BRITISH STANDARD

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Tunnelling machines — Shield machines, thrust boring machines, auger boring machines, lining erection equipment — Safety requirements

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National foreword

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- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

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English version

Tunnelling machines - Shield machines, thrust boring machines, auger boring machines, lining erection equipment - Safety requirements

Tunneliers - Boucliers, machines de fonçage, matériel de mise en place de revêtement - Prescriptions de sécurité

Tunnelbaumaschinen - Schildmaschinen, Pressbohrmaschinen, Schneckenbohrmaschinen, Geräte für die Errichtung der Tunnelauskleidung - Sicherheitstechnische Anforderungen

This European Standard was approved by CEN on 21 February 2005.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Contents

Foreword

This European Standard (EN 12336:2005) 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of an identical text or by endorsement, at the latest by November 2005, and conflicting national standards shall be withdrawn at the latest by November 2005.

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 includes a Bibliography.

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

Introduction

This European Standard is a type C standard as stated in EN ISO 12100-1:2003.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the scope of this document.

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 machines that have been designed and built according to the provisions of this type C standard.

In this European Standard it is assumed that:

— only competent persons operate the machine;

— components without specific requirements are:

  a) designed in accordance with the usual engineering practice and calculation codes, including all failure modes;

  b) of sound mechanical and electrical construction according to the state of the art;

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

  d) made of no harmful materials, such as asbestos;

— components are kept in good repair and working order, so that the required characteristics remain despite wear;

— the installation allows a safe use of the machine;

— negotiation occurs between the manufacturer and the user/purchaser concerning particular conditions of use and the places (e. g. ground and local safety conditions) of use of the machinery.

NOTE “Manufacturer” is understood within the European Union as intended in the Machinery Directive.

1 Scope

1.1 Description of the machines

This European Standard is applicable to all types of shield machines and associated back up equipment, thrust boring machines, auger boring machines and lining erection equipment. It specifies the essential safety requirements for the design, installation, maintenance, and information for use of such machines.

Shield machines and associated back up equipment include:

— open shields for both manual and mechanical excavation;

— shielded tunnel boring machines;

— micro tunnelling machines;

— towed or stationary back up equipment;

— pipe jacking equipment.

All shield machines provide lateral and radial ground support. In addition they may provide various types of face support and ground water control (see Clause 3).

Certain associated matters are not included in the scope of the standard:

— additional equipment which may form an integral part of a shield machine or back up equipment and is used for compressed air (hyperbaric/plenum) working (see EN 12110:2002);

— use under hyperbaric conditions;

— the supply of electricity up to the machine;

— ancillary tools and equipment used for, at or on the machine;

— electromagnetic compatibility;

— loading and transport equipment which is not an integral part of the machine, e.g. rolling stock, man riders, grout cars, segment cars, muck cars.

NOTE Within the European Union Directive 94/9/EC concerning equipment and protective systems intended for use in potentially explosive atmospheres can be applicable to the type of machine or equipment covered by this European Standard. The present document is not intended to provide means of complying with the essential health and safety requirements of Directive 94/9/EC.

1.2 Hazards

This European Standard deals with significant hazards, hazardous situations and events relevant to shield machines and associated back up equipment, thrust boring machines and auger boring machines when they are used as intended and under the conditions foreseen by the manufacturer (see Clause 4).

1.3 Validity

This European Standard is not applicable to machines which are manufactured before the date of publication of this European Standard by CEN.

2 Normative references

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

EN 3-7:2004, *Portable fire extinguishers - Part 7: Characteristics, performance requirements and test methods*

EN 294:1992, *Safety of machinery — Safety distance to prevent danger zones being reached by the upper limbs*

EN 418:1992, *Safety of machinery — Emergency stop equipment, functional aspects — Principles for design*

EN 563:1994, *Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish temperature limit values for hot surfaces*

EN 620:2002, *Continuous handling equipment and systems — Safety and EMC requirements for fixed belt conveyors for bulk materials*

EN 894-3:2000, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 3: Control actuators*

EN 954-1:1996, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

EN 981:1996, *Safety of machinery — System of auditory and visual danger and information signals*

EN 982:1996, *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*

EN 983:1996, *Safety of machinery — Safety requirements for fluid power systems and their components — Pneumatics*

EN 1088:1995, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

EN 1837:1999, *Safety of machinery — Integral lighting of machines*

EN 12094-1:2003, *Fixed firefighting systems — Components for gas extinguishing systems — Part 1: Requirements and test methods for electrical automatic control and delay devices*

EN 13627:2000, *Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements (ISO 3449:1992 modified)*

EN 60204-1:1997, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:1997)*

EN 60204-11:2000, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c. and not exceeding 36 kV (IEC 60204-11:2000)*

EN 60439-1:1999, *Low-voltage switchgear and controlgear assemblies — Part 1: Type-tested and partially type-tested assemblies (IEC 60439-1:1999)*

EN 60439-2:2000, *Low-voltage switchgear and controlgear assemblies — Part 2: Particular requirements for busbar trunking systems (busways) (IEC 60439-2:2000)*

EN 60439-3:1991, *Low-voltage switchgear and controlgear assemblies — Part 3: Particular requirements for low-voltage switchgear and controlgear intended to be installed in places where unskilled persons have access for their use — Distribution boards (IEC 60439-3:1991, modified)*

EN 60439-4:2004, *Low-voltage switchgear and controlgear assemblies — Part 4: Particular requirements for assemblies for construction sites (ACS) (IEC 60439-4:2004)*

EN 60529:1991, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*

EN 60825-1:1994, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide (IEC 60825-1:1993)*

EN 60947-1:2004, *Low-voltage switchgear and controlgear — Part 1: General rules (IEC 60947-1:2004)*

EN ISO 2860:1999, *Earth-moving machinery — Minimum access dimensions (ISO 2860:1992)*

EN ISO 3411:1999, *Earth-moving machinery — Human physical dimensions of operators and minimum operator space envelope (ISO 3411:1995)*

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

EN ISO 11202:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a workstation and at other specified positions — Survey method in situ (ISO 11202:1995)*

EN ISO 11688-1:1998, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning (ISO/TR 11688-1:1995)*

EN ISO 11688-2:2000, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 2: Introduction to the physics of low-noise design (ISO/TR 11688-2:1998)*

EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*

EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)*

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

ISO 3864-1:2002, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs in workplaces and public areas*

ISO 7745:1989, *Hydraulic fluid power — Fire-resistant (FR) fluids — Guidelines for use*

3 Terms, definitions symbols and abbreviated terms

For the purposes of this European Standard, the terms and definitions given in EN ISO 12100-1:2003 and the following apply.

3.1
shield machine
steerable protective structure within which tunnel excavation takes place by manual, mechanical or hydraulic means. Erection of tunnel support may take place within the shield machine. Examples of shield machines are given in Annex A (informative)

3.1.1
shield
shield machine in which an open or partial face is excavated by manual or independent mechanical means

3.1.2
shielded tunnel boring machine (TBM)
shield machine for full face excavation, having one or more rotating cutting heads in which the cutter head(s) may be separated from the rest of the shield by a bulkhead. Passage of material through the bulkhead may be controlled

3.1.3
micro tunnelling machine
shield machine designed for non man entry (except for maintenance purposes when out of service) which is remotely controlled by an operator from outside the tunnel

3.2
associated back up equipment

3.2.1
towed back up equipment
steel construction normally towed behind or attached and moving with the machine which accommodates equipment, to provide the machine with services for its operation and its crew with facilities for their work and comfort

3.2.2
stationary back up equipment
equipment for operation or control of pipe jacking and micro tunnelling equipment, thrust boring and auger boring machines which is installed at the bottom of an access shaft or on the surface adjacent thereto

3.2.3
pipe jacking equipment

3.2.3.1
pipe jacking rig
hydraulic jacking equipment at main jacking station, used to drive a pipe string through the ground to form a tunnel lining

3.2.3.2
intermediate jacking station
structure having the same external dimensions as the pipe and containing a number of hydraulic jacks used to drive a section of pipe string through the ground. Intermediate jacking stations subdivide a long pipe string into sections

3.3
thrust boring machine
machine for constructing pipelines by displacement

3.4
auger boring machine
non-steerable machine for constructing pipelines using continuous flight augers for excavation and spoil removal

3.5
lining erection equipment (Erector)
handling and erecting equipment which is situated within or immediately behind a shield machine which is used to install tunnel linings

3.6
control station
any location on a shield machine or back up equipment from where one or more functions of the shield machine, back up equipment or their separate working units are controlled by an operator

3.7
main control station
control station from where the boring operation and the advance of the shield machine is controlled

3.8
walkway
part of the access system that permits walking or crawling between locations on a shield machine or back up equipment

3.9
walkway surface
footpath within the walkway

3.10
servicing point
any location on a shield machine or back up equipment where maintenance or servicing is normally carried out

3.11
working area
area on or in a machine, where an operator assists in the function of the machine

4 List of significant hazards

This clause contains all the significant hazards, hazardous situations and events, as far as they are dealt with in this European Standard, identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce the risk.

Hazards	See clause
4.1 Mechanical hazards	
a) Crushing hazard	5.2.4, 5.2.7, 5.2.8, 5.5.4.3, 5.17.2
b) Friction or abrasive hazard	5.2.1
c) High pressure fluid injection hazard	5.2.3, 5.3.1
d) Loss of stability and structural collapse	5.2.6, 5.2.7
e) Slip, trip and fall hazards	5.2.8
4.2 Electrical hazards	
a) Electrical contact, direct or indirect	5.10, 5.11
b) External influences on electrical equipment	5.10.3, 5.10.4, 5.10.6, 5.10.7
4.3 Thermal hazards	5.2.2
4.4 Hazards generated by noise	
a) Hearing damage (deafness)	5.3.1, 5.9
b) Accidents due to interference with speech communication and acoustical signals	5.5.4.3
4.5 Hazards generated by radiation	
a) Laser	5.7
b) Radon	5.8.3.2
4.6 Hazards generated by materials and substances	
a) Materials processed, used or exhausted by machinery	5.8.2
b) Dust and gas	5.3.1, 5.8, 5.10.3, 5.13.1
c) Fire or explosion	5.8.3, 5.13
d) Falling objects, face collapse and flood	5.2.9
4.7 Hazards generated by neglect of ergonomic principles	
a) Unhealthy posture or excessive efforts	5.2.5, 5.3.2
b) Inadequate local lighting	5.10.8
4.8 Hazards caused by failure of energy supply	
a) Failure of energy system	5.5.6, 5.12
b) Failure of control system	5.5.2
4.9 Hazards caused by missing and/or incorrectly positioned safety related measures	
a) All kinds of guards	5.2.8, 5.4
b) All kinds of safety related devices	5.4, 5.5, 5.6
c) Starting and stopping devices	5.2.6, 5.5.2, 5.5.4
d) Safety signs and tags	5.4.1, 5.7, 5.16
e) All kinds of information or warning devices	5.4, 5.5, 5.6, 5.8.3.2, 5.8.3.4, 5.10.2, 5.16
f) Energy supply disconnecting devices	5.10.2
g) Emergency stopping devices	5.5.5
h) Safe handling of machinery and parts, loading and unloading operations	5.2.5
i) Essential equipment and accessories for safe adjustment and/or maintenance	5.17
j) Equipment evacuating gases	5.8

5 Safety requirements and/or protective measures

5.1 General

Machinery shall comply with the safety requirements and/or protective measures of this clause.

In addition, the machine shall be designed according to the principles of EN ISO 12100-1:2003 and EN ISO 12100-2:2003 for hazards relevant but not significant which are not dealt with by this European Standard (e.g. sharp edges).

For the application of EN 294:1992, EN 982:1996, EN 983:1996, EN 60204-1:1997 EN 60204-11:2000 the manufacturer shall carry out an adequate risk assessment for the requirements thereof where choice is necessary.

NOTE This specific risk assessment is part of the general risk assessment relating to the hazards not covered by this type C standard.

5.2 Specific requirements

5.2.1 Hazards due to sharp and rough parts

Machined or cut parts which are exposed or likely to be exposed shall be finished to remove burrs, rags and sharp edges by radiusing or chamfering.

5.2.2 Hazards due to hot surfaces

Where there is a risk of contact with hot surfaces in accessible areas suitable measures shall be taken:

— to limit the temperature of hot surfaces to the value given in EN 563:1994 based on 1 s contact time;

— and where this is not possible prevent contact with those surfaces/parts (e.g. screens, fixed distance guards) and

— provide warning signs against residual risks, see Clause 7.

5.2.3 Hoses, installation and shielding

Hoses shall be installed according to their manufacturers' instructions and out of reach of any moving load.

Adequate shielding in accordance with Clause 9 of EN ISO 3457:2003 shall be provided to protect persons in working areas.

5.2.4 Cutter head on TBMs

Where it is intended to gain access through a bulkhead to the area behind a cutter head and similarly through a cutter head to the area in front then access openings in accordance with 5.2.8.3 shall be provided.

The design shall allow for safety in the space between the bulkhead and the cutter head. In unstable ground this shall be ensured e.g. by slot gate closures and/or compressed air for ground water control.

NOTE Where size allows, roller cutters should be of a back loading type. Other cutting tools should be arranged to avoid the need to carry out maintenance work in front of the cutter head.

The cutter head shall be equipped with a system to prevent unintentional rotation in accordance with 5.4.3, 5.5.2 and 5.17.2.

5.2.5 Handling of heavy loads

5.2.5.1 Handling of consumables items

Equipment shall be provided for handling consumable items which require regular replacement such as cutters.

Where the weight, size or shape of consumables items prevents them from being moved by hand the consumable items shall be either:

— fitted with attachments for lifting gear or;

— so designed that they can be fitted with such attachments or;

— shaped in such a way that standard lifting gear can easily be attached.

NOTE See EN 1005-2:2003 as a guidance.

5.2.5.2 Handling of elements for ground support

When the ground support system requires the handling of elements weighing more than 50 kg a handling and erecting device shall be fitted. Erecting devices shall be either stationary with winch wires and levers moving the elements or rotary where the element can be lifted directly to any position around the circle of the tunnel.

The segment handling system shall be designed to avoid necessity of presence of persons in the handling area. Where presence is necessary means shall be provided to enable the operator to limit and to separate movements.

Where smooth faced segments are handled using vacuum attachment pads the segment pick-up devices shall be designed to maintain the vacuum for at least 20 min within the working pressure range and be fitted with a pressure gauge. When the pressure moves outside the operating range then an audible and visual alarm shall be activated.

Vacuum operated pick-up devices shall be designed so that the factor of safety against pull-off and sliding force shall be at least 1,5, taking into account the maximum loads. When this safety factor cannot be achieved, then a mechanical device e.g. a shear pin shall be provided to carry the full shear load. In this case it shall not be possible to rotate the erector after picking up a segment unless the mechanical device is in position.

All hydraulic and pneumatic rams and motors and vacuum pick-up devices which sustain load shall be designed to hold the load in the event of a circuit or power failure, by means of directly mounted pilot operated check valves or power off brakes or reserve vacuum for at least 20 min following the failure (see EN 982:1996 and EN 983:1996 for requirements).

In all cases winches and drive motors shall be fitted with mechanical brakes which are powered off during operation.

5.2.6 Rotation and displacement (axial movement)

5.2.6.1 Rotation

NOTE All shield machines can be subject to slow rotation due to imbalance of loads and forces.

Care shall be taken in the design and manufacture of the shield machine and back up equipment to avoid eccentric loadings and all machines shall be fitted with a roll indicator and an effective counter rotation system, such as an angled plough, for returning the machine and back up equipment to the correct orientation.

Sudden rotation of a shield machine may occur when a cutter head or boom becomes embedded in the face. All such machines shall therefore be fitted with a protective device which cuts off power to the drive motor in the event of the shield machine having rotated more than a pre-set angle as defined by the manufacturer.

5.2.6.2 Gripping and re-gripping

When grippers are fitted to a shielded TBM and are in use, it shall be possible for the operator to vary the minimum gripping pressure according to the geological conditions encountered. It shall not be possible to start the cutter head drive or apply the thrust force until the minimum gripping pressure has been reached.

Should the gripping pressure fall below this pre-set minimum gripping pressure value the cutter head rotation shall be stopped and the thrust force shut off automatically.

5.2.7 High compressive loads

5.2.7.1 Pipe jacking rigs

All load transfers between thrust jacks and pipes in pipe jack, thrust bore and auger bore rigs shall be via purpose designed spacers and thrust rings. Thrust jacks shall be supported normal to a thrust ring such that no bending shall occur during jacking operations.

5.2.7.2 Structural collapse of the shield

All shield machines act as temporary ground support during the tunnelling operations. They shall therefore be designed to withstand the loads imposed by the surrounding ground and ground water level through which the machine is intended to be used together with any loads imposed by the action of driving the machine forwards.

5.2.8 Access to and egress from operating positions and servicing points

5.2.8.1 General

NOTE Tunnelling can involve working in very confined spaces. During tunnelling operations access to a machine can only be gained through the tunnel being driven.

The areas of the machine and back up equipment where transfer of material to and from the tunnel transport system takes place shall be designed and constructed to maintain walkways, see 5.2.8.2.

For micro tunnelling machines, where the dimensions of 5.2.8.2 are not satisfied, entry in the machine shall be prevented by fixed guards.

5.2.8.2 Walkways

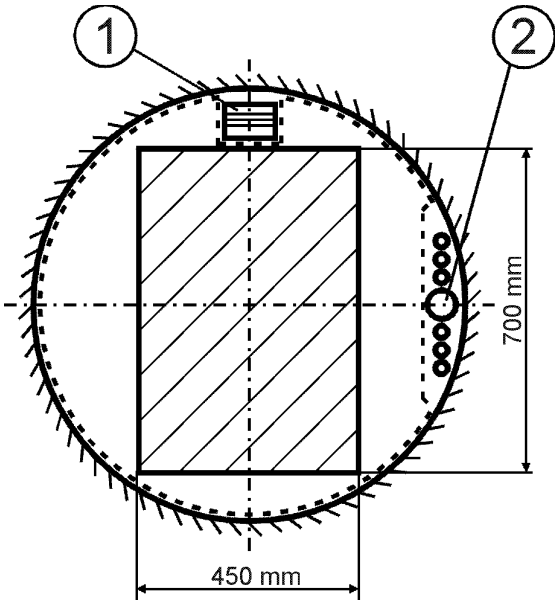
Walkways within the machine and between the machine and the tunnel wall shall have a minimum cross sectional area of at least 0,5 m^2 within which there shall be a rectangular clear body opening with a vertical dimension of at least 700 mm and a horizontal dimension of at least 450 mm. Examples of how these dimensions can be fitted in are shown in Figures 1, 2 and 3.

Walkway surfaces shall be at least 300 mm wide. Handrails and toeboards shall be provided wherever walkway surfaces are less than 300 mm wide. Walkways shall not be obstructed by access openings or by designated storage areas for materials or equipment.

Whenever possible changes in level and alignment of the walkway shall be avoided. Where ramps steps or stairways are necessary, handrails or handholds to at least one side shall be fitted.

NOTE Clauses 6 and 7 of EN ISO 2867:1998 and EN ISO 2860:1999 may be referred to for guidance but the above requirements should prevail.

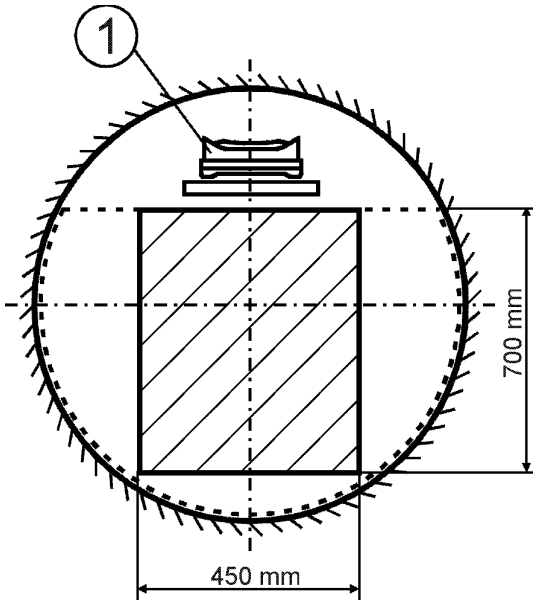
Guards shall be provided where there is a risk of squeezing or contact with moving parts.



Key

1 Laser
2 Services

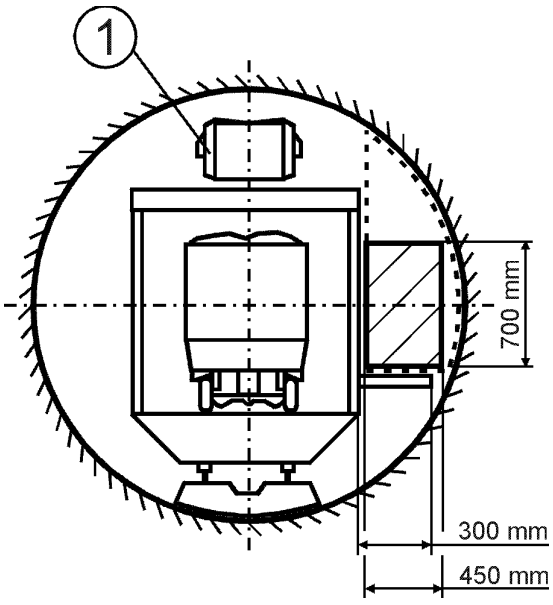
Figure 1 — Example of the application of the requirement of 5.2.8.2



Key

1 Conveyor

Figure 2 — Example of the application of the requirement of 5.2.8.2



Key

1 Conveyor

Figure 3 — Example of the application of the requirement of 5.2.8.2

Information to all figures:

1) areas within broken lines ≥ 0,5 m²;

2) areas hatched are 700 mm x 450 mm.

5.2.8.3 Access openings

Access openings shall comply with EN ISO 2860:1999, except body access openings to bulkheads and cutter heads. These body access openings shall have a clear body opening with a minimum cross sectional dimension of 400 mm within a minimum area of 0,2 m^2. Wherever feasible these dimensions shall be increased.

5.2.9 Protection against falling objects, face collapse and flood

5.2.9.1 Falling objects

On large shield machines, where there is the risk that objects may fall on permanent working places such as the control cabin, a falling object protective structure according to level I of EN 13627:2000 shall be provided at such locations.

5.2.9.2 Face collapse

NOTE 1 There is always a danger of face collapse in tunnels in unstable ground.

The shields shall be provided with face support systems designed to be appropriate to the ground conditions for which the machines are intended.

NOTE 2 The face may be stabilised by the use of face rams, hydraulically operated poling plates and face plates or face boards, breast plates or platforms or by the application of compressed air and sealing with bentonite or shotcrete.

5.2.9.3 Flood

NOTE There is a serious risk of physical injury or drowning to persons working on a shield machine should the tunnel or shaft be flooded.

All shield machines shall be designed to accommodate pumping equipment adequate for the conditions envisaged.

5.3 Control stations

5.3.1 General

Control stations shall be designed, positioned and protected to ensure operators are not exposed to mechanical hazards, harmful dust, gases, vapours, excessive noise emissions or high pressure fluids.

5.3.2 Ergonomics

Arm rests or other means shall be provided to ensure safe operation of sensitive controls (e.g. hold-to-run controls).

The operator's place shall meet the requirements of EN ISO 3411:1999, except for those machines where the size of the machine does not provide adequate space. The operator's seat, when fitted, shall in all cases keep the operator in a stable and comfortable position, for dimensions see ISO 11112:1995.

5.3.3 Visibility

Visibility from a control station shall be such that the operator has a clear view of the working area for which he has control.

Where necessary visual aids, for example closed circuit television shall be used.

Illuminated indicators or equivalent devices shall be installed to indicate the following:

— that the part of the machine that he controls is ready for operation;

— that all auxiliary equipment required for the operation is ready or has been started;

— that the monitoring equipment is functional (see 5.8.3.2);

— that no emergency stop is actuated (see 5.5.5).

5.4 Guards and protective devices

5.4.1 General

Where the hazards due to moving parts can not be eliminated by design those parts of the machine and the back up equipment shall be fitted with guards or protective devices to prevent risk of contact with moving parts which can lead to accidents. Where moving parts are exposed adequate warning signs in accordance with ISO 3864-1:2002 shall be positioned so as to be readily visible to persons on the machine.

5.4.2 Specification of guards

For design of suitable guarding see EN ISO 3457:2003 and EN 953:1997.

5.4.3 Access to cutter head

Access to the area where contact with the cutter head can occur shall only be possible when the cutter head has been brought to a complete standstill (see 5.2.4, 5.5.2, and 5.17.2).

This requirement may be relaxed for machines during creep or jog operations as defined in 5.5.2 “Control systems“.

5.4.4 Conveyor

Conveyors shall comply with the requirements of EN 620:2002.

Guardings shall be effective when a conveyor is equipped with a retract system.

When spare parts are intended to be moved by conveyor, care should be taken to ensure that they remain stable as long as they are on the conveyor. The primary conveyor belt drive shall be fitted with a key switch for the activation of creep speed. The key switch shall be at a control station close to the access to the cutter head. This control station shall be subject to the same specification as the control station in 5.5.2.

5.5 Control devices and systems and safety circuits

5.5.1 Control devices

Control devices shall conform to the requirements of EN 894-3:2000 and shall be:

— clearly visible and identifiable and appropriately marked where necessary;

— positioned in such a way that inadvertent activation is avoided;

— located close to each other when the start and stop functions are not operated by the same control device;

— within reach of the operator at the operators position. The controls need to be logically grouped;

— so arranged that the layout and movement are compatible with the action to be performed and be ergonomically designed;

— of a hold-to-run type for the creep operation of a cutter head or conveyor belt.

Where local control devices are provided mainly for maintenance purposes they shall be hold-to-run type and be provided with a key to switch off the operation of that part of the machinery.

Where a control device is designed and constructed to perform several different actions, the action to be performed shall be clearly displayed and subject to confirmation where failure to perform the correct functions will generate a hazard.

Each machine shall be fitted with devices which shall indicate during the machine cycle permissible and actual working levels of activities for the safe operation of the machine. An operator shall be able to read them from the control station(s).

5.5.2 Control systems

The control systems of the machinery shall be so designed that:

— there shall be a neutral start or similar protection of any drive motor to avoid any form of movement;

— control voltage or control pressure failure and subsequent restoration of control voltage or pressure shall not result in any movement;

— all normal operational functions which are sequentially started or stopped shall, during maintenance, be capable of being started and stopped individually.

At every control station there shall be a key operated device which can shut down and prevent the restart of all systems controlled from that point. This key device shall operate so that all systems controlled from that control station shall be shut down in a safe manner. On a TBM a control station shall be provided directly behind the cutter head. This control station shall override all other control functions controlling the cutter head and shall allow only the positioning of the cutter head in creep or jog operation (see also 5.17.2).

When on a tunnelling machine the creep or jog operation is actuated from this control station an automatic warning signal shall sound (see Table 1).

5.5.3 Safety circuits

The category of safety related parts of the control system (emergency stopping, interlocking, ...) shall be selected and designed in accordance with the principles of EN 954-1:1996.

— Each safety-related part of a control system shall fulfil at least the requirements of category 1 as described in Clause 6 of EN 954-1:1996. Reed contacts shall not be used. Interlocking shall be in accordance with EN 1088:1995.

5.5.4 Starting and stopping and warning systems

5.5.4.1 Starting

The machinery shall be fitted with a start control located at the main operator's control station if any. It shall not be possible for the machine to start or be started except by the intentional actuation of that control. All starting controls on auxiliary equipment shall be subordinated to this control.

5.5.4.2 Stopping

Machinery shall be fitted with a stop control whereby it can be brought safely to a complete stop.

Each control station shall be fitted with additional controls to stop some or all of the moving parts of the machinery, so that the machinery is rendered safe. Stop controls shall have priority over the start controls.

5.5.4.3 Warning system

A warning system shall be fitted to fast moving equipment such as fixed conveyors, cutter heads and erectors as required in Table 1. The warning system shall be electrically interlocked with the control system in accordance with the requirements of Table 1. EN 981:1996 gives specifications for different signals. Sound warning systems shall have a minimum sound level at least 10 dB above the expected ambient machinery noise level under operating conditions.

Table 1 — Audible and visible warning system

Function	Type of Warning	Duration	Location of perception
Any movement of cutter boom or back-acter: Operator's view restricted	Audible	5 s before start up	At cutter head area
Any jog operation of the cutter head	Audible	5 s before start up and during operation	At the cutter head area
Any operation of the conveyor	Audible	5 s before start up	Along the whole length of the conveyor
All movement of erector: Operator's view unrestricted	Audible or visible	During movement	In erection area
All movement of erector: Operator's view restricted	Audible and visible	10 s before start up and during movement	In erector area
All movement of the back up equipment independently of advance of the cutter head	Audible or visible	5 s before start up	Be heard or seen along the whole length of the back up equipment
Emergency evacuation, fire or flood	Audible see Table 2 of EN 981:1996	Continuous	Along the whole length of the back up equipment

5.5.5 Emergency stops

Shield machines including towed back up equipment shall be fitted with emergency stop devices which may include trip wires emergency stops fitted in accordance with 4.5 of EN 418:1992.

Emergency stop devices shall conform to EN 418:1992 and shall comply with categories 0 or 1, as applicable and in particular:

— be easily and safely accessible;

— be at each control station;

— at any potentially hazardous area such as alongside a conveyor or at the entrance to a cutter head;

— be mechanically locked in the stop position and may be reset only intentionally at the device which was actuated.

5.5.6 Failure of the power supply

An interruption, re-establishment after an interruption or fluctuation of the power supply to the machinery shall not lead to a dangerous situation. In particular provision shall be made for the following:

— after re-establishment of the power supply, the machinery shall only start after an intentional actuation of the start control;

— the machinery shall not be prevented from stopping if the command to stop has already been given;

— the safety measures relating to the access to the cutter head shall remain fully effective.

5.6 Towing connection

Each individual towing connection between shield machines and towed back up equipment and between the individual elements of the towed back up equipment shall be designed and constructed to withstand the tractive force normally required to tow the full towed back up equipment with safety factors as follows:

For chain connections a factor of 4 on the breaking load

For bars and other connections	a factor of 2 on the yield stress

The towing connections between shield machines and towed back up equipment shall be protected against overload.

For the calculation of the tractive force the following friction factors shall be applied:

For wheel mounted trailers when they run on rail track	$\mu = 0,2$
For wheel mounted trailers when they run on other surfaces	$\mu = 0,3$
For sledge mounted trailers on any surface	$\mu = 0,8$

Steel cables shall not be used as towing connections except between the towed back up equipment and ancillary trailers such as rail cross-overs.

If the back up equipment is moved independently, see 5.5.4.3.

5.7 Laser guidance

The laser window shall be positioned so that exposure of the laser beam to the operator's eyes is minimized and signs warning against excessive exposure shall be provided. Lower power lasers designed up to class 3a of EN 60825-1:1994 shall be used.

NOTE Generally the laser is supplied by the user.

5.8 Ventilation and the control of dust and gas

5.8.1 General

According to the intended use shield machines shall be designed to incorporate appropriate ventilation, dust suppression and collection equipment (see introduction, last indent, negotiation).

When this equipment is not supplied by the manufacturer of the shield machine then details of the sizes and type of equipment envisaged shall be listed in the instruction handbook (see 7.2.1).

5.8.2 Exhaust gases of internal combustion engines

Internal combustion engines shall only be used for emergency purposes on shield machines e.g. for emergency power supply and then only when appropriate ventilation equipment is incorporated.

Internal combustion engines driven hydraulic power packs for pipe jack rigs and micro tunnelling machines, auger boring machines and thrust boring machines shall be designed to allow for exhaust systems to be directed clear of tunnel and shaft openings.

5.8.3 Atmospheric changes and ingress of gases

5.8.3.1 General

Tunnelling may present a hazard due to ingress of gases from the surrounding ground. These gases may be toxic, flammable or may simply reduce the concentration of oxygen within the normal air to a harmful level.

5.8.3.2 Monitoring equipment

All shield machines connected to an electrical power supply, shall be fitted with explosion protected atmospheric monitoring equipment capable of detecting oxygen deficiency and flammable gases. Such equipment shall be fitted with internal batteries to provide for at least 24 h continuous monitoring in the event of a main power failure. Provision shall be made for housing additional equipment to monitor toxic and radiation gases (i.e. radon) that may be considered likely to occur in the ground conditions for which the machine is intended to be used.

For machines not connected to electrical power supply provision shall be made for the installation of portable atmospheric monitoring equipment.

5.8.3.3 Sensors

In all machines the sensors of the monitoring equipment shall be fitted as close as practicable to the working face. On machines where the architecture of the machine might allow gases to build up in less well ventilated places, additional sensors shall be provided.

In micro tunnelling machines sensors shall be carried on the jacking rig and in the surface operations container whenever this may be situated over the working shaft.

5.8.3.4 Alarms and automatic shutdown

Atmospheric monitoring equipment shall be capable of being pre-set to give a visual and audible warning of hazardous concentrations of flammable or toxic gases or of oxygen deficiency.

NOTE The adjustment of the alarm levels can depend on national regulations and local conditions.

When the intended use (see introduction, last indent, negotiation) of the machine includes a defined expectation of the presence of flammable gases, the monitoring equipment shall be interlocked with the control system for the main power supply to cause an automatic shutdown at a pre-set level. In these circumstances equipment for secondary ventilation, emergency lighting, fire fighting and communications shall be of explosion protected design and shall continue functioning after such an automatic shut-down of the main power supply.

5.9 Noise reduction

5.9.1 General

There is a risk of hearing damage being sustained by any persons working in or adjacent to tunnel machinery.

In order to protect personnel appropriate measures shall be taken to reduce noise from machinery in accordance with EN ISO 11688-1:1998 and EN ISO 11688-2:2000.

5.9.2 Noise reduction at source at the design stage

When designing a machine the available information and technical measures to control noise at source at the design stage shall be taken into account, according to EN ISO 11688-1:1998 and EN ISO 11688-2:2000.

Noise can be reduced by the following measures:

— use of components and ancillaries with the lowest possible noise emission;

— isolation of structure borne noise or impact sound of power units;

— control cabin with noise protection.

5.9.3 Noise emission determination

No practical established method is available to determine the total noise emission from a tunnelling machine in a tunnel. It is then not possible for a designer to predict the total noise emission from a machine working underground. Furthermore, process noise may dominate the total noise emission and is subject to variation.

However, A-weighted sound pressure levels at the control stations shall be measured according to EN ISO 11202:1995. Whether or not the control stations are within a cab, no environmental correction shall be made. These measurements shall be carried out at the first assembly with no excavation process noise present. Operating conditions that are typical of normal operation of the tunnelling machine and provide the highest noise levels shall be chosen. Positions of the measurement points and detailed information on the operating conditions during the noise measurement shall be recorded and reported.

5.10 Electrical equipment

5.10.1 General

All electric equipment shall comply with the relevant parts of EN 60204-1:1997 or EN 60204-11:2000 depending on voltage used and as modified below.

5.10.2 Protective measures

The circuits for portable equipment, accessories and lighting shall comply with Clause 16 of EN 60204-1:1997 with the addition of the following:

The measures to mitigate the problems associated with electrical equipment in a tunnel environment shall include:

— the use of residual current protective device with a fault current rating of a maximum of 30 mA;

or

— the use of 110 volt centre earth tap supply.

NOTE This system is predominantly used in the UK.

Control circuits shall comply with Clause 9 of EN 60204-1:1997, with the addition for handheld pendant controls that they shall operate at control voltages not exceeding 24 volts.

In power circuits up to 1 kV a residual current protective device with a fault current rating of a maximum of 300 mA or an insulation monitoring system shall be installed in accordance with the type of supply system. In the case of insulation monitoring, when a reduction of the insulation resistance to less than 100 ohm/v occurs the failure shall be indicated by means of a visual or acoustic signal. The circuit breaker shall open when the insulation resistance falls below 50 ohm/v.

Cables and leads together with switch gear and transformers operating on a voltage above 1 kV shall be monitored by devices which shall immediately shut off the power supply under any of the following conditions:

— interruption of the protective earth or the monitoring conductor;

— a short circuit between the protective earth conductor and the monitoring conductor;

— a short circuit between a phase conductor and the protective earth conductor;

— a short circuit between a phase conductor and the monitoring conductor;

— a short circuit between phase conductors.

It shall not be possible automatically to reconnect the power supply following a disconnection.

5.10.3 Cables and leads

Sheathing with low smoke and fume (LSF) materials shall be preferred for protection on all cables.

5.10.4 Transformers

Only air cooled, oil free transformers shall be used on tunnelling machines.

5.10.5 Earthing and bonding

An equipotential bonding conductor shall be installed within the boundaries of the shield machine. The material for the bonding conductor shall be a copper braid in accordance with EN 60204-1:1997 and EN 60204-11:2000 and have a minimum cross section of 50 mm^2. All exposed conductive parts and extraneous conductive parts shall be connected to the protective bonding conductor.

5.10.6 Switch gear

All low voltage switch gear shall comply with the relevant provisions of EN 60439-1:1999, EN 60439-2:2000, EN 60439-3:1991, EN 60439-4:2004 and EN 60947-1:2004 and shall, where space permits, be installed in cabinets or boxes. The cabinets or boxes shall have protection to at least class IP 55 and shall be arranged or built to protect the switch gear against mechanical damage. Switch gear outside such a cabinet or box shall have at least protection class IP 55 with mechanical protection where equipment may be subjected to mechanical damage. The degree of protection provided by an enclosure shall be indicated by the IP Code as described in Clause 4 of EN 60529:1991.

5.10.7 Lighting

The lighting shall comply with EN 1837:1999. Illumination at the level of an operator's controls shall be at least 100 lux. The illumination shall be 30 lux at walkway level. Where service work is intended to be carried out sockets for additional lighting shall be provided.

Light fittings shall be mechanically protected.

NOTE For example, they may be installed in glass domes with a protective armoured cage or mounted in domes made of high impact resistant material.

5.10.8 Emergency lighting

Independent emergency lighting shall be fitted which is switched on automatically in the event of failure of the main lighting system.

The level of illumination provided at walking level by the emergency lighting shall be at least 15 lux for 10 min.

5.11 Isolation of high voltage power supply

Devices for isolation of the mains supply (on both the high and low voltage side of the transformer) shall be provided. Such devices shall be lockable in the open position.

5.12 Energy supply other than electricity

Hydraulic pumps and motors, control systems and the interconnecting pipe work shall be designed and constructed according to EN 982:1996.

Compressors, air motors, control systems and interconnecting pipe work of any pneumatic system shall be designed and constructed according to EN 983:1996.

For control devices and systems see also 5.5.

5.13 Fire prevention and protection

5.13.1 General

NOTE There is a serious risk of physical injury or asphyxiation to persons working on a machine should fire occur in the tunnel or shaft.

All shield machines whose length including back up equipment exceeds 20 m shall be fitted with a fire detection system and with the means for raising the alarm in the event of a fire being detected (see 5.5.4.3, Table 1).

All shield machines shall be provided with clear and effective means of access and egress for all operatives working on any of the machinery and equipment.

All shield machines shall be designed to minimise the use of combustible materials.

Upholstery and insulation, where used, shall be made of fire-retardant material which has a linear velocity of flame propagation of a maximum of 250 mm/min tested in accordance with ISO 3795:1989.

On shield machines only fire-resistant hydraulic fluids according ISO 7745:1989 shall be used.

All hydraulic systems shall be designed so that in the event of rupture of a component the loss of hydraulic fluid is minimised and early warning is given of the rupture.

Hydraulic tanks shall be fitted with both low and high level warning alarms.

5.13.2 Fire extinguishing systems

Shield machines and back up equipment shall be equipped either with fire extinguishing systems or fire extinguishers having a mass of agent of not less than 6 kg. The extinguishing agents shall be suitable for the relevant classes of fires and for use in occupied confined spaces.

The fire extinguishing systems shall fulfil the requirements of EN 3-7:2004 and EN 12094-1:2003.

NOTE For maintenance and service it is preferable to have fire extinguishers supplied locally.

5.13.3 Installation of fire extinguishing systems

Fire extinguishing systems and/or fire extinguishers shall be installed on machines and their associated equipment particularly in places where the risk is great, for example:

— main operator's area;

— near to the main drive motors for the cutter head;

— hydraulic power packs;

— electrical cabinets;

— transformers.

Fire extinguishers shall be placed between personnel and the areas where a fire could be expected to occur. They shall be easily accessible. The fire extinguishers shall be mounted so that tools are not needed for removal from the brackets.

Automatic fire extinguishers using inert gas shall only be used in sealed cabinets.

A water spray system which provides a curtain of water across the whole of the tunnel cross section shall be fitted at the rear of towed back-up equipment. It shall be capable of being operated manually.

5.14 Storage of rescue equipment

On the back up equipment of shield machines accessible storage space shall be provided for personnel rescue equipment, e.g. stretchers, breathing apparatus and first aid equipment (see introduction, last indent, negotiations). Such space shall be clearly marked.

5.15 Forward probing equipment

All shield machines, except for micro tunnelling machines, shall be designed to allow for the future installation and use of forward probe drilling equipment.

The size and type of equipment shall be given in the instruction handbook.

5.16 Warning signs, warning devices, symbols

5.16.1 Warning signs

Warning signs shall be provided at the entrance to the machine warning of hazards such as:

— moving parts;

— high voltage;

— squeezing risks;

— noise;

— hot surfaces.

Warning signs shall be repeated at the location of each hazard.

Additional signs shall state that anyone operating separate working units of the machine shall be fully familiar with the operator's handbook and be authorised to operate those units.

5.16.2 Warning devices

Warning devices (audible or visual) shall be of robust design and construction and sited where they cannot be easily damaged.

5.16.3 Symbols

Symbols used on machines shall be selected from appropriate ISO and EN standards (see particularly EN 61310-1:1995).

5.17 Maintenance

5.17.1 General

NOTE There is risk of physical injury to maintenance personnel within the confined space of a tunnel machine and also whilst working on the cutter head.

Where possible the machine shall be designed so that adjustment, maintenance, repair, cleaning and servicing operations can be carried out when the machinery is at a standstill. Where it is only possible to undertake checks or maintenance with the engine running, the safe procedure shall be described in the operation manual.

5.17.2 Work on cutter heads

Where access to the cutter head of a machine is required for maintenance purposes, access ways and bulkhead openings shall be provided (see 5.2.8).

Wherever possible maintenance shall be designed to be carried out from within the protection of the shield.

Provision shall be made so that the rotation of motors for the cutter head shall be shut off and locked against unintentional restart using the control station referred to in 5.5.2.

6 Verification of the safety requirements and/or protective measures

Verification of the compliance with the safety requirements given in this European Standard shall be made by design, calculation, visual verification, measurement or functional testing during manufacture and trial assembly at the factory, see Annex B (normative).

7 Information for use

7.1 General

The manufacturer shall provide on delivery of a machine information for safe operation and maintenance. The written instructions shall be drawn up according to 6.5 of EN ISO 12100-2:2003 and in addition provide further information and instructions in a handbook as follows:

— information relating to the machine itself and its transport, handling, storage and commissioning in the handbook of general instructions as described in 7.2.1;

— instructions for operating the machine in the handbook of operating instructions as described in 7.2.2;

— instructions for the maintenance of the machine in the maintenance handbook as described in 7.2.3;

— information for safe replacement of parts in the spare parts handbook as described in 7.2.4.

This document specifies only safety related matters in the handbook.

The instruction handbook is part of the machine and is an important document for the safe and proper operation, maintenance and service of machines. The text shall be simple, adequate and complete. The wording shall be suited to the category of people who are using the machines. The information shall be comprehensive and explicit.

All information concerning personal safety shall be printed in a type conspicuously different from the rest of the text.

The handbook shall give on the first page or front cover at least the following information:

— title of handbook, with revision number and date of revision;

— type designation of machine, model, serial number if applicable;

— name and full address of the manufacturer and the sales company, distributor or authorised agent.

7.2 Content of handbook

7.2.1 General instructions

The handbook shall contain:

— a technical description of machine in accordance with the data plates, see 7.3;

— details of the ground and ground water conditions for which the machine is designed;

— it is the responsibility of the user of the machine to check with the manufacturer if the machine shall be used at other locations which are not envisaged at the time of its design;

— details of the loading conditions for which the shield is designed;

— a specification of the intended use of the machine;

— a specification of the identified hazards and what measures shall be taken to make the operation safe;

— a statement that the operators shall be given practical training in the operation of the machine with special emphasis on the above safety precautions including fire fighting;

— a general view of the machine in the form of drawings and photographs, circuit diagrams for electric, hydraulic and pneumatic circuits. All such illustrations shall be of sufficient size to be clear;

— details of the size and type of lining for which the machine has been designed and details of the size and type of rolling stock envisaged;

— details of the sizes and types of ventilation, dust suppression and dust collection equipment which the machine has been designed to incorporate;

— details of equipment to monitor toxic and radiation gases for which provision has been made;

— details of the size and type of forward probe drilling equipment which the machine has been designed to incorporate;

— instruction, that during work on the cutter head the locking key of the cutter head control station is be held by the operator, entering the cutter head area, see 5.5.2;

— instruction that communication between persons working in front of the cutter head and the operator at the cutter head control station shall be established and maintained throughout the period of work on the cutter head, see 5.17.2;

— the values of the A-weighted sound pressure levels determined according to 5.9.3, with details about the measurement positions and the operating conditions of the machine during noise measurements;

— instruction that access to fire extinguishers shall never be blocked.

For reference see EN ISO 12100-2:2003, 6.2 and 6.5.

7.2.2 Operating instructions

The handbook shall contain operating instructions covering:

— complete instructions for the operation of the machine;

— a description of the controls and their function;

— an explanation of any symbols used;

— list and location of the warning signs, warning devices and symbols displayed on the machine;

— a specification of how and where the emergency stops according to 5.5.5 are installed and function;

— a nomenclature of major components, their functions, locations and relationship within the whole machine shall be listed;

— special warnings to the operator or other personnel of such risks as moving parts, squeezing and high voltage and the danger of obstructing walkways especially in the erection area;

— detailed instructions covering the use of guards, for example that conveyors shall not be used unless guards are in place;

— instruction that while work is carried out on the cutter head of a machine, no work or tests of any electric or hydraulic system which could have an influence on the control systems of the cutter head, shall be carried out, see 5.5.2 and 5.17.2;

— information regarding the use of the segment handling system, if installed;

— information about any identified hazards that may occur due to shortcomings in the protection system;

— information regarding the location, use, service and check-up of fire extinguishers.

7.2.3 Maintenance

The handbook shall contain:

— instructions for carrying out safe maintenance operations, when possible with the machine in a "zero energy state" (including disconnecting the power supply, with provisions against reconnection, dissipation of accumulated energy, testing of safe state);

— instructions for carrying out safe maintenance and similar operations when the machine cannot be completely disconnected from the power supply or when accumulated energy cannot be released or when maintenance work can only be carried out with the engine running;

— instructions for the safe assembly and dismantling of parts which are heavy or difficult to handle. The weight of parts which are frequently replaced, e.g. cutters, shall be stated;

— a list of parts, which are classified by the manufacturer to be of particular importance for safety with instructions for the frequency of checking and instructions for replacement;

— special warnings for actions which can cause injuries to the maintenance personnel or other personnel;

— recommendations regarding the periodical retesting of stop controls, emergency stops, gas warning systems, brake systems and audible warning systems. Specification of regular cleaning of equipment, e.g. transformers.

For reference see EN ISO 12100-2:2003.

7.2.4 Spare parts

The handbook shall contain the spare parts list giving specifications of all spare parts relevant to maintaining the safety characteristics of the machine and data including the identification of the parts and their location on the machine.

7.3 Marking

The minimum markings shall include:

— name and address of the manufacturer;

— designation of series or type, if any;

— serial or identification number, if any;

— electrical power rating information;

— weight;

— standards of explosion protection, if any;

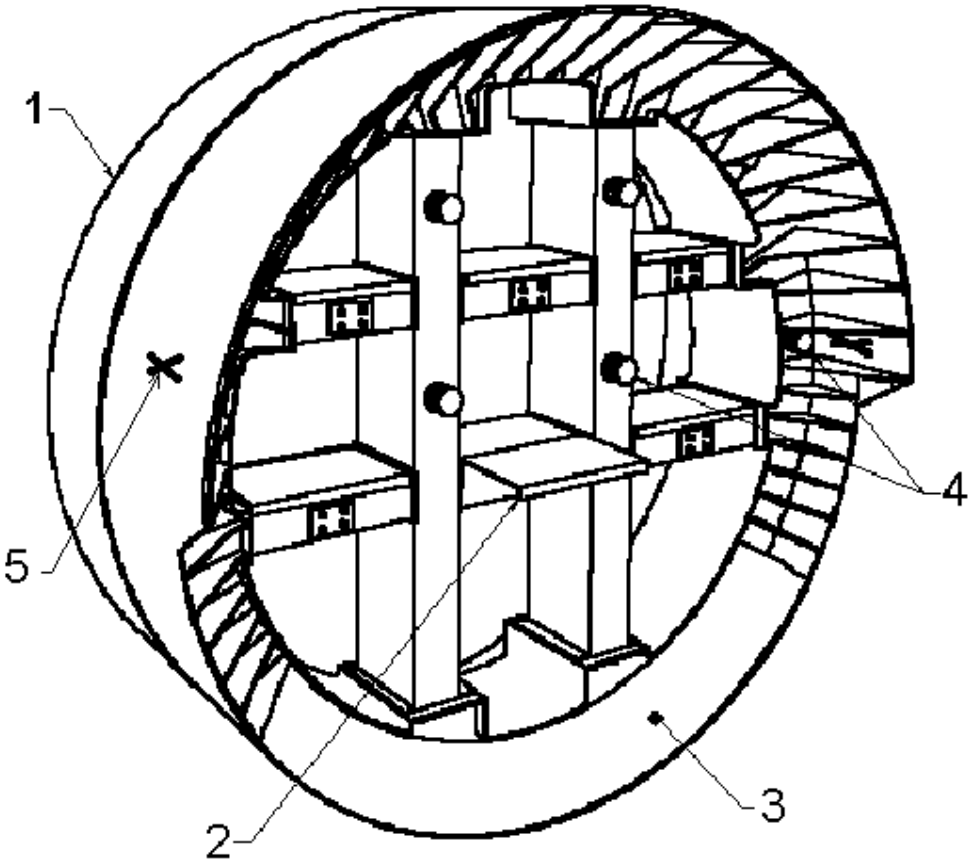
— mandatory marking[1)];

— year of construction.

1) For machines and their related products intended to be put on the market in EEA, CE marking as defined in the applicable European directive(s), e. g. Machinery, low Voltage, Explosive Atmosphere, Gas appliances.

Annex A
(informative)

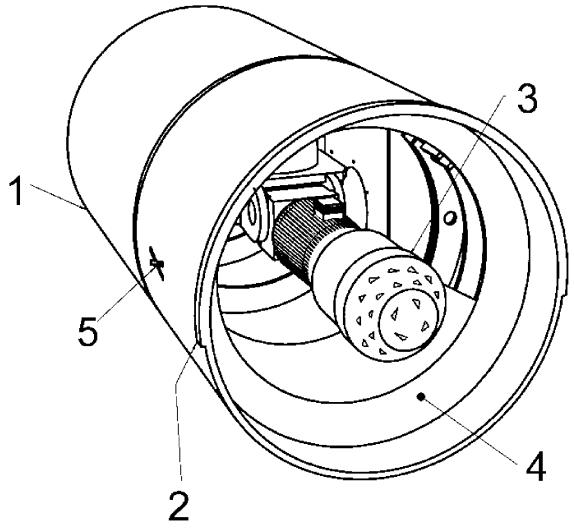
Examples of tunnelling machines



Key

1 Shield body
2 Extending working platforms
3 Plated front section
4 Face rams
5 Plough slots

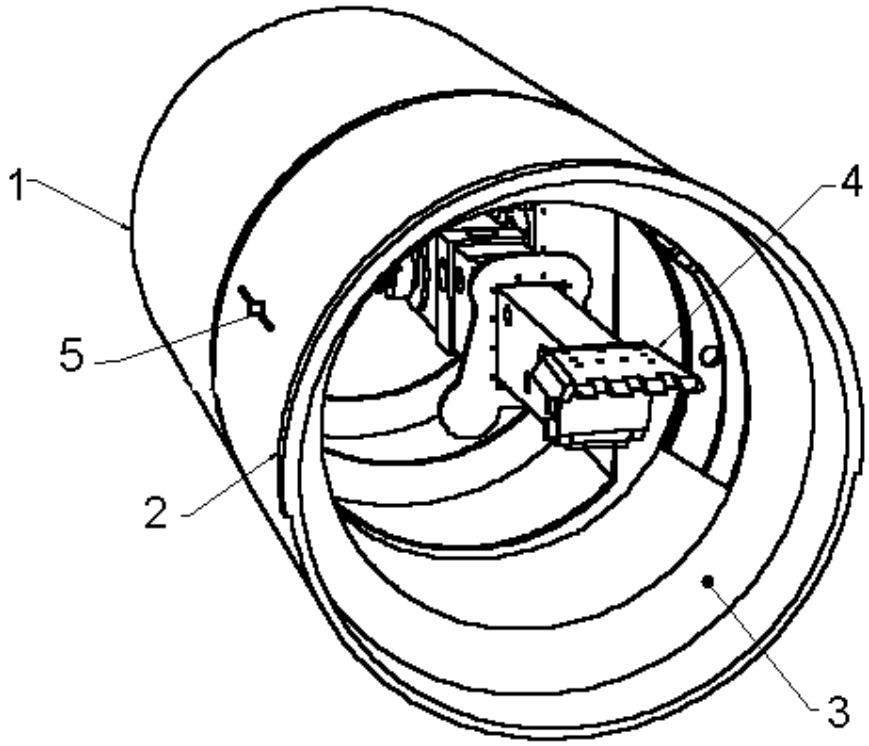
Figure A.1 — Shield showing face rams



Key

1 Shield body
2 Overbreak bead
3 Roof mounted cutter boom
4 Front cone
5 Plough slots

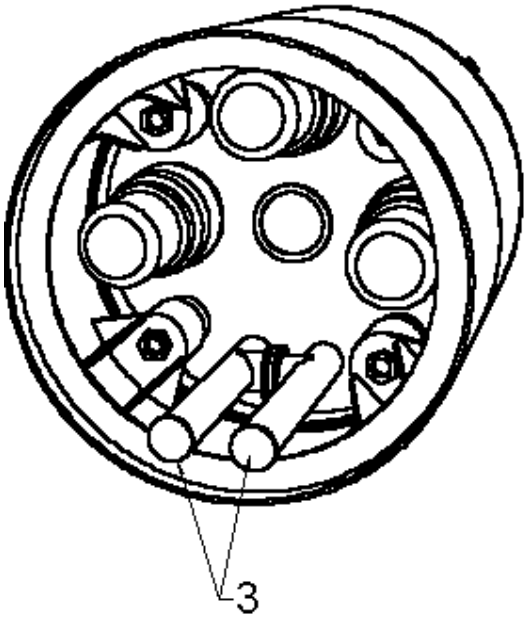
Figure A.2 — Shield with roof mounted cutter boom

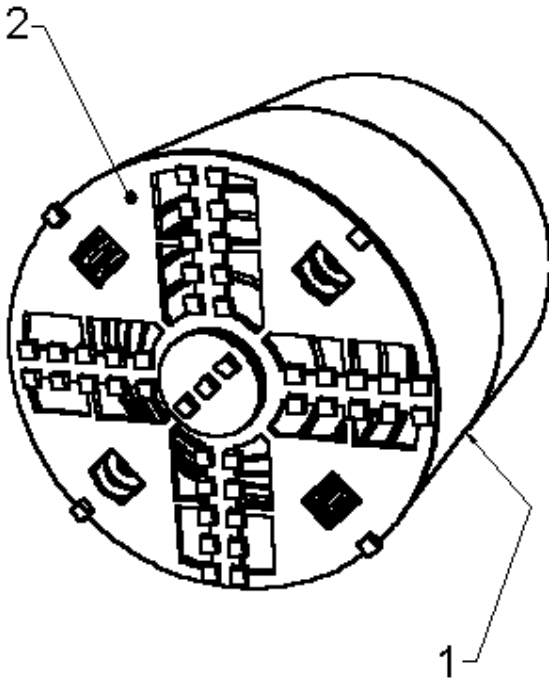


Key

1 Shield body
2 Overbreak bead
3 Front cone
4 Roof mounted backhoe
5 Plough slots

Figure A.3 — Shield with roof mounted backhoe



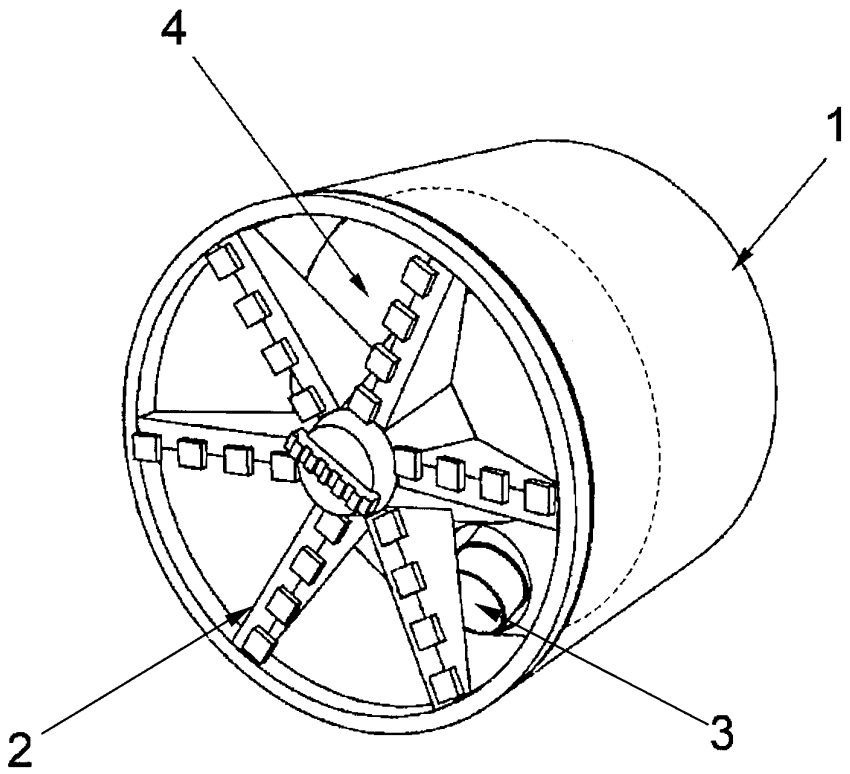


Key

1 Shield body
2 Cutter head
3 Slurry charge/discharge pipes

Figure A.4 — Slurry machine – Back view

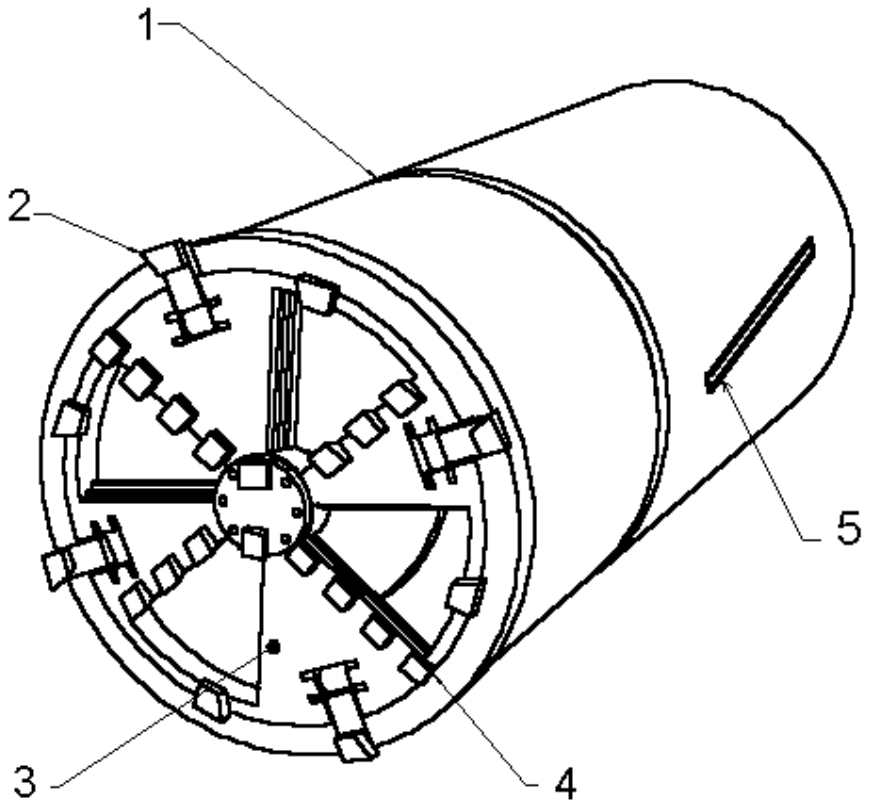
Figure A.5 — Slurry machine — Front view



Key

1 Shield body
2 Cutter head
3 Screw conveyor
4 Bulkhead

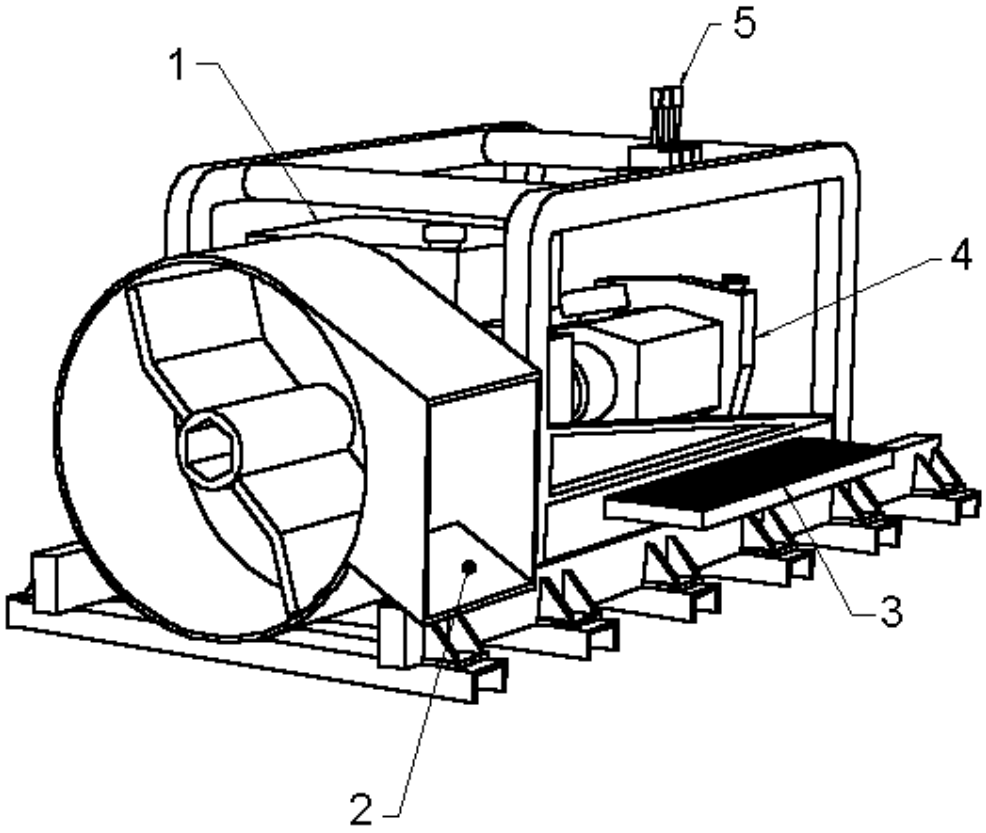
Figure A.6 — Earth pressure balance (EPB) machine



Key

1 Articulation joint
2 Gauge picks
3 Cutter head
4 Face picks
5 Plough slots

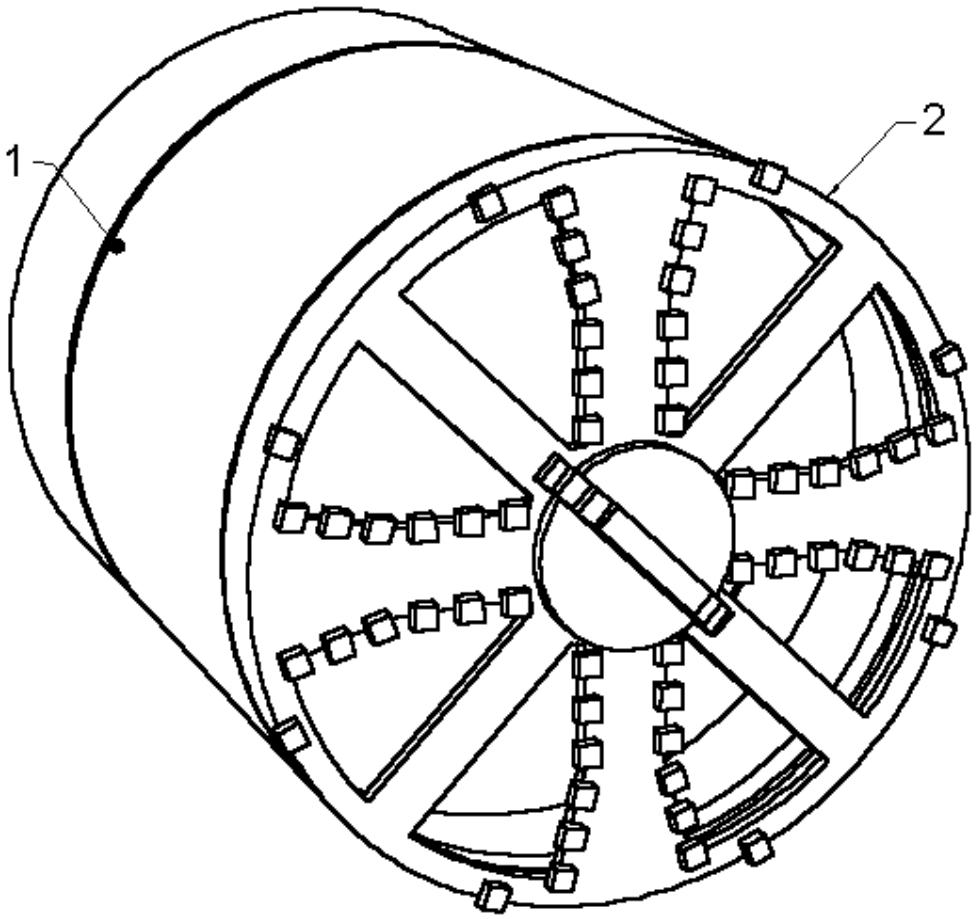
Figure A.7 — Micro tunnelling machine



Key

1 Fuel and hydraulic tanks
2 Spoil removal
3 Working platform
4 Power unit
5 Control console

Figure A.8 — Auger boring machine



Key

1 Shield body
2 Cutter head

Figure A.9 — Shielded TBM

Annex B
(normative)

Verification of safety requirements and/or protective measures

Safety requirements and/or protective measures of Clauses 5 and 7 of this European Standard shall be verified according to the table 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 being that the stated measurable parameters 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 under "remarks" or in the referred clause.

Table B.1 — Verification of safety requirements and/or protective measures

Clause	Design check	Calculation	Visual verification	Measurement	Functional test	Remarks, see in the end of this table
5.2.1			X			
5.2.2	X		X	X		
5.2.3	X		X	X		1)
5.2.4, para 1	X		X	X		
5.2.4, para 2	X					
5.2.4, para 3					X	
5.2.5.1			X		X	
5.2.5.2, para 1			X			
5.2.5.2, para 2	X				X	
5.2.5.2, para 3				X	X	
5.2.5.2, para 4	X		X		X	
5.2.5.2, para 5				X		
5.2.5.2, para 6	X				X	
5.2.6.1, para 1	X		X			
5.2.6.1, para 2	X		X			
5.2.6.2, para 1	X				X	
5.2.6.2, para 2	X				X	
5.2.7.1		X		X		
5.2.7.2	X	X				2)
5.2.8.1	X		X			
5.2.8.2, para 1				X		
5.2.8.2, para 2				X		
5.2.8.2, para 3			X			
5.2.8.3				X		
5.2.9.1	X		X			
5.2.9.2	X		X			2)
5.2.9.3	X		X			
5.3.1	X					

(to be continued)

Table B.1 — *(continued)*

Clause	Design check	Calculation	Visual verification	Measurement	Functional test	Remarks, see in the end of this table
5.3.2			X			
5.3.3, para 1			X			
5.3.3, para 2					X	
5.4.1			X			
5.4.2			X			
5.4.3					X	
5.4.4, para 1						3)
5.4.4, para 2			X			
5.4.4, para 3					X	
5.4.4, para 4			X			
5.5.1			X		X	3)
5.5.2			X		X	
5.5.3	X				X	3)
5.5.4.1					X	
5.5.4.2					X	
5.5.4.3				X	X	3)
5.5.5, para 1	X		X			3)
5.5.5, para 2					X	3)
5.5.6	X				X	3)
5.6, para 1		X				
5.6, para 2		X				
5.6, para 3			X			
5.6, para 4					X	
5.7			X			
5.8.1	X					
5.8.2			X			
5.8.3.2			X		X	
5.8.3.3	X		X			
5.8.3.4, para 1	X		X		X	
5.8.3.4, para 2	X				X	
5.9	X			X		3)
5.10.1						3)
5.10.2, para 1						3)
5.10.2, para 3						3)
5.10.2, para 4					X	
5.10.2, para 5					X	
5.10.2, para 6			X		X	
5.10.3	X		X			
5.10.4			X			
5.10.5				X	X	
5.10.6			X			3)
5.10.7				X		
5.10.8				X	X	
5.11			X		X	
5.12						3)
5.13.1	X	X	X	X	X	3)
5.13.2			X			3)
5.13.3			X			
5.13.3 last para	X				X	
5.14			X			
5.15	X					
5.16.1			X			3)

(to be continued)

Table B.1 — *(concluded)*

Clause	Design check	Calculation	Visual verification	Measurement	Functional test	Remarks, see in the end of this table
5.16.2			X			
5.16.3						3)
5.17.1	X		X			
5.17.2, para 1			X			2)
5.17.2, para 2	X					
5.17.2, para 3					X	
7.2.1			X			
7.2.2			X			
7.2.3.			X			
7.3			X			

1) Verification by reference to hose manufacturers documents
2) See also Introduction
3) Verification by reference to standard which is mentioned in the corresponding clause

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/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 Directive 98/37/EC, amended by Directive 98/79/EC.

Once this standard is cited in the Official Journal of the European Communities 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 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.

Bibliography

Below are listed standards which have a bearing on the specifications of this European Standard and are not normative references.

[1] EN 953:1997, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

[2] EN 1005-2:2003, *Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery*

[3] EN 12110:2002, *Tunnelling machines — Air locks — Safety requirements*

[4] EN 61310-1:1995, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, auditory and tactile signals (IEC 31310-1:1995)*

[5] EN ISO 2867:1998, *Earth-moving machinery — Access systems (ISO 2867:1994)*

[6] ISO 11112:1995, *Earth-moving machinery — Operator's seat — Dimensions and requirements*

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