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Stroji za gradnjo predorov - Varnostne zahteve

Tunnel boring machines - Safety requirements

Tunnelbohrmaschinen - Sicherheitstechnische Anforderungen

Tunneliers - Prescriptions de sécurité

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Tunnel boring machines - Safety requirements

Tunneliers - Prescriptions de sécurité

Tunnelbohrmaschinen - Sicherheitstechnische
Anforderungen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 151.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (prEN 16191:2023) 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 document is currently submitted to the CEN Enquiry.

This document will supersede EN 16191:2014.

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

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

prEN 16191:2023 includes the following significant technical changes with respect to EN 16191:2014:

- revision of definitions;
- revision of all safety requirements;
- update of list of significant hazards;
- update of Annex ZA.

[oSIST prEN 16191:2023](https://standards.iteh.ai/catalog/standards/sist/6c1e4325-75e7-48a2-94a2-b37ceda2746d/osist-pren-16191-2023)

<https://standards.iteh.ai/catalog/standards/sist/6c1e4325-75e7-48a2-94a2-b37ceda2746d/osist-pren-16191-2023>

Introduction

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

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

The intended use of the machinery is agreed between the manufacturer and the user, taking into account information on predicted ground, ground water, tunnel diameter, tunnel alignment and environmental conditions.

It also takes account of operational procedures agreed between the manufacturer and user including services to the TBM, power supply, tunnel ventilation system, spoil removal systems and supply logistics as well as emergency procedures.

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

- machine manufacturers (small, medium and large enterprises);
- health and safety bodies (regulators, accident prevention organizations, market surveillance, etc.).

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

- machine users/employers (small, medium and large enterprises);
- machine users/employees (e.g. trade unions, organizations for people with special needs);
- service providers, e.g. for maintenance (small, medium and large enterprises);
- consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

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

1 Scope

This document is applicable to tunnel boring machines and associated machines and equipment as defined in Clause 3 used for the primary purpose of creating an underground void through the construction of horizontal and inclined tunnels and other underground excavations.

NOTE 1 Other underground excavations can include access structures to complex tunnel layouts such as in underground stations, utilities, underground storage facilities as well as below ground tunnel portals.

It deals with all significant hazards, hazardous situations and events relevant to such machinery when they are used as intended and under the conditions of misuse which are reasonably foreseeable by the manufacturer (see 4).

This document covers monitoring for hazardous atmospheres within the confines of the tunnel boring machines.

Requirements for air locks and pressurized transfer shuttles are covered by prEN 12110-1:2023 and prEN 12110-2:2023.

Hand-arm and whole-body vibration are not considered as significant hazards for tunnel boring machines.

The following items and applications are not covered by this document:

- the additional requirements for the use of entire tunnelling machinery within a hyperbaric environment;
- the additional requirements for use of tunnel boring machines in potentially explosive atmospheres;

NOTE 2 For the application in potentially explosive atmospheres, see EN ISO/IEC 80079-38:2016 for guidance.

- ancillary tools and equipment which are not an integral part of the tunnel boring machine, but located on the machinery;
- supply network for services to the tunnel boring machine (e.g. power supply, water, pipes, compressed air, ventilation duct, etc.);
- loading and transport machinery which is not an integral part of the tunnel boring machine, e.g. delivery vehicle for logistic support, tunnel spoil removal system;
- EMC interactions between the tunnelling machinery and third-party surface and underground assets, e.g. railway signalling.

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 3-7:2004+A1:2007, *Portable fire extinguishers — Part 7: Characteristics, performance requirements and test methods*

EN 620:2021, *Continuous handling equipment and systems — Safety requirements for fixed belt conveyors for bulk materials*

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EN 818-4:1996+A1:2008, *Short link chain for lifting purposes — Safety — Part 4: Chain slings — Grade 8*

EN 894-3:2000+A1:2008, *Safety of machinery — Ergonomics requirements for the design of displays and control actuators — Part 3: Control actuators*

EN 981:1996+A1:2008, *Safety of machinery — System of auditory and visual danger and information signals*

FprEN 1570-1:2022, *Safety requirements for lifting tables — Part 1: Lifting tables serving up to two fixed landing*

EN 1808:2015, *Safety requirements for suspended access equipment — Design calculations, stability criteria, construction — Examinations and tests*

EN 1837:2020, *Safety of machinery — Integral lighting of machines*

EN 1993-1-1:2005¹, *Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings*

EN 1993-1-8:2005, *Eurocode 3: Design of steel structures — Part 1-8: Design of joints*

EN 12021:2014, *Respiratory equipment — Compressed gases for breathing apparatus*

prEN 12110-1:2023, *Tunnel boring machines — Air locks — Part 1: Requirements for air locks utilising compressed air as the pressurising or breathing medium along with requirements for oxygen breathing systems for decompression purposes*

prEN 12110-2:2023, *Tunnel boring machines — Air locks — Part 2: Safety requirements for the use of non-air breathing mixtures and saturation techniques in personnel locks and for pressurised transfer shuttles*

EN 12195-1:2010², *Load restraining on road vehicles — Safety — Part 1: Calculation of securing forces*

EN 13414-1:2003+A2:2008, *Steel wire rope slings — Safety — Part 1: Slings for general lifting service*

EN 13480-3:2017³, *Metallic industrial piping — Part 3: Design and calculation*

EN 14359:2017, *Gas-loaded accumulators for fluid power applications*

EN 14973:2015, *Conveyor belts for use in underground installations — Electrical and flammability safety requirements*

EN 16228-1:2014+A1:2021, *Drilling and foundation equipment — Safety — Part 1: Common requirements*

EN 16228-2:2014+A1:2021, *Drilling and foundation equipment — Safety — Part 2: Mobile drill rigs for civil and geotechnical engineering, quarrying and mining*

EN 60076-2:2011, *Power transformers — Part 2: Temperature rise for liquid-immersed transformers (IEC 60076-2:2011)*

¹ As impacted by EN 1993-1-1:2005/A1:2014.

² As impacted by EN 12195-1:2010/AC:2014.

³ As impacted EN 13480-3:2017/A1:2021.

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

EN 60204-32:2008, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for hoisting machines (IEC 60204-32:2008)*

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

EN 60825-1:2014, *Safety of laser products — Part 1: Equipment classification and requirements (IEC 60825-1:2014)*

EN 61310-1:2008, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals (IEC 61310-1:2007)*

EN IEC 60079-0:2018, *Explosive atmospheres — Part 0: Equipment — General requirements (IEC 60079-0:2017)*

EN IEC 60204-11:2019, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for equipment for voltages above 1000 V AC or 1500 V DC and not exceeding 36 kV (IEC 60204-11:2018)*

EN IEC 61439-1:2021, *Low-voltage switchgear and controlgear assemblies — Part 1: General rules (IEC 61439-1:2020)*

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

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

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

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

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

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

EN ISO 10218-2:2011, *Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration (ISO 10218-2:2011)*

EN ISO 11161:2007, *Safety of machinery — Integrated manufacturing systems — Basic requirements (ISO 11161:2007)*

EN ISO 11202:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections (ISO 11202:2010)*

EN ISO 11688-1:2009, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning (ISO/TR 11688-1:1995)*

prEN 16191:2023(E)

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

EN ISO 12922:2020, *Lubricants, industrial oils and related products (class L) — Family H (Hydraulic systems) — Specifications for hydraulic fluids in categories HFAE, HFAS, HFB, HFC, HFDR and HFDU (ISO 12922:2020)*

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

EN ISO 13766-1:2018, *Earth-moving and building construction machinery — Electromagnetic compatibility (EMC) of machines with internal electrical power supply — Part 1: General EMC requirements under typical electromagnetic environmental conditions (ISO 13766-1:2018)*

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

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

EN ISO 14118:2018, *Safety of machinery — Prevention of unexpected start-up (ISO 14118:2017)*

EN ISO 14119:2013, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection (ISO 14119:2013)*

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

EN ISO 14122-1:2016, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means and general requirements of access (ISO 14122-1:2016)*

EN ISO 14122-2:2016, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways (ISO 14122-2:2016)*

EN ISO 14122-3:2016, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails (ISO 14122-3:2016)*

EN ISO 14122-4:2016, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders (ISO 14122-4:2016)*

EN ISO 19353:2019, *Safety of machinery — Fire prevention and fire protection (ISO 19353:2019)*

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

ISO 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

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

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

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

ISO 15380:2016, *Lubricants, industrial oils and related products (class L) — Family H (Hydraulic systems) — Specifications for hydraulic fluids in categories HETG, HEPG, HEES and HEPR*

3 Terms and definitions

For the purposes of this document the terms and definitions given in EN ISO 12100:2010 and the definitions given below apply.

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

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

3.1

tunnelling machinery

tunnel boring machines and associated machines and equipment designed for excavation and construction of tunnels and shafts, as described in 3.2 to 3.10

3.2

shield machine

steerable ground support structure within which tunnel excavation takes place by manual, mechanical or hydraulic means and within which erection of tunnel support can take place

Note 1 to entry: The shield machine is propelled forward by reaction onto the tunnel lining. See Figure B.1 in Annex B. Shield machines provide lateral and/or radial ground support. In addition, they can provide various types of face support and ground water control. <https://standards.iteh.ai/catalog/standards/sist/6c1e4325-75e7-48a2-94a2-b37ceda2746d/osist-pren-16191-2023>

3.3

shielded tunnel boring machine

shield machine for full face excavation, having one or more rotating cutter heads in which the cutter head(s) can be separated from the rest of the shield by a bulkhead, the passage of material through which can be controlled

Note 1 to entry: Reaction forces caused by the excavation process are transferred into the tunnel lining. See Figure B.2.

3.4

telescopic shield machine

shielded tunnel boring machine as defined in 3.3 equipped with a gripping system as described in 3.12

Note 1 to entry: Telescopic shield machine is also known as a double shield machine.

3.5

unshielded tunnel boring machine

machine fitted with a rotating cutter head, but which lacks a shield for ground support or can be partially shielded for protection of the cutter head only

Note 1 to entry: See Figure B.3.

Note 2 to entry: The torque and thrust reactions are resisted by anchoring the complete machinery against the ground by means of a gripping system.

prEN 16191:2023(E)**3.6****reaming machine**

unshielded tunnel boring machine intended to enlarge a pilot tunnel in one or more steps

Note 1 to entry: In most cases, unshielded tunnel boring machinery work the full face of the tunnel. However, in some cases the tunnel is driven in two or more phases, by starting with a pilot hole which is enlarged in one or more steps. This method is called reaming. In principle these machines are the same as an unshielded tunnel boring machine driving the whole tunnel area in one step.

3.7**incline shaft boring machine**

tunnelling machine as defined in 3.2 to 3.6 designed to operate in incline, decline or near vertical direction

3.8**micro tunnelling machine**

shielded tunnel boring machine designed for non-man entry operation (except for maintenance purposes when out of service) which is remotely controlled by an operator from outside the tunnel

Note 1 to entry: See Figure B.4.

3.9**thrust boring machine**

machine for constructing pipelines by displacement

3.10**auger boring machine**

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

3.11**partial face excavation equipment**

cutter boom or backhoe excavator installed in a shield machine

Note 1 to entry: See Figure B.1.

3.12**gripping system**

equipment for the transfer of the reactive forces caused by the excavation process into the tunnel wall

3.13**regripping**

process of disengaging the gripping system, relocating and re-engaging the gripping system

3.14**excavation chamber**

front part of a shield between ground face and shield bulkhead, into which the ground is excavated

Note 1 to entry: Depending on the type of tunnelling machinery the excavation chamber may be separated into different compartments.

3.15

back-up equipment

steel construction which accommodates equipment, to provide the machine with services (including water, compressed air, electrical power, hydraulic power) for its operation and its crew with facilities for their work and comfort

Note 1 to entry: For tunnelling machinery described in 3.2 to 3.7 the back-up equipment is normally towed behind the machine, i.e. it is “towed back-up equipment”, whereas for pipe jacking and micro tunnelling equipment, thrust boring and auger boring machines, the back-up equipment is installed at the bottom of an access shaft or on the surface adjacent thereto.

3.16

pipe jacking rig

hydraulic jacking equipment, intended to drive a pipe string through the ground to form a tunnel lining

3.17

lining erection equipment (erector)

handling and erecting equipment for tunnel lining segments, situated within or immediately behind a shield machine

3.18

erecting device

equipment for handling and erection of other ground support elements such as steel ribs, situated within a tunnel boring machine and its back-up equipment

3.19

rock bolting device

equipment for drilling and installation of rock bolts, situated within or behind an unshielded tunnel boring machine

3.20

probe drilling equipment

drilling equipment for ground investigation ahead of and around the tunnel

3.21

control station

any location on a tunnelling machinery or back-up equipment from where one or more functions of the tunnelling machinery, back-up equipment or their separate working units can be controlled by an operator

3.22

main control station

control station from where the excavation operation and the advance of the tunnelling machinery is controlled

3.23

walkway

3.23.1

main walkway

provides access along the entire length of the backup equipment including permitting moving between working areas and also forms an escape route

prEN 16191:2023(E)**3.23.2****servicing point access walkway**

part of the walkway system on tunnel machinery, including micro tunnelling machines accessible only in standstill mode that permits walking or moving to servicing points

3.24**access opening**

opening within tunnelling machinery through which a man may pass to access servicing points, for example in the shield bulkhead or the cutterhead

3.25**servicing point**

any location on a tunnelling machinery or back-up equipment where maintenance or servicing is carried out

3.26**working area**

area on or in tunnelling machinery, where work is performed, for example rock bolt installation, ring beam erection, segment handling and ring erection, services extension

3.27**trailing cable**

power cable which extends from the towed back-up equipment to the tunnel power supply normally stowed on the cable drum or cable trail

3.28**essential services**

services as defined in this standard which are maintained in the event of a loss of the main power supply

3.29**refuge chamber**

enclosed space which provides life support for persons trapped in tunnel by smoke, fume or gas other than methane

3.30**air lock**

pressure vessel with one or more compartments that permits passage between areas of different pressure

[SOURCE: prEN 12110-1:2023, 3.3]

3.31**shield bulkhead**

structure which separates the excavation chamber from the tunnel

3.32**internal diameter**

internal diameter of the lining through which the backup equipment is being towed

Note 1 to entry: For unshielded machines, the internal diameter is that within the planned rock support.

3.33**external diameter**

outer shield diameter for shielded tunnelling machinery, which is defined in 3.2, 3.3, 3.4 or excavation diameter for tunnelling machinery which is defined in 3.5, 3.6, 3.7

3.34**quick unloading device**

device to unload multiple tunnel lining elements and/or other materials simultaneously from the delivery vehicle to reduce required unloading time

3.35**closed mode operation**

shielded tunnel boring machine as defined in 3.3 with a bulkhead and operated with the cutterhead chamber in front of the bulkhead under pressurized conditions

3.36**accessible cutterhead**

pressure-tight cutterhead structure for man access for maintenance under atmospheric conditions

3.37**delivery vehicle**

self-propelled device for transportation of materials or people in the tunnel

Note 1 to entry: Delivery vehicles can be multi-service vehicles, rail cars.

3.38**standstill mode**

tunnelling machinery in static conditions with no functions activated which are required for advance or installation of ground support elements

3.39**pressurized transfer shuttle**

mobile personnel lock for undertaking the transfer under pressure of personnel from one fixed hyperbaric system to another

[SOURCE: prEN 12110-2:2023, 3.1]

Note 1 to entry: Referred to as “shuttle” in the text of this document.

3.40**shuttle docking position**

location on the tunnelling machinery at which the shuttle can be connected to a pressurized compartment

3.41**shuttle path**

shuttle passage route through the tunnelling machinery between the point of arrival on the transport vehicle to the docking position

3.42**hyperbaric intervention**

personnel access to a pressurized compartment of the tunnelling machinery, e.g. air lock, intermediate chamber, excavation chamber