BS EN 16228-5:2014

BSI Standards Publication

Drilling and foundation equipment — Safety

Part 5: Diaphragm walling equipment

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National foreword

This British Standard is the UK implementation of EN 16228-5:2014. Together with BS EN 16228-1:2014, BS EN 16228-2:2014, BS EN 16228-3:2014, BS EN 16228-4:2014, BS EN 16228-6:2014 and BS EN 16228-7:2014, it supersedes BS EN 791:1995+A1:2009 and BS EN 996:1995+A3:2009, which are withdrawn.

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Foreword

This document (EN 16228-5:2014) 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of an identical text or by endorsement, at the latest by November 2014 and conflicting national standards shall be withdrawn at the latest by November 2014.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, *Drillling 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*

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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, together with part 1, deals with all significant hazards for diaphragm walling equipment 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 (see Clause 4).

The requirements of this part are complementary to the common requirements formulated in EN 16228-1:2014.

This document does not repeat the requirements from EN 16228-1, but adds or replaces the requirements for application for diaphragm walling equipment.

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

EN 474-12:2006+A1:2008, *Earth-moving machinery — Safety — Part 12: Requirements for cable excavators*

EN 16228-1:2014, *Drilling and foundation equipment — Safety — Part 1: Common requirements*

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100:2010, EN 16228-1:2014 and the following apply.

3.1
diaphragm wall
structural retaining wall or cut-off wall, both of which can be impermeable and constructed in-situ in the ground as a series of contiguous panels

Note 1 to entry: Panels are typically narrow but deep and are cut between surface guide walls and can depend on a slurry or mud suspension for temporary ground support. Structural walls are typically of reinforced concrete with the concrete placed from the bottom of the panel upwards to displace the slurry or mud suspension.

Note 2 to entry: There are other diaphragm wall techniques, for example continuous trenchers; these techniques use machines and cutting tools such as digging chain or wheel disc, which are covered by EN 474–10.

3.2
diaphragm walling equipment
equipment for cutting panels for diaphragm walls

3.3
diaphragm walling rig
carrier machine equipped with diaphragm wall cutting tool

Note 1 to entry: The diaphragm walling rig is either:

— a complete machine, or

— a carrier machine with interchangeable equipment in the form of diaphragm wall cutting tools, which can be provided by different suppliers or manufacturers.

Note 2 to entry: The carrier machine can be:

— foundation equipment as defined in EN 16228–4; or

— a crane complying with EN 13000 or EN 13001–1; or

— a cable excavator complying with EN 474–12; or

— a hydraulic excavator complying with EN 474–5.

3.4
diaphragm wall cutting tool
tool for cutting panels for diaphragm walls

Note 1 to entry: Diaphragm wall cutting tools can either be:

— diaphragm wall grab, see definition 3.5;

— diaphragm wall cutter, see definition 3.6.

Note 2 to entry: Diaphragm wall cutting tools can be rope suspended and guided by frames or kelly bars.

3.5
diaphragm wall grab
clamshell grab within a guide device for cutting a diaphragm wall either hydraulically or rope operated

Note 1 to entry: See illustration A.2.24 of EN 16228–1:2014.

3.6
diaphragm wall cutter
assembly of counter-rotating cutting or milling wheels within a guide body used to break up soil or rock for cutting a diaphragm wall

Note 1 to entry: There are other non-mechanical diaphragm wall cutting tools used in the construction of a diaphragm wall such as a chisel and are not covered by this document.

Note 2 to entry: See illustration A.2.25 of EN 16228–1:2014.

3.7
recovery
extraction of a diaphragm wall cutting tool

Note 1 to entry: For example, grab or cutter when it is stuck in the panel.

4 List of additional significant hazards

Clause 4 of EN 16228-1:2014 applies with the following additional Table 1.

Table 1 of EN 16228-1:2014 with the additional Table 1 in this document contain all hazards, (hazardous situations and events), identified by risk assessments as significant for diaphragm walling equipment and which require action to eliminate or reduce 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 between working positions on the work site;

— out of service on the work site;

— in storage at the plant depot or on the work site;

— maintenance;

— changing diaphragm wall cutting tools and their components;

— changing ropes used to suspend diaphragm cutting wall tools.

Table 1 — List of additional significant hazards and associated requirements

No.	Hazard	Relevant clause(s) in this standard
1	Mechanical hazards and events	
1.1	Inadequacy of mechanical strength	5.2.2, 5.2.3
1.2	Overturning	5.2.3, 5.3, 5.8, 6, 7.1
1.3	From inadequate design of pulleys, drums	5.3
1.4	From inadequate selection of ropes	5.3
1.5	Ejection of teeth from milling cutters	7.1
1.6	Impact through excessive oscillation of tools when tramming	7.1
2	Elementary forms of mechanical hazards	
2.1	Crushing/shearing between jaws of grabs	5.5, 7.1, 7.2
2.2	Drawing–in/trapping from teeth of milling cutters	5.4.2, 5.6, 7.1, 7.2
2.3	Crushing/entanglement/drawing-in/ abrasion when replacing ropes	5.4.3, 5.7, 7.1, 7.2
3	Fall of persons during access to (or at/from) the work position (including changing ropes)	7.1, 7.2
4	Hazards generated by noise, resulting in:	
4.1	Hearing losses and physiological disorders	Annex A
4.2	Accidents due to interference with speech communication and warning signals	Annex A

5 Safety requirements and/or protective measures

5.1 General

Diaphragm walling equipment shall comply with the requirements of EN 16228-1:2014 except as modified or replaced by the requirements of this part of the standard.

The requirements of EN 16228-1:2014 shall take precedence over the standards for the carrier machine.

Diaphragm wall grabs and milling cutters shall only be part of a complete machine or be attached to a carrier machine (e.g. hydraulic excavators, cable excavators) which comply with EN 474-5 or EN 474-12.

5.2 Requirements for strength and stability

5.2.1 General

Subclause 5.2 of EN 16228-1:2014 applies with the following additions:

5.2.2 Loads from diaphragm wall cutting tools

When calculating stability in accordance with EN 16228-1:2014 the following shall be taken into account:

— weight of the diaphragm wall cutting tools (including any hose and cable handling system and their mounts);

— weight of the excavated material, slurry or suspension materials and any material adhering to the tool;

— loads applied to the tools during tool extraction;

— all loads induced by rope suspended components are acting at the point where the rope is leaving the upper pulley.

5.2.3 Stability of diaphragm walling rig

5.2.3.1 General

Diaphragm walling equipment can have diaphragm wall cutting tools either rope suspended or guided by frames or kelly bars rigidly connected to the carrier machine.

In both cases a general method for calculating stability shall be used, see 5.2.3.2 below.

For rope suspended cutting tools, a simplified method for calculating stability may be used, see 5.2.3.3 below which differs from subclause 5.2.3 of EN 16228-1:2014.

The simplified method ensures the equipment is stable only when the working platform is horizontal. Therefore it cannot be used when working on slopes and travelling.

5.2.3.2 General method for calculating stability

The required stability angle as mentioned in 5.2.3.5 of EN 16228-1:2014 shall be as stated in Table 2 below:

Table 2 — Required stability angle, dynamic influences included

	Stability class NC (normal conditions)	**Stability class SC (special conditions)**
Travelling	8 degrees	5 degrees + β (see c) below)
Operating and tramming	5 degrees	2,5 degrees + β (see c) below) [a]
Recovery	3,5 degrees	1 degree + β (see c) below)
[a] A static stability angle of 5 degrees + β (see c) below) calculated without dynamic accelerations and wind loads is also required.		

NC and SC are the stability classes (see explanations below).

Use of stability class NC is recommended.

The manufacturer may use stability class SC provided that all of the following conditions are fulfilled:

a) The ground shall support the machine and can reliably withstand the supporting forces, without significant unintended displacements or taking into account their affect on stability (support by, e.g. timber plates, steel plates and/or improved ground surface may be required). This shall also be shown in the case, if supports (those not causing rigid body movement) become unloaded and thus cause maximum forces at other supports.

b) Masses of relevant parts of the machine shall be evaluated by weighing with an accuracy of ± 2,5 %.

c) When using tipping line 1 as defined in Figure 1 of EN 16228-1:2014 the required tipping angle shall be increased by β.

d) Hoist speed is not greater than 10 m/min.

e) No free fall winch mode is used.

f) Freely suspended loads are secured when travelling and tramming, in order to avoid swinging.

5.2.3.3 Simplified method for calculating stability

The calculation of stability shall be done in the most unfavourable position of track orientation and at the maximum operating radius on the horizontal platform.

The sum of all overturning moments shall not exceed 75 % of the sum of all stabilizing moments, where the stabilizing and tipping moments include:

— the base machine alone, its tipping moment is given by the load chart for the actual boom configuration. The safety percentage given by the manufacturer has to be converted to 100 % in order to get of limit tipping moment;

— additional equipment permanently mounted to the carrier machine, e.g. power pack, guiding system, hose reels, special boom head, walkways, etc. Moments are calculated with the load at the distance of the tipping line.

When using a rope suspended grab:

— the moment induced by the weight of the rope suspended part multiplied by 1,25 (excavating tool, with clamshells full of soil of specific weight = 20 kN/m^3).

When using a rope suspended cutter:

— moment induced by the weight of the cutter with full hydraulic hoses;

— moment induced by the weight of mud hose. Depending on the configuration of mud circuit (suspended on the boom or hose reel at the back of the machine) the mud weight can create tipping or stabilizing moments. So the stability has to be calculated with full and/or empty mud hose;

— minimum specific weight of mud = 12,5 kN/m^3.

5.3 Winches and pulleys

Subclauses 5.8.2 and 5.8.3 of EN 16228-1:2014 apply with following additions and/or modifications:

For working ropes used to lift cutting tools only, the minimum factor of safety (minimum breaking load, guaranteed by the manufacturer, in relation to the maximum static load on the rope caused by the winch line pull in the first layer) shall be 2,5.

Diameters of sheaves and drums used to lift the excavation tools only shall meet the following minimum requirements:

winch drum pitch: 16,0 *d*

sheave pitch: 16,0 *d*

compensation pulley: 14,0 *d*

where *d* is the diameter of the rope.

Freefall mode shall be prevented on the winches of the diaphragm walling rigs fitted with diaphragm wall cutting tools (e.g. by a key-operated control).

5.4 Control devices

5.4.1 General

Subclause 5.16 of EN 16228-1:2014 applies with the additions of 5.4.2 and 5.4.3:

5.4.2 Control of the diaphragm walling rig equipped with cutter

During operation, the diaphragm wall cutter shall be controlled from the diaphragm walling rig operator's position.

Diaphragm walling rigs shall be designed and equipped with a remote control for providing slow rotation speed and to give the operator/maintenance staff clear view of a cutter during maintenance tasks and assembly/dismantling.

5.4.3 Control of winches for suspending grabs or cutters when changing ropes

There shall be a control station adjacent or close to each winch with a full view to the winch. This control station shall be activated by a lockable mode selector with acts on all winches. Once the lockable mode selector is activated, it shall only be possible to operate the selected winch drum at a maximum rotation speed of 2 rpm by a hold-to-run control. The lockable mode selector shall be in the control station. All other winches cannot be operated.

5.5 Moving parts involved in the process

Subclause 5.23.2 of EN 16228-1:2014 does not apply.

NOTE It is not practicable to guard the rotating parts of cutters and the clamshells of grabs.

5.6 Maintenance of diaphragm wall cutters

It shall be possible to secure the wheels of diaphragm wall cutters to prevent them moving unintentionally during transportation or maintenance.

5.7 Hose and cable handling systems

A purpose built diaphragm walling rig shall be fitted with a hose and cable handling system.

NOTE Hoses include hydraulic hoses for the diaphragm wall excavation tools and any slurry/mud hoses. Cables include; electrical and control cables for the diaphragm wall excavation tools.

5.8 Inclination of the carrier

Subclause 5.10.2 of EN 16228-1:2014 applies with the following addition:

Systems for measuring the inclination of the carrier shall be accurate within ± 0,2°.

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 3 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 3 — Verification of safety requirements and/or protective measures

Clause	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						
5.1	General	x					2
5.2	Requirements for strength and stability						2
5.2.2	Loads from diaphragm walling cutting tools	X	X				2
5.2.3	Stability of diaphragm walling rig	X	X				2
5.2.3.2	General method for calculating stability	X	X				2
5.2.3.3	Simplified method for calculating stability	X	X				2
5.3	Winches and pulleys	X			X		
5.4	Control devices						2
5.4.2	Control of the diaphgram walling rig equipped with cutter	X				X	
5.4.3	Control of winches for suspending grabs or cutters when changing ropes	X			X		
5.5	Moving parts involved in the process						2
5.6	Maintenance of diaphragm wall cutters	X		X			
5.7	Hose and cable handling systems	X		X			1
5.8	Inclination of the carrier	X			X	X	
7	Information for use						
7.1	Operator's manual			X			2
7.2	Maintenance instructions			X			2

1 Verification by reference to hose manufacturers documents.
2 Verification by reference to standard which is mentioned in the corresponding clause.

7 Information for use

7.1 Operator's manual

7.1.1 General

Subclause 7.3.2 of EN 16228-1:2014 applies with following addition:

— detailed specification of the operational conditions and parameters of use (weight of the working part, boom length, boom angle, permitted deviation of the base carrier machine from the horizontal, specification of ropes);

— instructions for travelling on slopes;

— instructions for changing of teeth on diaphragm wall cutting tools;

— instructions that the ropes on carrier machines for diaphragm walling rigs where diaphragm wall cutting tools are used (excluding ropes used to suspend the diaphragm wall cutting tools) shall be checked at least every 50 working hours;

— instructions that the ropes for suspending diaphragm wall cutting tools shall be checked at least every day;

— illustrations showing the danger zones;

— if the capacity table is made according to the simplified method the machine shall operate on a plane horizontal platform;

— the capacity table for class SC only may be used if the requirement of 5.2.3.2 a) is tested and secured;

— instructions about the special conditions for the recovery of the diaphragm walling cutting tool (i. e. grab or cutter) when it is stuck in the trench if the diaphragm walling cutting tool has provisions or devices for the recovery.

7.1.2 Specific instructions on the diaphragm wall cutting tools put on the market separetely

To comply with 7.3.2 of EN 16228-1:2014 the manufacturer of diaphragm wall cutting tools shall specify in the instruction books the machinery with which it can be safely assembled either by all technical information required or by reference to specific models.

The manufacturer of the diaphragm wall cutting tools shall also provide the necessary instructions for safe assembly and use of the interchangeable equipment.

The manufacturer shall provide all the technical data including dimensions, masses and position of centre of gravity to allow revised calculations for stability of diaphragm walling equipment to be carried out.

The manufacturer shall inform, that the person or company that assembles the combination shall check to ensure that this equipment fulfils all relevant requirements as specified in the instructions for the diaphragm wall cutting tools.

The manufacturer of the diaphragm wall cutting tools shall place a warning in the instructions that the person or company which is assembling the diaphragm wall cutting tools with a carrier machine equipment and changing the original shape or functions of the equipment which departs from the manufacturer's instructions will be fully responsible for the final assembled machine.

7.2 Maintenance instructions

Subclause 7.3.3 of EN 16228-1:2014 applies with following additions:

— instructions for the safe assembly and dismantling of a purpose built diaphragm wall rig;

— instructions for changing components of hose and cabling handling systems;

— instructions for the maintenance/examination of grabs and diaphragm wall cutting tools;

— instructions that during transportation of grabs, the shells shall be secured against unintentional opening or closing;

— instructions for changing ropes used to suspend diaphragm wall cutting tools.

Annex A
(normative)

Noise test code

For complete diaphragm walling equipment Annex B of EN 16228-1:2014 applies.

For a machine according to 3.3, Note 1 to entry indent 2 of this standard, the noise measurements shall be carried out according to ISO 6395 (use test code for excavator) for the determination of sound power level and ISO 6396 (use test code for excavator) for determination of emission of sound pressure level at operator's position.

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 one means of conforming to Essential Requirements of the New Approach Directive Machinery 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 part 1 of this series confers, within the limits of the scope of this standard, a presumption of conformity with the Essential Requirement of the 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.

Bibliography

[1] EN 474-10:2006+A1:2009, *Earth-moving machinery — Safety — Part 10: Requirements for trenchers*

[2] EN 13000:2010, *Cranes — Mobile cranes*

[3] EN 13001-1:2004+A1:2009, *Cranes — General design — Part 1: General principles and requirements*

[4] EN 16228-4:2014, *Drilling and foundation equipment — Safety — Part 4: Foundation equipment*

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