;

— maximum allowed mass and capacity of accessories as piling hammer, vibrator, rotary drive etc.(see EN 16228-7:2014);

— requirements for electric power, specified in electrical units as volt (V), hertz (Hz), kilowatt (kW);

— full information on matters of stability so as to enable parking, driving and operation of the drilling and foundation equipment. Maximum allowed gradient angle shall be stated for parking, working and tramming conditions;

— limits of ambient temperatures for which the drilling and foundation equipment is designed;

— maximum wind speed in m/s and Beaufort scale, see ISO 4302:1981;

— maximum slope inclination for travelling and operation;

— maximum pulling load in vertical and other directions;

— speed limits during intended operation;

— maximum operating pressures during intended operation;

— the highest gradient allowed for the drilling and foundation equipment with retained stability margins when tramming on slopes;

— information relative to the stability of the drilling and foundation equipment in the course of use, transport, assembly or dismantling, etc.:

  — tipping lines for all possible positions including additional supports;

— where starting requires that any series of operations shall be performed in a specific sequence;

— instructions for handling of drilling tools and pile elements;

— in case of external energy (see 5.21) instructions for certain circuits which may remain connected to their energy sources, e.g. to hold parts in position, to protect information, to provide interior lighting.

7.3.2.4 Operating instructions

The operator's manual shall contain information and instructions for the safe use of the drilling and foundation equipment:

— inspections and functional checks prior to the start and operation of the equipment with a particular attention to:

  — the need to check the emergency stop(s), sensitive protective devices and additional pressure sensitive devices for their proper function;

  — fluids and lubrication levels;

— where and how emergency stop(s) according to 5.15.4.2, sensitive protective devices according to 5.23.2.2.3 and additional pressure sensitive devices according to 5.23.2.2.6 are installed and function;

— how to safely replace drill rods/pipes with the help of the rotation mechanism and other auxiliary means where available;

— how to handle pile elements;

— a description of the operator's controls and direction of movements;

— the location, operation and function of guards and protective devices;

— instructions concerning the restricted operating mode and worksite organizational measures;

— instructions concerning special protective mode for specific circumstances and worksite organizational measures;

— instructions concerning the use of pressure sensitive devices, where fitted;

— measures which are necessary when the wind load exceeds the maximum value allowed for parked and out of service condition;

— special measures necessary on floating craft;

— information about the location where stored energy is not automatically dissipated (e.g. hydraulic accumulator) and how to release;

— how to remove ice under sub-zero temperature conditions.

7.3.2.5 Transportation and assembly instructions

— description of modular assembly and disassembly of the drilling and foundation equipment;

— information regarding means for towing and the procedure of towing the mobile drill rig in the event of a breakdown;

— information of tying down points and the procedure of securing the rig during transportation;

— information of lifting points and the procedure of lifting the rig.

7.3.3 Maintenance instructions

The precautions to be observed during maintenance and service shall be stated in the maintenance and service manual.

The maintenance instructions shall at least contain:

— the same identification as for the operator's manual;

— names and addresses or a reference to a list of authorized repair and service agents;

— daily, weekly and other scheduled maintenance intervals;

— instructions for ropes particularly subjected to excessive wear (e.g. free-fall winches rope) to be checked at least every day and replaced if damaged;

— specification of oils, lubricants and hydraulic fluids;

— instructions on the maintenance of fire extinguishers;

— methods to safely remove or replace components and parts;

— methods to safely remove and replace ropes;

— information about measuring points and/or locations of diagnostic fault finding equipment and they shall be clearly marked in pictures and tables;

— drawings/functional diagrams for electric, hydraulic and pneumatic circuits, including relevant settings. Illustrations shall be of sufficient size to be clear and show the designation of major components, their functions, locations and relationships in the whole drilling and foundation equipment;

— instructions of how to use special tools provided by the manufacturer;

— instructions for frequency of checking and for replacement of parts which are classified by the manufacturer to be of particular importance for safety (safety critical components). Methods to check the wear of such parts shall be given and the criteria for their repair, adjustment or replacement;

— instructions for the maintenance/examination of wire ropes, see ISO 4309:2010;

— instructions for the maintenance/examination of winches and travelling blocks;

— special warnings against actions which can cause injuries to the repairer or other personnel;

— instructions for required personel protective equipment (PPE).

When there is a need for an operator or a helper to work on the rig in the working area or danger zone and this involves activation of one or several machine functions, such work shall only be done under the following conditions and these details/requirements shall be added in the maintenance manual:

— there shall be at least two persons present, both being fully instructed on the safety issues. One of them shall supervise the safety of the service personnel doing the work;

— the supervisor, who is fully instructed to operate the machine, shall have immediate access to an emergency stop in all situations, if the machine is required to be operational;

— the area where the service work is to be carried out shall be properly illuminated;

— communication between the service personnel and the supervisor shall be established at all times;

— only when the drilling and foundation equipment is shut down completely and the means of starting are isolated is a person is allowed to perform repair and maintenance work alone on the drilling and foundation equipment.

7.3.4 Spare parts list

The spare parts list shall contain all relevant spare parts with unambiguous identification and information on the location of the part in the drilling and foundation equipment.

Annex A
(informative)

List of drilling and foundation equipment

A.1 General

This annex is not a complete list, but is a sufficiently accurate guideline to identify the various types of drilling and foundation equipment. Manufacturers may use this to compare their special equipment and find the right parts of this standard to be used.

EN 16228 "Drilling and foundation equipment – Safety " is divided into seven parts:

— *Part 1: Common requirements*

— *Part 2: Mobile drill rigs for civil and geotechnical engineering, quarrying and mining*

— *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*

In part 2, the general term “drill rig” covers several different types of machines for use in:

— civil engineering;

— geotechnical engineering (including ground investigation, anchoring, soil nailing, mini-piling, ground stabilisation, grouting);

— water well drilling;

— geothermal installations;

— landfill drilling;

— underpinning, tunnelling, mining and quarrying;

— for use above ground as well as underground.

In part 4 the general term “foundation equipment” covers several different types of machines used for installation and/or extracting by drilling, driving, vibrating, pushing, pulling or a combination of techniques, or any other way, of:

— longitudinal foundation elements;

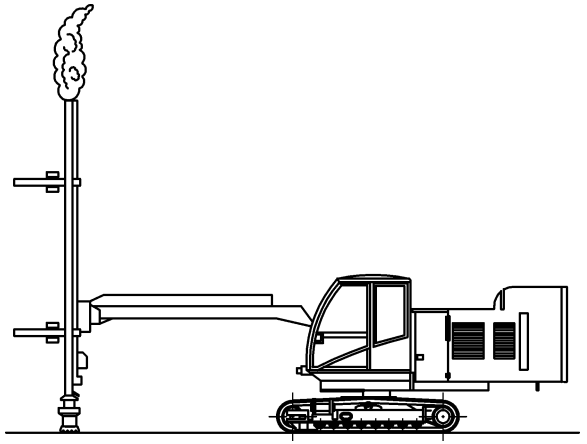
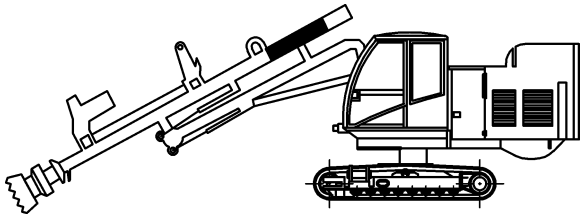
— soil improvement by dynamic compacting, vibrating and soil mixing techniques;

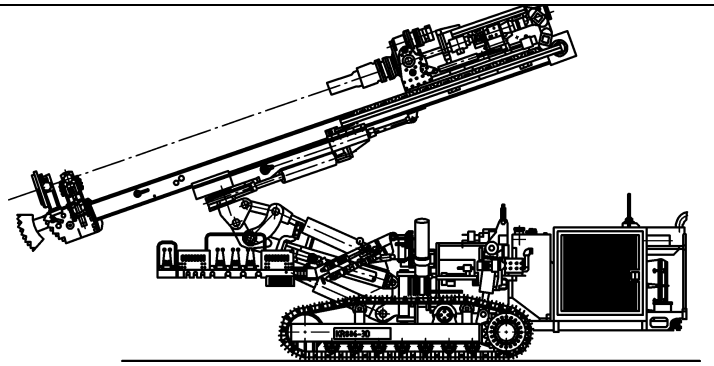
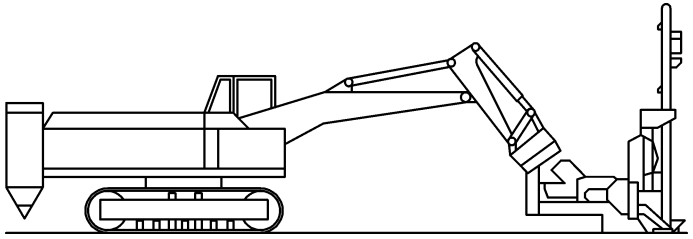
— vertical drainage.

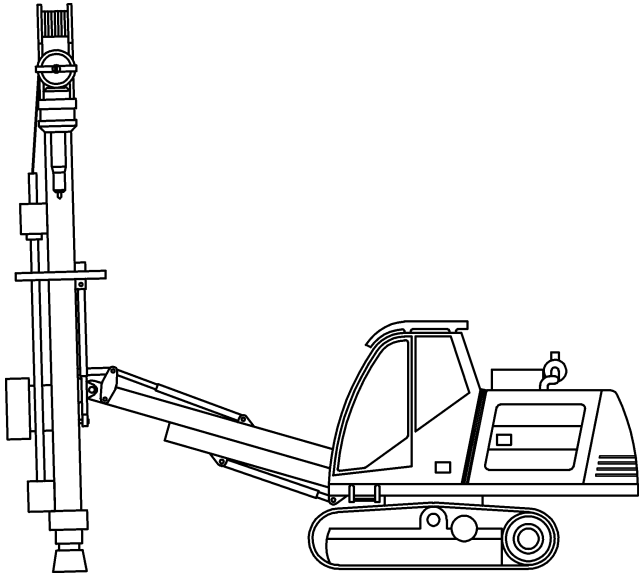
Typically the process of foundation techniques involves the addition of longitudinal elements such as concrete piles, steel beams, tubes and sheetpiles, injection elements as tubes and hoses, casings for cast in situ.

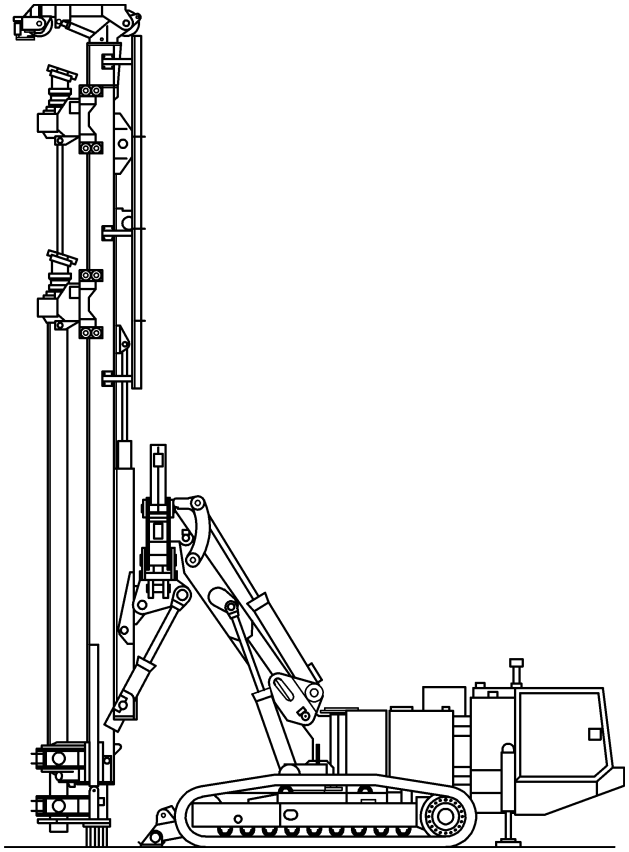
A.2 Illustrations

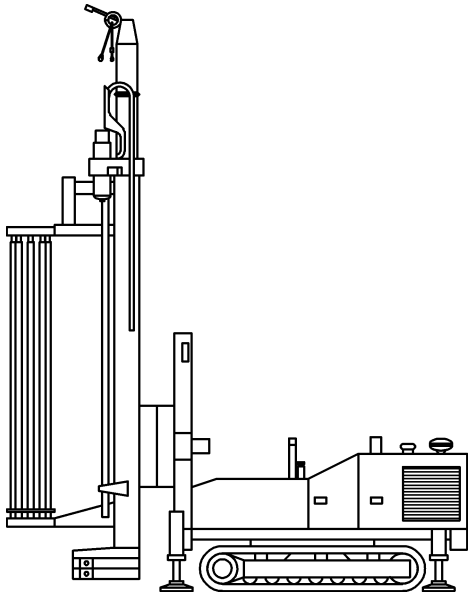
The last column in the table of illustrations below gives the relevant parts of this standard which the equipment needs to comply with.

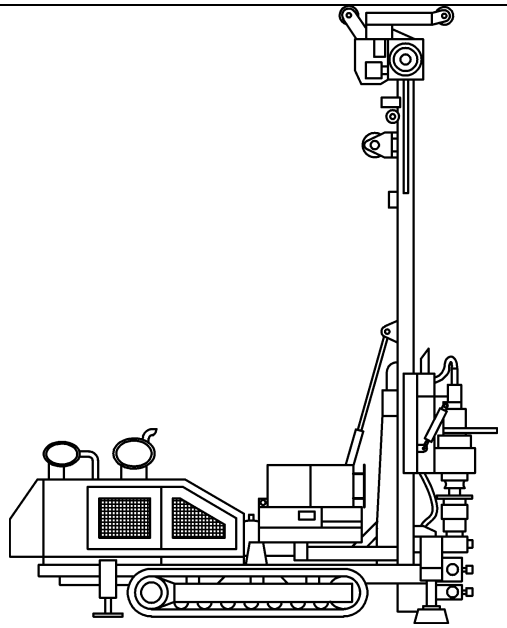
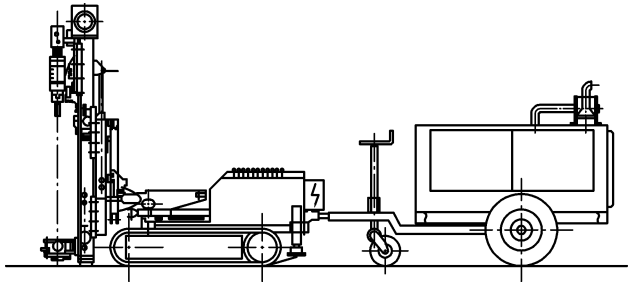
	Equipment	**Description**	**Picture**	**Part number of this standard**
A.2.1	Surface top hammer drill rigs	These drill rigs are equipped with hydraulic (percussive) hammer drills. They may be diesel-powered, self-propelled and equipped with onboard compressors and dust collectors. To be used in construction, road cutting, pipeline drilling and foundation drilling, quarrying or surface mining. They may have a revolving superstructure, articulated boom, mechanized rod changer, remote control and they can handle very rough terrain. Models range from lightweight rubber-tired rigs to heavy crawler drill rigs.	 a)  b)	1 **and** 2

	Equipment	Description	Picture	Part number of this standard
			 c) **Figure A.1**	
A.2.2	Dimensional stone drill rig	Drilling equipment for the dimensional stone industry includes compact rig assemblies for attachment to carriers such as hydraulic excavators, as well as complete, self-propelled, diesel-powered drill rigs that are completely self-contained. Covering applications such as channelling, line drilling, splitting, trimming and pilot-hole drilling.	 **Figure A.2**	1 and 2 or 7

	Equipment	Description	Picture	Part number of this standard
A.2.3	Surface down the hole drill rigs	Designed for high-capacity rock drilling in quarries, opencast mines and construction projects, equipped with down-the-hole hammers. They may be completely self-contained, with onboard compressors or water pump and dust collectors. They can also operate water DTH hammers.	 Figure A.3	1 and 2

	Equipment	Description	Picture	Part number of this standard
A.2.4	Double head drilling systems	Used for several applications where two different stems are running (one inside the other).	 Figure A.4	1 and 2 or 4

	Equipment	Description	Picture	Part number of this standard
A.2.5	Exploration/ soil investigation drill rig	Equipment for drilling boreholes, smaller diameters to explore/take samples in soil or rock, or install tubes, or perform in situ tests. The rod change and storage may be mechanized.	 a)	1, 4 and 7

	Equipment	Description	Picture	Part number of this standard
			 b) **Figure A.5**	
A.2.6	Micro pile drill rig	Used for drilling and/ or foundation applications (might be specially designed for application in low headrooms). Rigs can be driven by direct power of diesel engine, or electric motor. Some rigs use separate power packs with long hydraulic hoses or electric cables.	 **Figure A.6**	1 and 2 or 4

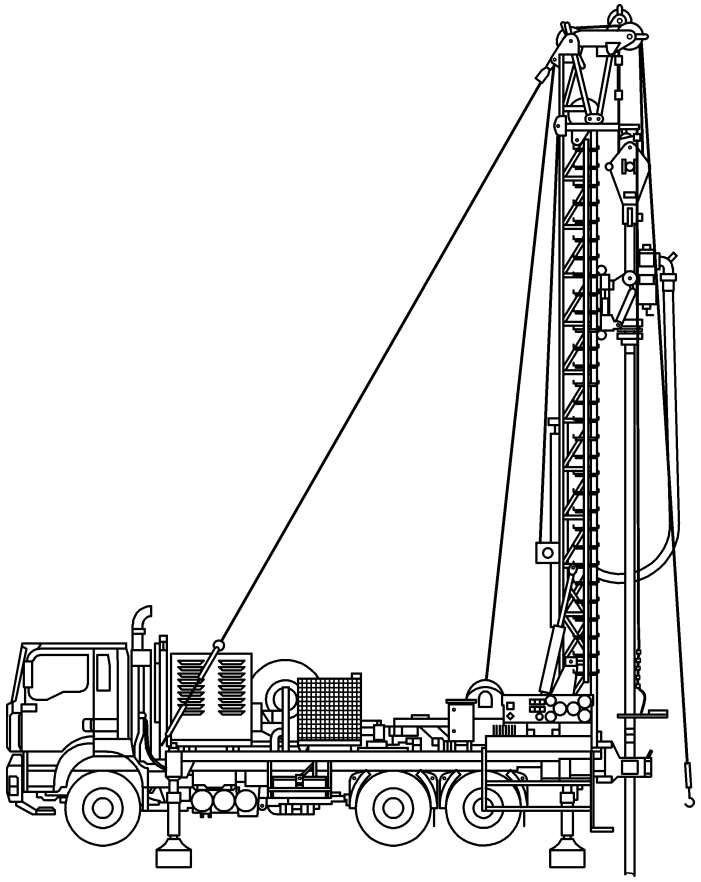
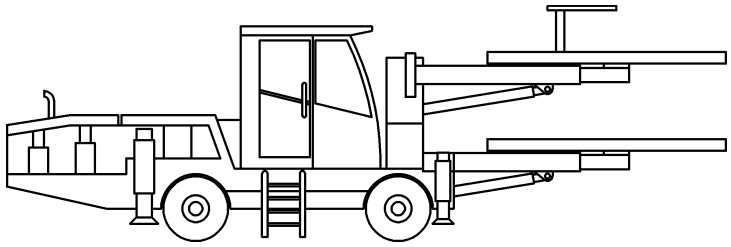
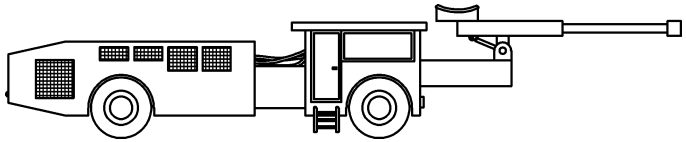
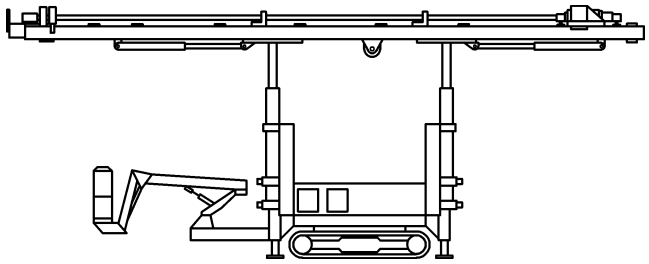
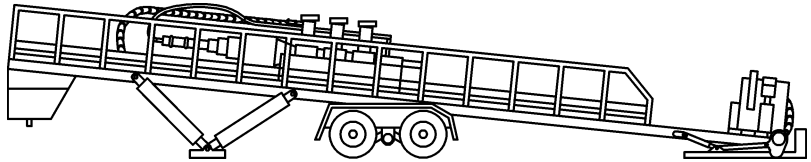
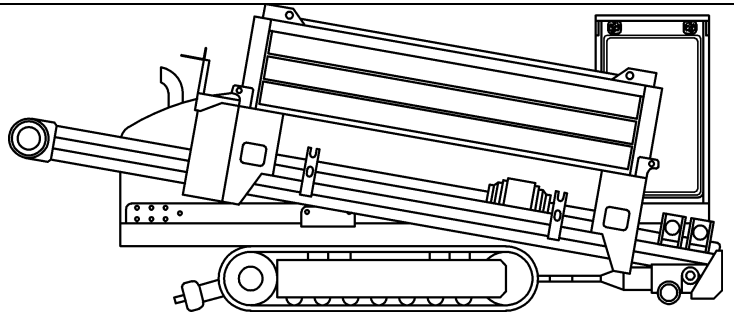
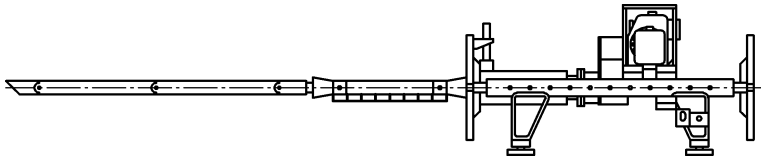
	Equipment	Description	Picture	Part number of this standard
A.2.7	Truck mounted drill rig	To be used for exploration, water well, geothermal applications, piling, etc. Upper structure fixed or rotating.		1, 2 and 4

Figure A.7

	Equipment	Description	Picture	Part number of this standard
A.2.8	Underground drill rig	A machine for drilling blastholes, rockbolting or anchoring in tunnels, mines or similar underground structures. It can be fitted with one or more feed beams and a boom mounted platform. Most of these machines are rubber-tyred. Low-profile and extra low-profile drilling rigs are designed to make it safer and more economical to extract valuable ores from reefs and seams as low as 1,1 meters. Most of these machines are rubber-tyred.	 a)  b) **Figure A.8**	1 and 2 1 and 2
A.2.9	Pre-armouring underground drill rig	Pre-armouring drill rigs specifically designed for and solely intended to be used underground. These machines are typically designed for advanced roof and side wall ground reinforcement, e.g. pre-armouring, fore-poling, spiling etc., in a horizontal or almost horizontal orientation. The machine may be fitted with one or more feed beams and a boom mounted elevating working platform. Reinforcement bar loader may be present depending on the reinforcement technology.	 **Figure A.9**	1 and 2
A.2.10	Horizontal directional drill rig HDD	For drilling horizontal or almost horizontal boreholes. The drill string can be steered to drill underneath roads, canals, buildings, etc.	 a)	1 and 3

	Equipment	Description	Picture	Part number of this standard
			 b) **Figure A.10**	
A.2.11	Horizontal shaft drill rig	To be used in shafts or tunnels for HDD techniques.	 **Figure A.11**	1 and 3

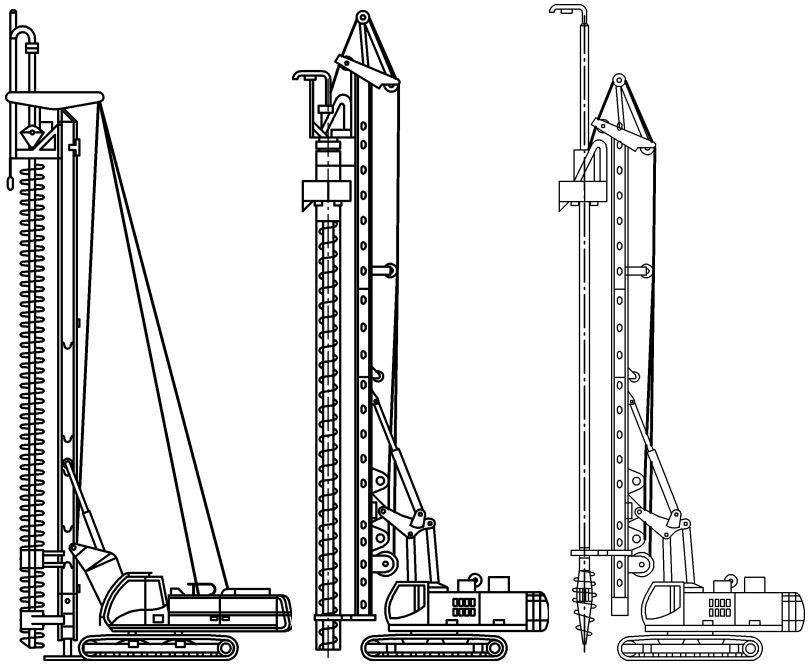
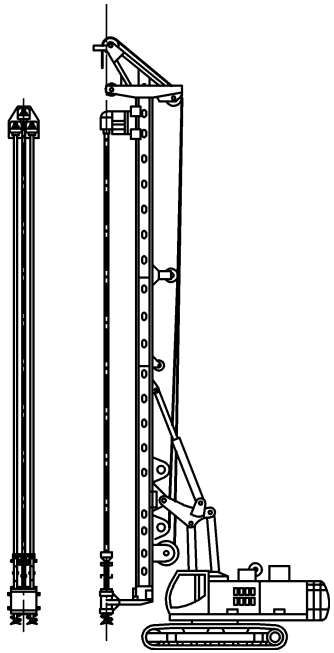
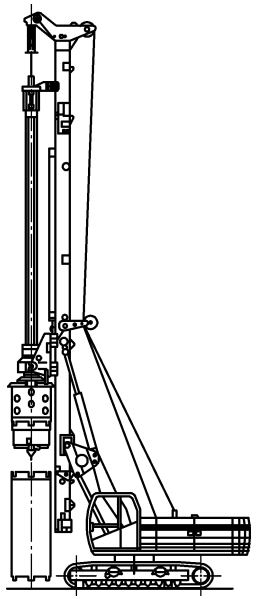
	Equipment	Description	Picture	Part number of this standard
A.2.12	Drilling rig for rotary drilling A Continuous flight Auger (CFA) B Twin rotary drive drill C Soil displacement drilling	With rotary and auger with hollow stem. With double rotating rotary for auger inside a casing which rotate both in opposite direction. With rotary and stem with at the end two flights in different directions (left and right screwed). Or a special pile shoe with tapered screw flight.		1 and 2 or 4

Figure A.12

	Equipment	Description	Picture	Part number of this standard
A.2.13	Soil mixing equipment	Rotary drill rig with one or more hollow drill stems. At the end of the stem, wings for mixing soil with additives as cement, lime, chemicals or mixtures.	 Figure A.13	1 and 4

	Equipment	Description	Picture	Part number of this standard
A.2.14	Kelly drill rigs	Rig fitted with rotary, auger or bucket tools are to be used, with or without casings. Leader not supported to the ground. Commonly used for large diameter piles.	 **Figure A.14**	1 and 4

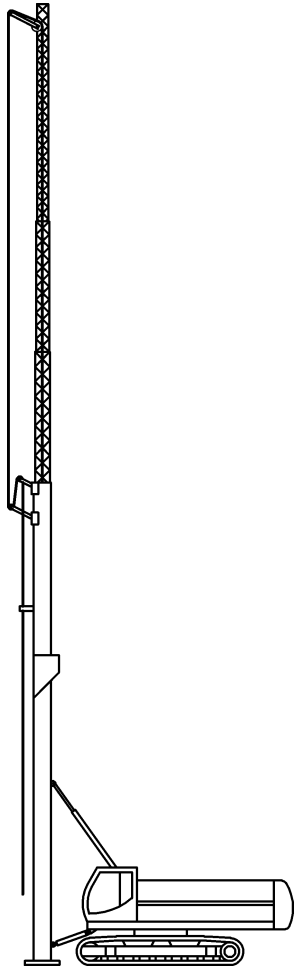
	Equipment	Description	Picture	Part number of this standard
A.2.15	Soil injection drill rig	To install tubes for injection of grout or cement, or direct injection by the injection lance. Can be used for jet-grouting.		1 and 2

Figure A.15

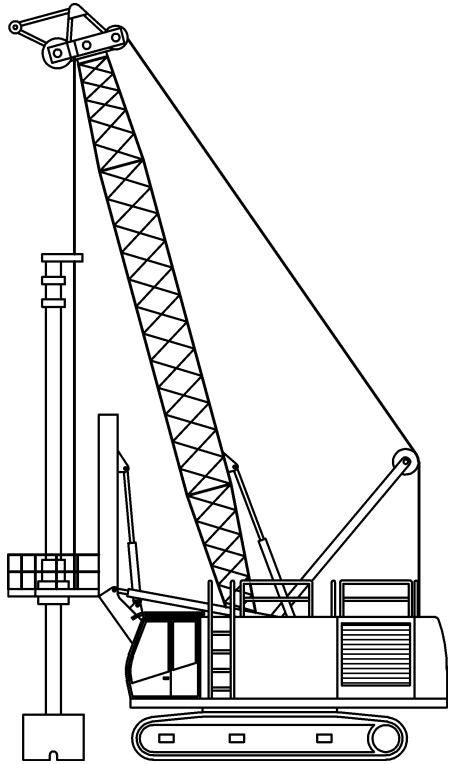
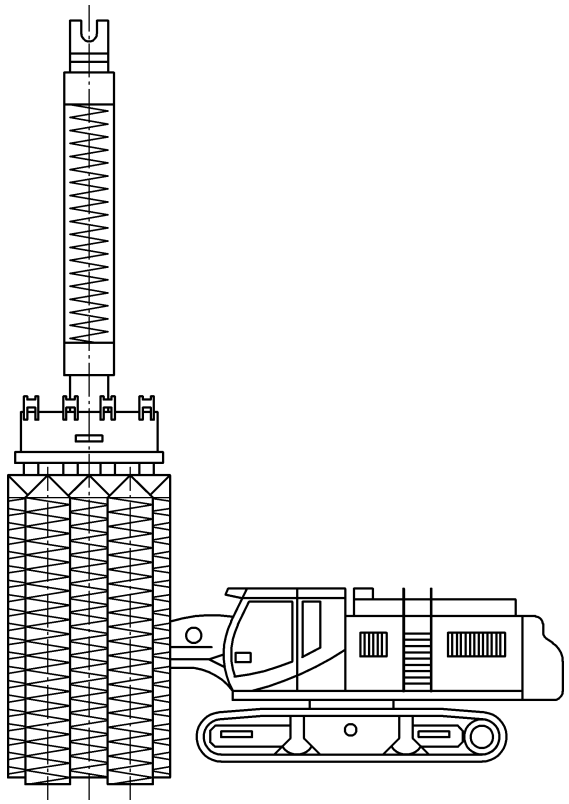
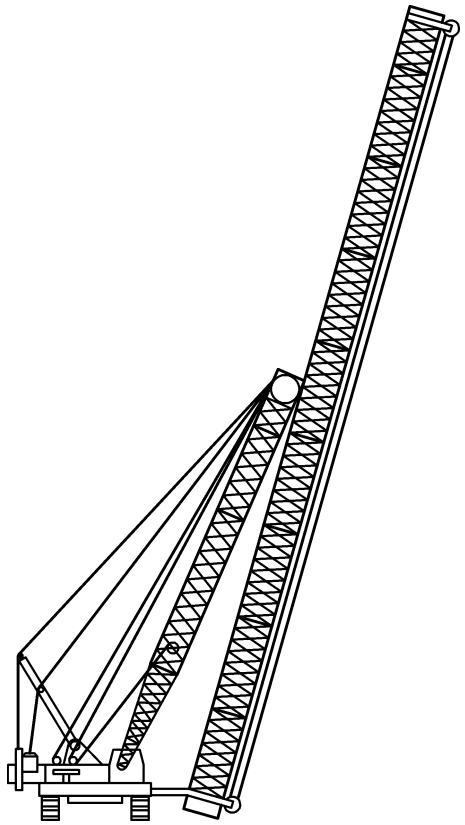
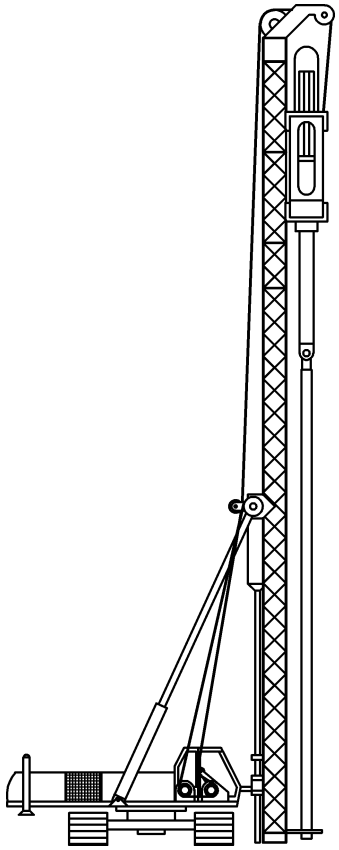
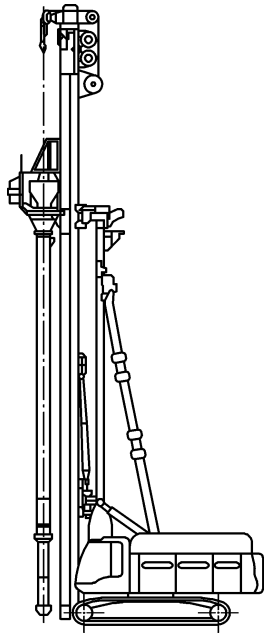
	Equipment	Description	Picture	Part number of this standard
A.2.16	Crane attached drill rigs	Rotating drilling equipment attached to a cable excavator or crawler crane. To be used for large diameter boreholes. The rotary table can be driven by own power source or by the base carrier		1, 4 and 7

Figure A.16

	Equipment	Description	Picture	Part number of this standard
A.2.17	Sheet pile push-pull equipment	Equipment guided by a leader, or free riding at the top of a sheet pile wall. Sheet piles will be installed or pulled by force of hydraulic cylinders. Sheet piles are gripped by hydraulic clamps.	 Figure A.17	1 and 4

	Equipment	Description	Picture	Part number of this standard
A.2.18	Prefabricated pile driving rig	Rig with leader, equipped with diesel, pneumatic or hydraulic driven piling hammer, for driving precast concrete piles, steel beams, sheet piles, steel tubes	 Figure A.18	1 and 4

	Equipment	Description	Picture	Part number of this standard
A.2.19	Cast in situ pile driving rig	Piling rig with leader equipped with diesel or hydraulic piling hammer or vibrator. For driving a casing with bottom cover. After driving, reinforcement and concrete will be poured in. The casing will be extracted by the hammer or a vibrator.	 Figure A.19	1 and 4

	Equipment	Description	Picture	Part number of this standard
A.2.20	Rig for vibro-floatation	A guided (or unguided) tube vibrator for improvement of soil. At the bottom of the tube a rotating eccentric counter weight will generate vibrations, which cause better soil conditions. If necessary, concrete, sand or gravel will be added to the borehole, beside the lance. The vibrator can be powered by the hydraulic circuits of the base machine or a hydraulic power pack or a generator.	 **Figure A.20**	1 and 4

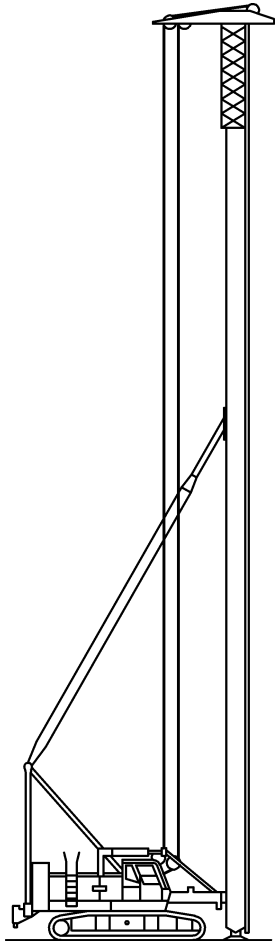
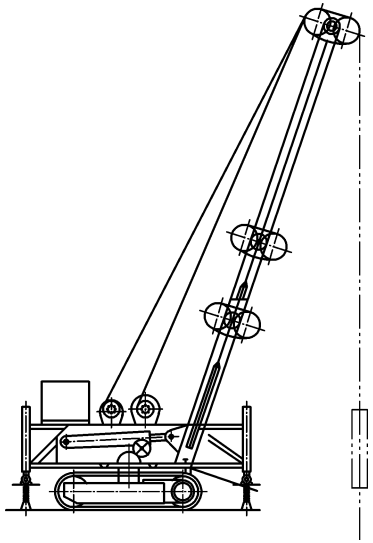
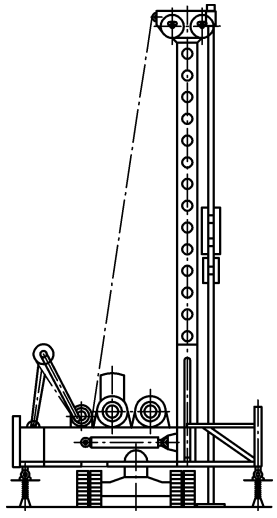
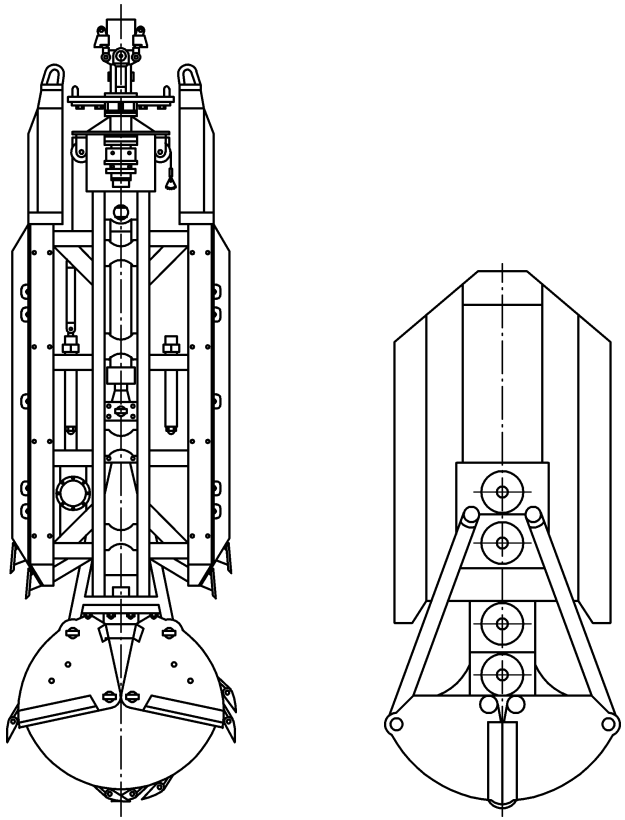
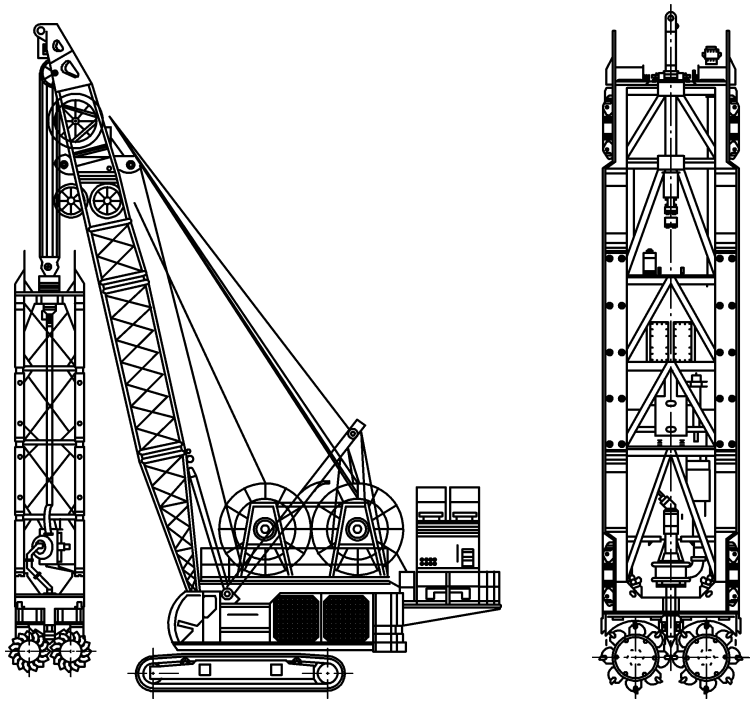
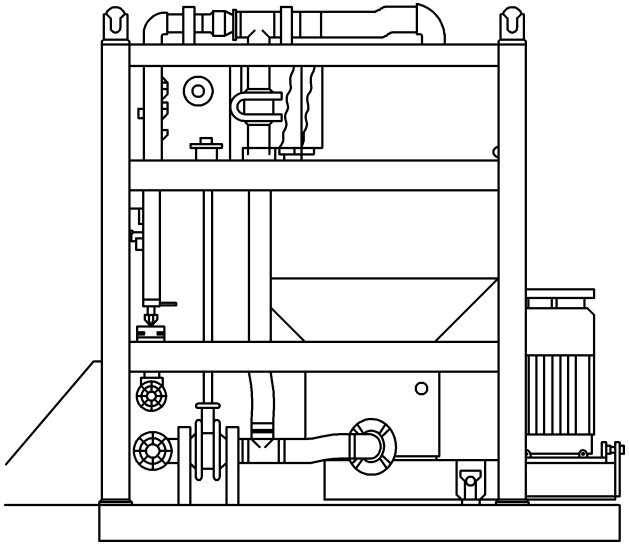
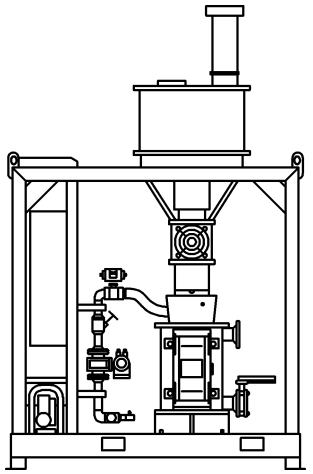
	Equipment	Description	Picture	Part number of this standard
A.2.21	Piling rig with fixed leader	This multifunctional rig is to be used for several techniques as drilling, precast piling, sheet piling, steel tube piling, etc. Carrier machine equipped with rear A-frame for raising and securing leaders of lengths up to 60 m. Fixed leader can be positioned at various operating angles. To be used with piling hammers, vibrators, sonic vibrators/drills or rotary heads. Most of the auxiliary equipment will be driven by a built- in or a separate power pack at the counterweight.		1 and 4

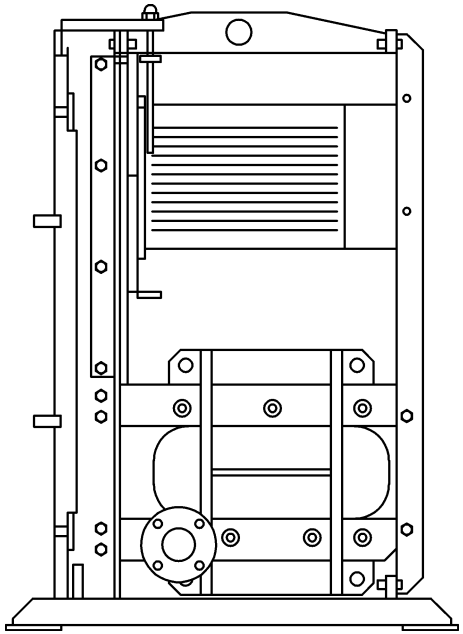
Figure A.21

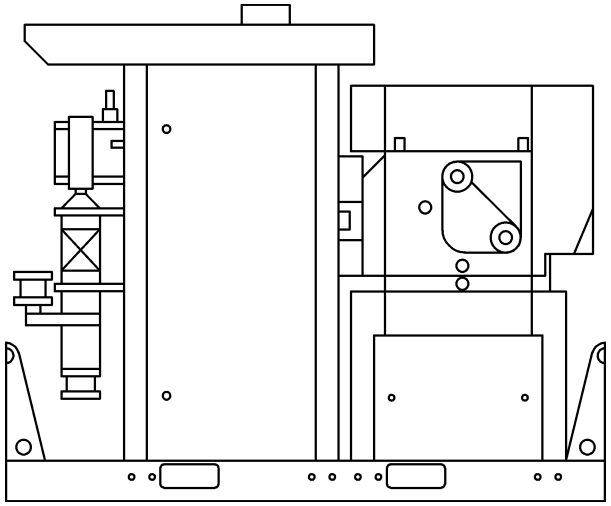
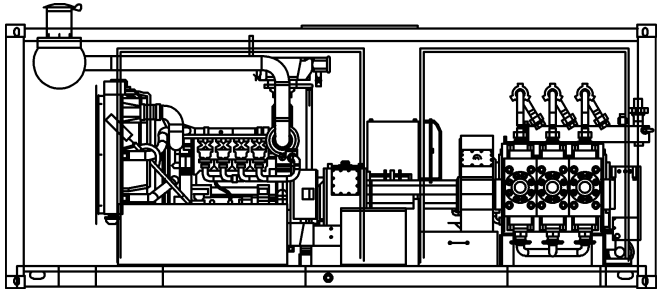
	Equipment	Description	Picture	Part number of this standard
A.2.22	Micro pile free fall rig	For preparing micro piles in close headrooms and/or narrow places. Uses manual or automatic operated free fall winch operated drop hammer. inside a casing. The casing will be welded or screwed together.	 **Figure A.22**	1 and 2 or 4
A.2.23	Micro pile top drive hammer rig	For preparing small diameter concrete, timber or steel piles in close headrooms and/or narrow places. Uses a manual or automatic operated free fall winch operated drop hammer on top of the pile or casing.		1 and 2 or 4

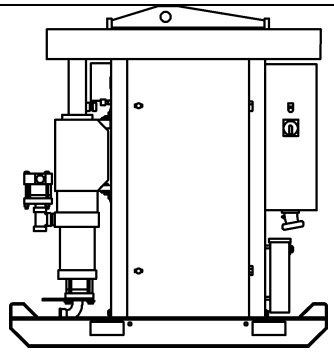
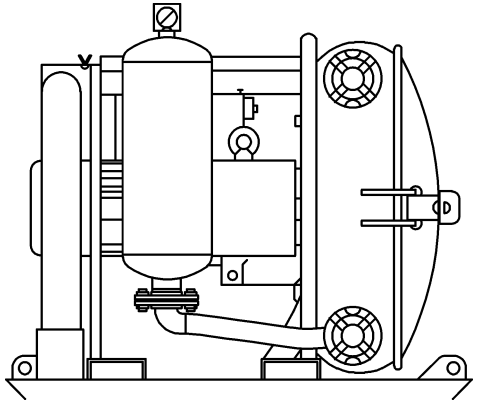
	Equipment	Description	Picture	Part number of this standard
			Figure A.23	
A.2.24	Diaphragm wall grab	Grab for excavation of diaphragm wall sections, can be rope suspended or guided and hydraulically or mechanically opened and closed.	 a) b) **Figure A.24**	1 and 5

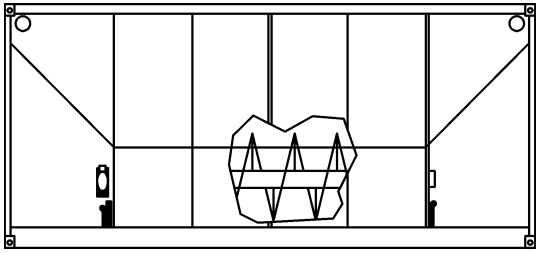
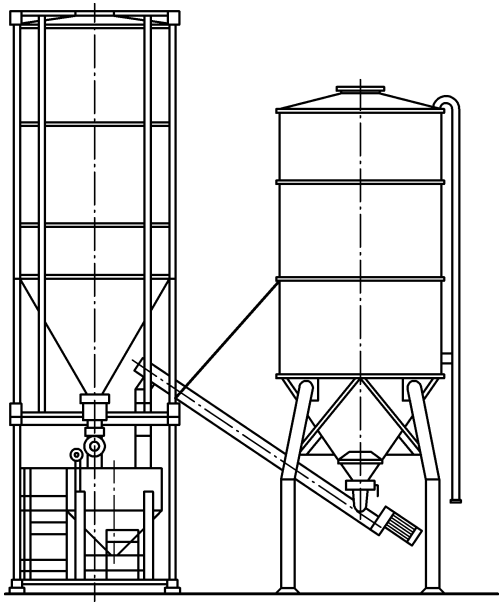
	Equipment	Description	Picture	Part number of this standard
A.2.25	Diaphragm wall cutter	Equipment for cutting diaphragm wall panels. Cuttings will be removed by a pumping system in the cutter which pumps the mud including cuttings to the surface where the mud will be transported to a desanding system. The cutter can be suspended to or guided by a specially designed carrier or a standard carrier with some adaptations.	 **Figure A.25**	1 and 5

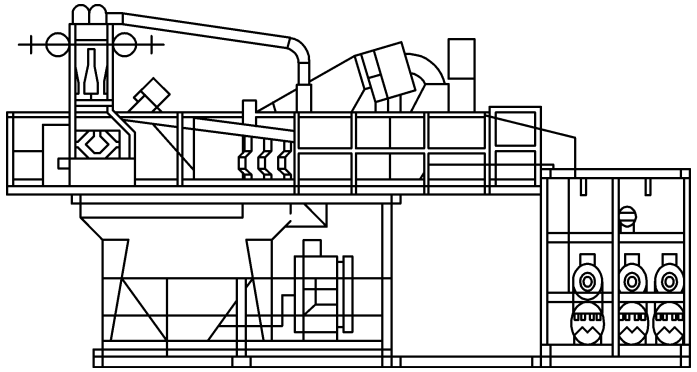
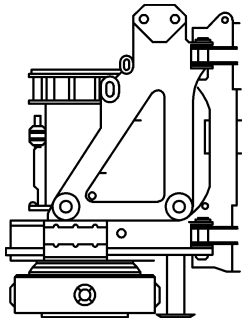
	Equipment	Description	Picture	Part number of this standard
A.2.26	Batch mixers	For mixing cement and/or chemical grout, mud etc. for drilling and/or foundation applications. Mixes a mixture per batch, for a fixed amount per borehole or pile.	 **Figure A.26**	1 and 6
A.2.27	Continuous mixers	For mixing cement and/or chemical grout, mud etc. for drilling and/or foundation applications. Mixes a continues flow of mixture.	 **Figure A.27**	1 and 6

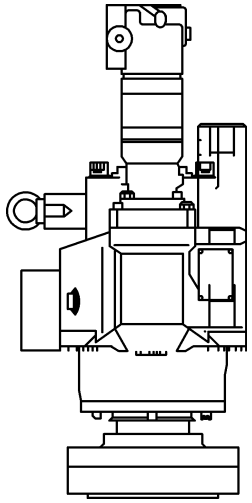
	Equipment	Description	Picture	Part number of this standard
A.2.28	Inline dispersers	For mixing cement and/or chemical grout, mud etc. for drilling and/or foundation applications. Mixes a continues flow of mixture. To be connected into the pressure line for dispersing added liquids and/or solids to the mixture.	 **Figure A.28**	1 and 6

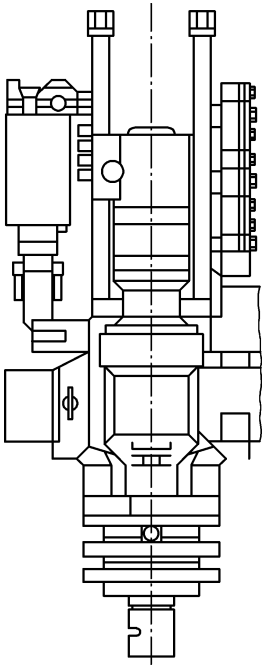
	Equipment	Description	Picture	Part number of this standard
A.2.29	Injection plants	Mixing and pumping system with high pressure plunger pump for pumping the injection mixture to the injection lance, or tube.	 Figure A.29	1 and 6
A.2.30	High pressure pumps	Pump for pumping water, mud or cement grout to a high pressure jetting system (jet grouting).	 a)	1 and 6

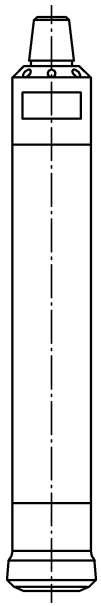
	Equipment	Description	Picture	Part number of this standard
			 b) **Figure A.30**	
A.2.31	Hose pumps	Low pressure pump for transportation of large amounts of mud, slurry, grout, concrete, etc. Hose diameters from 25 mm to 200 mm.	 **Figure A.31**	1 and 6

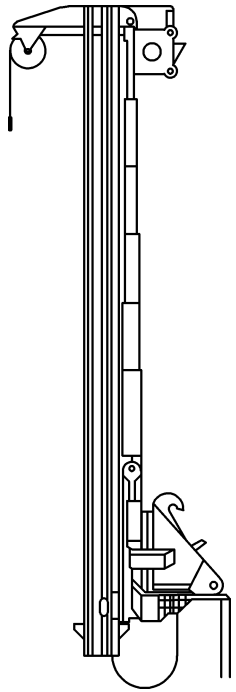
	Equipment	Description	Picture	Part number of this standard
A.2.32	Agitator tanks	Buffer container for mud, grout or concrete to keep the mixture fluid.	 Figure A.32	1 and 6
A.2.33	Silos and screw conveyors	Buffer tanks for solid and liquid aggregates combined with screw conveyors for dosaging the aggregates to the mixer(s).	 Figure A.33	1 and 6

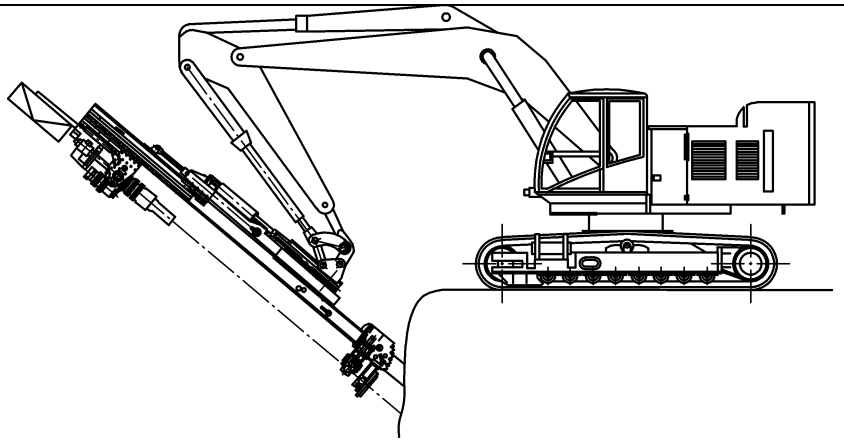
	Equipment	Description	Picture	Part number of this standard
A.2.34	Desanding plant	Drilling or digging mud will be desanded and regenerated to normal mud, by cyclones, screens and shakers.	 Figure A.34	1 and 6
A.2.35	Rotary heads for pile rigs	Used at drill rigs for piling and foundation applications. Usual rotating speeds 15 rpm to 75 rpm. Left or right turning. Used in combination with auger, kelly or casing. Generally torque more than 35 kNm.	 Figure A.35	1, 4 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.36	Rotary heads for drilling rigs	Used at several types of drill rigs for drilling and foundation applications. Available with closed or open stem. Rotation generated by hydraulic power, variable speed by oil flow and/or gearbox. Drill string will be connected by fixed or quick releasable couplings. Generally torque less than 35 kNm.	 Figure A.36	1, 2, 4 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.37	Rotary percussion hammer	Used at several types of drill rigs for drilling and foundation applications. Available with closed or open stem. Rotation and percussion generated by hydraulic power, variable speed and frequency by oil flow and/or gearbox. Drill string will be connected by fixed or quick releasable couplings.	 **Figure A.37**	1, 2 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.38	Down the hole hammer	Percussion hammer located at cutting end of drill string for drilling in hard (for example, rock) conditions. Can be pneumatically or hydraulically (drilling fluid) driven.	 Figure A.38	1, 2 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.39	Excavator mounted leader	Leader to fix at an excavator for different drilling and/or foundation applications, with rotary head or piling hammer.	 a)	1 and 7

	Equipment	Description	Picture	Part number of this standard
			 b) **Figure A.39**	

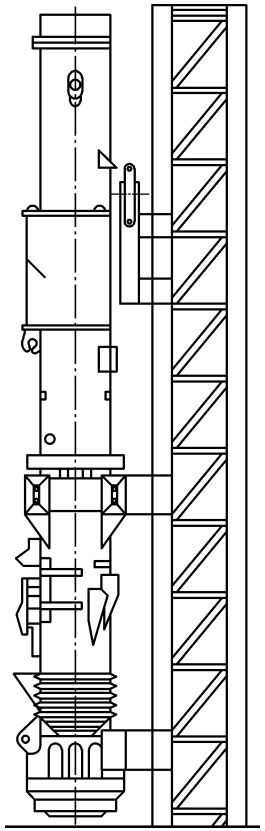
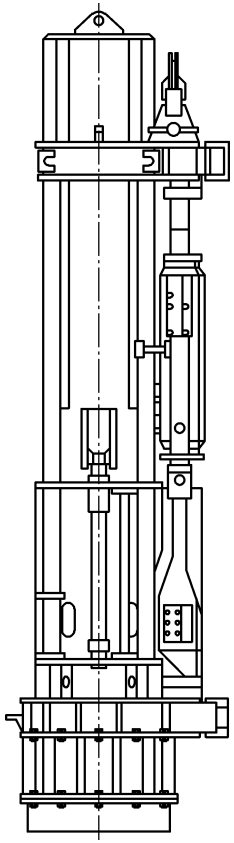
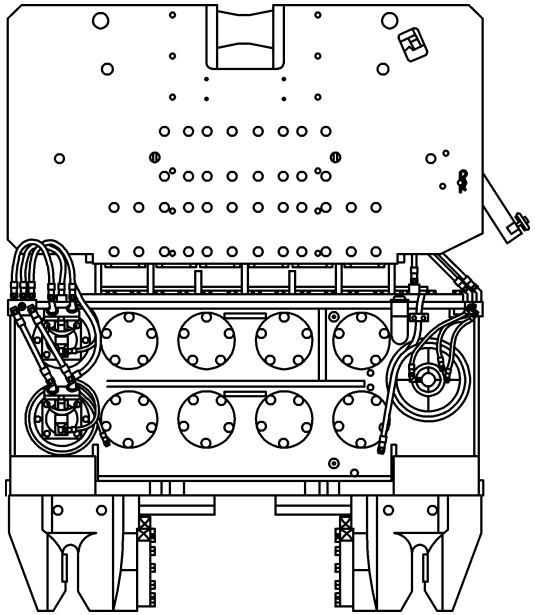
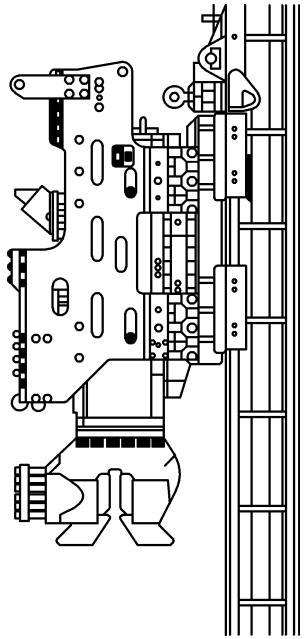
	Equipment	Description	Picture	Part number of this standard
A.2.40	Diesel hammer	Piling hammer, driven by combustion of diesel fuel or other fuels, single or double acting. The impact occurs by striking the piston on an anvil at the bottom of the cylinder.		1, 4 and 7

Figure A.40

	Equipment	Description	Picture	Part number of this standard
A.2.41	Hydraulic hammer	Piling hammer, driven by hydraulic cylinder(s). The impact occurs by striking the impact body on pile cap directly on the pile.	 Figure A.41	1, 4 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.42	Vibratory driver	Vibrating system which will transmit a pulsating power to the pile, tube, sheet pile or beam. Vibration is generated by a combination of rotating eccentric counterweights. Frequency normally between 20 Hz and 50 Hz. Vibrator is free suspended at a crawler crane or cable excavator or guided by a leader.	 a)	1, 4 and 7

	Equipment	Description	Picture	Part number of this standard
	High frequency vibratory driver	Vibrating system which will transmit a pulsating power to the pile, tube, sheet pile or beam. Vibration is generated by a combination of rotating eccentric counterweights. Frequency normally between 20 Hz and 50 Hz. Vibrator is guided by a leader of a piling rig.	 b)	1, 4 and 7

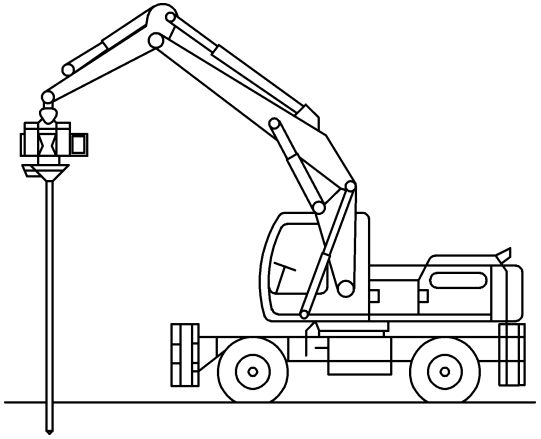
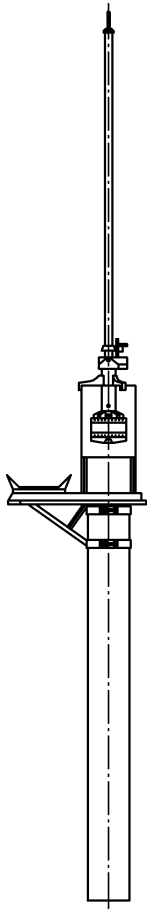
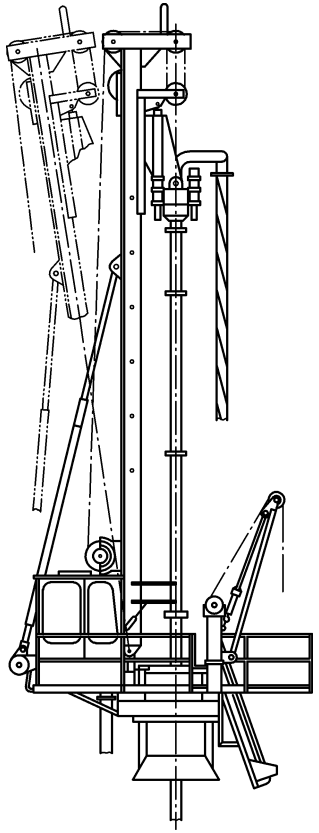
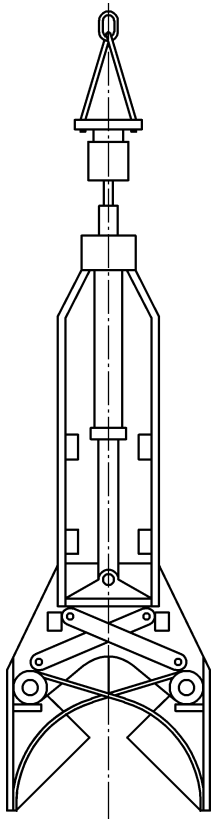
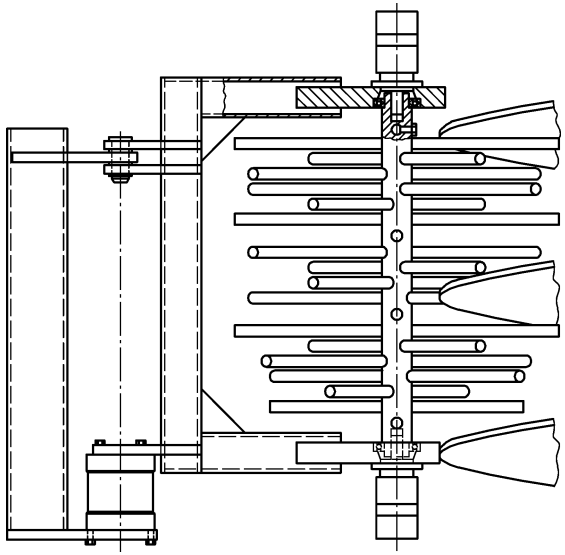
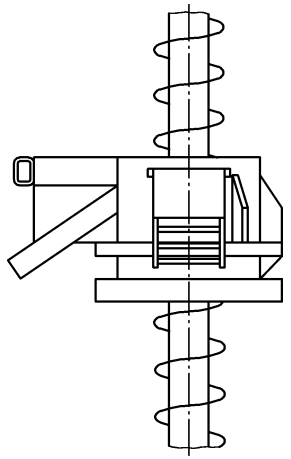
	Equipment	Description	Picture	Part number of this standard
	Boom connected vibratory driver	Vibrator connected by means of a universal joint to the boom of an excavator.	 c)	1, 4 and 7

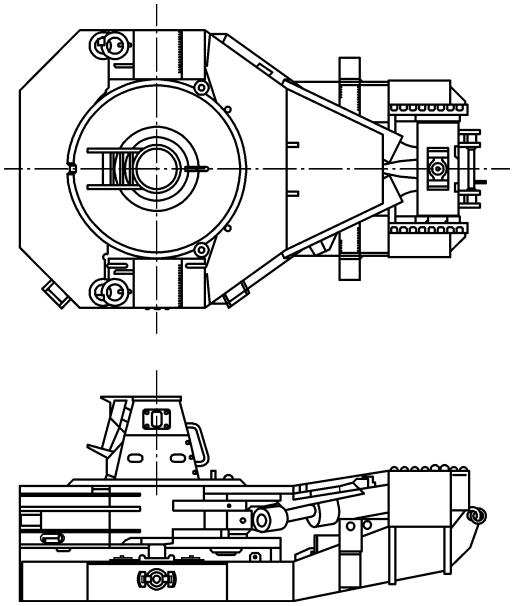
Figure A.42

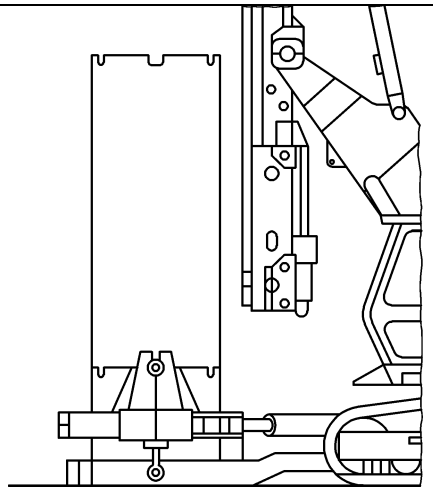
	Equipment	Description	Picture	Part number of this standard
A.2.43	Flying drilling equipment	Drilling equipment to connect to a casing to drill the hole inside and underneath the casing suspended to a crane or cable excavator. To unload the bucket or auger, the whole equipment will be lifted off from the casing and slewed to unload beside the borehole.	 **Figure A.43**	1 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.44	Top drilling equipment with reverse circulation spoil removal	Drilling equipment to connect to the top of a casing. The drill string will carry roller bits. Spoil will be removed by a reverse circulation system through drill string.	 Figure A.44	1, 2 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.45	Drilling clamshell	Circular clamshell (hammer grab) for excavating into boreholes.	 Figure A.45	1 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.46	Brush auger cleaner	To remove spoil from an (rotating) auger.	 Figure A.46	1, 2, 4 and 7
A.2.47	Rotating auger cleaner	To remove spoil from a rotating or non-rotating auger. The cleaning device is rotating with the pitch of the auger.	 Figure A.47	1, 2, 4 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.48	Casing Oscillator	Equipment to move casings by left, right or oscillated turning whilst vertical movement up or down by hydraulic jacks. Can be free operating and driven by separate power pack, or connected to the lower body of a drill rig and powered by that rig.	 a)	1 and 4 or 7

	Equipment	Description	Picture	Part number of this standard
			 b) **Figure A.48**	

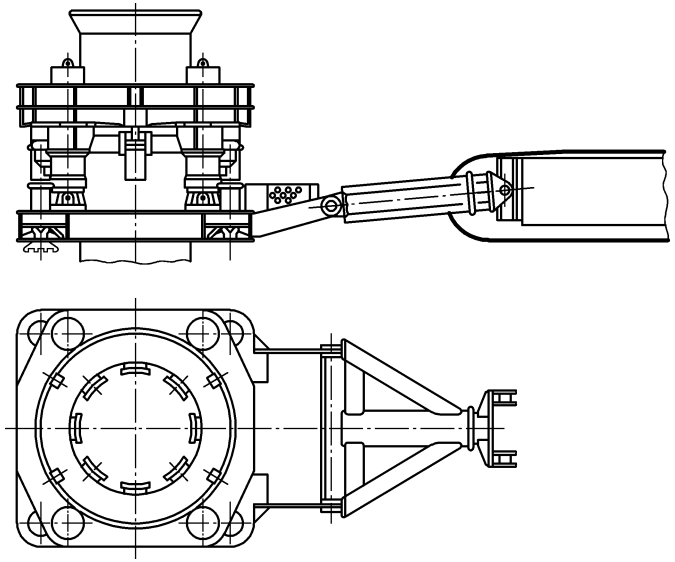
	Equipment	Description	Picture	Part number of this standard
A.2.49	Casing rotator	Equipment to move casings by means of 360° continuous turning whilst vertical movement up or down by hydraulic jacks. Can be free operating and driven by separate power pack, or connected to the lower body of a drill rig and powered by that rig.		1, 4 and 7

Figure A.49

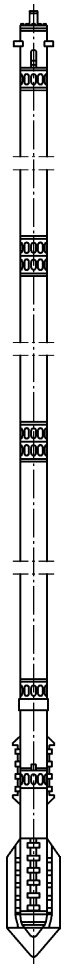
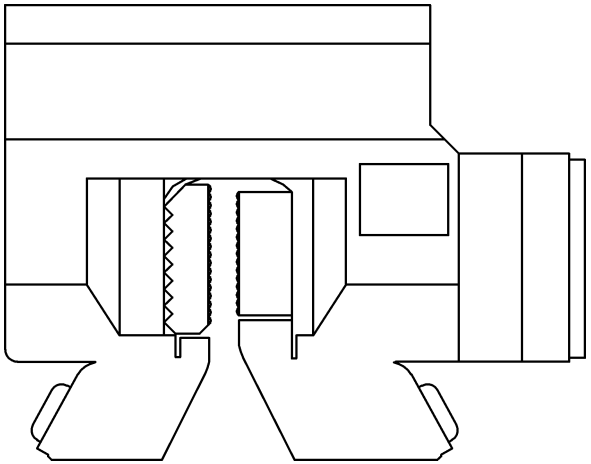
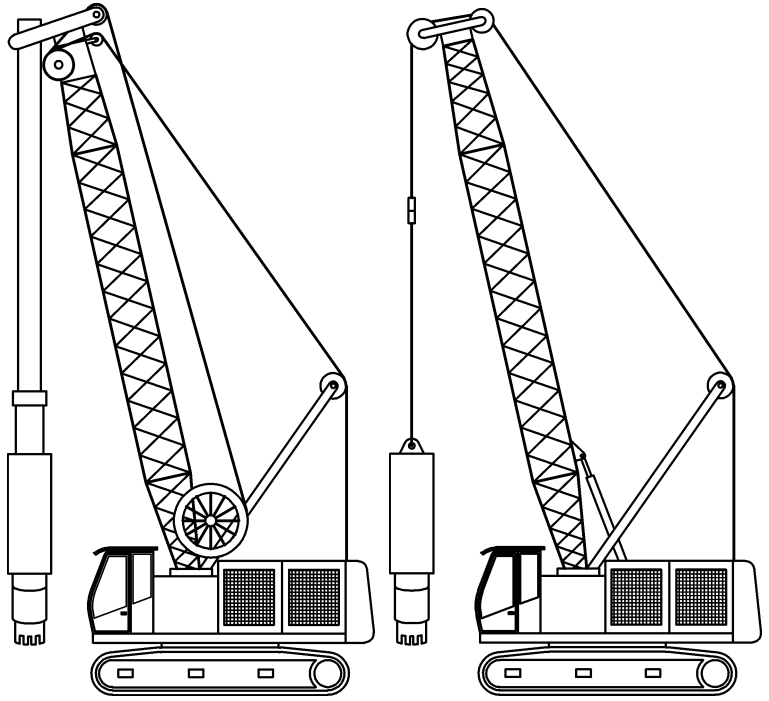
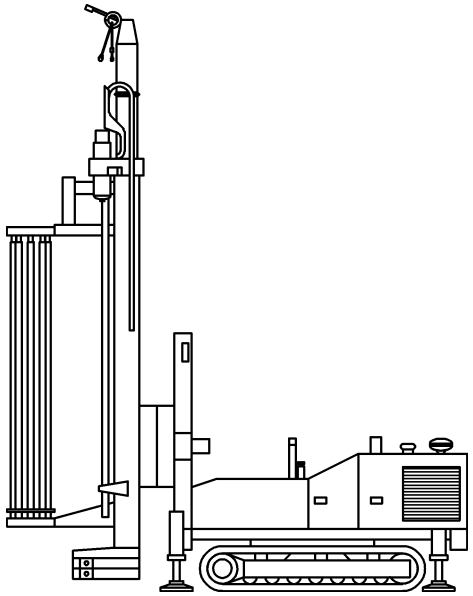
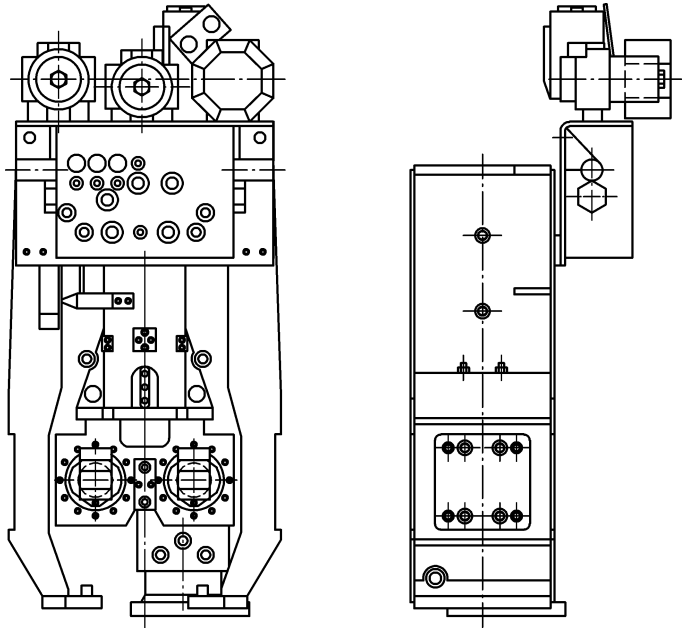
	Equipment	Description	Picture	Part number of this standard
A.2.50	Deep Vibrator	Vibrator for improvement of soil. At the bottom of the tube a rotating eccentric counter weight will generate vibrations, which cause better soil conditions. If necessary, concrete, sand or gravel will be added to the borehole.		1 and 7

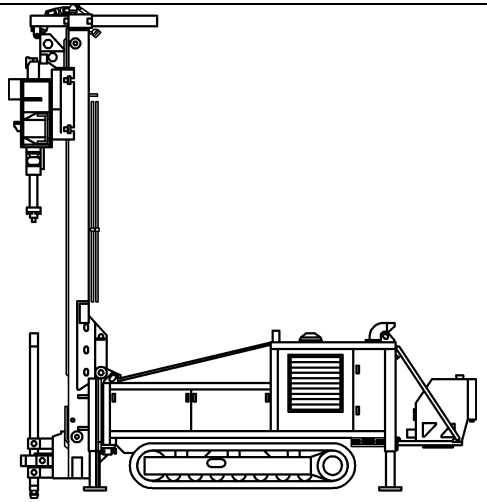
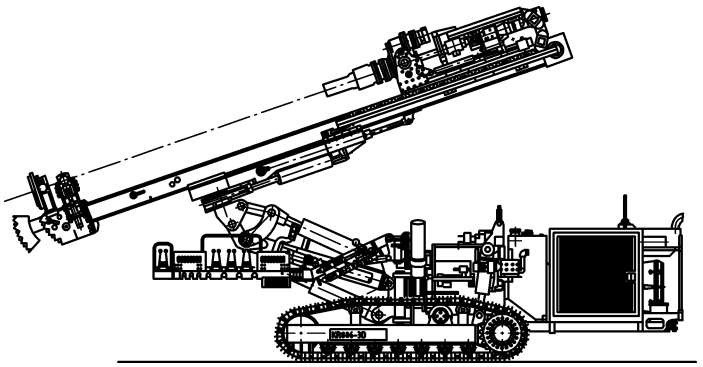
Figure A.50

	Equipment	Description	Picture	Part number of this standard
A.2.51	Hydraulic clamps	Clamp to be connected to a vibrator or pushing pulling device to grip sheet piles, steel beams or tubes.	 Figure A.51	1 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.52	Carrier machine with cutting tools	For rope suspended diaphragm grabs or cutters to excavate panels for diaphragm walling.	 Figure A.52	1 and 5

	Equipment	Description	Picture	Part number of this standard
A.2.53	Geothermal drill rig	For drilling boreholes, small diameters to install tubes for geothermal purposes.	 Figure A.53	1, 2 and 7

	Equipment	Description	Picture	Part number of this standard
A.2.54	Sonic drill head	Used on several types of drill rigs for mineral exploration, geothermal drilling, environmental sampling and drilling, geotechnical sampling and seismic drilling. Available as vibration only or combined with rotary. Tilt function on head can be integrated. Vibration frequency from 0 up to 150 Hz to 200 Hz, variable by oil flow. Drill head for sampling applications or drilling boreholes, diameters 40 mm to 300 mm. Drill string is connected by thread.	 a)	1, 2, 4 and 7

	Equipment	Description	Picture	Part number of this standard
			 b) **Figure A.54**	
A.2.55	Anchor drilling rig	Used for drilling and/or foundation applications. Equipped with a kinematics allowing drilling in various angles typically 20° from horizontal. Rigs can be driven by direct power of diesel engine, or electric motor. Some rigs use separate power packs with long hydraulic hoses or electric cables. The drilling head can be rotation, sonic or roto percussion. Augers or down the hole hammer can also be used. The rod change and storage may be mechanized.	 **Figure A.55**	1 and 2 or 4

Annex B
(normative)

Noise test code

B.1 General

This test code, together with additional requirements in relevant parts of the standard, specifies all the information necessary to carry out efficiently and under standardized conditions the determination and declaration of the noise emission characteristics of drilling and foundation equipment.

Noise emission characteristics include emission sound pressure levels at operator's positions and the sound power level. The determination of these quantities is necessary for:

— manufacturers to declare the noise emitted;

— comparing the noise emitted by machines in the family concerned.

The use of this noise test code ensures reproducibility of the determination of the noise emission characteristics within specified limits determined by the grade of accuracy of the basic noise measurement method used. Noise measurement methods allowed by this standard are engineering methods, grade 2, as defined in EN ISO 3740:2000 and EN ISO 11200:2009.

NOTE These standards are being revised. It is the intention that the revised text will be used in relation to EN 16228-1:2014.

Noise emission from drilling and foundation equipment is generated by the machine itself and to a large extent also by the process. Noise may vary with the type of ground or rock in which the drilling and foundation equipment is operating. For a type test, an operation at fully specified conditions is necessary so that a sufficiently good reproducibility is achieved.

B.2 Operation of the drilling and foundation equipment during noise tests

B.2.1 General

Before carrying out any measurement, the engine and the hydraulic system of the drilling and foundation equipment shall be brought to their normal working temperature following the instruction of the manufacturer and all relevant safety-related procedures given in the instruction book shall be carried out.

The measurement time shall not be less than 15 s.

The operating conditions during noise tests shall be identical for the determination of both the sound power level and emission sound pressure levels at operator’s positions.

B.2.2 Multiple power units

Separate tramming engines on the drilling and foundation equipment shall not be in operation during the test.

When providing a power unit which is different from the engine of the base machine, this power unit shall be measured and declared separately. An exception is when the power unit is dedicated to a specific interchangeable equipment, in which case the measurement shall be carried out with the power unit in operation.

B.2.3 Fan speed

If the engine of the machine or its hydraulic systems is fitted with (a) fan(s) it (they) shall operate during the test. The fan speed shall be in accordance with one of the following conditions, stated and set by the manufacturer of the machine:

a) Fan drive directly connected to the engine:

If the fan drive is directly connected to the engine and/or hydraulic equipment (e.g. by belt drive), it shall operate during the test.

b) Fan drive with several distinct speeds:

If the fan can work at several distinct speeds, the test shall be carried out:

1) either at the maximum working speed of the fan;

or

2) in a first test, with the fan set at zero speed and in a second test, with the fan set at maximum working speed. The resulting sound pressure level L_{pA} shall then be calculated by combining both test results using the following formula:

$$L_{\mathrm{pA}} = 10 \log \left\{ 0,3 \times 10^{0,1 L_{\mathrm{pA},0\%}} + 0,7 \times 10^{0,1 L_{\mathrm{pA},100\%}} \right\} dB$$

where

$L_{\mathrm{pA},0\,\%}$ is the sound pressure level determined with the fan set at zero speed;

$L_{\mathrm{pA},100\,\%}$ is the sound pressure level determined with the fan set at maximum speed.

NOTE 1 The formula applies to the determination of the sound power level with L_{pA} replaced by *LWA*.

c) Fan drive with continuously variable speed:

If the fan can work at continuous variable speed, the test shall be carried out either according to B.2.3 b) or with the fan speed set by the manufacturer at no less than 70 % of the maximum working speed.

d) If the machine is equipped with more than one fan, all fans shall run at either the conditions specified in a) or b) or c).

NOTE 2 This is valid for both the sound power and the emission sound pressure level(s) at operator's position(s).

B.2.4 Different types of drilling and foundation equipment

Unless otherwise specified in other parts of this standard, drilling and foundation equipment shall be operated with all motors and engines running at rated speed. Auxiliary equipment (except cooling fans), which forms an integral part of the machine, shall be running at normal operating speed as specified by the manufacturer.

B.3 Determination of the sound power level

B.3.1 Basic noise emission standards

The A-weighted sound power level shall be determined according to a basic noise emission measurement standard providing engineering methods (grade 2 of accuracy), considering the influencing factors (see

Table B.1). The preferred method is described in EN ISO 3744:2010. Other standards that can be used are EN ISO 3747:2010 and EN ISO 9614-2:1996.

Table B.1 — Factors influencing the choice of the method

		EN ISO 3744	EN ISO 3747	EN ISO 9614-2
Grade of accuracy	Precision (grade 1)			
	Engineering (grade 2)	x	x	x
	Survey (grade 3)		x	x
Environment specially designed for determination of sound power	Hemi-anechoic room	x[a]		
In-situ environment	Indoors in a sufficiently reverberant field		x	x
	Indoors in an approximate free field over a reflective plane			x
	Outdoors and indoors in an essentially free field over reflecting plane	x		x
Background noise level	$\Delta L \geq 10$ dB	x	x	x
	$\Delta L \geq 6$dB	x	x	x
	$\Delta L \geq 3$ dB			x
	$\Delta L < 3$ dB			x[b]
Character of noise	All types as defined in EN ISO 12001	x		
	All types, except isolated bursts		x	
	Stationary in time			x
Instrumentation	Sound level meter Class1	x	x	
	Frequency band filter Class1	x	x	
	Sound intensity instrument			x
Sound power obtainable	One-third-octave band levels	x		x
	Octave band levels	x	x	x
	A-weighted levels	x	x	x[c]
Optional information available	Other frequency weightings	x	x	
	Directivity information	x		
	Temporal pattern	x		

[a] Environmental correction $K2 \leq 2$ dB.

[b] Lower limit is approximately -10 dB, but it depends on measurement conditions.

[c] Applicable

B.3.2 Determination according to EN ISO 3744

When applying EN ISO 3744:2010, a hemisphere measurement surface with following additions shall be used.

The radius r of the hemisphere shall be equal to or greater than twice the largest dimension of d_O (characteristic source dimension) as defined in EN ISO 3744:2010. The reference box is defined as the smallest possible rectangular box just enclosing the drilling and foundation equipment (without attachments) and terminating on the reflecting plane. The radius of the hemisphere shall be rounded to the nearest higher of the following values: 4 m, 10 m, 16 m.

If the largest dimension of the reference box is larger than 8 m, or if the use of a hemisphere measurement surface is not possible due to, e.g. background noise or requirements for the reflecting surface, a parallelepiped according to EN ISO 3744: 2010 shall be used. The reason for using a parallelepiped instead of a hemisphere shall be reported.

NOTE The parallelepiped method overestimates the sound power.

EN ISO 3744: 2010 shall be applied with microphone array according to Table F.1.

The machine shall be positioned such that the reference box centre point is approximately vertical above the centre of the hemisphere. The longitudinal axis of the machine shall coincide with the x-axis and the front of the machine shall face to microphone position 1.

At least the 6 microphone positions numbered 2, 4, 6, 8, 10 and 12 shall be used following the requirement in EN ISO 3744: 2010 for reduced number of microphones.

Non sound-emitting parts of the drilling and foundation equipment, such as mast or a feed beam, shall be left outside of the reference box as defined in EN ISO 3744: 2010.

The surface sound pressure level shall be determined at least three times. If at least two of the determined values do not differ by more than 1 dB, further measurements will not be necessary; otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The A-weighted surface sound pressure level to be used for calculating the sound power level is the arithmetic mean of the two highest values that do not differ by more than 1 dB.

B.4 Measurement of emission sound pressure level at the operator’s position

B.4.1 General

The A-weighted emission sound pressure level and the peak C-weighted instantaneous sound pressure value at the operator's position shall be measured. For the purposes of this standard, the operator’s position, when operating, is defined in the manufacturer's instruction book.

B.4.2 Performance of test at a fixed operator's position

The test shall be carried out in accordance with EN ISO 11201:2010, method providing Grade 2 results.

When the fixed operator's position is in a cabin, the following requirements apply:

— Measurements shall be taken with the doors and windows closed and the air-conditioning and/or ventilation system(s) in operation. If there is more than one operating speed available, the air conditioning and/or the pressurised ventilation system(s), shall be operated at the second speed for systems of up to four speeds. For systems of more than four speeds, the third speed shall be used and for continuously variable speeds the mid range speed.

— If the air-conditioning and/or ventilating systems have a recirculation and outside air position control, the control shall be set for outside air.

The operator shall be present at operator's position during the test (9.1 of EN ISO 11201:2010 applies) and the sound pressure level at both ears shall be measured.

B.4.3 Performance of test for operator's and assistant(s) position for remote-controlled machines

In addition to the requirements for fixed operator's positions, the following shall apply for operators and specified assistant positions for remote-controlled machines.

A-weighted emission sound pressure level shall be determined by calculation according to EN ISO 11203:2009. The radius used for calculating Q2 shall be 4 m. If the noise emission is impulsive, the highest value of L_{pCpeak} shall be taken from measurements according to EN ISO 11201:2010 at several positions at 4 m from the machine at least one on each side.

B.4.4 Acceptance criteria of measurements

The A-weighted sound pressure level shall be measured at least three times. If at least two of the determined values do not differ by more than 1 dB, further measurements will not be necessary; otherwise the measurements shall be continued until two values differing by no more than 1 dB are obtained. The emission sound pressure level is the arithmetic mean of the two highest values that do not differ by more than 1 dB.

The microphone position at the ear where the time-averaged A-weighted sound pressure level is the higher shall be taken into account.

B.5 Uncertainty of measurements

The total uncertainty of the sound power level and emission sound pressure level at workstation of machines covered by this standard is 3 dB for Non-percussive operation or 6 dB for Impact/Percussive operation. Alternatively, manufacturers may use lower values if these can be substantiated by testing (see EN ISO 3744:2010, Clause 9 and H.3) and (see EN ISO 11201:2010, Clause 9 and A.3).

NOTE These values include uncertainty due to measurement, operation of equipment and production variances. These values are based on a coverage factor of 2.

B.6 Information to be recorded and reported

The test record and report shall contain the information required by the basic standards used to determine the sound power level and the emission sound pressure level at operator's position.

Additionally the test record and report shall state:

— the rated power of the drilling and foundation equipment;

— the number and type of drill heads/rock drills and drill steel/rod types;

— type of fan-drive system(s), as specified in B.2.3 a), b) or c), including the corresponding system maximum fan speed and fan speed(s) used during the test for each fan;

— set-up of air-conditioning and/or pressurised ventilation system;

— normal speed as specified by manufacturer for auxiliary equipment.

Deviations, if any, from this noise test code shall be recorded and reported in detail together with justification for these deviations.

B.7 Noise declaration

The noise declaration shall explicitly state that the noise emission values have been obtained according to this Annex B. If the statement is not true, the noise declaration shall indicate clearly what the deviations are.

The noise emission values to be declared are:

— the A-weighted emission sound pressure level at the operator's position where this exceeds 70 dB. Where the level does not exceed 70 dB, the fact shall be indicated;

— the peak C-weighted instantaneous sound pressure level value at operator position, where this exceeds 63 Pa (130 dB in relation to 20 µPa);

— the A-weighted sound power level emitted by the machine.

NOTE 1 Declaration of the sound power level is only required where the emission sound pressure level at operator's position exceeds 80 dB(A) or the machine is covered by Directive 2000/14/EC.

The measurement uncertainty shall be dealt with in the following manner:

— the declaration of the emission sound pressure level at the operator’s position shall have the format of a dual-number declaration, as defined in EN ISO 4871:2009;

— the declaration of the sound power level shall have the format of a single-number declaration, as defined in EN ISO 4871:2009 if the machine is covered by Directive 2000/EC/14, and the format of dual-number declaration, as defined in EN ISO 4871:2009 in other cases.

The declaration of noise emission values shall be done according to EN ISO 4871:2009. Values of the standard deviation of reproducibility (σ_R) other than those offered by EN ISO 4871:2009 can be selected by the manufacturer if supporting data is provided.

NOTE 2 The methodology is based on the use of the measured values and uncertainties. The latter are the uncertainty associated with the measurement procedure (which is determined by the grade of accuracy of the measurement method used) and the production uncertainty (variation of noise emission from one machine to another of the same type made by the same manufacturer).

Additional noise emission values may be given in the noise declaration, but only in such a way, that they cannot be confused with the declared values.

In the case of verification of declared values, measurements shall be carried out in accordance with this Annex B by using the same operating conditions of the machine as those used for the initial determination of the noise emission values.

Annex C
(normative)

Whole-body and hand-arm vibration test

C.1 General

The operating conditions shall be according to B.2.

C.2 Measurement

The vibration shall be measured for an operator either sitting or standing as foreseen by the manufacturer at the operator's position. The vibration shall be measured in accordance with ISO 2631-1:1997 and in all three directions, x, y and z. The declared vibration value shall be the highest (rms) value determined on three orthogonal axes (1,4 a_{wx}, 1,4 a_{wy}, a_{wz}).

NOTE 1 Experience has shown that for the machines in the scope the vibration total value to which the hand-arm system is subjected is in general significantly below 2,5 m/s^2. In this case it is sufficient to mention that the acceleration is below this limit.

NOTE 2 As the tramming operation is relatively short during the normal operational cycle, it is not necessary to consider tramming during vibration measurement.

NOTE 3 As an alternative to the measurement of these vibration values through the manufacturer, these values can be determined on the basis of measurement taken for technically comparable machinery which is representative of the machinery to be produced.

Annex D
(informative)

Symbols and signs

D.1 Introduction

This annex gives a collection of symbols to be used to promote the safe use and operation of drilling and foundation equipment. The symbols are taken from ISO 7000:2012, ISO 6405-1:2004, ISO 6405-2:1993 and ISO 7010:2011, however some symbols included are specific to drilling and foundation equipment.

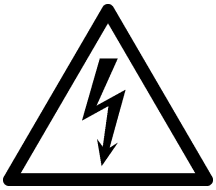
This annex is divided into parts, the first one containing general symbols regarding warning of hazards to safety and health, followed by parts containing symbols for control and operation in general, for engines, hydraulic and pneumatic systems and drilling operations specifically.

The symbols given are basic symbols for a single function but several symbols can be combined to symbolise a more complex function and some examples are given for such combinations that are common in operation of drilling and foundation equipment.

In this annex the carrier part of the machine is symbolised by a triangle or a block which may be replaced in the actual case by a symbol picturing the carrier configuration.

D.2 General safety and warning signs

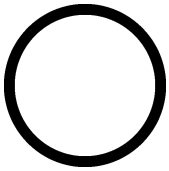
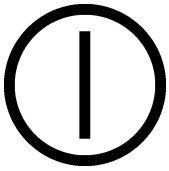
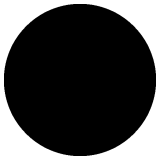
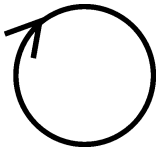
Symbol	Symbol application	Remark
	Read the operator's manual Mandatory on all drilling and foundation equipment Symbol white Background blue	ISO 7000:2012 0419 ISO 7010-M002
	Ear protection shall be worn Symbol white Background blue	ISO 7010-M003
	Safety harness shall be worn Symbol white Background blue	ISO 7010-M018

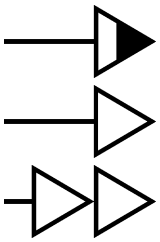
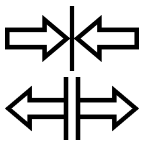
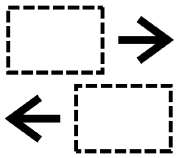
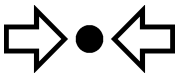
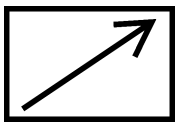
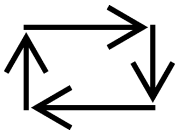
Symbol	Symbol application	Remark
	Safety helmet shall be worn Symbol white Background blue	ISO 7010-M014
	Foot protection shall be worn Symbol white Background blue	ISO 7010-M008
	Hand protection shall be worn Symbol white Background blue	ISO 7010-M009
	Eye protection shall be worn Symbol white Background blue	EN 61310-1:2008
	Respirator equipment shall be worn Symbol white Background blue	ISO 7010-M017
	General warning Caution, risk of danger Symbol and triangular band black Background yellow	ISO 7010-W001 ISO 7000:2012 0434
	Caution, risk of electric shock Symbol and triangular band black Background yellow	ISO 7010-W012
	Emergency exit Symbol white Background green	ISO 7010-E001

Symbol	Symbol application	Remark
	No access for unauthorized persons Symbol black and circular band and crossbar red Background white	
	Risk of squeezing Sign and triangular frame black Background yellow	ISO 7010-W019

D.3 General control symbols

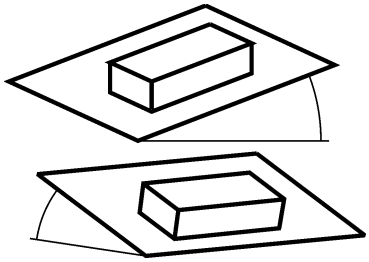
NOTE All symbols are black unless otherwise stated.

Symbol	Symbol application	Remark
	On/Start	ISO 6405-1:2004 IEC 417 5007
	Off/Stop	ISO 6405-1:2004 5008
	On and off	ISO 6405-1:2004 5010
	Emergency stop actuator Colour red, mushroom type push-button with yellow background	As specified in EN ISO 13850:2008
	Rotation Colour black	ISO 7000:2012 0258
	Continuously variable - linear	ISO 6405-1:2004 7.12
	Continuously variable - rotational	ISO 6405-1:2004 7.13 ISO 7000:2012 1364

Symbol	Symbol application	Remark
Linear **Rotation**	Speed	
	Slow Normal Fast	
	Locking function Unlocking function	ISO 7000:2012 0018; 0019
	Direction of movement The dashed square to be replaced by a symbolic sketch of affected machine	ISO 6405-1:2004 7.17; 7.18
	Pressure (to be used where the medium under pressure is not specified)	ISO 6405-1:2004 6.9 ISO 7000:2012 1701
	Oil pressure	Combined symbol
	Remote control	ISO 7000:2012 0093
	Automatic cycle	ISO 7000:2012 0026

D.4 Symbols for information

Symbol	Symbol application	Remark
	Lift point	ISO 6405-1:2004 7.25

Symbol	Symbol application	Remark
	Stability limit Longitudinal angle Transversal angle The block may be replaced by a symbol picturing wheel mounted or crawler mounted drilling and foundation equipment	

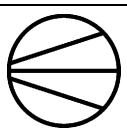
D.5 Symbols to be used for the control of the engine, fuel, brake transmission systems and hydraulic system

For drilling and foundation equipment, symbols from ISO 6405-1:2004 for the control of the following functions should be chosen as follows:

Basic symbol;	
shapes	in accordance with Clause 6;
general symbols	in accordance with Clause 7;
engine	in accordance with Clause 8;
transmission	in accordance with Clause 9;
hydraulic system	in accordance with Clause 10;
brakes	in accordance with Clause 11;
fuel system	in accordance with Clause 12;
light systems	in accordance with Clause 13;
window	in accordance with Clause 14;
climate system	in accordance with Clause 15;
seat	in accordance with Clause 16.

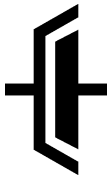
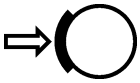
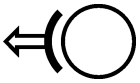
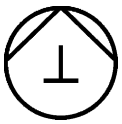
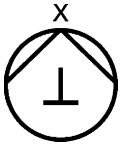
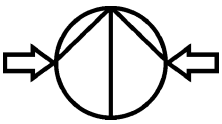
D.6 Symbols to be used for the control of the drilling operation

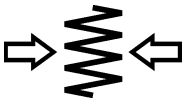
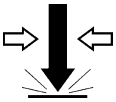
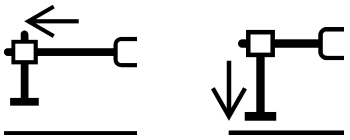
D.6.1 General symbols

Symbol	Symbol application	Remark
	Pneumatic energy (Compressed air)	ISO 7000:2012 0231
Full  Reduced 	Compressed air flushing	Pneurop

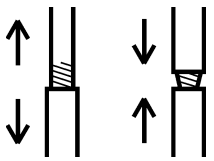
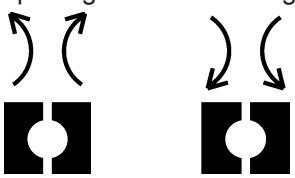
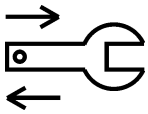
Symbol	Symbol application	Remark
Full  Reduced 	Air flushing with oil	Combined symbol
Full  Reduced 	Fluid flushing	Pneurop
	Air pressure	Combined symbol
	Water pressure	Combined symbol
 	Oscillation Limited rotation and return Oscillating rotary movement (continuous)	ISO 7000:2012 0007; 0008

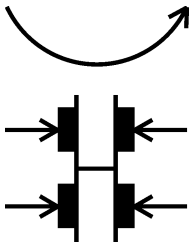
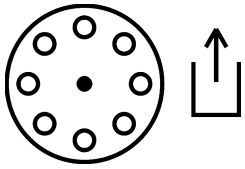
D.6.2 Symbols for general machine functions

Symbol	Symbol application	Remark
	Clutch	ISO 6405-1:2004 9.7 ISO 7000:2012 1308
Engaged  Disengaged 	Brake	ISO 7000:2012 0020; 0021
	Centrifugal pump	ISO 7000:2012 0135
	Piston pump	
x  Example	Pump function symbols x = G for grout pumps x = C for cement pumps x = M for mud pumps	
	Centrifugal pump, pressure	Combined symbol

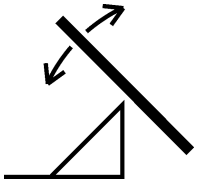
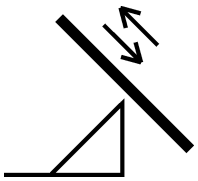
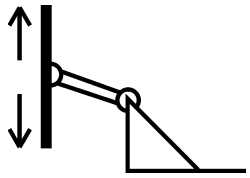
Symbol	Symbol application	Remark
	Feed	ISO 7000:2012 0259;0262
	Feed pressure	Combined symbol
	Feed load	Combined symbol
	Float	
 Full power Reduced power	Percussion	
	Percussion pressure	Combined symbol
 Left beam out Left jack down	Stabilising jack	ISO 6405-2:1993 7.2; 7.6

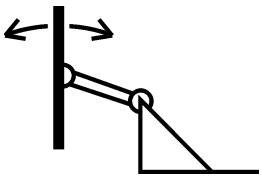
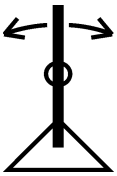
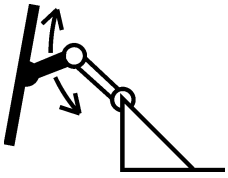
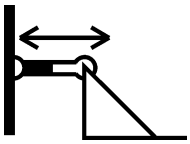
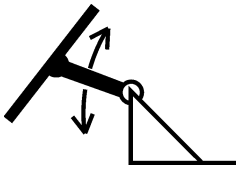
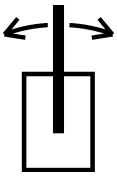
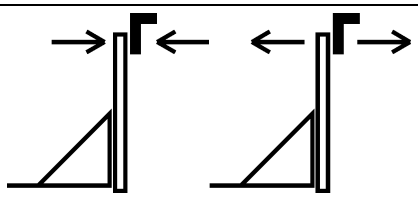
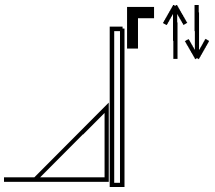
D.6.3 Rod handling system

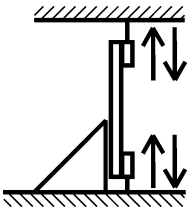
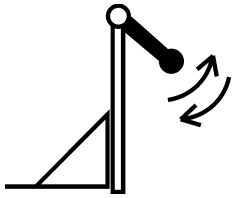
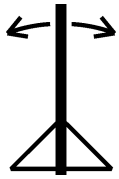
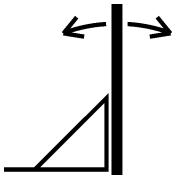
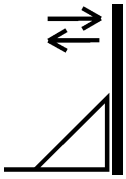
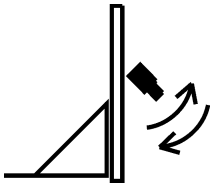
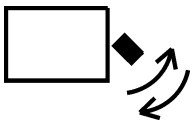
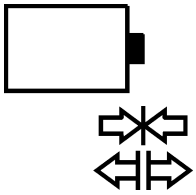
Symbol	Symbol application	Remark
	Rod coupling and uncoupling	
	Clamp Opening	
	Closing	
Opening Closing 	Retaining flaps	
	Retaining spanner	

Symbol	Symbol application	Remark
	Chuck/Break-out table Rotating arrow for breaking	Combined symbol
	Rod handling magazine, combined with rotation symbol	
	Rod handling arm moving from magazine to drill centre	
	Rod handling arm moving from drill centre to magazine	
	Rod handling magazine for vertical movement of rods	
	Rod gripper Closing	
	Opening	

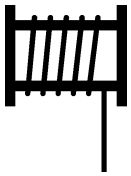
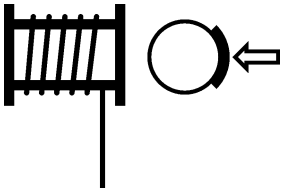
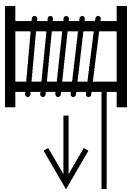
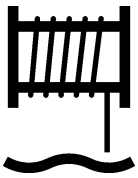
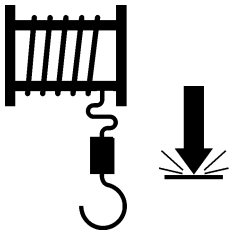
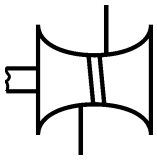
D.6.4 Mast erection and positioning

Symbol	Symbol application	Remark
	Mast raising and lowering respectively	
	Mast displacement/crowd, combined with direction arrows	
	Feed beam extension	

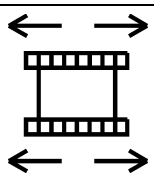
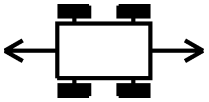
Symbol	Symbol application	Remark
	Feed beam dump	
	Feed beam swing	
	Boom extension, folding boom	
	Boom extension, telescopic boom	
	Boom lift	
	Boom swing	
	Feed beam rollover	
	Mast extension, locking and unlocking	
	Mast extension, up and down	

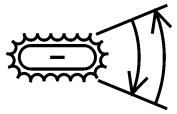
Symbol	Symbol application	Remark
	Feed beam support, up and down	
	Folding mast	
	Mast inclination sideways	
	Mast inclination, front - rear	
	Mast movement, parallel movement	
	Power swivel tilt	
	Power swivel swing out	
	Sliding power swivel	
	Power swivel, locking and unlocking	

D.6.5 Winch and slip rope drum

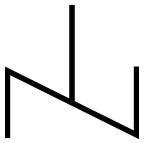
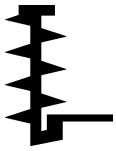
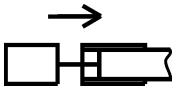
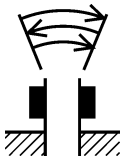
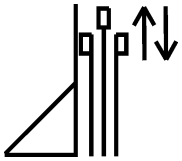
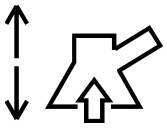
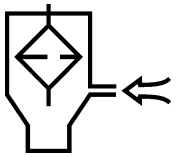
Symbol	Symbol application	Remark
	Winch – Basic symbol	ISO 6405-2:1993, 4 18.1 ISO 7000:2012 1176
	Winch – Brake engaged	Combined symbol
	Winch – Spool out	ISO 6405-2:1993 18.2
	Winch – Free spool	ISO 6405-2:1993 18.4 ISO 7000:2012 1540
	Cable tool winch (free fall)	Combined symbol
	Slip rope drum	

D.6.6 Tramming

Symbol	Symbol application	Remark
	Tramming of crawlers, forward and reverse	Pneurop
	Tramming of wheel mounted rigs, forward or reverse	

Symbol	Symbol application	Remark
	Track oscillation	

D.7 Miscellaneous symbols

Symbol	Symbol application	Remark
	Mixer	ISO 7000:2012 0131
	Auger cleaner	
	Core extruder	
	Casing oscillator or rotator	Combined symbol
	Slewing of superstructure	
	Relative displacement of double drilling head system	
	Suction hood, up and down	
	Dust collection	

Annex E
(normative)

Instruction selecting and fitting of wire rope grips for free fall application

E.1 General

The following instructions are applicable to ropes utilising wire rope grips, see 5.8.4.

Other design of grip may be used providing they have been satisfactorily tested by the grip manufacturer, and sustain minimum of 80 % of the minimum breaking load of the rope. Installation of the grips shall be in accordance with the grip manufacturer's instructions.

E.2 Installation

The distance between the grips shall be at least 1,5 times, and not more than 3,0 times the thickness of the bridge, ”H”, (see Figures E.1 and E.2).

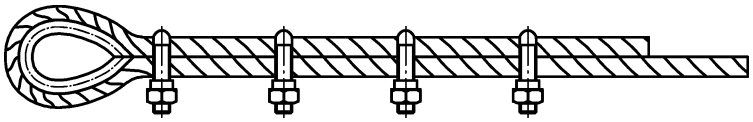


Figure E.1 — Installation and spacing of grips

When using a thimble in the eye, the first wire rope grip shall be placed immediately against the thimble. The bridge shall always be placed on the load bearing part of the rope.

E.3 Number of grips

The recommended number of grips to be used is given in Table E.1.

E.4 Tightening torque

When making the assembly, and before bringing into service, the collar nuts shall be tightened to the torque given in Table E.1.

The recommended tightening torques are for grip with the bearing surfaces and threads of the nuts greased.

After the load has been applied a few times, the torque shall be checked.

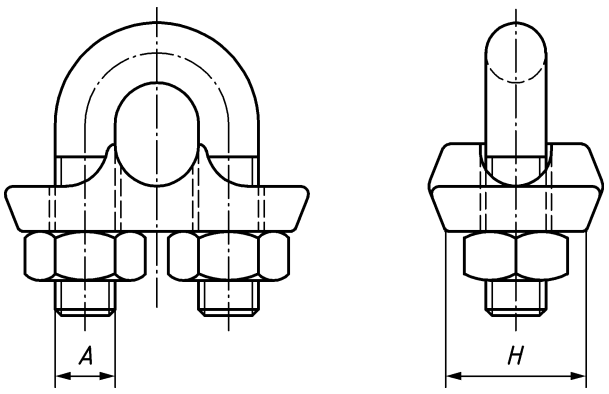


Figure E.2 — Thickness and tightening thread diameter

Table E.1 — Number and torque of wire rope grips

Nominal size of grip to suit wire rope diameter [a] mm	Number of grips	Tightening thread diameter *A*	Tightening torque Nm
14	4	M12	33
16	4	M14	49
19	4	M14	68
22	5	M16	107
26	5	M20	147
30	6	M20	212
34	6	M22	296
40	6	M24	363
[a] For intermediate sizes of wire rope, use next larger grip size.			

E.5 Detachable connections

A wedge socket shall be mounted in such a way that the central axis of the part of the rope under load passes through the centre of the forked eye.

The wedge clamp shall be secured by fitting immediately after it a locking fitting, e.g. a U-bolt grip, on the dead part of the rope, in accordance with one of the methods shown in Figure E.3. This locking fitting shall be capable of absorbing at least 10 % of the maximum permissible working load on the rope.

On a winch drum this securing is not required.

The load and the diameters of the steel wire ropes and the pin for which the wedge socket is intended shall be clearly marked on the clamp. On the appertaining wedge, the diameter of the steel wire rope shall be marked.

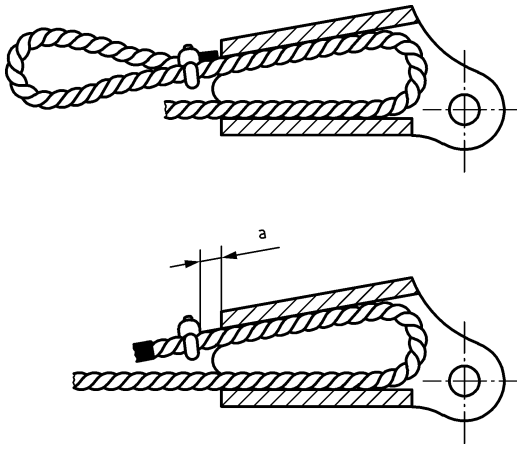


Figure E.3 — Methods of securing for wedge socket

Annex F
(normative)

Ground pressure calculation for crawler mounted drilling and foundation equipment

F.1 General

For crawler mounted drilling and foundation equipment, the highest ground pressure which can occur shall be calculated according to F.2 for all relevant operating positions and orientations, including all types of operations, tramming and working on slopes if applicable. The values for all these conditions shall be stated in the operator's manual.

F.2 Calculation of ground pressures

The calculation of the ground pressure that can occur in the contact point between tracks and ground shall be carried out in accordance with Figure F.1. The component perpendicular to the ground of resultant load shall be divided into single loads, *P*, on each track according to the position of the resultant load.

The position of the resultant load perpendicular to the ground shall be adjusted as to take into account the overturning effect of the resultant forces parallel to the ground, according to the principle of moment equivalence.

Definition of parameters:

— P is the load on one track, in Newton;

— e is the eccentricity of the load *P*, in metres, see Figure F.1;

— d is the length of the contact area, either d_1 or d_2:

  — d_1 is the distance between the idler and driver, in metres, in case of tipping line 1 according to 5.2.3.3.2, Figure 1, if β is less or equal to 2º;

  — d_2 is the distance between the end rollers, in metres, in case of tipping line 2 according to 5.2.3.3.2, Figure 1, if β is more than 2º;

— b is the width of the track grouser, in metres;

— σ_2, σ_1 are the maximum and minimum ground pressures, in N/m^2.

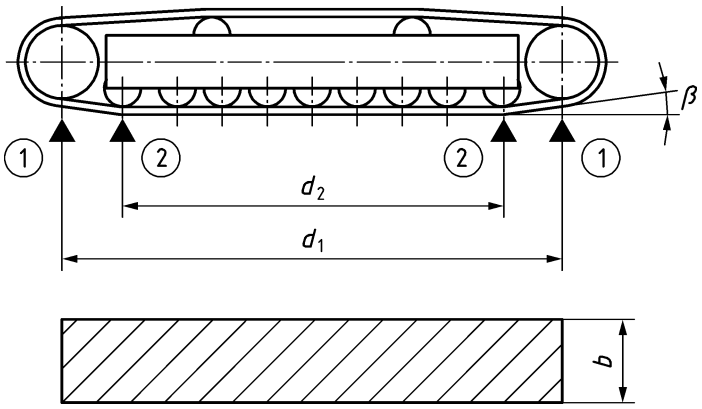
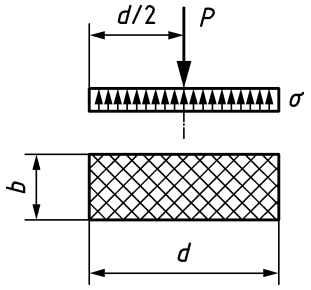
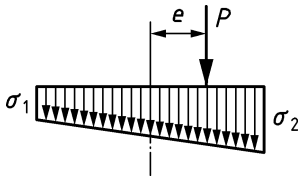
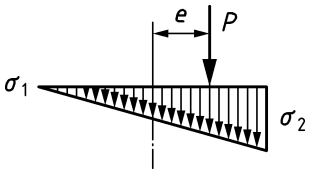
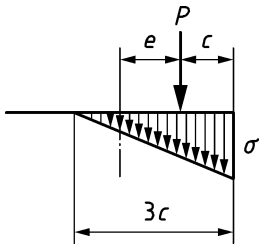
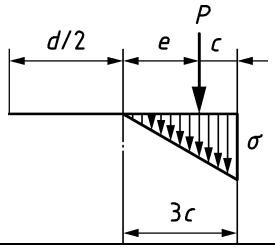


Figure F.1 — Contact area of track

Table F.1 — Ground pressure

	Load and stress diagram	Position of the single load *P*	Ground pressure
1		$e = 0$ *P* in the middle	$\sigma = \frac{P}{bd}$
2		$e < \frac{d}{6}$	$\sigma_1 = \frac{P}{bd}\left(1 - \frac{6e}{d}\right)$ $\sigma_2 = \frac{P}{bd}\left(1 + \frac{6e}{d}\right)$
3		$e = \frac{d}{6}$	$\sigma_1 = 0$ $\sigma_2 = \frac{2P}{bd}$
4		$e > \frac{d}{6}, c = \frac{d}{2} - e$	$\sigma = \frac{2P}{3cb}$
5		$e = \frac{d}{3}$	$\sigma = \frac{4P}{bd}$

Annex G
(normative)

Test conditions of the stopping performances of the rotation of the drilling head

G.1 General

Drilling and foundation equipment with restricted operating mode or special protective mode shall be tested to verify that:

— it satisfies the specifications of the standard in terms of stopping distance in restricted operating mode (see 5.23.2.2.4) and in special protective mode (see 5.23.2.2.5);

— rotation and feed speed of the drilling head, obtained in restricted operating mode, comply with the values announced in the relevant parts of the standard;

— the sensitive protective devices (see 5.23.2.2.3) cover the danger zone according to the stopping time of the moving parts involved in the process of drilling.

G.2 Conditions of measure

The drilling and foundation equipment shall be measured under the following conditions:

— the drilling head shall rotate at its maximum allowed speed as fitted;

— the drilling and foundation equipment shall be parked in working position;

— the drilling head shall have revolved to any time necessary to have warmed up to normal operating temperature;

— no tool, rod, tube or tool transmission device shall be mounted on the output shaft of the drilling head, with the exception of parts where it is necessary to take measurements;

— the rotating movement is considered as stopped when the rotation speed is lower than 3 rpm.

G.3 Measures implementation

G.3.1 General

The measures are taken by applying a command to stop to the control circuit of the moving parts involved in the drilling process and by recording the stopping parameters.

The following requirements shall be applied:

— In the special protective mode the stopping order that activates the measurement shall act in an equivalent way as the actuation of the pressure sensitive devices installed on the machine or if need be of the sensitive protective devices during the calculation of its location.

— During the measurement, whatever is the type of manual control actuator (hold-to-run control or the movement (order with maintained action or notched-indexed control) the operator has to hold the manual control of the movement.

G.3.2 Measurements

The following measurements shall be taken:

— with the maximum speed that can be achieved when the restricted operating mode is selected;

— with the maximum speed that can be achieved when the special protective mode is selected;

— where applicable, the maximum speed stated in the characteristics of the machine (in the case of location of protective devices).

G.3.3 Data to be recorded

For each measurement point, the following data shall be recorded:

— initial speed of the moving part when the command to stop is given. It is an angular speed for the rotation (rpm);

— stopping time (ms) between the command to stop and the stopping of the rotating movement;

— distance crossed by the moving part between the command to stop and the stopping of the rotating movement. It is expressed as an angle (radian).

G.3.4 Evaluation of results

For every measurement point, take three records. If the distance between the biggest and the smallest stopping measurement is greater than 20 % of the mean value, two supplementary records shall be taken.

If three measurements were taken, calculate average of three values.

If five measurements were taken, to remove the best and the worst measurements, and calculate average of the three others.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 2006/42/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard and of the relevant part in the series confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive, and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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6) This document is impacted by a Corrigendum published in 2009.

[18] ISO 6405-2:1993, *Earth-moving machinery — Symbols for operator controls and other displays — Part 2: Specific symbols for machines, equipment and accessories*[7)]

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[7)] This document is impacted by stand-alone Amendment 2, *Additional Symbols*, published in 2004.

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