

TECHNICAL DOCUMENTATION

M-1641M EPB1500TB / M-1642C OPERATION CONTAINER

This Technical Documentation has to be kept close to the machine / system. It has to be guaranteed that people working on the machine / system have access to the Technical Documentation at all times. In addition to this Technical Documentation, the operator has to provide manuals required by the labour protection act.

This Technical Documentation is part of the machine / system and has to be completely handed over to the purchaser if the machine / system is sold.

This Technical Documentation is protected by copyright. It is forbidden to copy this Technical Documentation as well as to pass it on to third parties. If you have questions concerning the usage and copying of this Technical Documentation, please contact Herrenknecht AG.

- I. General**
- II. Product Description**
- III. Safety**
- IV. Transport, Assembly, Connection**
- V. Operation**
- VI. Maintenance, Repair**
- VII. Disassembling, Storage, Disposal**
- VIII. Annex**
- IX. Internals, Accessories**
- X. Drawings**
- XI. Fluid Diagrams**
- XII. Electric Diagrams**

MAIN TABLE OF CONTENTS

I. General

1. Product Identification	I - 3
1.1 Machine / system data	I - 3
1.2 Operating Manual	I - 3
1.3 Manufacturer address	I - 3
2. Notes about this Operating Manual	I - 4
2.1 General	I - 4
2.2 Availability of information	I - 4
2.3 Version	I - 5
2.4 Purpose	I - 5
2.5 Target group	I - 5
2.6 Pictograms	I - 6
2.7 Design	I - 7
2.7.1 Scope	I - 7
2.7.2 Chapter structure	I - 7
2.7.3 Chapter	I - 7
2.7.4 Individual pages	I - 8
2.7.5 Illustrations	I - 8
2.8 Disclaimer of warranty and liability	I - 9
2.9 Copyright	I - 10
2.10 Modifications	I - 10
2.11 Spare parts and accessories / technical modifications	I - 11
2.12 Translations	I - 11

TABLE OF CONTENTS

GENERAL

1. Product Identification

1.1 Machine / system data

IDENTIFICATION	DATA
Project number	M-1641M / M-1642C
Machine type	EPB1500TB / Operation container
Order number	102856 / 102857
Year of manufacture	2011

Table I - 1: Machine / system data

1.2 Operating Manual

IDENTIFICATION	DATA
Edition dated:	13. January 2012
Version	001
Main drawing number	3474-01-002-00 / 3478-04-000-00

Table I - 2: Operating Manual

1.3 Manufacturer address

HERRENKNECHT AG
Schlehenweg 2
77963 Schwanau
Germany

Phone: +49 (0) 7824 302-0

Fax.: +49 (0) 7824 34-03

2. Notes about this Operating Manual

2.1 General

To be able to use the machine/system safely, properly and economically, read this Operating Manual carefully before you put the machine/system into operation for the first time. This also applies to all manufacturer operating manuals that are listed in the section „Manufacturer operating manuals“ on the enclosed CD-ROM.

This Operating Manual contains all information and instructions required for the operation and maintenance of the machine / system.

This Operating Manual is a part of the complete documentation.

Prior to each commissioning of the machine / system, all requirements must be met which are related to the safety of personnel and machine / system.

Company-internal regulations must take the instructions of the manufacturer into account.



To protect the health and safety of the personnel and to ensure that the machine / system functions properly you must always observe the chapter "Safety".

Nonobservance of these instructions may affect the warranty granted by the manufacturer.

2.2 Availability of information

This Operating Manual and all related manufacturer operating manuals should be kept directly on the machine / system. It must be ensured that persons working on the machine / system have access to this Operating Manual at all times.

In addition to this Operating Manual, the operating company must also provide the type of instructions that is required by the labour protection act.

This Operating Manual is a part of the machine / system. The complete set must be handed over to the purchaser when the machine / system is sold.

This Operating Manual is protected by copyright. Copying and handing it over to third parties is forbidden. Please contact **Herrenknecht AG** if you have any queries regarding using and copying the documentation.

2.3 Version

Only the documents that belong to the related order are valid. They are identified unambiguously with version number, project number and project name in the footer line of the Operating Manual.

2.4 Purpose

This Operating Manual contains information and instructions for the operation of the purchased machine / system.



This Operating Manual is meant to support the operating company and their staff in operating the machine / system.

The Operating Manual does not have any effect on contractual agreements.

2.5 Target group

Every person who is tasked with commissioning, operation, maintenance and repair **must have read and understood the following:**

- The Operating Manual
- The safety regulations
- The safety instructions in the individual chapters and sections

To avoid operating errors and to ensure faultless operation, the operating staff must always have direct access to the Operating Manual.

The operating company must add the applicable national regulations for the prevention of accidents and the environment protection regulations to the Operating Manual.

NOTES ABOUT THIS OPERATING MANUAL

GENERAL

2.6 Pictograms

The following icons inform about and give help for the proper handling of the TBM and its components.

Note or tip



Highlights particularly useful context-related information that must be observed.

Paragraph



Ignoring these instructions is a violation of rules and regulations or an offence against legal requirements.

Nonobservance and any resulting injuries or damage may have legal consequences.

2.7 Design

2.7.1 Scope

The Operating Manual is delivered in a printed version and as a digital version on CD-ROM.

2.7.2 Chapter structure

The Operating Manual is subdivided into the following chapters:

- I. General
- II. Product Description
- III. Safety
- IV. Transport, Assembly, Connection
- V. Operation
- VI. Maintenance, Repair
- VII. Storage, Disassembling, Disposal
- VIII. Annex
- IX. Internals, Accessories
- X. Drawings
- XI. Fluid Diagrams
- XII. Electric Diagrams

The supplier documentation is only contained on the enclosed CD ROM.

2.7.3 Chapter

The first page in each chapter is a table of contents which contains the complete structure of the chapter.

NOTES ABOUT THIS OPERATING MANUAL

GENERAL

2.7.4 Individual pages

The individual pages of each chapter are numbered consecutively.

I	-2	
I		= Chapter
	-2	= Page

Table I - 3: Explanation of the page number structure

2.7.5 Illustrations

The illustrations in this Operating Manual serve the explanation of texts. They may deviate from the machine / system configuration without affecting the factual information of this Operating Manual.

2.8 Disclaimer of warranty and liability

This Operating Manual contains important information and must thoroughly be read before the machine / system is commissioned.

Our "General Conditions of Sale and Delivery" always apply. These conditions are provided to the operating company at the time of the signature of the contract, at the latest.

Herrenknecht AG shall not accept any liability for damage and malfunctions resulting from a non-compliance with the Operating Manual. Warranty claims must be announced immediately after the deficiency has been noticed.

Warranty can expire in the following cases, in particular:

- Nonobservance of the Operating Manual
- Damage caused by operating errors
- Improper maintenance
- Use not in accordance with the intended use
- Failure to use genuine spare parts and accessories
- Accessories, spare parts and additional equipment which caused damage and had not been approved by **Herrenknecht AG**. **Herrenknecht AG** will not assume any liability for consequential damage.
- Modifications that have not been approved by **Herrenknecht AG**.
- Unauthorized conversion, repair, manipulation and modification of design, electrical circuits or control system of the machine / system.
- Catastrophes resulting from the influence of foreign bodies and force majeure.



Wearing parts are not subject to warranty.

2.9 Copyright

Handle this Operating Manual confidentially. It shall only be used by the persons authorized to do so.



All documents related to the Operating Manual are protected in the sense of the copyright.

Unless expressly permitted, handing documents over or copying them partly or in full, using and conveying its contents are not permitted.

It may only be handed over to third parties with a written agreement from **Herrenknecht AG**.

Contravention is a legal offence and may incur damages.

We reserve the right of exercising commercial proprietary rights.

2.10 Modifications

Any technical information, data and advice on operation given in this Operating Manual corresponds to the state of our knowledge at the time of printing. **Updated releases will not be provided.** All specifications are based on our previous experience and know-how to the best of our knowledge.

We reserve the right of making technical changes that arise from the further development of the components described in this Operating Manual. No claims may therefore be derived from the details, illustrations, and descriptions contained in this Operating Manual.

Important modifications to the serial state of the machine are included in the next version of the Operating Manual.

2.11 Spare parts and accessories / technical modifications

Never install any non-approved spare parts or accessories.



For safety reasons, unauthorized conversions or modifications are not permitted. **Herrenknecht AG** exclude any and all liability for damage resulting from such unauthorized conversions or modifications.

2.12 Translations

Translations are made to the best of our knowledge. We accept no liability for mistakes in translations. This applies also if the translation has been carried out by us or on our instructions. The original text remains binding in all cases.



The original Operating Manual always forms the basis of any translation.

The translated Operating Manual is thus a **translation of the original Operating Manual**.

NOTES ABOUT THIS OPERATING MANUAL

GENERAL

II. Product Description

1. Overall view	II - 3
2. Purpose	II - 4
2.1 Intended use	II - 4
2.2 Improper use	II - 5
3. Marking	II - 6
3.1 Type plate	II - 6
4. Conformity	II - 7
5. System description	II - 8
5.1 Tunnelling machine	II - 8
5.1.1 Earth pressure balance principle	II - 8
5.1.2 Tunnelling and material excavation	II - 9
5.2 Operation container	II - 11
5.2.1 Control room	II - 12
Control cabin	II - 12
Tunnel boring machine control	II - 13
Bentonite lubrication control	II - 13
Jacking frame control	II - 13
Interjack station / telescopic station control (optional)	II - 14
Conveying system control	II - 14
5.2.2 Control cabinet area	II - 15
5.2.3 Power unit room	II - 16
5.2.4 Connection area	II - 17
5.3 Bentonite lubrication	II - 18
5.3.1 Bentonite lubrication system	II - 18
Method of operation	II - 19

TABLE OF CONTENTS

PRODUCT DESCRIPTION

6. Technical specifications II - 20

6.1 Tunnelling machine II - 20

6.2 Conveyor system. II - 21

 6.2.1 Screw feeder. II - 21

 6.2.2 Belt conveyor II - 21

 6.2.3 Conveyor bucket. II - 21

 6.2.4 Machine winch II - 22

6.3 Jack frame. II - 22

 6.3.1 Shaft winch II - 23

6.4 Operation container. II - 23

7. Transport data. II - 24

7.1 Cutterhead tool II - 24

5.1 Tunnelling machine II - 8

7.3 Machine pipe 2 II - 25

7.4 Belt conveyor. II - 25

7.5 Conveyor bucket II - 25

7.6 Start-up seal II - 25

7.7 Jacking frame II - 26

 7.7.1 Guide frame II - 26

 7.7.2 Thrust ring. II - 26

 7.7.3 Abutment plate II - 26

 7.7.4 Bridging plate II - 27

 7.7.5 Telescopic cylinder II - 27

 7.7.6 Shaft winch II - 27

7.8 Operation container. II - 28

1. Overall view

An overall view of the machine / system can be found on the following drawings:

DESIGNATION		PART NO.	DRAWING NO.
Designation 1	TUNNELLING MACHINE		
Designation 2	DA1865-EPB1500-D400	30207769	3474-01-002-00
Cons. No.	15896		
Designation 1	OPERATION CONTAINER		
Designation 2	C30-T300-P02-I4-F0000-B1-M20-0	30208764	3478-04-000-00
Cons. No.	15912		

Table II - 1: Overall view

PURPOSE

PRODUCT DESCRIPTION

2. Purpose

2.1 Intended use

This machine / system was designed for the construction of a tunnel that is adapted to the machine diameter.

The operation container is intended to control and to operate the machine / system (tunnel boring machine, jacking frame, conveying system etc.).

Any other use or any use beyond the specified use is not in accordance with the intended use. This applies to the machine / system as a whole, as well as for individual components of the machine / system. The manufacturer does not assume any liability resulting from such improper use. The operating company solely bears all risks in these cases.

The machine/system has been built according to the state-of-the-art and according to the approved safety-related rules and regulations. Nevertheless, using it may pose hazards to life and limb of the operating personnel or third parties, or may have an adverse effect on the machine/system or on other material assets.

This is why the machine/system may only be used in a proper technical state, by instructed operating staff who take the valid safety instructions and accident prevention regulations into consideration.

Faults which may impair safety must be eliminated immediately. The machine/system may only be started up again after all faults have been eliminated. All faults must be documented and reported to **Herrenknecht AG**.

Intended use also includes compliance with the Operating Instructions and the inspection / maintenance instructions.

2.2 Improper use

Certain activities are illegal with respect to handling individual components in the machine / system. They can cause hazards for life and limb.

Illegal modes of operation include:

- Transport of persons with crane systems (when installed).
- Transport of persons with belt conveyor systems (when installed).
- Transport of persons on the erector (when installed).
- Transport of persons through the material lock (when installed).
- Operating a defective machine / system.
- Operating the machine / system without protective enclosure.
- Operating the machine / system with components that are not approved by **Herrenknecht AG**.
- Operating the machine / system after unauthorized modifications or conversions.
- Operating the machine / system under the influence of alcohol, drugs, or other narcotics.
- Operating the machine / system by untrained staff or personnel who have not been instructed by Herrenknecht.



Hoisting devices, winches, vehicles, and all tools may only be used as intended.

Other illegal methods of using the machine / system and its components are listed in the Chapter "Safety instructions".

MARKING

PRODUCT DESCRIPTION

3. Marking

Each machine / system is fitted with a type plate.

The type plate contains the following specifications:

- Order number
- Type
- Part number
- Weight
- Year of manufacture
- Consecutive number (consecutive type plate number)

3.1 Type plate



Typical type plate

1	Order number	6	Rated output
2	Type	7	Consecutive number
3	Part number	8	Miscellaneous
4	Weight	9	Manufacturer's address
5	Year of manufacture		

4. Conformity

See Declaration of Conformity

5. System description

5.1 Tunnelling machine

5.1.1 Earth pressure balance principle

The Earth Pressure Balance Shield (or EPB Shield or Earth Pressure Shield for short) are used in particular in the case of cohesive soils with a high clay, loam or silt content that exhibit low water permeability.

The principle of the EPB Shield relies on using the excavated soil to support the tunnel face, and thus avoiding uplift or settling at the surface. This is achieved by adapting the performance rate to the amount of material removed by the screw conveyor (including water and additives to improve conveying ability).

To allow the soil removed at the tunnel face to be used as a supporting medium, it should possess the following characteristics:

- good plastic deformability
- pulpy to soft consistency
- low internal friction
- low water permeability

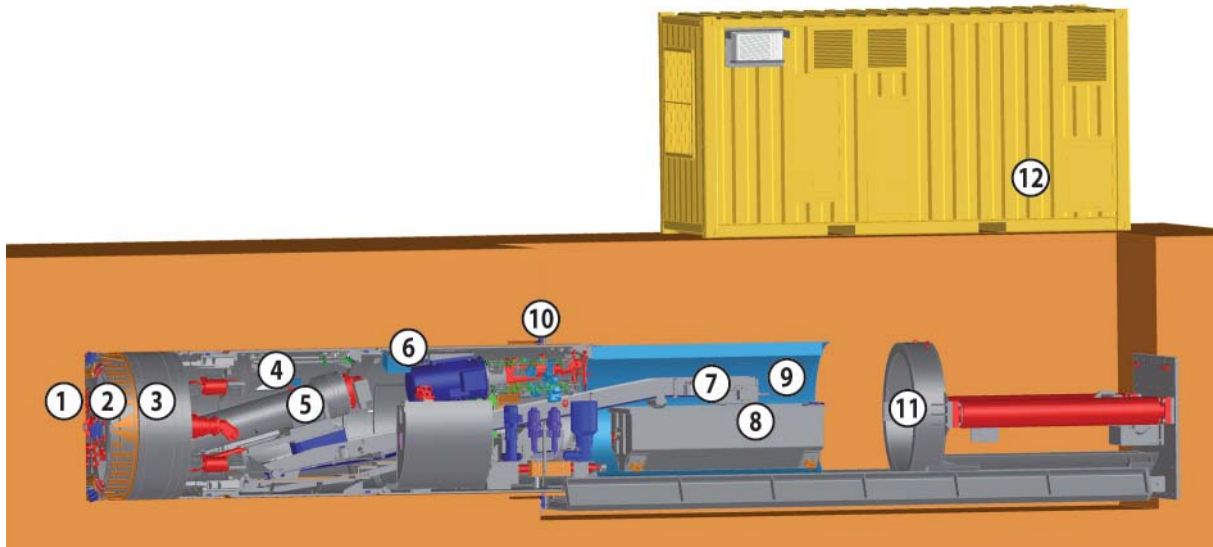
To uphold the earth pressure while advancing, and to keep the cutting tool at the same rotational speed, the rotational speed of the screw conveyor and screw feeder aperture must be accommodated to match. If more material is transported than excavated, the earth pressure at the tunnel face drops, and settling occurs on the surface. If not enough material is conveyed, the earth pressure becomes too high, and this leads to uplift.

To achieve good plasticity and conveying ability of the excavated material, it can be necessary to use bentonite or foam additives.

The earth pressure is measured by sensors at the bulkhead and the screw conveyor, and displayed in the control cabin.

The excavated soil is handed over by the screw conveyor and the screw feeder to the conveying system in the machine or tunnel for ongoing transport. Geological conditions can make it impossible to maintain the earth pressure at the tunnel face using only the screw speed. In this case, partial closing of the screw feeder can cause help to build up additional pressure.

5.1.2 Tunnelling and material excavation



Tunnelling machine and operation container

1	Tunnel face	7	Belt conveyor
2	Cutterhead/cutting wheel	8	Conveyor bucket
3	Shield/steering head	9	Product pipe
4	Machine pipe	10	Start-up seal
5	Screw feeder	11	Jack frame/jack station
6	Machine pipe 2	12	Operation container

The soil is loosened by the tools on the rotating cutting wheel at the tunnel face [1], and pressed through the openings in the cutting wheel [2] into the excavation chamber. Here it is mixed with the existing deformable slurry. The thrust jack force is transferred to the slurry via the bulkhead, thus preventing uncontrolled penetration of the soil from the tunnel face into the excavation chamber.

A state of equilibrium is reached when the slurry in the excavation chamber cannot be compacted any further by the earth and water pressure. The earth pressure that then exists at the tunnel face is roughly equivalent to the earth pressure at rest.

If the face support pressure provided by the slurry is increased above the equilibrium point, further compacting of the slurry occurs in the excavation chamber and the subsoil which can cause uplift in the terrain in front of the shield. If the earth pressure is reduced, the subsoil can penetrate into the excavation chamber and thus cause settling on the surface of the terrain.

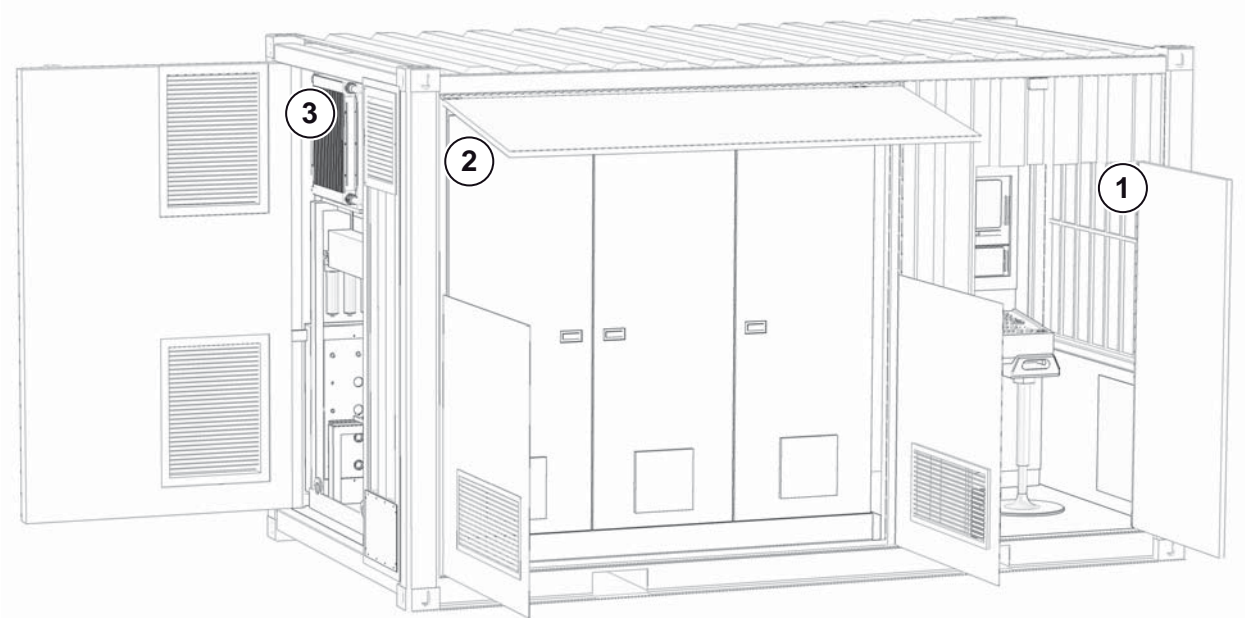
SYSTEM DESCRIPTION

PRODUCT DESCRIPTION

The excavated material is fed by the screw conveyor [6] from the pressurized excavation chamber into the tunnel which is at atmospheric pressure. To remove the need for an airlock at the material hand-over point between the screw discharge and the transport belt, the soil should have a low water permeability to avoid a flow process through the screw conveyor.

The remaining gap between the outer side of the pipe and the excavation diameter is continually injected with a bentonite suspension via injection apertures in the machine pipe [6].

5.2 Operation container



Typical operation container

- | | | | |
|---|----------------------|---|-----------------|
| 1 | Control room | 3 | Power unit room |
| 2 | Control cabinet area | | |

The operation container consists of control room, power unit room and control cabinet area. It should be positioned in the vicinity of the launch shaft. The rear part of the operation container contains the connecting bulkheads for the electric and hydraulic systems.

SYSTEM DESCRIPTION

PRODUCT DESCRIPTION

5.2.1 Control room

The machine /system is steered and controlled from the control cabin. For start-up operation, the cabin is located in the operation container control room. During the start-up, this is the machine driver's workplace. After completing the start-up, the control cabin is decoupled from the control room and docked onto the tunnelling machine; the machine driver's workplace is in the tunnelling machine during tunnelling operations.

Control cabin

Measured values are displayed on the visualisation monitor Advance screen bottom right in the control cabin.

The monitor for U.N.S. measurement is located top right in the control cabin.

On the control panel, the controls for operating the machine/system are divided into control areas. The control areas are described in the main OPERATION section, Controls subsection.

Tunnel boring machine control

The following machine functions can be controlled from the control cabin:

- Steering cylinders
- Cutting wheel drive
- Conveyor system
- Hydraulic power units
- etc.

Steering cylinders

The steering cylinder are retracted / extended individually via the related pushbuttons in the control cabin.

Cutting wheel drive

The cutting wheel can be rotated in either sense of rotation. The sense of rotation is preselected via the related button on the control panel. Next, the speed can gradually be increased with the controller. The actual cutting wheel torque is shown as cutting wheel pressure on the visualization monitor. Likewise, the speed shows on the visualization monitor.

Bentonite lubrication control

The bentonite pump is switched on / off via the control cabin. Malfunctions are shown on the monitor.

Jacking frame control

The press cylinders are driven by a hydraulic power unit that is installed in the operation container. Functionally, the Jacking frame is the thrust unit of the tunnel boring machine. Like all the other machine functions, the Jacking frame is operated via the control cabin.

SYSTEM DESCRIPTION

PRODUCT DESCRIPTION

Interjack station / telescopic station control (optional)

Interjack station / telescopic station can be used for long-distance tunnelling to be able to move the pipe section in individual segments. The interjack station / telescopic station splits the resistance resulting from the pipe jacket friction to avoid that the pressing forces of the pipe are exceeded.

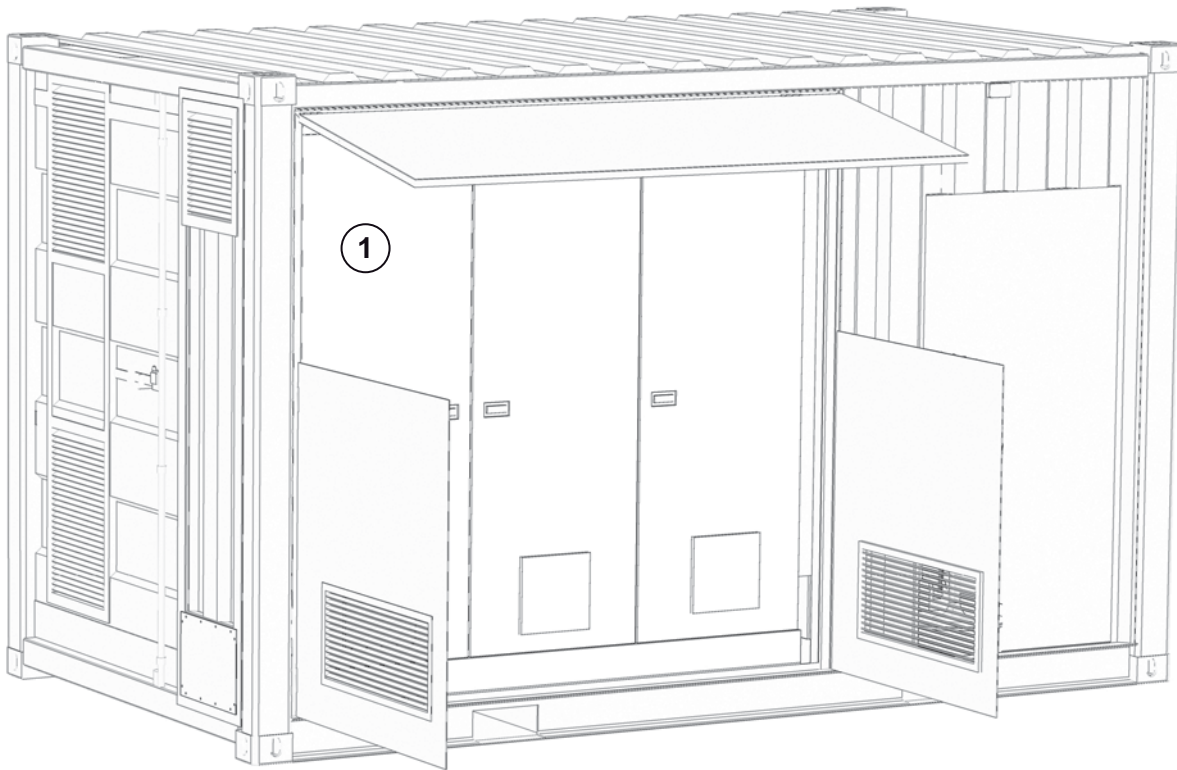
Operational sequence when several interjack stations are used

The interjack stations can be controlled individually via the control cabin. After one interjack station has been extended, the next one is switched on. This process is repeated until the entire chain is processed.

Conveying system control

The conveying system, comprising the screw conveyor and the belt conveyor is switched on and controlled from the control cabin. The potentiometers for switching the screw conveyor (belt conveyor) on/off are located on the control panel. Display via the visualization monitor in the Advance screen.

5.2.2 Control cabinet area



Control cabinet area in the operation container

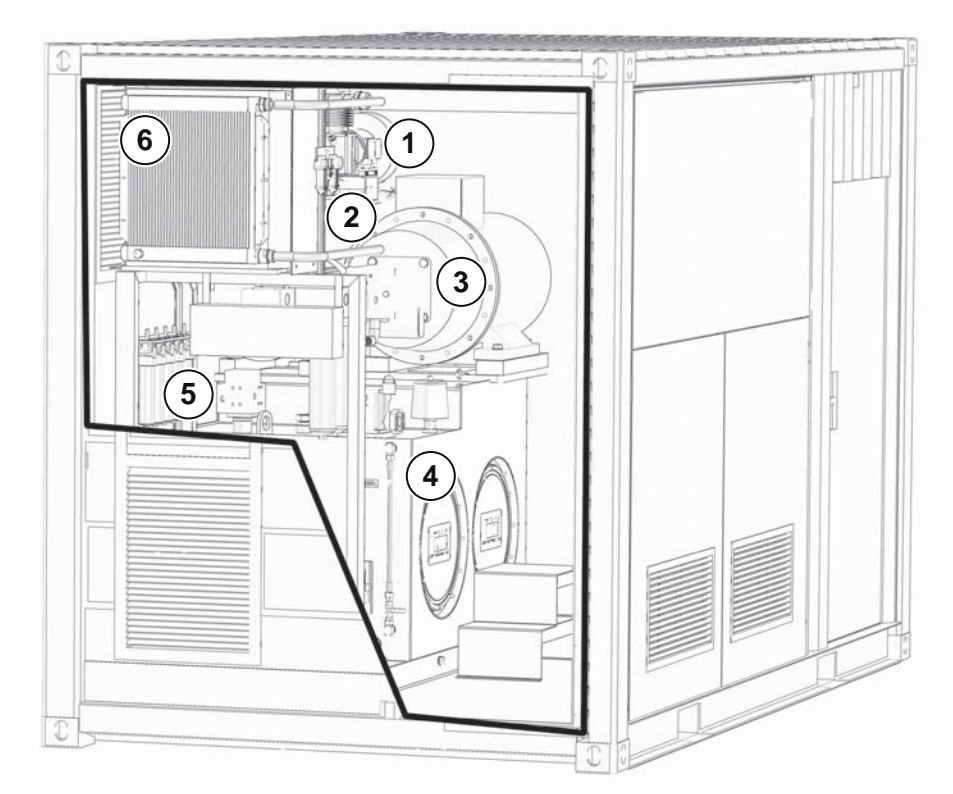
- 1 Control cabinet area / main distribution

Electric components are installed in the control cabinet area / main distribution. The main distribution contains components such as frequency converters, transformers, fans etc. that are required for controlling the machine / system

SYSTEM DESCRIPTION

PRODUCT DESCRIPTION

5.2.3 Power unit room

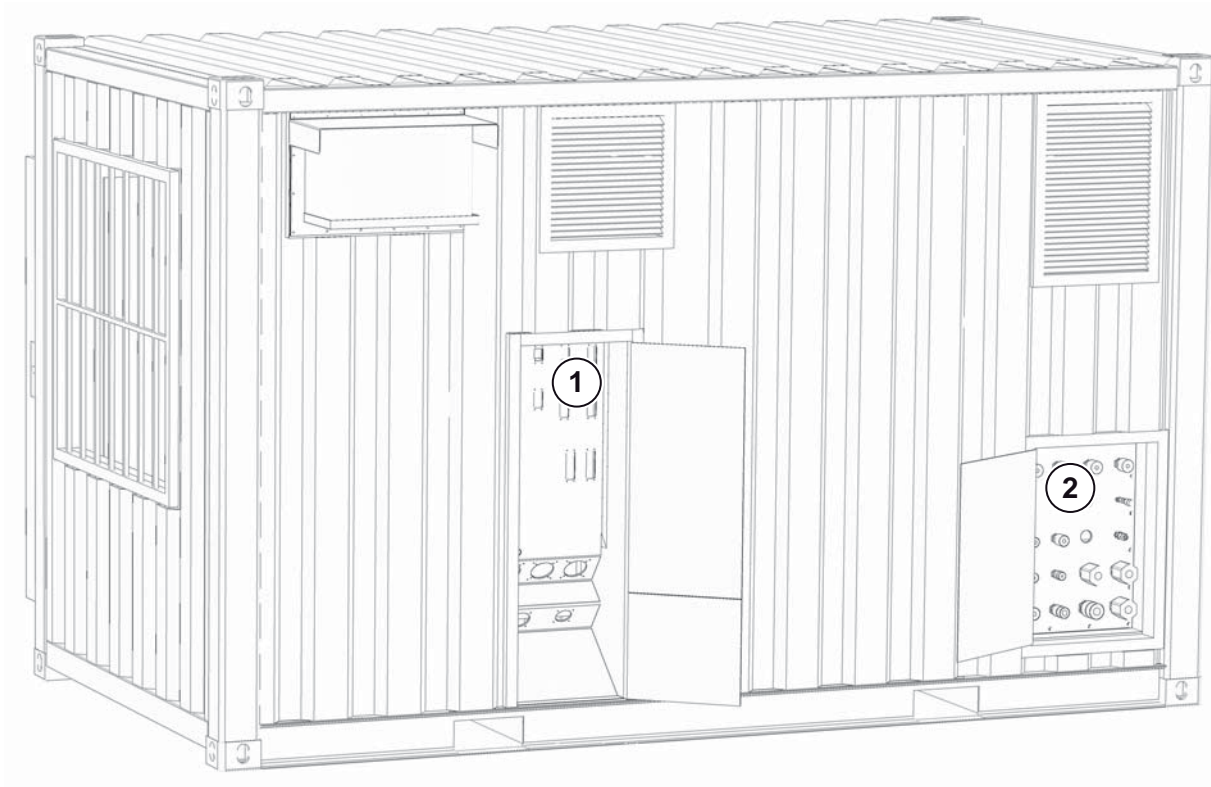


Power unit room in the operation container

- | | | | |
|---|----------------------------------|---|------------------|
| 1 | Compressor | 4 | Tank |
| 2 | Thrust cylinder motor pump units | 5 | Filters |
| 3 | Cutting tool motor pump units | 6 | Oil / air cooler |

The power unit room contains components such as hydraulic power unit, motor pump units, compressor, oil / air cooler, etc. These components are required for controlling the machine / system.

5.2.4 Connection area



Connection area in the rear area of the operation container

1 Connection area of electric system

2 Connection area of hydraulic system

The rear part of the operation container contains two connecting bulkheads. Here, the electric and hydraulic connections of components like tunnel boring machine, Jacking frame, feed and slurry pump, etc. are established.

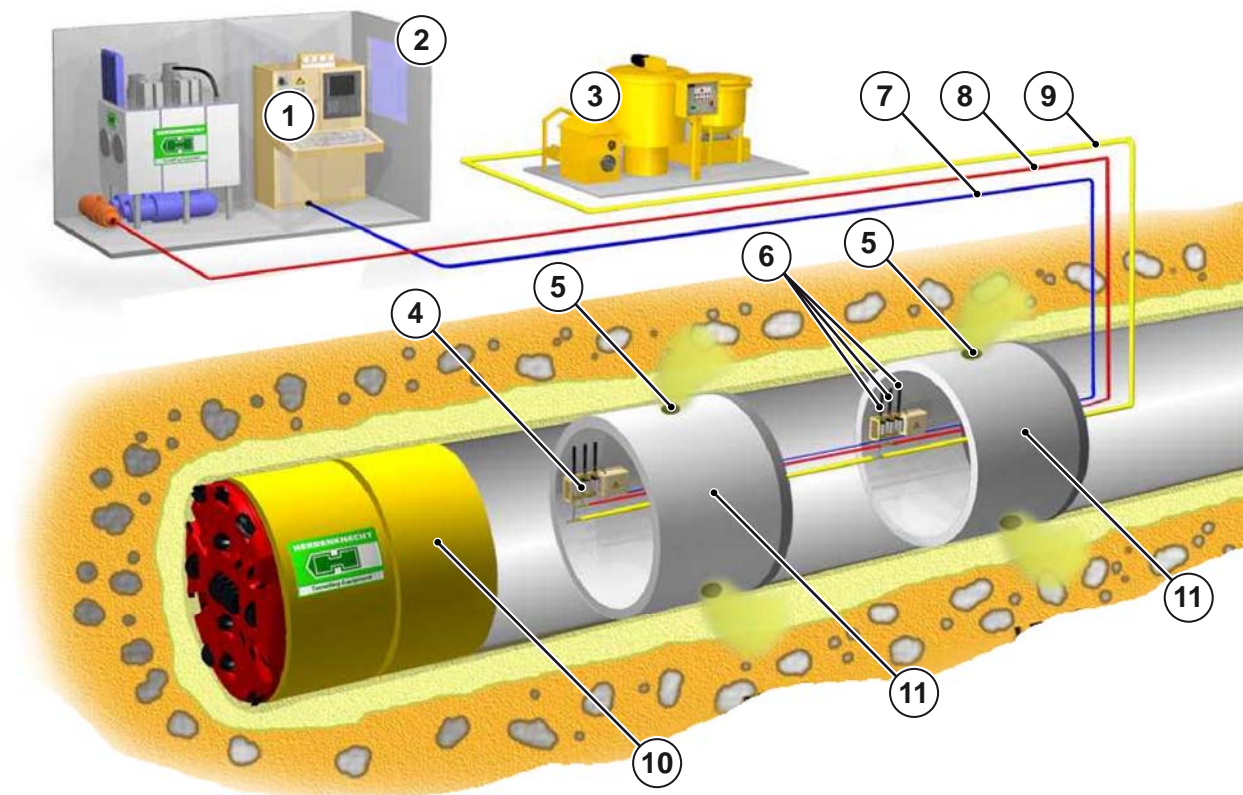
SYSTEM DESCRIPTION

PRODUCT DESCRIPTION

5.3 Bentonite lubrication

The bentonite suspension is used as supporting and lubricating means in pipe advance operation. Bentonite is pressed outward through injection nozzles in the concrete pipe. It fills the ring gap that results from the difference in the diameters of tunnel boring machine (cutting tool diameter) and concrete pipe.

5.3.1 Bentonite lubrication system



Overview of bentonite lubrication system

- | | | | |
|---|--|----|----------------------------|
| 1 | Control cabin | 7 | Control line |
| 2 | Operation container | 8 | Compressed air supply line |
| 3 | Bentonite system | 9 | Bentonite supply line |
| 4 | Bentonite distributor | 10 | Tunnel boring machine |
| 5 | Bentonite nozzle | 11 | Product pipe |
| 6 | Bentonite line to the bentonite nozzle | | |

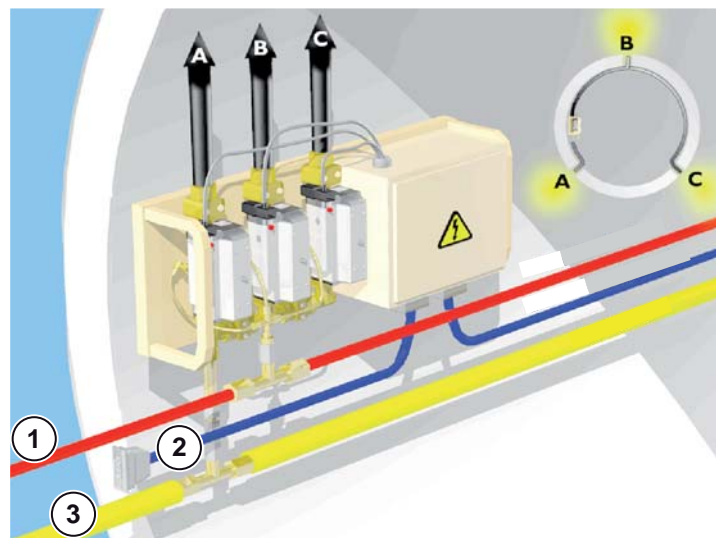
Method of operation

Each required advance pipe contains a valve block with three pilot-controlled ball valves. The valve block is fed from the central bentonite line via a line. A hose is routed between valve block and lubrication point.

Electric signals from the control cabin control the individual pilot valves. Supported by compressed air, the main piston is opened and the bentonite flows to the preselected lubrication point.

An electric distribution box with the corresponding Dupline electronic blocks is installed at each valve block. The signals are routed via the PLC in the control cabin. Here, the PLC signal is converted into a Dupline signal, and transferred to the distribution box of the selected valve. There, a transmitter / receiver block converts the Dupline signal into a digital signal that is used for controlling the individual valves.

In the opposite direction, the transmitter / receiver block reports the existence of the individual distribution boxes back to the control cabin. The activation of the individual valves and the related indicators and selector switches are shown in the visualization.



Typical activation

- | | | | |
|---|----------------------------|---|-----------------------|
| 1 | Compressed air supply line | 3 | Bentonite supply line |
| 2 | Control line | | |

6. Technical specifications

6.1 Tunnelling machine

DESIGNATION	DATA
Machine type	EPB1500TB
Outer diameter	1865 mm
Length (without cutterhead tool)	approx. 3483 mm
Weight approx.	16000 kg
Torque	187 kN m
Continuously variable rotational speed	0 - 5.9 min ⁻¹
Number of drive motors	4 units
Number of steering cylinders	4 units
Steering cylinder stroke	60 mm
Steering cylinder piston diameter	140 mm
Steering cylinder rod diameter	90 mm
Steering cylinder maximum pressure	500 bar
Steering cylinder pressure compression force	770 kN
Steering cylinder pulling force	406 kN

Table II - 2: Technical data EPB1500TB

6.2 Conveyor system

6.2.1 Screw feeder

DESIGNATION	DATA
Nominal diameter	400 mm
Helix gradient	280 mm
Continuously variable rotational speed	0 - 32 min ⁻¹
Permanent torque	15 kN m
Maximum torque	78.5 kN m
Number of drive motors	1 units
Screw feeder opening	350 x 380 mm

Table II - 3: Technical data screw feeder

6.2.2 Belt conveyor

DESIGNATION	DATA
Belt speed	1.5 m/s
Belt width	400 mm

Table II - 4: Technical data belt conveyor

6.2.3 Conveyor bucket

DESIGNATION	DATA
Volume	1.8 m ³

Table II - 5: Technical data conveyor bucket

TECHNICAL SPECIFICATIONS

PRODUCT DESCRIPTION

6.2.4 Machine winch

DESIGNATION	DATA
Winch type	MH 2
Cable diameter	5 mm
Max. cable length	400 m
Cable speed inner position	0.7 m/s
Cable speed outer position	1.25 m/s
Pulling force inner position	4320 n
Pulling force outer position	2430 n
Mean pulling force	3105 n
Operating pressure	160 bar

Table II - 6: Technical data machine winch

6.3 Jack frame

DESIGNATION	DATA
Minimum height tunnel floor/tunnel axis	1146.5 mm
Length of tunnel pipe	4000 mm
Max. outer diameter of pipe	1840 mm
Number of mount points	4 units
Number of thrust jacks	2 units
Thrust jack stroke	4000 mm
Maximum pressure per cylinder push/pull	480 / 200 bar
Jacking force per cylinder	3500 kN
Total jacking force F	7000 kN
Distance between axes for F/2	875 mm
Distance between axes for F/2	1146.5 mm

Table II - 7: Technical data jack frame

6.3.1 Shaft winch

DESIGNATION	DATA
Winch type	MH 1
Cable diameter	8 / 10 mm
Standard cable length	350 m
Max. cable length	650 m
Cable speed inner position	3 m/s
Cable speed outer position	4.2 m/s
Pulling force inner position	9803 n
Pulling force outer position	5681 n
Mean pulling force	7205 n
Operating pressure	200 bar

Table II - 8: Technical data machine winch

6.4 Operation container

DESIGNATION	DATA
Compatible machine types	EPB1500
Jacking pump	55 kW
	100 l / min
Transformers	690 V
	250 kVA
Hydraulic tank	1500 litres

Table II - 9: Technical data operation container C30

7. Transport data



Please refer to the drawings and diagrams provided for additional specifications for the transport (such as suspension points, fill levels of liquids and lubricants, etc.).

7.1 Cutterhead tool

DESIGNATION	DATA
Cutter head tool type	Mixed soil head
Part no.	30207923
Diameter of steel structure	1875 mm
Diameter with cutting tools	1911 mm
Length of steel construction	708 mm
Weight approx.	5100 kg

Table II - 10: Transport data cutterhead tool

7.2 Tunnelling machine

DESIGNATION	DATA
Diameter	1865 mm
Length (without cutterhead tool)	3483 mm
Weight approx.	16000 kg

Table II - 11: Transport data tunnelling machine

7.3 Machine pipe 2

DESIGNATION	DATA
Diameter	1855 mm
Length	3172 mm
Weight approx.	7350 kg

Table II - 12: Transport data machine pipe 2

7.4 Belt conveyor

DESIGNATION	DATA
Height	382 mm
Width	693 mm
Length	6530 mm
Weight approx.	720 kg

Table II - 13: Transport data belt conveyor

7.5 Conveyor bucket

DESIGNATION	DATA
Height	825 mm
Width	1160 mm
Length	2756 mm
Weight approx.	739 kg

Table II - 14: Transport data conveyor bucket

7.6 Start-up seal

DESIGNATION	DATA
Height	170 mm
Width	2450 mm
Length	2450 mm
Weight approx.	615 kg

Table II - 15: Transport data start-up seal

7.7 Jacking frame

DESIGNATION	DATA
Height	2037 mm
Width	2080 mm
Length	7870 mm
Weight approx.	9350 kg

Table II - 16: Transport data jack frame

7.7.1 Guide frame

DESIGNATION	DATA
Height	425 mm
Width	1580 mm
Length	7806 mm
Weight approx.	2370 kg

Table II - 17: Transport data guide frame

7.7.2 Thrust ring

DESIGNATION	DATA
Height	1810 mm
Width	2080 mm
Length	900 mm
Weight approx.	1480 kg

Table II - 18: Transport data thrust ring

7.7.3 Abutment plate

DESIGNATION	DATA
Height	260 mm
Width	1800 mm
Length	2230 mm
Weight approx.	1360 kg

Table II - 19: Transport data abutment plate

7.7.4 Bridging plate

DESIGNATION	DATA
Height	372 mm
Width	1138 mm
Length	2850 mm
Weight approx.	300 kg

Table II - 20: Transport data bridging plate

7.7.5 Telescopic cylinder

DESIGNATION	DATA
Height	466 mm
Width	365 mm
Length	2850 mm
Weight approx.	1745 kg

Table II - 21: Transport data telescopic cylinder

7.7.6 Shaft winch

DESIGNATION	DATA
Height	454 mm
Width	850 mm
Length	533 mm
Weight approx.	316 kg

Table II - 22: Transport data shaft winch

TRANSPORT DATA

PRODUCT DESCRIPTION

7.8 Operation container

DESIGNATION	DATA
Height	2800 mm
Width	2400 mm
Length	5618 mm
Weight approx.	9000 kg

Table II - 23: Transport data operation container

III. Safety

1. About this main chapter	III - 5
2. Significance and Contents	III - 6
2.1 Classification of the hazard levels	III - 7
2.2 Signal forms and colours	III - 8
2.3 Employed icons	III - 9
2.3.1 Warning signs	III - 9
2.3.2 Prohibitory sign	III - 10
2.3.3 Mandatory sign	III - 11
2.3.4 Rescue and firefighting signs	III - 12
2.3.5 Dangerous substances	III - 12
2.3.6 Information signs	III - 13
3. Organisation and staff	III - 14
3.1 Area of responsibility of the operating company	III - 14
3.2 Area of responsibility machine operator	III - 16
3.3 Qualification and training of the staff	III - 17
3.3.1 Installation staff	III - 18
3.3.2 Operating staff	III - 20
3.3.3 Service staff	III - 21
4. Basic safety instructions	III - 22
4.1 General	III - 22
4.1.1 General safety instructions	III - 23
4.2 Warning of residual dangers	III - 25
4.2.1 Danger to life	III - 25
4.2.2 Risk of injury	III - 26
4.2.3 Material damage	III - 26
4.3 Safety instructions for specific life cycles	III - 27

TABLE OF CONTENTS

SAFETY

4.3.1	Transport.	III - 27
	Transport from construction site to construction site on public transport routes 27	
	Transport during assembly	III - 27
4.3.2	Erection and assembly	III - 28
4.3.3	Connection	III - 28
4.3.4	Initial commissioning.	III - 28
4.3.5	Operation	III - 29
4.3.6	Maintenance and repair	III - 31
4.3.7	Decommissioning and disassembly	III - 33
4.3.8	Bearing	III - 33
4.4	Hydraulic and pneumatic systems.	III - 34
4.5	Electric power	III - 37
4.6	Liquids and lubricants	III - 40
4.6.1	General notes	III - 40
	Personal protective gear	III - 41
4.6.2	Notes on safe handling of hydraulic oils and greases.	III - 42
4.6.3	Notes on safe handling of bentonite	III - 43
	Personal protective gear	III - 44
	Notes on disposal	III - 44
4.7	Operation below the freezing point	III - 45
4.8	Risk of fire and explosion	III - 46
4.9	Laser radiation.	III - 48
4.10	Noise	III - 48
5.	Product-related safety instructions	III - 49
5.1	Special dangers at the machine / system	III - 49
5.2	Safety instructions for working in the shaft	III - 50
6.	Hazardous areas and safety devices	III - 51
6.1	Danger areas and working areas	III - 51
6.2	Safety devices.	III - 52
6.2.1	General	III - 52

6.2.2	Emergency stop button . . . . .	.III - 53
	Emergency stop buttons in the shaft. . . . .	.III - 53
6.2.3	Main switch, key switch. . . . .	.III - 54
6.2.4	Warning signals. . . . .	.III - 54
6.3	Fire fighting . . . . .	.III - 55
6.3.1	Fire extinguishers . . . . .	.III - 55
6.3.2	Water curtain. . . . .	.III - 55
6.3.3	Smoke detectors . . . . .	.III - 55
6.3.4	Heat detector. . . . .	.III - 56
6.4	First aid equipment . . . . .	.III - 56

SAFETY

1. About this main chapter

This main chapter mainly deals with the following topics:

- Significance and contents
- Organization and staff
- Basic safety instructions
- Product-related safety instructions
- Hazardous areas and safety devices

2. Significance and Contents

Safety instructions in the operating instructions and warning signs at the dangerous spots of machine/system warn of residual dangers which may occur during the operation of machine/system in the individual operating states.

In these operating instructions, safety instructions are structured as follows:



DANGER!

Signal word

Source

- Consequence
- Avoidance

STRUCTURE	CONTENTS
Warning sign	Exact definition of the danger
Signal word	Classification according to the severity of the danger
Source	Description of the source of danger
Consequence	Possible consequences as a result of the danger
Avoidance	Actions to be taken to avoid the danger

Table III - 1: Safety instructions - structure

Various signal words are used in addition to the safety and warning icons. The signal words specify the severity of the danger.

The warning texts related to the signal words explain the type of danger and the possible consequences for humans and machine/system in a clear, short and concise manner. They provide information on the consequences in case of non-observance and refer to specific risk management measures.

2.1 Classification of the hazard levels

SIGNAL WORD	DESCRIPTION
Danger	Signal word that identifies a hazard with a high risk that will lead to imminent serious or fatal injuries when it is not avoided.
Warning	Signal word that identifies a hazard with a medium risk that can lead to serious or fatal injuries when it is not avoided.
Caution	Signal word that identifies a hazard with a low risk that will lead to light or moderately severe injuries or to damage when it is not avoided.

Table III - 2: Classification of hazard levels (to ISO 3864)

Notes which are directly attached to the machine/system must be observed and kept in a completely legible condition.

The operating company is responsible for maintaining the readability of the safety instructions, and for providing the necessary training, instructions and proofs.

2.2 Signal forms and colours


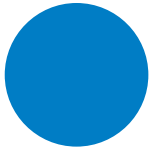


SIGNAL FORM	COLOUR	MEANING
	Yellow with a black frame	Warning signs
	Blue	Mandatory sign
	White with a red frame	Prohibitory sign
	Green	Rescue sign
	Red	Fire protection sign
	White with a blue frame	Note
	Orange	Hazard sign

Table III - 3: Signal forms and colours

2.3 Employed icons















Warnings and warning signs warn of residual dangers during machine operation.

The following icons are - depending on the components installed - used on the machine/system and in the Operating Instructions. They warn of residual dangers, show actions for a safe application, or identify escape routes, rescue and fire fighting equipment.













Any damaged or illegible warning signs must be replaced immediately. The warnings signs on the machine/system must remain legible.

2.3.1 Warning signs







ICON	MEANING	ICON	MEANING
	General danger		Hot surfaces
	Falling hazard		Noise hazard
	Caustic substances		Laser radiation
	Electric voltage		Risk of crushing limbs
	Risk of explosion		Radioactive substances
	Inflammable substances		Rotating machine parts
	Hand injuries		Rotating rollers

SIGNIFICANCE AND CONTENTS









SAFETY

ICON	MEANING	ICON	MEANING
	Risk of slipping		Dropping objects
	Suspended loads		Falling stones
	Risk of tripping		System damage
	Gases that are hazardous to health!		Cutting off / shearing of body parts!
	Drowning!		Environmental pollution!

2.3.2 Prohibitory sign

ICON	MEANING	ICON	MEANING
	Access to the track system prohibited!		Mobile radio prohibited
	Smoking prohibited		No access for unauthorized persons
	Naked flames prohibited		General prohibition










2.3.3 Mandatory sign

ICON	MEANING	ICON	MEANING
	Use a safety harness		Use head protection / hard hat
	Use light breathing protection		Use protective gloves
	Use head and eye protection		Use safety shoes
	Use head and ear protection		Use breathing protection - self-rescue respirator

SIGNIFICANCE AND CONTENTS

SAFETY


2.3.4 Rescue and firefighting signs

ICON	MEANING	ICON	MEANING
	First aid		Fire detector
	Escape route		Fire hose
	Stretcher		ABC fire extinguishers
	Mustering point		CO ₂ fire extinguishers
	Eye rinsing equipment		

2.3.5 Dangerous substances

ICON	MEANING	ICON	MEANING
	Hazards for the environment		Risk of fire

2.3.6 Information signs

ICON	MEANING	ICON	MEANING
	Note		Observe the operating instructions
	Note on directives and legal requirements		

3. Organisation and staff



The persons instructed to work on the machine must have read and understood the Operating Instructions and, in particular, the Chapter "Safety Instructions" **before** they start working.

Reading the Operating Instructions after work has been started will be too late.

This particularly applies to personnel who work only occasionally on the machine (doing maintenance work, for example).

3.1 Area of responsibility of the operating company

- To monitor compliance with the safety measures, the operating company nominates a safety officer.
- The operating company of the machine / system is responsible for providing the power supply, and the industrial and cooling water supply.
- The operating company has to ensure that only qualified, trained and specifically instructed personnel work on the machine / system.
- These Operating Instructions must permanently be available at the place where the machine / system is used.
- In addition to these Operating Instructions, the company operating the machine / system has to observe all legal and other binding provisions on accident prevention and environmental protection and instruct the operating personnel accordingly. These supplements form part of the Operating Instructions, and must be complied with.
- Safety instructions in the Operating Instructions guaranteeing a higher degree of accident prevention than the national accident prevention regulations must be observed. The safety instructions must be supplemented by the operating company by instructions concerning the supervisory and reporting obligations, the different operating sequences or the operating staff used.
- Prior to starting work, the operating staff must have read and understood the Operating Instructions, in particular the chapter "General safety instructions". The operating company must maintain the necessary proof documents for the training.

- The operating personnel must regularly be instructed on all aspects of their areas of responsibilities, and must act accordingly. The operating company supervises these actions within the scope of its duties resulting from the ordinance on industrial safety and health.
- The operating company must inform the personnel about all safety installations, their function and operation.
- The responsibilities of the operating staff regarding operation, mounting, maintenance and repair must clearly be specified.
- The operating company must specify the responsibilities of the machine operator. He must be allowed to disregard instructions from third parties which are contrary to the safety code of practice.
- The operating staff has to be regularly assessed by the operating company on its ability to work in compliance with these operating instructions and the national regulations and to follow a safety- and risk-conscious work approach. If required, the operating company must implement corrective training measures for the staff. The corrective training measures must be documented.
- The operating company must ensure that mandatory, information and warning signs which are attached to the system are complete and in a legible condition. Damaged and illegible mandatory, information and warning signs must be replaced.
- The operating company initiates all recurring crane and chain hoist inspections. The results must be documented in the inspection and test logbook.

3.2 Area of responsibility machine operator

The machine operator is responsible for the following points:

- For the intended use.
- For observing all necessary safety precautions.
- For industrial safety and accident prevention at the machine and its environment.
- The machine operator is authorized to order any unauthorized persons out of the working area.
- For the completion of the maintenance work.

3.3 Qualification and training of the staff

Only qualified, trained and instructed personnel may carry out work with and on the machine / system.

This staff is subdivided into the following groups:

- Installation staff
- Operating staff
- Service staff

The required qualifications, the tasks and obligations of the individual employees are defined by their allocation to one of the above-mentioned groups.

Qualified personnel must:

- be at least 18 years old. Persons who are not yet 18 years old may only work on the system under the supervision and guidance of a person authorised by the operating company.
- have attended first aid training and be able to provide first aid.
- have been trained on the basics of fire fighting and be able to implement them.
- know the relevant accident prevention and safety regulations, and be able to use them.
- have read and understood the general safety instructions.
- being able to implement and use in practice the contents of the general safety instructions.
- have received training and information on the rules of conduct in fault cases.
- have the physical and mental skills required to be able to execute the tasks and work within their area of responsibility.
- be trained according to their assigned fields of responsibility, tasks and work.
- have read and understood the operating instructions with respect to their responsibilities, tasks and work on the system.
- refrain from all activities which may result in personal injuries / material damage.

3.3.1 Installation staff

The installation staff are responsible for:

- transport
- installation
- disassembly
- Bearing

The installation staff must:

- be familiar with and follow the safety instructions applicable to the attachment of loads.
- recognize damage on the load handling equipment, and remove and replace damaged load handling equipment.
- be familiar with and comply with the safety regulations dealing with the operation of crane systems and hoisting devices.
- be familiar with and comply with the safety regulations dealing with the operation of hydraulic wrenches and bolt tensioning cylinders.
- be familiar with and comply with the safety regulations dealing with the operation of pneumatically operated impact wrenches.
- wear the required personal protective equipment.
- be familiar with and comply with the regulations and safety measures dealing with commissioning and operation of hydraulic systems.

The installation staff are responsible for ensuring that:

- all safety installations are reinstalled and fully functioning during and after completion of the installation work.
- the appropriate work instructions are observed (e.g. cementing screwed connections).
- all screwed connections under water are cemented
- all mounting bolts are properly mounted and secured.
- all bolts are fastened to the correct torque
- all hydraulic bolted connections are connected, properly fastened and secured in accordance with the hydraulic diagram.
- all electrical connections are connected and secured in accordance with the electric circuit diagram.
- stored machine and system components are properly preserved and stored (store them such that they cannot fall over).

3.3.2 Operating staff

The operating staff are responsible for:

- regular inspections
- switching the machine/system on and off
- manual operation
- automatic operation

The operating staff must:

- be familiar with and comply with the regulations and safety measures dealing with commissioning and operation of hydraulic systems.
- use the machine / system in accordance with the specified intended use.
- wear the required personal protective equipment.
- immediately shut down the machine / system in the event of a fault or abnormal operating conditions.
- Immediately report and document any faults or abnormal operating conditions.
- keep transport routes and transport areas free of obstacles.

The operating staff are responsible to ensure that:

- the regular checks and maintenance work are carried out.
- the protection devices and safety installations of the tunnelling system are operating properly.
- the safety and information signs on the machine / system are in a legible condition.
- the system is protected against unauthorised use.
- the machine / system is only operated in a fully functioning condition.

3.3.3 Service staff

The service staff are responsible for:

- commissioning
- setup
- cleaning
- maintenance

The service staff must:

- be familiar with and comply with the regulations and safety measures dealing with commissioning and operation of hydraulic systems.
- wear the required personal protective equipment.

The service staff are responsible to ensure that

- after completion of maintenance and repair work, all protective devices are reinstalled and properly functioning.
- commissioning, set-up and maintenance and repair work is carried out properly and correctly.
- service activities and restart are fully documented.

4. Basic safety instructions

4.1 General

The machine / system is equipped with safety installations and protective devices. These safety installations serve the personal protection during machine operation and prevent material damage on and by the machine. Material damage may result in dangerous situations during operation.

Safety instructions help to operate the machine / system safely, properly and efficiently. They avoid or reduce dangerous situations during operation and allow for a reliable utilization of the machine during its service life.

The machine / system meets all requirements of the EC directive 2006/42 EEC for machines, concerning the basic safety and health requirements. If the machine / system is operated in accordance with its intended use, no undetected dangers will emanate from the machine.

Faulty components or technical defects resulting from improper use of the machine / system may cause significant hazards. All general regulations for occupational safety and health protection must always be observed during the operation of the machine.

Never remove, bypass or render useless any safety installations and protective guards.

4.1.1 General safety instructions

- One person alone is not allowed to stay on the machine / system.
- When working on and with the machine / system, personal protective equipment, particularly protective clothing, protective gloves, hard hat, ear protectors and safety shoes, must be permanently worn.
- Do not deposit or leave objects and tools which may cause trip hazards on the transport routes or on work surfaces.
- Provide for sufficient illumination.
- Never bridge, bypass or render useless the safety installations.
- In case of uncommon noises and odours, immediately switch off the machine and identify the cause.
- The operating personnel has to be familiar and comply with the instructions contained in the safety data sheets of the used liquids and lubricants.
- When executing mounting, adjusting and maintenance work, the machine / system has to be switched to a state which ensures that unintended machine / system functions endangering the maintenance personnel are not possible.
- Stay clear of all moving parts when the machine / system features automatic operation.



DANGER!

Laser radiation!

Dangerous laser beams.

- Serious eye injuries, blindness.
- Switch off the laser system before you start any maintenance and repair work.
- Cover the laser before you start working in the laser beam area.



No access for unauthorized persons.

BASIC SAFETY INSTRUCTIONS

SAFETY

- Prior to cleaning / maintaining machine parts or components, ensure that these parts are disconnected from the power supply and that no dangerous residual voltage is present.
- Only specialist staff are allowed to replace tools and to perform service work. The industrial safety regulations must be observed.



DANGER!

Risk of tripping!

Disorder from objects lying around

- Risk of falling - serious injuries.
- Keep working place and working environment always clean and tidy.
- Always keep escape routes clear.

- Do not block the work environment and escape routes with objects such as pallets, boxes or similar parts.
- Secure tools and other objects against dropping.



Prior to starting work with the machine / system, all operators must be made familiar with the following points:

- Safety installations
- Safety precautions
- Escape routes
- Possible hazards
- Behaviour in dangerous situations
- Actions to rescue trapped persons
- Emergency actions

4.2 Warning of residual dangers

The residual dangers were analyzed during the design of machine / system in accordance with the directives and standards, and documented in a hazard / risk analysis.

Residual dangers which cannot be eliminated by constructional measures and which affect the entire service life are:

- Danger to life
- Risk of injury
- Environmental pollution
- Damage to the machine / system and further material damage
- Performance or function restrictions

Existing residual dangers can be avoided by:

- Observing the danger and warning signs on the machine / system and in the Operating Instructions.
- Observing the general safety instructions in these Operating Instructions.
- Observing the applicable accident prevention regulations.
- Observing the manufacturer instructions.
- Observing the ordinance on hazardous substances.

4.2.1 Danger to life

There is danger to life in the following cases:

- Use conflicting with the intended use.
- Missing or faulty protective devices
- Defective or damaged mechanical / hydraulic components.
- Dropping loads due to improper use of lifting accessories
- Dropping loads due to wrong lifting devices
- Falling from heights if the necessary protective equipment is not used

4.2.2 Risk of injury

There is a risk of injury in the following cases:

- Improper handling
- Improper storage
- Improper handling of hazardous substances
- Wrong pressure settings at the hydraulic system

4.2.3 Material damage

Material damage may be caused by:

- Improper handling of hazardous substances
- Wrong pressure settings at the hydraulic system
- Using auxiliary power units that were not agreed with and approved by Herrenknecht AG.
- Selecting the wrong relationship of the speeds of pulling and pushing unit of the entire system, consisting of HDD rig and pipe feeding unit (only pipe thruster).

4.3 Safety instructions for specific life cycles

4.3.1 Transport

Transport from construction site to construction site on public transport routes

- The respective national road traffic regulations must be observed.
- The driver of the transport vehicle is responsible for the safety of the load and for complying with the national traffic regulations.
- The permissible load capacity of the transport vehicle must not be exceeded.
- Use only suitable and technically faultless hoisting devices and load handling equipment of sufficient load capacity.
- Any necessary special authorizations (excessive width, heavy load) must be obtained from the authorities responsible before the transport is started.
- The transport route must be selected such that only bridges of sufficient carrying capacity are passed and that all underpasses on the road are of sufficient height.

Transport during assembly

- Transport work may only be carried out by qualified personnel in compliance with the safety instructions.
- Use only lifting accessories of adequate carrying capacity.
- When selecting suitable load handling equipment, always consider the total weight of the components/assembly groups that are to be lifted.
- Damaged lifting accessories must be discarded and may no longer be used.
- Machine and system components may only be suspended from the marked suspension points.
- Transport routes must be blocked and secured in a way which ensures that unauthorised person cannot enter the danger area.
- Transport routes must withstand the permissible total weight of the transport vehicle.
- Existing transport locks may only be removed after installation.
- Dispose of the packing material properly or store it in a way that it can be reused for the next transport.

4.3.2 Erection and assembly

- The system must be set up on a horizontal surface.
- The local conditions must allow for a stable operation
- Use compatible bolts and nuts for installation, and tighten them with the specified torque.
- Never drive connecting bolts forcibly into the boreholes.
- The local circumstances must provide for a stable, slip-free, and, if applicable, dry operation. The operating company of the system must take the necessary precautions.
- Only use the specified bolts, washers, nuts, sealing rings etc. for installation.
- Tighten all screwed connections with the specified torque. All screwed connections under water must additionally be cemented. Always contact Herrenknecht AG if there are any uncertainties.
- Use scaffolding or working cage when you work at a height. Wear safety equipment.

4.3.3 Connection

- Only qualified personnel are allowed to connect the system.
- Ensure that only authorized persons are within the working area of the system, and that nobody else is endangered when the system is connected.
- Observe special protective measures (e.g. grounding).
- If a "residual current protection" is implemented as electrical protective measure for the electrical operating equipment, an RCCB with a nominal fault current of 0.3 A must be used.

4.3.4 Initial commissioning

- Only qualified personnel are allowed to commission the system, observing the safety instructions.
- Ensure that only authorized persons are within the working area of the system, and that nobody else is endangered when the system is commissioned.
- Check the firm seating of all electrical and hydraulic connections before the first start.

4.3.5 Operation

- No modification, attachment or conversion of the machine/system that could affect the safety is allowed without prior approval of the manufacturer.
- Using cell phones in the control cabin is prohibited.
- Never manipulate, bypass or remove safety devices.
- Maintain all safety and hazard information labels on the machine/system in a complete and readable state.
- Never modify the programs of the programmable control systems without previous agreement.
- Keep all handles, steps, handrails, platforms and ladders free of contamination.
- Keep all escape routes (also for ambulance services) clear.
- Use the machine/system only when all safety installations are fully operational.
- Refrain from any safety-critical work methods.
- Watch the activation and deactivation processes and the control indicators according to the specifications in the Operating Instructions.
- Prior to commissioning the machine / system, make sure that the start-up cannot endanger any persons.
- Only use diesel fuel of a proven flashing point of more than 55°C for diesel engines.
- Wear ear protectors in noisy areas.
- In the event of a malfunction, shut down the machine / system at once. Eliminate the faults immediately.
- Electric machines contain live, bare or rotating parts during operation. Removing the required covers without authorization, using the system improperly, starting the system up in an improper way, or carrying out inadequate or incorrect maintenance may lead to serious injuries and damage to the system.
- Prior to commissioning the machine / system, make sure that the start-up cannot endanger any persons.
- Condensation water forms in control cabinet and control cabin if there are large temperature differences between day and night (15° C and more). This can lead to faults in the electronic components of the system. Switch on the heating during the night.
- When you notice any unfamiliar noise or odour, watch the machine and look for the cause immediately.
- When working on and with the machine, personal protective equipment, particularly protective gloves, hard hat, ear protectors and

BASIC SAFETY INSTRUCTIONS

SAFETY

- safety shoes, must be permanently worn.
- To avoid the risk of skidding you must always keep the working environment clean.
 - Prior to cleaning machine parts or components, make sure that these parts are disconnected from the power supply, and that there are no more dangerous residual voltages.
 - Only specialist staff are allowed to replace tools and to perform service work. The industrial safety regulations must be observed.
 - Never cross a barrier of any kind. If crossing a barrier cannot be avoided, this may only be done when the corresponding safety measures (using safety harness, shutting down the system, etc.) are taken.

4.3.6 Maintenance and repair

- Maintenance and repair work may only be carried out by personnel with the proper expert knowledge who were instructed to do so.
- Never service the machine/system during operation.
- The deadlines and specifications for inspections, maintenance work, and replacement of assembly groups and components must be complied with and documented.
- The operators must be informed before special work and maintenance work is started. A supervisor must be appointed.
- Use only genuine spare parts and accessories approved by the manufacturer.
- Use only the specified and approved operating supplies and operating materials (grease, oil, cleaning agents).
- If required, secure a wide area around the maintenance area.
- The machine / system must be secured against being switched back on inadvertently when it is switched off completely during maintenance and repair work.
- A motor that is switched off during maintenance and repair work must be secured against being switched back on inadvertently.
- When executing maintenance work above head height, use the provided or other suitable climbing aids and working platforms.
- Safety harnesses must also be worn when completing other work at heights.
- Clean machine parts - in particular connections and screwed connections - before you start maintenance or repair work. Never use aggressive cleansers. Always use lint-free cloths.
- Before you start cleaning with water, high pressure cleaner or other cleansers, cover all openings where penetrating liquids or cleansers represent a risk for safety and functioning. Particularly jeopardized are electric motors and switch cabinets.
- Remove all covers completely when cleaning is completed.
- Clean all handles, steps, handrails, platforms and ladders after maintenance work has been carried out.
- O-rings, seals and other sealing elements must be replaced after each relief.
- Cemented screwed connections must be cleaned, re-cemented and tightened to the specified torque during maintenance and repair work.
- Screwed connections which were released for maintenance and repair work must be retightened to the specified torque.
- If safety installations must be removed during maintenance or repair

BASIC SAFETY INSTRUCTIONS

SAFETY

work, these safety installations must be reinstalled immediately after the work has been completed, and be checked for their tight fit and correct setting.

- Prior to starting work on a potentially pressurized line (slurry, air, water, hydraulic, vacuum or oxygen line), make sure that the line is definitely pressureless. Switch off pressure-generating units (such as pumps or compressors) and secure them against being switched back on before you start work.
- The pressure in lines could also be caused by a clamped hydraulic cylinder, a pressure accumulator or other components under load. You must therefore secure hydraulic cylinders and other components under load against being moved, and depressurise pressure accumulators.
- Protect heavy parts against toppling or falling before you start releasing bolts or pulling pins.
- The maintenance switches must be used during maintenance or repair work. They are designed such that up to three padlocks can be attached. Each fitter working on the system has to secure the maintenance switch with his own personal padlock against being switched back on, even when the switch has already been secured with the padlock of one of his colleagues.
- Keep switch cabinets closed. For maintenance and repair work, only the doors related to the current work may be opened and must immediately be closed upon the completion of the work or when the person performing the work leaves the workplace.
- Ensure that the operating supplies and auxiliary materials and replacement parts are disposed of in a safe and environmentally compatible way.

4.3.7 Decommissioning and disassembly

- Only authorized experts are allowed to decommission and disassemble the system.
- Ensure that only authorized persons are within the working area of the system, and that nobody else is endangered when the system is dismantled.
- The specified special tools must be used for dismantling.
- Avoid any trip hazards from cables, hoses or pipes in the area where the shutdown and dismantling work is performed.
- Use only approved agents to clean the system.
- Observe the disposal requirements for the employed operating material, lubricants and process material.
- Use only the suspension points provided to lift the system components.
- Use only sufficiently dimensioned and undamaged load suspension devices and lifting accessories to lift the system or system components.
- Consider the total weight of the components/assembly group that is to be lifted when you select suitable load handling equipment.
- Put down machine and system components in a way that they cannot overturn.
- Install all transport locks before the units are carried away.

4.3.8 Bearing

- Store all components such that they cannot overturn.
- Ensure that the underground is sufficiently stable.
- Ensure that there is adequate ventilation to prevent the formation of condensation water and, consequently, rust.

4.4 Hydraulic and pneumatic systems



WARNING!

Risk of crushing limbs!

There is a risk of shock and crushing limbs when the hydraulic system fails because of defective components, improper operation, or mains failure.

- Eye and hand injuries and system damage.
- Staying in the vicinity of a pressurized hydraulic system is prohibited. Wear personal protective equipment during the work.

- The hydraulic systems of the machine / system are equipped with pressure limiting valves. Never change the set pressure values.
- The hydraulic system of the plant is shut down immediately when the hydraulic supply fails. The residual energy will continuously be relieved.
- Entering the hydraulic area during operation is strictly prohibited.
- Only persons with special know-how and experience in the field of hydraulics are allowed to work on hydraulic equipment.
- All cables, conduits, hoses and bolted connections must regularly be checked for leaks and externally visible damage. Repair any damage immediately. Spurting oil can cause injuries and fire.
- Prior to starting any maintenance work, you must depressurize the related hydraulic system, interrupt the power supply via the motor circuit switch of the related unit, and secure the motor circuit switch against being switched back on.
- Never exceed the maximum permissible pressure of the hydraulic system.
- Check all components in the supply circuit at regular intervals.
- Wear protective clothing during service and maintenance work.

WARNING!

Risk of crushing limbs!



Risk from residual hydraulic energy and oil pressure accumulators, and from pressure changes in the hydraulic system.

- There is a risk of concussion and crushing injuries and system damage.
- Wait for the pressure to compensate before you start working on the hydraulic system. Wear personal protective equipment during the work.

-
- Hydraulic oil pressure accumulators contain residual energy immediately after the system was switched off or the operating mode changed (pressure oil level change).
 - Additional risk is posed by the mechanical energy of electrical drives when the system is switched off or the operating mode changed (pressure oil level change).
 - Hydraulic cylinders are able to execute fast piston movements even in "underpressure" situations.
 - Entering the hydraulic area and opening of separating guards only after relief of residual energy in the oil pressure accumulator (min. two seconds).
 - Only persons with special knowledge and experience in the field of hydraulics are allowed to work on hydraulic equipment.
 - All cables, conduits, hoses and bolted connections must regularly be checked for leaks and externally visible damage. Repair any damage immediately. Spurting oil can cause injuries and fire.

WARNING!

Etching substances!



Risk from contact with hydraulic oil due to emerged hydraulic oil and damaged lines.

- Skin and eye injuries and injuries of the respiratory system.
- Staying in the vicinity of a pressurized hydraulic system is prohibited.

BASIC SAFETY INSTRUCTIONS

SAFETY

- Wear protective clothing during service and maintenance work.
- Wear safety goggles and protective gloves if there is a risk of splashing.
- Use skin-protecting cream if protective gloves made from PVC or nitrile rubber are not permitted for safety reasons.
- Never eat, drink, smoke or take snuff when you work on the system.
- In case of skin contact: Slight skin irritations possible. Repeated or long skin contact may result in degreasing and dermatitis. The skin can react more to other irritating substances.
- Take off contaminated clothes. Thoroughly clean affected skin.
- See a physician immediately when high-pressurized oil penetrates your skin.
- In case of eye contact: Severe eye injuries possible. Spread the eye lids and rinse the eyes immediately with an eye rinsing device for 15 minutes.
- In case of inhalation: The respiratory tract may be subject to injuries, which in severe cases may be fatal. The affected person must be immediately removed to fresh air and laid down at a calm place.
- After swallowing: Do not cause the affected person to vomit (mucosale irritations).
- Ventilate the affected rooms thoroughly.
- Establish a suitable blockage to prevent hydraulic liquid from penetrating into the sewage system.
- The authorities responsible must be notified when harmful substances enter surface waters, the sewage system or the underground.
- Only authorized maintenance personnel are allowed to remove escaped hydraulic oil.
- Never modify the hydraulic system without consulting Herrenknecht AG and without prior written approval from Herrenknecht AG.

4.5 Electric power



DANGER!

Voltage!

Danger to life and property damage caused by electrical voltage.

- Earthing not to standards can lead to death.
- The machine / system must properly be earthed before it is put into operation.



DANGER!

Voltage!

Danger from touching voltage-carrying parts or damaged cables.

- This can lead to serious paralyzation and burns, that can even be fatal.
- Never touch live parts.
- Switch off the power before you start working on the electric system. Only skilled electricians are allowed to work on the electric system.



Prior to putting the system into operation you must check the tight fit of all contact screws.



Always observe the national regulations for the operation of electric systems that are valid in the country of operation

BASIC SAFETY INSTRUCTIONS

SAFETY

- Access to electrical equipment and devices is only allowed for authorized persons.
- Only qualified electricians are allowed to work on electrical systems or other equipment.
- Cordon off the working area with a red-and-white safety chain and a warning sign. Use insulated tools only.
- When working on energized units, you must observe the applicable country-specific accident prevention measures.
- All electric lines and electric motors are protected against overload and short-circuit. Never change the set values.
- Electric machines contain live, bare or rotating parts during operation. Removing the required covers without authorization, using the system improperly, starting the system up in an improper way, or carrying out inadequate or incorrect maintenance may lead to serious injuries and damage to the system.
- The electrical equipment must be inspected and tested at regular intervals. Repair any defects (loose connections, burnt cables, etc.) immediately.
- Touch and hold devices only in a way which ensures that no components are bent and/or insulation clearances are changed.
- Avoid touching electronic components (static discharge!).
- Operate the system only when all switchgear cabinets are closed.
- Use a suitable measuring instrument of an internal resistance of at least 10 kohms to measure signal voltages.
- Only use genuine fuses of the specified tripping characteristics. Switch off the machine / system immediately when there are faults in the electric power supply.
- Oscillations or heavy machine vibrations can damage components or conduits.
- After the main switch on the power supply has been switched off, voltage is applied to energized components until the UPS (uninterrupted power supply) switches off.
- The main switches on the switch cabinets can be locked with a padlock in the individual switch positions. This prevents unauthorized persons from changing the switch position inadvertently.
- Observe the warnings on the doors of the switch cabinets.
- Observe the voltage and current ratings on I/O devices.
- Never modify the electrical system without consulting Herrenknecht AG and without prior written approval from Herrenknecht AG.
- When working on high-voltage assembly groups, the power supply has to be disconnected. Then, connect the supply cable to ground and

short-circuit the components (e.g. capacitors) with an earthing rod.

- If work has to be carried out on voltage-carrying parts, a second person must assist who, in emergency cases, will press the emergency stop button or the main switch to disconnect the power supply. The second person must be familiar with resuscitation measures.
- Components that are subject to inspection, maintenance and repair work must be de-energized. Ensure that the isolated parts are voltage-free, before you start working on them.
- Do not use mobile phones, 2-way radios, or other wireless transmitters in the immediate vicinity of the control cabin. They can interfere with the system.

4.6 Liquids and lubricants

4.6.1 General notes



Refer to the safety data sheet of the manufacturer for special information about handling and safety with respect to the employed substances.

Notes on handling oils, greases and other chemical substances

- When handling oil, grease or other chemical substances, always take the usual precautions, observe the safety regulations for the specific products, the instructions for handling and the requirements for the personal protective equipment.
- Be careful when you handle hot operating supplies and auxiliary materials (risk of burns and scalds).
- Remove spilled oil and grease immediately. Risk of fire and slipping.
- Keep away from ignition sources.

Notes on storage

- Provide for sufficient room ventilation.
- Only use containers which are approved for the specific material / product.
- Keep the containers closed.
- Ensure that the material cannot penetrate the ground.

Notes on environmental protection measures

- Notify the authority responsible when a substance gets into surface waters, drainage systems or underground.
- Do not allow substances to get into the sewage system.
- Cover the sewage system.
- Oils, greases and other chemical substances must always be handed over to approved waste management companies

Personal protective gear

Breathing protection

- Under normal circumstances, breathing protection is not required.
- Use a protective mask with filter when oil mist occurs.

Hand protection

- Wear protective gloves which are in accordance with the safety code of practice. Apply skin protection cream.

Eye protection

- Wear safety goggles if there is a risk of splashing of operating supplies.

Body protection

- Avoid skin contact.
- Wear overalls as protective clothing.
- Wear oil-resistant protective clothing if there is a risk of splashing.
- Wear oil-resistant boots.

General protective and hygienic measures:

- Immediately take off clothes soaked in grease or oil.
- Do not carry product-soaked cleaning rags in your clothes.
- After work clean and treat your skin.
- Do not eat, drink, smoke or take snuff during the work.
- Keep oil, grease, and other chemical substances away from food and drink.

BASIC SAFETY INSTRUCTIONS

SAFETY

4.6.2 Notes on safe handling of hydraulic oils and greases

- Avoid spilling the product.
- Avoid the generation of oil mist.
- Wear safety shoes and use adequate tools when handling heavy barrels.
- Wear personal protective equipment.
- Wear protective gloves which are in accordance with the safety code of practice.
- Avoid lasting, frequent or intense skin contact. Lasting or frequent skin contact can lead to skin diseases.
- Keep hydraulic oils away from food and drinks.
- Do not eat, drink, smoke or take snuff during the work.
- Immediately take off clothes which are soaked in grease or oil.
- Do not carry product-soaked cleaning rags in your clothes.
- After work clean and treat your skin.
- Do not allow the product to enter the environment in an uncontrolled way.

4.6.3 Notes on safe handling of bentonite



WARNING!

Acute and chronic risk of health!

Nonobservance of safety instructions and not wearing protective gear.

- Irritation of eyes and respiratory system.
- Breathing in bentonite can cause lung diseases, including silicosis and lung cancer. Bentonite is also connected with sclerodermitis and kidney diseases.
- Read the safety instructions and wear protective gear.

Personal precautions

- Use adequate protective equipment.
- Avoid whirling up and breathing dust.

Notes on cleaning

- Take up clean material and transfer it to reconditioning.
- Take up contaminated material, fill it into clean containers, and dispose of it properly.

Notes on handling

- Avoid dusty conditions.
- Provide for adequate ventilation.
- Wear breathing protection that complies with the local regulations.
- When wet, bentonite is slippery.

Notes on storage

- Store the containers tightly closed at a dry place.

BASIC SAFETY INSTRUCTIONS

SAFETY

Personal protective gear

- Wear clothes that are suitable for the work. Dusty clothes should be washed before they are use again.
- Wear protective clothing, in particular working gloves.
- Wear safety goggles.
- Wash your hands with water and soap after you have been in contact with the product.
- Preventive skin protection with skin protective cream.

Notes on disposal

- Dispose / store in an officially admitted disposal site, taking all regional and national regulations into account. The system user is responsible for proper disposal.

4.7 Operation below the freezing point

- The temperature in machine / system and operation container (optional) must not be lower than 0 °C when the machine / system is started. If necessary, you must heat up operation container and machine / system.
- The temperature in the switch cabinet must be +10 °C.
- The oil temperature in the power units must be at +10 °C. This prevents cavitation from highly viscous oil during a cold start of the hydraulic pumps. If necessary, you must heat up the power units.
- Slurry circuit and centrifugal pumps must completely drained and well insulated after the end of the advance operation.
- The bypass must be switched through three to four times end of the advance operation and after the machine / system has been removed from the shaft. This permits the water to run out of feed and slurry line.
- Open all ball valves halfway. This allows the remaining water to expand when freezing without damaging the seals or the housings of the ball valves. Any gate valves in the machine must be completely open.

4.8 Risk of fire and explosion

Risk of gas formation, fire, explosion and burns



Smoking on the machine / system is absolutely prohibited.



WARNING!

Inflammable substances!

Risk from hydraulic oil escaping at high pressure, welding, grinding and burning work, methane gas, hot surfaces, insufficient cooling of electric motors or defective household appliances.

- This can lead to burn injuries, poisoning and system damage.
- Always provide fire fighting equipment. The hydraulic system must be maintained at regular intervals and gas measurement should be performed if necessary.

- The contact points of welding gun and ground must be on the same component and as closely together as possible.
- Always observe the national regulations when you work in small rooms, and when you handle naked flames or fire.
- Try to get fire immediately under control.
- Hydraulic oil is categorized in fire class B to DIN EN2.
- Formation of complex gas-aerosol mixtures, which may contain carbon monoxide, soot, sulphur dioxide and organic compounds.
- In an atmosphere containing oil mist, use a protective mask with a filter for organic vapours and a particle filter. Breathing protection is not required under normal circumstances.
- Suitable fire extinguishing agents: Use foam, powder, carbon dioxide, sand or soil as fire extinguishing agent.

- Wear protective clothing when you work in the vicinity of hot surfaces (gearbox, leakage oil conduits, hydraulic tanks).
- Do not cover air-cooled motors. Clean them at regular intervals.
- Never operate household appliances (coffee machines, microwaves, boilers) on inflammable surfaces. Inspect such devices at regular intervals.
- Repair or replace defective bearings or defective mechanical brakes.
- Unsuitable fire extinguishing agents: Never use water (sharp water jets, in particular) for firefighting.
- Keep inflammable liquids away from ignition sources.
- Welding, burning and grinding work poses a risk of fire and explosion. The above-mentioned work always requires adequate fire fighting equipment and the appointment of a supervisor who can take the required measures immediately if necessary.
- Whenever you have to carry out welding, burning and grinding work, watch the rear side of the working site for any potential fire hazards, in particular if you do not have direct eye contact to this area.
- When selecting and arranging the fire extinguishers, take the individual fire types into account (electrical fires / liquid fires).
- To secure the escape routes, fire extinguishers are distributed over the entire system, and installed wherever required.
- Prior to welding, burning and grinding, the machine parts to be processed and their vicinity must be cleaned of dust and other combustible materials. Sufficient ventilation must be provided.
- Prior to welding, burning and grinding, cover adjacent combustible parts with a fire blanket.

4.9 Laser radiation



DANGER!

Laser radiation!

Dangerous laser beams.

- Serious eye injuries, blindness.
- Switch off the laser system before you start any maintenance and repair work.
- Cover the laser before you start working in the laser beam area.



The national regulations of the country of operation always apply for the operation of laser equipment.

If national regulations of the country of operation do not exist, the national regulations of the manufacturer country apply.

4.10 Noise

The operating staff must wear ear protectors when the average noise level of 8 hours exceeds the limit value of 85 dB/A in the working area.



DANGER!

Noise hazard!

Machine / system in operation.

- Receding attention, permanent hearing damage.
- Wear ear protection, even at low noise levels.
- Keep noise insulation housing closed.

5. Product-related safety instructions

5.1 Special dangers at the machine / system

- Nobody is allowed to stay in the drive area of the tunnel boring machine during advance operation. Maintenance work is only allowed there when the tunnel boring machine is shut down.
- Any maintenance and repair work is only allowed after the complete hydraulic system has been switched off and depressurized.
- All maintenance and repair work requires the complete power supply of the machine / system to be switched off.
- Absperrungen jeglicher Art dürfen nicht übertreten werden. However, should this be necessary, it may only be carried out while applying corresponding safety measures.
- The special safety instructions for all crane systems and hoisting devices must be observed. The national regulations from the country of the operator for cranes and hoists, must be observed.
- Nobody is allowed to stay under a suspended load.
- Nobody is allowed to stay in the excavation chamber during advance operation. Trained people are only allowed to stay in the excavation chamber as long as maintenance work is in progress (e.g. cutter exchange on the cutterhead tool). These persons must have passed a medical test if they are to be locked in. In this case, the operation of the cutting wheel may ONLY be controlled via the remote control in the machine.
- Prior to entering the excavation chamber you MUST verify the stability of the tunnel face and ensure that the excavation chamber is empty. If the tunnel face is not stable enough, you must take appropriate measures (e.g. injection, producing a bentonite cake) to ensure that the tools can safely be changed.
- The hydraulic systems of the machine / system are equipped with pressure limiting valves. Never change the set pressure values.

Ausnahme: Die Druckeinstellungen für den Pressenrahmen und Dehnerstationen sind der zulässigen Belastung des verwendeten Rohrtyps anzupassen. Die Druckeinstellung für die Pumpe „Antrieb Abbauwerkzeug“ ist gemäß dem Datenblatt der verwendeten Maschine einzustellen.

5.2 Safety instructions for working in the shaft

- Working in the shaft must be particularly risk-conscious.
- Personal protective equipment must be worn for all work in and on the shaft.
- Wherever the electrical protection measure "residual current protection" is used for electrical equipment in the shaft, you must use an RCCB of a nominal fault current of 0.3 A.



DANGER!
Falling hazard!

Working on the shaft.

- Risk of falling - serious injuries.
- Deploy only trained and authorized staff.



DANGER!
Laser radiation!

Dangerous laser beams.

- Serious eye injuries, blindness.
- Switch off the laser system before you start any maintenance and repair work.
- Cover the laser before you start working in the laser beam area.

6. Hazardous areas and safety devices

6.1 Danger areas and working areas

The work to be carried out during the individual life cycles determines the hazard and working areas at the machine / system.

Danger areas can bear hazards for persons. Depending on the operating mode of the machine, a working area can become a danger area.



Prior to entering a working area you must register the operating mode the machine is in.

LIFE CYCLE		STAFF	HAZARDOUS AREA	WORKING AREA
Transport and storage		Installation staff	Radius of 5 m	
Assembly and disassembly				
Commissioning		Operators and service staff	Radius of 5m	Radius of 1.5m
Operation	Setup			
	Regular inspections	Operating staff		
	Switching on / off			
	Manual mode			
Switches automatic mode				
Cleaning and care		Service staff		
Maintenance				
Repair		Manufacturer staff		

Table III - 4: Danger areas and working areas

- The excavation chamber and the area of the steering cylinders are to be considered as particularly dangerous areas during any work in the tunnel boring machine.
- The area of the Jacking frame and the complete working area in and around the shaft are to be considered as particularly dangerous areas during advance operation.

6.2 Safety devices

6.2.1 General

Safety devices protect against operational hazards, and permit the machine / system to be used in an optimum way.

Never bypass, manipulate, bridge or render useless the safety devices.

- Safety installations and protective devices reduce the risk and permit the machine / system to be used safely.
- The operator/operating personnel must know where safety installations are located and how they work.
- Prior to each operation and at regular intervals you must check the functioning of the safety devices.
- The operator/operating personnel must know where safety installations are located and how they work.
- Keep all handles, steps, handrails, platforms and ladders clean.
- Never obstruct escape routes.
- In the event of a failure of a safety devices, you must switch off the machine / system completely, and notify Herrenknecht AG.



Operation of the machine / system is only permitted when all guards are fully functioning.



Electrical safety components must be replaced after 20 years!



Bypassing, deactivating, removing or manipulating safety devices is prohibited.

6.2.2 Emergency stop button

Symbol:



Emergency stop buttons to shut down the machine / system sit in the control cabin and on the control panels installed on site.

In addition, various emergency stop switches, key switches and maintenance switches are installed on the machine / system.

As soon as a danger is detected, the machine / system must be shut down at the nearest emergency stop button.

Emergency stop buttons in the shaft

Two emergency stop buttons are available in the shaft. One button sits directly on the shaft remote control. The second one is connected to the shaft remote control via an extension cable.

These two emergency stop buttons must be installed in the shaft such that they can be reached at any time without climbing over the Jacking frame.

Pressing one of these emergency stop buttons switches off the machine / system. Lighting and crane (optional) remain in operation.

6.2.3 Main switch, key switch

- Main switch: Switching the machine / system on/off.
- Key switch: Defining different functions, e.g. control priority.
- Maintenance switch: Turn key to maintenance position before maintenance. Pull off key to prevent an unintentional restart.



DANGER!

Voltage!

Voltage on the machine / system.

- Despite switched off main switch or activated emergency stop button, different components of the machine / system are live.
 - Work on electrical components may only be carried out by qualified electricians.
 - Prior to working on electrical components of the machine/system, the voltage must be checked.
-

6.2.4 Warning signals

In case of a device failure, an audible signal sounds and the button „RESET“ or the corresponding pushbutton or LED on the control panel is ON.

At the same time, a general fault display appears on the monitor of the visualisation (optional).

6.3 Fire fighting

6.3.1 Fire extinguishers

Take the different fire types (electric fires / liquid fires) into account when you select and arrange the fire extinguishers.

There are two types of hand-held fire extinguishers: ABC and CO₂ fire extinguishers.



ABC FIRE EXTINGUISHERS	CO ₂ FIRE EXTINGUISHERS
	
<ul style="list-style-type: none"> • Solid matters • Liquids • Gases 	<ul style="list-style-type: none"> • Liquids • Electric fires

Table III - 5: Icons fire extinguisher

- The system user must install the fire extinguishers and mark their locations. The system user must ensure the proper function of the fire extinguishers and that they are serviced within the required intervals.
- CO₂ fire extinguishers must be used for fighting electric fires in the vicinity of electric systems, power generators and similar equipment.
- To secure the escape routes, fire extinguishers are distributed over the entire system. Never obstruct the access to the fire extinguishers.

6.3.2 Water curtain

In the event of a fire in the tunnel or on the machine / system, the water curtain on the machine / system at the end of the last gantry must be activated manually. The water curtain prevents excessive penetration of smoke into the machine / system or tunnel area.

6.3.3 Smoke detectors

Smoke detectors are installed on the machine / system and on the gantries. An audible alarm and a visual alarm are released when smoke is detected.

6.3.4 Heat detector

Heat detectors are installed on the machine / system and on the gantries.
An audible alarm and a visual alarm are released when heat is detected.

6.4 First aid equipment

- The system user must install first aid equipment and mark their locations. The system user must ensure that the first aid equipment is complete and functioning.
- Safety and first aid equipment must always be ready to hand.
- Whenever you are involved in first aid measures, take care of your own safety. Call a doctor immediately.

IV. Transport, assembly, connection

1. Transport	IV - 5
1.1 Safety regulations	IV - 5
1.2 Special risks	IV - 6
1.2.1 Removing the packaging	IV - 6
1.2.2 Cleaning surfaces	IV - 6
1.2.3 Contamination with oil	IV - 6
1.3 Transport regulations	IV - 7
1.4 Suspension points	IV - 8
1.4.1 Use	IV - 8
1.5 Transporting the system component	IV - 9
1.5.1 Tunnelling machine	IV - 9
Into the launch shaft	IV - 10
From the target shaft	IV - 10
1.5.2 Trailing tube	IV - 11
2. Construction site structure	IV - 12
2.1 Launch shaft and target shaft	IV - 12
2.1.1 General notes	IV - 12
2.1.2 Surveying the shaft	IV - 13
2.2 Launching seal	IV - 15
2.2.1 Assembling the launching seal in the concrete shaft	IV - 16
2.2.2 Assembling the launching seal in the sheet pile shaft	IV - 16
2.3 Reception seal	IV - 17
2.3.1 Assembling the reception seal	IV - 17
2.3.2 Remove the reception seal and recover the tunnelling machine ..	IV - 18
2.4 Positioning the jacking frame and control container	IV - 19
2.4.1 Positioning and aligning the jacking frame	IV - 20
2.4.2 Positioning the control container	IV - 20
2.5 Starting up the tunnelling machine	IV - 21

TABLE OF CONTENTS

TRANSPORT, ASSEMBLY, CONNECTION

2.5.1 Additional documentation IV - 21

2.5.2 Preparation IV - 21

 Correcting the oil level. IV - 21

2.5.3 Starting up the steering head and machine pipe 1 IV - 22

2.5.4 Starting up machine pipe 2 IV - 23

3. Installation IV - 25

3.1 Safety regulations IV - 25

3.2 Cutting tool IV - 26

 3.2.1 Removing the cutting tool IV - 26

 3.2.2 Removing the cutting tool IV - 27

 3.2.3 Brief operating instructions for hydraulic driving tools. IV - 29

 Accident and damage prevention IV - 29

 Handling instructions. IV - 31

 Bracing for the reactive moment IV - 32

 Hydraulic driving system operation IV - 34

3.3 Tunnelling machine IV - 36

3.4 Extension kit (optional) IV - 36

 3.4.1 Disassembly IV - 36

 3.4.2 Connect the bentonite lines (if this option exists) IV - 36

 3.4.3 Fitting the extension kit IV - 36

 Assembling the shield extension kit and machine pipe extension kit . . . IV - 37

3.5 Assembling the launching seal IV - 38

 3.5.1 Adapting the retention sheets to the machine diameter IV - 38

4. Connection IV - 39

4.1 Information about the electrical connection. IV - 39

4.2 Information about the hydraulic connection. IV - 40

 4.2.1 Preparing the connection IV - 41

 4.2.2 Connecting hose lines. IV - 42

 4.2.3 Laying hydraulic hoses IV - 44

 4.2.4 Screw-type coupling IV - 45

4.3 Bentonite lubrication system IV - 46

 4.3.1 General notes IV - 46

4.3.2	Connection diagram for bentonite units in the tunnel	IV - 46
4.3.3	Installing/connecting the bentonite unit.	IV - 47
	Installing the bentonite unit in the product pipe.	IV - 47
4.3.4	Pipe exchange approach	IV - 49
4.3.5	Installing a further bentonite unit.	IV - 50

TABLE OF CONTENTS

TRANSPORT, ASSEMBLY, CONNECTION

1. Transport

1.1 Safety regulations



WARNING!

Suspended loads!

Inadequately dimensioned crane, subsoil of insufficient carrying capacity, improperly dimensioned lifting accessories

- Life-threatening injuries or death by parts which are toppling over or falling down.
- The crane must adequately be dimensioned, and sit on a firm ground.
- The load handling equipment must have a sufficient load carrying capacity.
- All applicable safety regulations must be observed.
- Never stay or work under suspended loads.
- Wear your personal protective equipment during all transport work.
- Secure lifting accessories only at the lifting points provided on the system. These are marked red.

-
- Always observe the applicable safety instructions before you operate the hoisting devices and cranes.
 - Heavy machine parts must carefully be attached to hoisting devices, and must be secured before they are transported.
 - Use only suitable and technically faultless hoisting devices and load handling equipment of sufficient load capacity.
 - Secure loads reliably.
 - Only experienced personnel are allowed to attach loads.

1.2 Special risks

1.2.1 Removing the packaging

- Parts of the machine / system are packed in wooden crates. The packages must be removed carefully. Secure nails that protrude from the wood.
- The operating company of the system is responsible for the disposal or a reuse of the wood.

1.2.2 Cleaning surfaces

- Blank surfaces which were treated with protective wax for transport must be cleaned with thinner and a cloth. Provide for adequate ventilation during this work.
- Collect the used cloths and dispose of them in accordance with the applicable environmental protection regulations.

WARNING!



Dangerous gases accumulate when you work with thinner.

- Poisoning and cauterization.
 - When you work with diluting agents, wear protective clothing, safety goggles, protective gloves, safety shoes and use breathing protection.
 - Ensure that the ventilation is adequate when you work with diluting agents.
-

1.2.3 Contamination with oil

Leaking oil can not always be avoided when you connect hydraulic lines or fill the hydraulic system.

- Collect the oil with suitable means at the predictable leaking points.
- Remove contamination of any kind.
- Dispose of collected oil and oil-contaminated cloths and containers according to the local environmental protection regulations.

1.3 Transport regulations

Always observe the "Safety instructions" when you carry out transport work.



Prior to unloading the machine and system parts you must position the crane such that there is sufficient free space for additional manoeuvring. Machine and system components should always be unloaded in the immediate vicinity of the potential installation site.

1. Secure the lifting accessories to the proper suspension points.
2. Stretch the lifting accessories without actually lifting the attached load.
3. Visually double-check the stability and the employed load handling equipment.
4. Lift the load without jerky movements.
5. Transport the load to the final site and stabilize it.
6. Position and lower the attached load without jerky movements. Continue to align the load.
7. As soon as the load has correctly been positioned, release the lifting accessories and check the firm seat of the load again. Reposition if necessary.
8. Remove the lifting accessories from the suspension points.

1.4 Suspension points

1.4.1 Use

- The general accident prevention regulations apply to the selected suspension points.
- Use only suitable suspension points.
- Suspension points of the individual system components and assembly groups are marked red.
- The location of the suspension point must be such that the plane contact surface is suitable to withstand the forces that are expected to be transferred.
- Functioning and usability of a device must be checked before every use.



DANGER!

Suspended loads!

Insecurely or improperly attached loads.

Not using the load attachment points provided.

- Serious or fatal injuries from parts which are toppling over or falling down.
 - Secure lifting accessories only at the lifting points provided on the system. Other fixing points may cause the system components to fall, and exempt the manufacturer of his liability.
-



Load handling equipment must be checked by a qualified person after the assembly and at least once a year. The employed load handling elements must be checked for wear and elongation according to the regulations.



DANGER!

Suspended loads!

Damaged bolts and threaded holes.

- Serious of fatal injuries from dropping parts.
- Ensure that the threaded holes in the tunnelling machine and the bolts to secure the cable hangers are in a proper and faultless state.
- Replace damaged bolts with new ones. Recut damaged threaded holes.

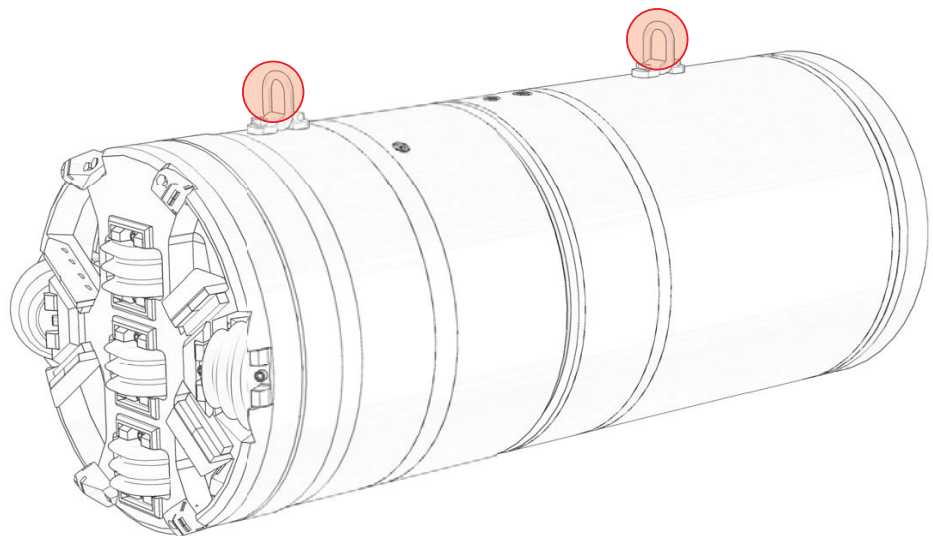
1.5 Transporting the system component



Please refer to the related drawings for a detailed specification of transport and suspension points. The drawings can be found on the enclosed CD or in a printed form in the drawings folder (see also chapter "Transport data" in Main chapter II "Product description").

The suspension points of the individual system components are highlighted in the following drawings.

1.5.1 Tunnelling machine



Example Tunnelling machine transport

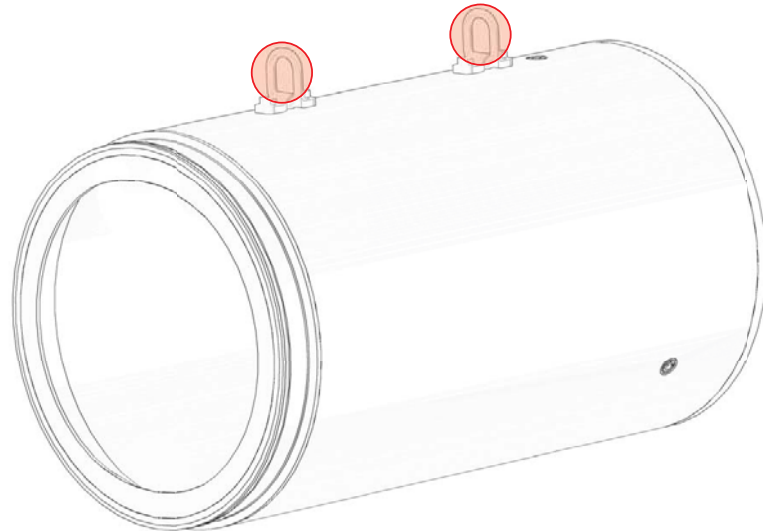
Into the launch shaft

1. Suspend the tunnelling machine on the cable hangers.
2. Slowly lower the tunnelling machine into the shaft and position the machine in the jacking frame.
3. Remove all cable hangers.
4. To protect the thread, fill all threaded holes with silicon.
5. Connect all couplings (water, hydraulics and power lines, etc.).
6. Do the same for the remaining system components.

From the target shaft

1. After reaching the target shaft, remove the silicon from the threaded holes.
2. Bolt all cable hangers onto the tunnelling machine. The contact surfaces of the cable hangers must lie flush against the tunnelling machine.
3. Disconnect all couplings (water, hydraulics and power lines, etc.).
4. Lift the tunnelling machine.
5. Do the same for the remaining system components.

1.5.2 Trailing tube



Transporting the trailing tube

Follow the same approach as for the tunnelling machine for lifting the trailing tube and lowering into the launch shaft and/or recovering the trailing tube from the target shaft.

2. Construction site structure

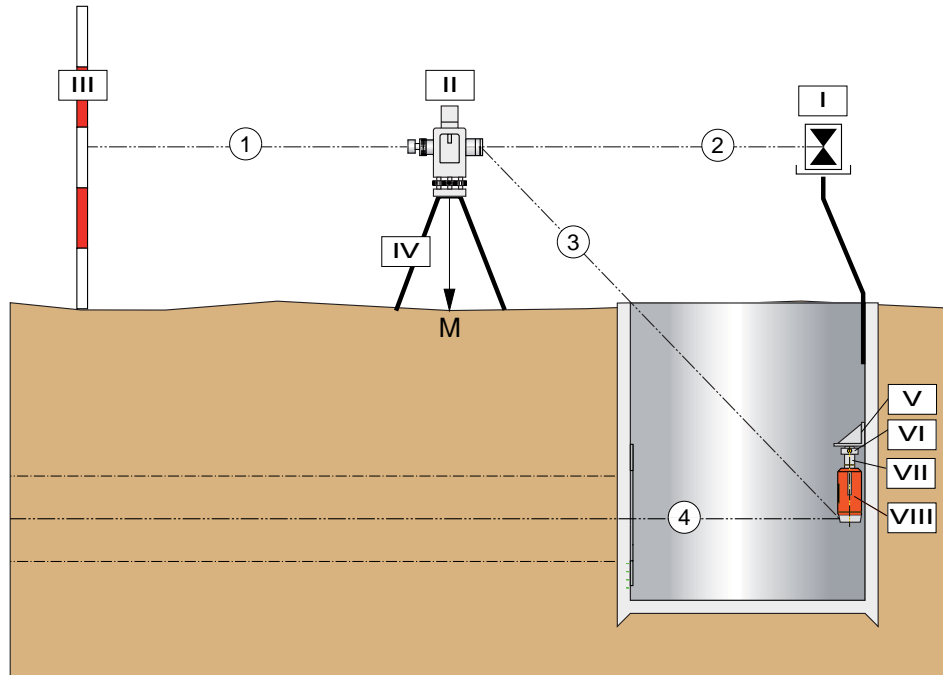
2.1 Launch shaft and target shaft

2.1.1 General notes

- The launch shaft should be perpendicular. Otherwise there can be problems with installing the Jacking frame.
- In a round shaft, you must install the bottom shaft ring perpendicularly to the pressing axis.
- To prevent the shaft from moving when the pressure force is applied, the bottom of the launch shaft must well be compacted. Insufficient soil-mechanical boundary conditions may require additional measures (e.g. injections outside the shaft) that contribute to stabilizing the shaft.
- Free space for the start-up sealing must be taken into account in the launch shaft (recess in the concrete to install the sealing lip)
- The launch shaft must be equipped such that concentrated press forces can be supported.
- Please remember that the passage openings of launch shaft and target shaft are made from lean concrete, and are not reinforced.

2.1.2 Surveying the shaft

Suggested approach for surveying the shaft



Surveying the shaft 1

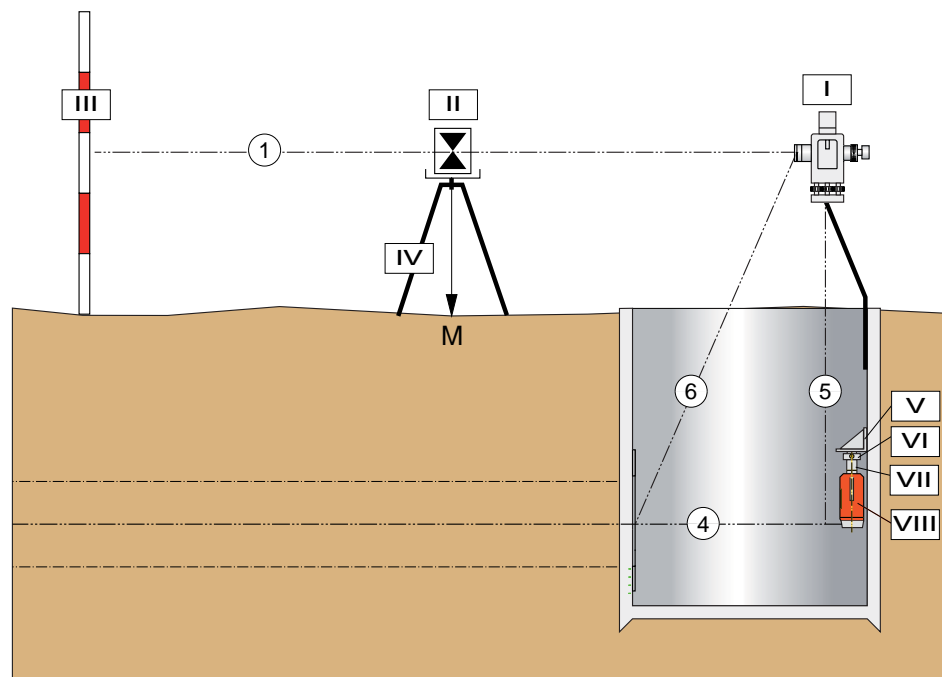
I	Target pole	M	Measuring point
II	Theodolite	1	Aim at the target point
III	Target point	2	Aim at the target pole
IV	Tripod	3	Project the axis into the shaft
V	Laser suspension point	4	Laser beam
VI	Sliding carriage	5	Theodolite plumb line axis
VII	Height adjustment	6	Projecting the axis into the shaft
VIII	Laser		

Table IV - 1: Legend shaft surveying

CONSTRUCTION SITE STRUCTURE

TRANSPORT, ASSEMBLY, CONNECTION

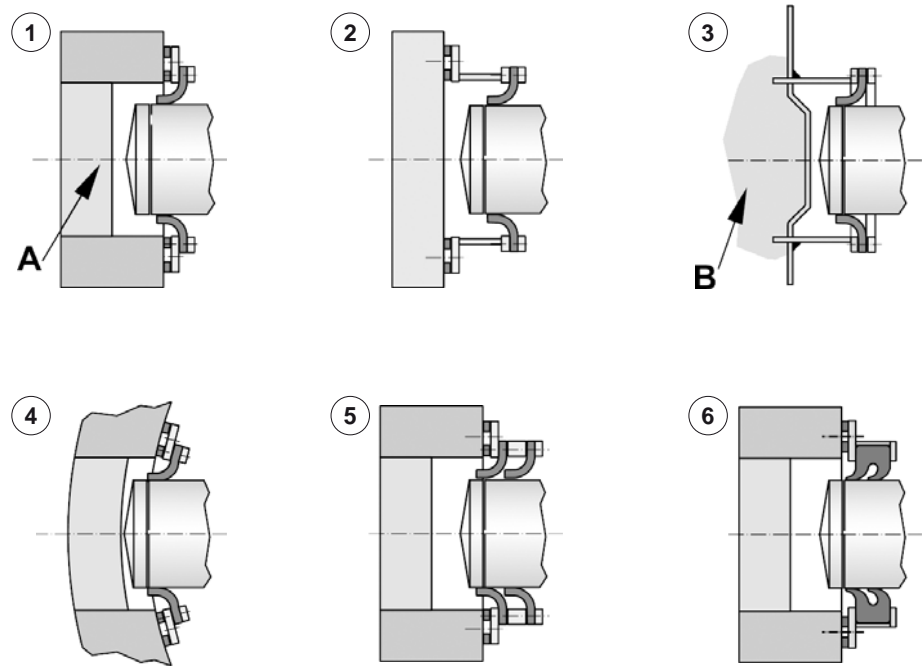
1. Set up the laser at the correct height and roughly adjust the alignment.
2. Set up the theodolite so that it is centred and levelled above measuring point (M). (The measuring point can also be behind the excavation pit.)
3. Aim at the target point.
4. Align the telescope on the theodolite with the target pole.
5. Align and level the target pole and fix in place.
6. Use the theodolite to project the alignment into the excavation pit and level the laser.



Surveying the shaft 2

1. Switch the target pole and the theodolite and aim at the target point.
2. The perpendicular axis of the theodolite must match the laser beam.
3. Use the theodolite to project the alignment into the excavation pit.
4. Align the laser beam using the directional adjustment.
5. Recheck the theodolite's perpendicular axis; if necessary repeat the steps until the theodolite's perpendicular axis matches the laser beam.

2.2 Launching seal



Various launching seals

1	Concreted rectangular shaft with recess: low water pressure.	4	Round shaft: low water pressure. Shaft type like 2 and 3.
2	Concreted rectangular shaft without recess: low water pressure.	5	Rectangular shaft: high water pressure. Shaft type like 2 and 3.
3	Rectangular sheet pile shaft: low water pressure.	6	Rectangular shaft: high water pressure. Shaft type like 2 and 3.
A	Lean concrete	B	Injection area. After injecting lean concrete, the sheet pile wall is torch cut, the seal package is fitted and welded.

Table IV - 2: Legend launching seals

2.2.1 Assembling the launching seal in the concrete shaft

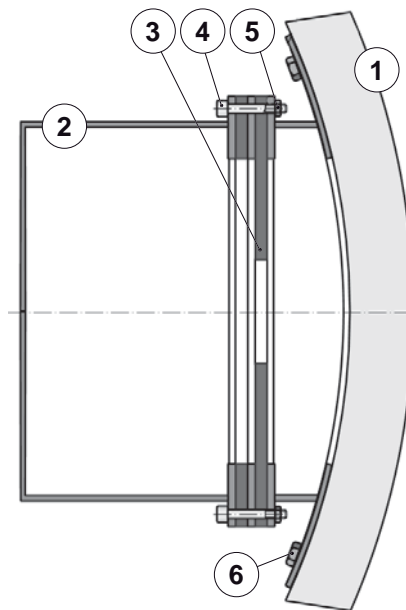
1. Position the launching seal flange plate against the shaft wall and mark the bolt hole positions for the launching seal on the shaft wall.
2. Drill the marked bolt holes for the launching seal and install rawl plugs.
3. Loosely attach the launching seal to the shaft wall using bolts.
4. Fill the gap between the shaft wall and the flange plate on the launching seal with PU foam.
5. Bolt the launching seal onto the shaft wall.
6. Check the launching seal for tightness.

2.2.2 Assembling the launching seal in the sheet pile shaft.

1. Inject lean concrete at the drive through position behind the sheet pile wall.
2. Torch cut the sheet pile wall at the drive through point.
3. Weld the launching seal flange plate into place (make sure that the welds are tight).
4. Bolt the rubber seal, clamping plate and flange plate of the launching seal into place.
5. Check the launching seal for tightness.

2.3 Reception seal

The reception seal is assembled during tunnelling or shortly before reaching the target shaft.



Example example in concrete shaft

1	Shaft wall	4	Bolts for seal
2	Reception package	5	Nuts for seal
3	Seal on reception seal	6	Bolts for shaft wall

Table IV - 3: Legend reception seal

2.3.1 Assembling the reception seal

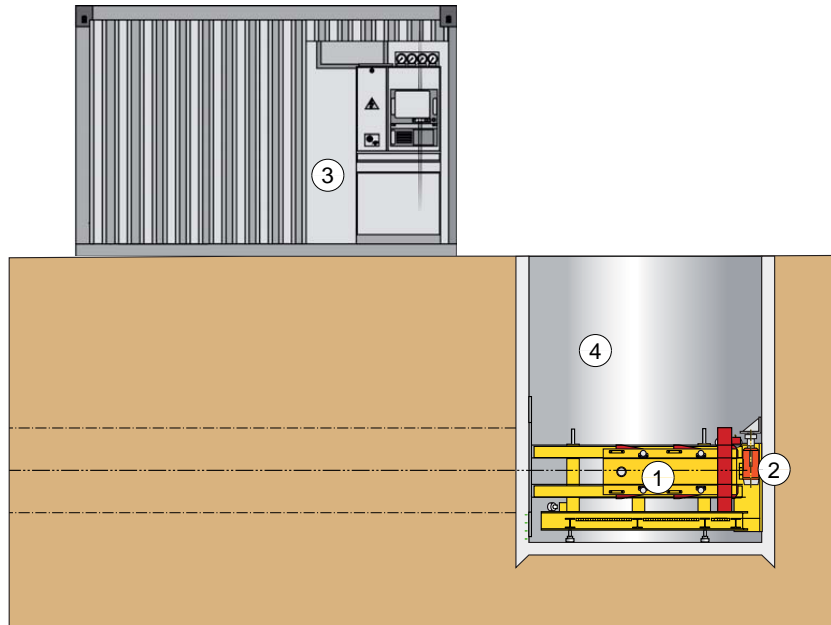
1. Bolt the reception seal onto the shaft wall. Weld on the reception seal for shafts with sheet pile walls.
2. Bolt the reception seal onto the reception seal package. Use nuts to counter the bolts on the seal.

2.3.2 Remove the reception seal and recover the tunnelling machine

Approach after driving the tunnelling machine into the reception package:

1. Drain the water or bentonite suspension from the reception package (open ball valve or plug on underside of reception package).
2. Loosen the bolts and remove the reception package along with the seal. The reception seal remains in the shaft at this point.
3. Drive the tunnelling machine through. Disconnect all couplings and recover the tunnelling machine.
4. Drive the trailing tube /machine pipe 2 through. Disconnect all couplings and recover the trailing tube /machine pipe 2.
5. After the pipe section reaches the target position on the shaft, the reception seal can be unbolted and recovered.

2.4 Positioning the jacking frame and control container



Positioning the jacking frame and control container

- | | | | |
|---|---------------|---|---------------------|
| 1 | Jacking frame | 3 | Operation container |
| 2 | Laser | 4 | Launch shaft |

Table IV - 4: Legend construction site layout

2.4.1 Positioning and aligning the jacking frame

1. Align the jacking carriage precisely using the adjusting feet. To ensure a flush fit of the tube sheet, the vertical angle and the direction must match that of the jacking axis.



To avoid damage to the thrust pipes due to uneven application of force, the tube sheet must lie flush against the pressure ring.

2. Anchor the jacking frame in the shaft. Ensure that the axial supports are tightened evenly. Uneven clamping of the jacking frame can cause undesirable torsion in the base frame and thus displacement of the guide slide bearings.
3. After aligning the jacking frame in the launch shaft, fill the gap between the abutment plate and shaft with fast setting mortar. This ensures optimum force introduction into the ground via the shaft while at the same time avoiding damage to the shaft wall.

2.4.2 Positioning the control container

1. Position the control container such that the operator has a good view into the shaft. Select the location such that lines are as short as possible. Position the control container on a horizontal foundation.
2. Grounding the operation container.
3. Connect all required lines (hydraulic and electrical).

2.5 Starting up the tunnelling machine

2.5.1 Additional documentation

Observe the drawings in addition to the text

DESCRIPTION	DRAWING NO.	ARTICLE NUMBER
Start-up situation	3474-01-000-00	30202631
Cutting wheel drive	809-04-022-00	30207773
Screw gear drive	809-08-002-00	30018956

2.5.2 Preparation

All gearboxes are filled with oil for preservation purposes.



CAUTION!

Oil level too high

- Damage to seals and bearings.
- Before commissioning check the oil level and drain the oil to the required fill level.

Correcting the oil level

Required tools / material

- Sufficiently large collecting container
- Flat spanner to match the width across flats of the oil filler screw and oil drain screw.

Drain the gearbox oil

1. Place the collecting container below the oil drain screw.
2. Remove the oil filler screw on the gearbox (breath the gearbox).
3. Remove the oil drain screw and drain the oil until the required fill level is reached.
4. Replace the oil drain screw and oil filler screw.

2.5.3 Starting up the steering head and machine pipe 1

Requirement:

- The launching seal is in place.
- The jacking frame is installed in the shaft and aligned.
- Machine pipe 2 is securely stored outside of the shaft, connected and ready for operation.
- The oil level in the gearboxes (screw conveyor drive and cutting tool drive) has been checked and is OK
- The tunnelling machine is in place in the jacking frame.

Procedure:

1. Install the start-up belt in the tunnelling machine. Make sure that the hopper is positioned below the screw conveyor gate valve.
2. Attach the start-up belt to the tailskin on machine pipe 1 using the prepared mount (see photos "Installing the start-up belt").
3. Connect the start-up belt to the power supply.



The start-up belt is equipped with a 1.5 kW drive and must be connected to a suitable power supply.

4. Push the tunnelling machine through the start-up seal.
5. Place a muck skip below the muck discharge.
 - Connect the start-up lines from machine pipe 2 to machine pipe 1.



When starting up the steering head and machine pipe 1, the grease supply for the bearing is not connected.

6. Select the direction of rotation and start up the cutterhead.
7. Start the screw conveyor and belt conveyor.
8. Open the screw gate valve and start advancing.



Installing the start-up belt

2.5.4 Starting up machine pipe 2

Requirement:

- Advancing of the steering head and machine pipe 1 complete.
- The thrust ring on the jacking frame has been retracted to starting position.

Procedure

1. Remove the start-up belt from the tunnelling machine.
2. Fit a splash guard on the screw gate valve (see photos installing the conveyor belt).
3. Position machine pipe 2 in the jacking frame.
 - Thread machine pipe 2 into the tailskin of machine pipe 1.
 - Connect all lines from machine pipe 1.

CAUTION!

No supply of grease to the seals

Soiling can enter

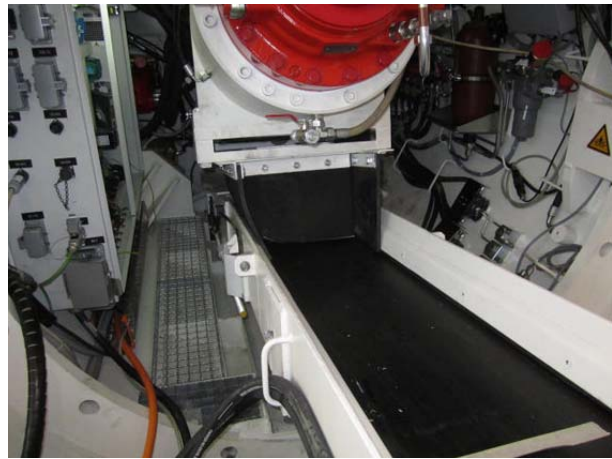
- Damage to seals and bearings.
 - Connect the grease supply for machine pipe 2 to machine pipe 1 in line with the diagram.
-



CONSTRUCTION SITE STRUCTURE

TRANSPORT, ASSEMBLY, CONNECTION

4. Install the conveyor belt (see photos "Installing the conveyor belt") and position a muck skip below the muck discharge.
5. Preselect the cutterhead direction of rotation.
6. Start the conveying system.
7. Start advancing.



Installing the conveyor belt

3. Installation

3.1 Safety regulations

Ensure that the following safety instructions are observed when you assembly the machine / system. This is necessary to avoid life-threatening injuries, system damage and other material damage.

- Only qualified persons are allowed to install the system, taking the safety instructions into account.
- Remove the transport locks only after assembly.
- Check the machine / system for transport damage before you start with the installation.
- Ensure that only authorised personnel are in the working area, and verify that no other persons are endangered by the installation work.
- All system connections (e.g. cables / hoses/ lines) must be laid such that they do no produce trip hazards.
- Always observe the specified bending radii when you lay cables/hoses/ lines.
- During any installation work you must ensure that the main switch is switched off and secured against being switched back on inadvertently.
- During any installation work you must wear your personal protective equipment, and observe the safety instructions.
- Ensure that the employed hoisting devices is sufficiently dimensioned.

INSTALLATION

TRANSPORT, ASSEMBLY, CONNECTION

3.2 Cutting tool

3.2.1 Removing the cutting tool

Clean the area between the cutting tool and the bulkhead thoroughly with a steam cleaner or high pressure water hose.



Depending on its diameter, a cutting tool weighs between 4 and 20 tonnes.

Refer to the technical specifications for the transport dimensions and weights of the installed cutting tool.

You will also find the weight of the new cutting tool in the technical specifications for the product.

DANGER!



- Serious or fatal injuries
- Before lifting any part of the machine/system, the plant operator must ensure that the crane and lifting gear are sufficiently dimensioned, and that the crane is standing on a sufficiently solid substrate; observe all applicable safety regulations.

1. Attach the cutting tool to the crane, or secure it in some other way against falling.
2. Remove the hexagon bolts and washers. Keep to the order shown in Figure 1 when doing so.

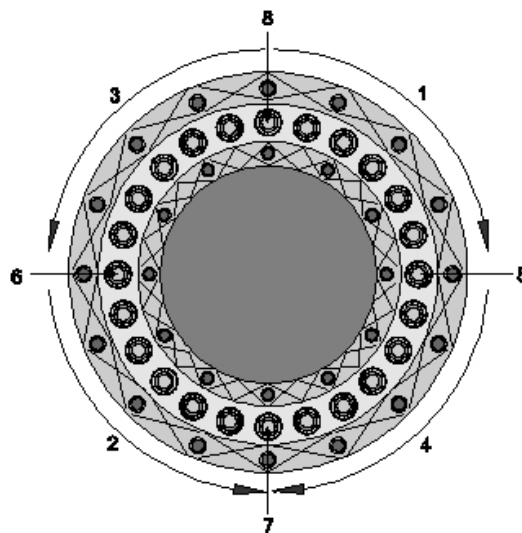


Figure 1

3.2.2 Removing the cutting tool



When changing the cutting tool, you also need to replace all of the high tensile hexagon bolts.

1. Before mounting the cutting tool clean all contact surfaces thoroughly.
-



DANGER!

Falling or dropping parts due to incorrectly dimensioned lifting gear.

- Serious or fatal injuries
 - Use lifting gear and a crane capable of bearing the weight of the cutting tool.
-

1. Use a suitable crane to transport the cutting tool to the required position.
2. Secure the cutting tool with 4 washers and bolts. (See Figure 2).
3. Tighten the bolts crosswise with a spanner until the cutting tool is correctly positioned on the drive flange.
4. Fit the remaining bolts and washers. Observe the order shown in Figure 2.

INSTALLATION

TRANSPORT, ASSEMBLY, CONNECTION

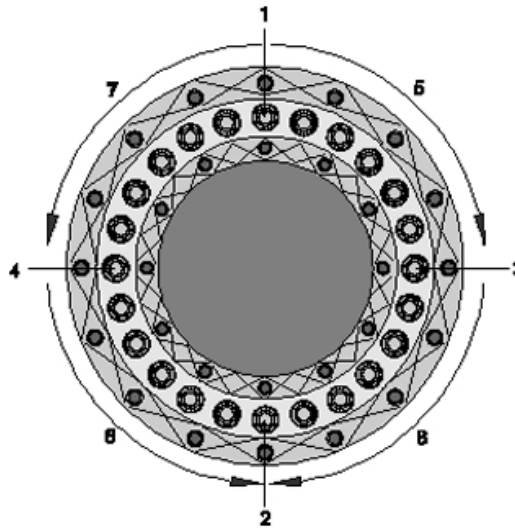


Figure 2

After fitting all the bolts, use a hydraulic driving tool to tighten to the correct tightening torque. Again keep to the order shown in Figure 2 when doing so.

3.2.3 Brief operating instructions for hydraulic driving tools

Accident and damage prevention



During operation, observe the applicable accident prevention rules, guidelines, safety rules, principles, features and other best practices for occupational safety.

-
- The device operates at a max. pressure of 800 bar. The unit is equipped with a safety valve set to the max. permissible pressure. Never change the valve setting. Additionally, the torque adjustment valve is set to the maximum pressure of the unit.



WARNING!

Incorrectly coupled hoses

- Risk of accident
- Make sure the hose coupling latches correctly into place; secure hose couplings with a threaded ring.

-
- Use the handles provided for transporting and holding the unit. During operation, never hold the support, the moving parts, or the hoses on the unit. Position the unit's handle so that the handle is outside of the danger area.
 - Ensure a safe, positive locking coupling between the unit and the screw union, and between the support and abutment plate so that the unit cannot slip off during operation. During operation, monitor the correct position of the unit. The unit must only be used in the area shown on pages 19/20 to avoid the risk of damage to the unit.
 - During operation, keep out of the driving unit's longitudinal axis as components, or the screw union, can fracture and the unit can be propelled off the screw union.

INSTALLATION

TRANSPORT, ASSEMBLY, CONNECTION

- Only expose ratchet heads and accessories to the maximum torque permissible for these parts. The permissible torques for normal operating conditions are stamped onto the ratchet heads and accessories.
- Protect the unit against knocks and falling. Do not remove the covers and protective equipment from the unit. Secure accessories against falling out and dropping.
- In most cases, the torques required for loosening screw unions are far higher than those required for tightening. In this scenario, standard sockets and accessories typically do not offer the strength required. The unit's output is also typically greater than that of the accessories. For this reason, always make sure that accessories are only exposed to the maximum loads stamped on them. Overloading can cause fractures which in turn can lead to injuries.
- Make sure the hose coupling latches correctly into place. Secure hose couplings with a threaded ring to avoid accidental detaching.
- Allow sufficient clearance for hose connections. Never bend or twist high pressure hoses; do not drag over sharp edges. Do not expose to temperatures above 70°C. Regularly check hoses and couplings for damage. In case of hose leaks, immediately disable the unit. Replace all hoses, couplings, etc. in case of visible damage. Observe safety regulations for hydraulic hose lines.
- If the return stroke hose is not attached, or in case of defective couplings in the return stroke hose, an overpressure safety valve opens in the hose connection of twin hose units. The backlog of oil can then escape without any risk.

WARNING!

Changing the overpressure safety valve setting.



- Risk of accident!
- Never change the setting of the overpressure safety valve.

-
- Changing the setting of the overpressure safety valve involves a risk of the hose or some other component bursting due to the high pressure.

Handling instructions

OPERATING MODE	PLEASE OBSERVE	POSSIBLE CONSEQUENCES IN CASE OF FAILURE TO OBSERVE	REMEDY
Permanent load	Only use the driving unit up to max. 75 % of its torque output.	Damage to the unit	Use a more powerful unit.
Support situation	Observe the guidelines in the operating manual.	Overload of the drive frame due to bending forces; deformation of the torque arm; reduced torque output and/or imprecise torque output.	Set up the supports as shown in the guide.
Normal operation	Observe the torque table for the unit and the torque limits for the accessories.	Breakage of the unit or accessories. Risk of accident!	See the torque table in the operating instructions and the specifications on the unit and/or accessories.
	Observe the maintenance interfaces as per the operating instructions.	Unit malfunctions	Observe correct lubrication and check for wear.
	If the unit fails to build up hydraulic pressure.	Hose connection between the power unit and the unit not okay. Hose line not tight, device not tight. Oil leakage.	Connect the hoses correctly; make sure the hose couplings latch into place. Secure hose couplings with threaded ring. Replace hose lines or couplings. Call customer service.

Table IV - 5: Handling instructions

For maintenance intervals and maintenance instructions for the unit, see the manufacturer's documentation.

Bracing for the reactive moment



The driving system can and must be deployed with the provided support only. Do not modify the support arm and support leg beyond the defined permissible dimensions.

Before switching on the driving system tighten the support (torque arm or counter holder) against the abutment plate on the screw union in the opposite direction to the direction of rotation.

WARNING!

Device slipping off



- Injuries, crushing
- The abutment plate on the screw union must be designed so that the support cannot slip off the contact surface!

CAUTION!

Partial contact of the support on a slanted surface. High levels of force with the tendency for the support to slip off the unit, or the unit off the bolt



- . Danger of breakage to accessories
- The abutment plate on the screw union must be designed so that the support cannot slip off the contact surface!

The following guidelines apply for the whole swivel range of the support.

Support swivel range

OPTIMUM SUPPORT

IMPERMISSIBLE SUPPORT

OPTIMUM SUPPORT	IMPERMISSIBLE SUPPORT
-----------------	-----------------------

Table IV - 6: Optimum/Impermissible support

Hydraulic driving system operation

The hydro-unit creates hydraulic pressure which can be set at a pressure limiting valve and read off at a manometer. High pressure hoses (supply and return line) feed this pressure to the driving system which converts it into a torque via a lever and nut system.

1. Insert the required accessory into the device; place the adapter bush on the shaft and secure in place. To release a screw union, insert the accessory into the device from the opposite side. On each change, ensure that the adapter bush and the bearings in the housing are sufficiently lubricated.
2. Connect the high pressure hoses to the driving system and hydraulic unit. Make sure that the quick couplings latch into place. Make sure the hose coupling latches correctly into place. Secure hose couplings with a threaded ring to avoid accidental detaching. Ensure that the hoses are routed without obstruction.
3. Press the "On Advance" button on the remote control and hold down until the pressure setting is complete. Turn the pressure adjustment valve on the unit to set the pressure for the required torque and read off on the manometer. If the manometer does not have a torque scale, set the pressure for the required torque in line with the enclosed torque table.

4. Hand-tighten the bolt to be tightened. To keep friction in the thread and the head contact surface to a minimum, we recommend using a lubricant (e.g. Molykote or similar).
5. Apply the driving system to the screw union so that the complete height of the bolt head and or the nut is enclosed in the socket head. If this is not possible, reduce the torque applied via the accessory, or use a special socket or a different accessory.
6. Swivel the driving system support against a suitable counter holder opposite to the driving direction. Make sure the system is securely supported. Avoid skewing the system and/or the accessories on the screw union. If the support situation leads to pronounced skew of the system or the accessories, maximum torques must be reduced for safety reasons.
7. Make sure the high pressure hoses are freely routed and that there is sufficient clearance for the hose connection. Never kink hoses. Pressing the "On Advance" button moves the piston in the system's cylinder to the end position and thus causes a rotational movement of the hexagon socket or any other accessory used. The torque is transferred to the screw union by the inserted accessory.

The piston retracts automatically when the button is released. Applies to units with a separately controlled advance and retract stroke: press and hold the "Advance" button - the piston advances; press and hold the "Retract" button - the piston retracts. Actuate the button until no rotational movement is visible; the preset torque has now been reached. After the pressure display drops to zero on the manometer, press the "On Advance" button again on the unit and build up the preset pressure. Monitor the pressure display and the driving system until standstill.



On each return stroke, you will be able to hear the carrier clicking. This ensures that the ratchet lever is retracted by the piston.

The units are equipped with an automatic switch-off system to prevent the oil heating. If the remote control is not used for a period of 20 seconds, the unit automatically switches off. Press the "On Advance" button to be able to carry on working without delay.

After completing the driving process, press the "Off" button; the unit switches off. Before detaching the hose, press the "Off" button multiple times. After detaching the hoses, you must protect the connections with seal caps to avoid dirt entering the oil lines.

3.3 Tunnelling machine

1. Position the tunnelling machine in the jacking frame and connect.
2. Test all machine functions.

3.4 Extension kit (optional)

3.4.1 Disassembly

- Remove the cutterhead tool.
- Remove the wear ring.
- Remove the tailskin.
- Remove the seals.

3.4.2 Connect the bentonite lines (if this option exists)

1. Connect the bentonite lines between the tunnelling machine and the extension kit.
2. Seal any threaded holes that are not in use with silicon or grub screws.

3.4.3 Fitting the extension kit

Always observe the following points when fitting extension kits:

- Grease the guide rails on all of the extension kits to reduce friction.
- When assembling the extension kit on the tunnelling machine or the machine pipe, the tunnelling machine and the machine pipe must be attached to the rear of the crane and dragged into the respective extension kits from the front.
- Use chain hoists or winches. Bolt threaded spindles into each machine pipe; they are used to help centre the extension kit in the correct position.
- Use the threaded rods and nuts to pull the extension kit into its final position.

Assembling the shield extension kit and machine pipe extension kit

1. Push the tunnelling machine from the rear into the shield extension kit.
2. Fit the shield articulation sealing on the machine pipe extension kit.
3. Push the machine pipe extension kit from the rear into the tunnelling machine. While doing so, take care to avoid damaging the seal between the shield extension kit and the machine pipe extension kit.
4. Bolt the steering head extension kit onto the tunnelling machine.
5. Bolt the tailskin onto the machine pipe extension kit. Take care to avoid damaging the o-rings while doing so.
6. Tighten all screws to the required torque.
7. Bolt the wear ring supplied with the cutterhead onto the steering head extension kit and tighten all bolts to the required torque.

3.5 Assembling the launching seal

1. Position the seal carrier on the shaft wall. Observe the tunnel axis.
2. Mark all drill holes.
3. Remove the seal carrier.
4. Drill all required holes and insert rawl plugs.
5. Grease the o-ring groove in the seal carrier and insert the o-ring.
6. Press the o-ring side of the seal carrier against the shaft wall and bolt into place.

3.5.1 Adapting the retention sheets to the machine diameter



CAUTION!

Machine damage!

Starting with a rotating cutterhead tool.

- Damage to the launching seal.
- The cutterhead tool on the tunnelling machine must be stationary when pushing through the launching seal.

1. Push the tunnelling machine into the launching seal.
2. Release the screws on the retention plates.
3. Push the retention plates to the tunnelling machine.



The minimum gap between the tunnelling machine/product pipe and the retention plate is 3 mm.

The maximum gap between the tunnelling machine/product pipe and the retention plate is 5 mm.

4. Tighten all bolts to the required torque.

4. Connection

4.1 Information about the electrical connection

- An authorized expert must establish the connections to the power supply and implement the protective measures in accordance with the DIN VDE regulations and the provisions of the utility responsible.
- Prior to switching on the system, the insulation of the main distributor feeder must be tested!
- VDE regulations and the regulations of the country concerned must be observed.
- The applicable national and international regulations must be observed for the electrical supply lines in the tunnel.
- Observe the minimum bending radius
- The emergency stop cable is connected according to the electric diagram.
- To ensure proper functioning, all couplings (electric and hydraulic couplings) must completely be screwed / plugged together.
- Control lines are control cables with an integrated power supply up to 400 V DC. Prior to separating the plug-in connections you must switch off the electrical power on the control lines.
- The electrical connection must be made by a qualified electrician. The corresponding country-specific regulations must be considered.

4.2 Information about the hydraulic connection

The functional safety and service life of the hydraulic system depends on a proper handling. The following directives should therefore always be observed

- **Commissioning and maintenance of oil-hydraulic systems (VDI 3027)**
- **German Standard "Hydraulic systems" DIN 24346**
- **ISO standard ISO 4413**

WARNING!



The supporting mesh of the hydraulic hoses can kink or break when vehicles drive over the hydraulic hoses.

- Risk of injury from spurting pressurized hydraulic oil.
 - Route the hydraulic hoses on the ground such that they are protected against damage. Use a transfer bridge, for example, to protect hydraulic hoses against damage from crossing vehicles.
-

WARNING!

Risk of tripping!



Tripping hazard from improperly laid hydraulic hoses.

- Sprains and bone fractures.
 - Always lay hydraulic hoses such that there are no trip hazards.
-

4.2.1 Preparing the connection

With each hydraulic connection, you must observe the following points:

- The environment in which hydraulic connections are installed and/or parts are replaced or added must be clean.
- The hydraulic oil must be free from contamination and humidity.
- The hydraulic oil tank must be clean.

CAUTION!



Insufficiently filtered hydraulic oil.

- Damaged hydraulic components.
 - Refilling hydraulic oil or new filling of the power unit through a 1...3 μm fine filter.
 - Topping up hydraulic oil or refilling the power unit only via the filler connection
-

CONNECTION

TRANSPORT, ASSEMBLY, CONNECTION

4.2.2 Connecting hose lines

- To avoid tension and transverse forces onto the pipelines and the equipment, never use force during assembly.
- Never use putty or hemp for sealing. These sealing materials can contaminate the hydraulic oil and thus cause malfunctions.

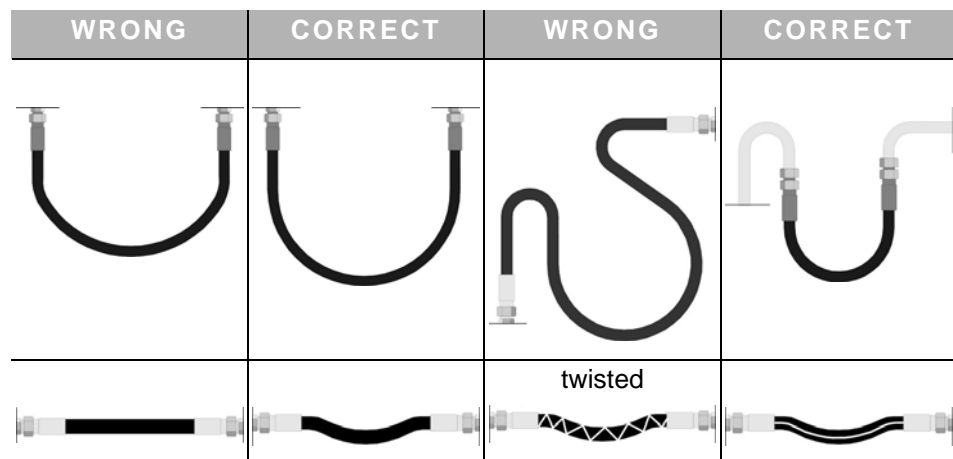


Table IV - 7: Hose lines

Hoses connect connecting points which move towards each other. Always observe the following instructions for laying hose lines:

- Lay the hose line with a sag to compensate for any shortening of the hose.
- Do not twist the hose lines during installation.
- Do not bend the hoses excessively.
- Use pipe bends or elbow sections.
- Observe the minimum bending radii of the hoses. Minimum bending radii refer to a rigid routing of the hose lines. The bending radius of a hose should be as large as possible if the hose has to be moved frequently at a narrow bending radius (continuous operation).
- Prior to putting the system into operation you must check the sense of rotation of the hydraulic pumps.

CAUTION!



Illegal bending radii of the hose lines.

- Kinking damages the hose.
- Observe the minimum bending radii.
- Make sure that the hoses are not bent. Use external supporting spirals if required.

CAUTION!



Sealing hydraulic lines with cotton waste or other fibrous material.

- Contamination of the hydraulic oil, and thus malfunctions up to destruction of the hydraulic component.
- Never use fibrous material for sealing hydraulic lines.

4.2.3 Laying hydraulic hoses



Hydraulic hoses must be routed such that they

- are parallel
- do not chafe
- are not twisted
- do not hit
- are not laid in a narrow radius

1. Route the hydraulic hose between the power unit and the consumer. Do not open the sealing cap.
2. Open the sealing cap to the power unit. Leave the other end closed.
3. Unscrew the plug at the power unit connection point and install the hose. Escaping hydraulic oil must be collected.
4. Open the sealing cap of the consumer or the next hose.
5. Open the sealing cap of the already routed hose and screw it to the consumer or to the next hose.
6. Check whether all hoses have been properly fastened and all bolted connections are tight.
7. Check the oil level on the hydraulic power unit and refill it if required.
8. Operate the hydraulic power unit without load until the air has escaped from the hydraulic circuit. If necessary open a plug at the top and bleed the circuit.

CAUTION!

Risk of slipping!

The hydraulic hoses are filled with oil.



- Risk of skidding and damage to the environment from escaping hydraulic oil.
- Always open hydraulic hoses at one side only.
- Always collect leaking oil and dispose of it in accordance with the environmental protection regulations.
- Remove spilled hydraulic oil immediately.

4.2.4 Screw-type coupling

The screw-type coupling is a coupling that locks on both sides. The valves in the female and male halves open and close automatically during the coupling process. The screw-type lock allows the coupling to be achieved against a residual pressure. The coupling minimises the pumping medium loss during the coupling and disconnecting operations. Coupling under the full operating pressure is not allowed. Do not use pliers for coupling and uncoupling.



Screw-type coupling

1 female halves

2 male halves

Connecting

1. Remove contamination on coupling parts and clean the connecting pieces.
2. Place male half axially centred on the plug part of the female half.
3. Keep screwing the male half against the spring forces of the valve springs and against any remaining pressure onto the female half.
4. Pressure-relief valve will open automatically. A small amount of the pumping medium will escape.
5. Screw connecting thread of the male half to the female half as far as it will go.
6. This will lock and seal the coupling.

Disconnecting

1. Hold the male half and unscrew it counter clockwise from the female half.
2. This will close the valves in the coupling halves by spring force.
3. This will unlock the coupling, allowing it to be taken off.

4.3 Bentonite lubrication system

4.3.1 General notes

At least one shut-off valve must be installed in the bentonite line and the compressed air line. These two shut-off valves should be in the shaft near the coupling point if possible.

It is also a good idea to install additional shut-off valves on the compressor pressure vessel and the bentonite pump outlet side to be able to interrupt the flow of bentonite and compressed air if the need arises to replace damaged lines to or in the shaft.

4.3.2 Connection diagram for bentonite units in the tunnel

Connection diagram for bentonite units in the tunnel

- | | | | |
|---|-----------------------|---|---|
| 1 | Ball valve (optional) | 5 | Compressed air hose up to 10 bar operating pressure |
| 2 | Bentonite unit | A | Bentonite nozzle (crown) |
| 3 | Hose 22 L/DN 20 | B | Bentonite nozzle (left) |
| 4 | Hose 28 L/DN 25 | C | Bentonite nozzle (right) |

4.3.3 Installing/connecting the bentonite unit

Connecting the bentonite unit

1	Compressed air actuated valve	4	Electric connection
2	Tunnel line connection	5	Tunnel line connection
3	Compressed air connection	6	Bentonite valve control cable

Installing the bentonite unit in the product pipe

Required tools / material

- Hand drill with stone bit to match the rawl plugs used.
- 4 rawl plugs per lubricating unit.
- Allen key to match the hexagon head on the bolts
- Flat spanner

Procedure

1. Mark the drill holes for rawl plugs at the required positions in the product pipe.
2. Drill the plug holes to a sufficient depth q.
3. Insert the rawl plugs.
4. Bolt the lubricating unit into the product pipe.
5. Connect the bentonite valves to the lubricating unit.

CONNECTION

TRANSPORT, ASSEMBLY, CONNECTION



CAUTION!

Seal missing between male and female connectors - connection not secured.

- Moisture on contracts (corrosion)
- Inadvertent separation of the connection, signal loss
- When laying the electric cables, make sure that the seal between the male and female connectors is in place and undamaged.
- Secure the two parts with a locking lever.

6. Connect the control line and power supply from the control cabin to the lubricating units in the tunnel to connector 4.
7. Connect the bentonite line with the t-piece on the bentonite unit (connector 2).
8. Connect the compressed air supply line with the quick couplings on the bentonite unit (connector 3)
9. Actuate the individual valves in the block to test whether the bentonite unit is working correctly. To do so select only one of the 3 newly fitted bentonite valves in the visualisation and press the start button at the control console.



Bentonite unit no. 1 must always be installed as the first bentonite unit in the bentonite system. This unit is equipped with a terminating resistor which is needed for controlling the system.

4.3.4 Pipe exchange approach

1. Switch off the bentonite lubrication (press the ON/OFF button). Any valves that are open at this point will now close.



DANGER!

Voltage!

Danger from touching voltage-carrying parts or damaged cables.

- This can lead to serious paralyzation and burns, that can even be fatal.
- Never touch live parts.
- Switch off the power before you start working on the electric system. Only skilled electricians are allowed to work on the electric system.

-
2. Switch off the bentonite pump and shut off the valve in the bentonite line.
 3. Shut off the valve in the compressed air line.



DANGER!

Opening pressurised lines/pipes.

- Risk of serious injuries.
- Do not open lines/pipes that are under pressure.

-
4. Interrupt all lines at the corresponding coupling points in the shaft.
 5. Insert the product pipe into the jacking frame.
 6. Pull all the lines through the product pipe and connect.
 7. Open the compressed air and bentonite supply lines again.
 8. Re-connect the bentonite controller.

CONNECTION

TRANSPORT, ASSEMBLY, CONNECTION

4.3.5 Installing a further bentonite unit

1. Switch off the bentonite controller as described above in items 1 - 4.
2. Uncouple any control and supply lines that lead out from the tunnel (bentonite and compressed air lines).
3. Connect the bentonite line in the tunnel and the bentonite line in the shaft with the t-piece on the bentonite unit.
4. Connect the compressed air line from the previous bentonite unit to the new bentonite unit via the t-piece.
5. Connect the shaft compressed air supply line to the t-piece.
6. Route the control line and power supply from the previous bentonite unit to the new one and connect.
7. Route the control line and power supply from the previous bentonite unit to the new one and connect.
8. Switch on the bentonite controller and test the bentonite units as described in item 5 "Testing the bentonite unit connection".

V. Operation

1. About this main chapter	V - 5
2. Control elements	V - 6
2.1 Control cabin	V - 6
2.1.1 Button and switch assignments	V - 8
Control area ON / OFF button	V - 8
Steering cylinder control area	V - 10
Operating area thrust cylinder	V - 11
Cutting tool control area	V - 12
Control area belt conveyor	V - 15
Control area screw conveyor	V - 16
Control area interjack preselection	V - 18
Control area interjack functions	V - 19
2.2 Auxiliary control panel	V - 21
2.2.1 Overview	V - 21
2.2.2 Button and switch assignments	V - 22
2.3 Cutting tool control panel	V - 25
2.3.1 Overview	V - 25
2.4 Shaft panel	V - 29
2.5 Performance panel	V - 34
2.6 Video monitoring	V - 38
3. Basic functions	V - 39
3.1 Switch on cutting tool	V - 39
3.2 Switch on conveyor system	V - 39
3.3 Position the muck skip under the muck discharge	V - 39
3.4 Advance	V - 39
4. Commissioning	V - 40

TABLE OF CONTENTS

OPERATION

- 4.1 Safety regulations V - 40
 - 4.1.1 General V - 40
 - 4.1.2 Dangers during commissioning V - 41
 - 4.1.3 Requirements placed upon the executing personnel V - 41
 - 4.1.4 Frequent commissioning mistakes V - 42
- 4.2 Initial commissioning V - 43
 - 4.2.1 Power supply V - 43
 - 4.2.2 Hydraulic system V - 43
 - Hydraulic hoses V - 44
 - 4.2.3 Gearbox V - 44
 - General V - 44
 - Correcting the oil level V - 44
 - Oil level too high V - 45
 - Oil level too low V - 45
 - 4.2.4 Further checks V - 46
- 4.3 Daily startup V - 46
- 4.4 Commissioning of the hydraulic power unit V - 47
 - 4.4.1 Test run V - 47
 - 4.4.2 Leak test V - 48
 - 4.4.3 Bleeding the hydraulic system V - 48
 - Check whether there is air in the hydraulic system V - 49
 - 4.4.4 Temperature monitoring V - 50
 - 4.4.5 Hydraulic oil level V - 51
 - Special notes V - 51
 - Top up hydraulic oil V - 51
 - Changing hydraulic oil V - 52
- 4.5 Commissioning the conveying system V - 52
 - 4.5.1 Commissioning the belt conveyor V - 52
 - 4.5.2 Commissioning the winches V - 52
- 4.6 Individual commissioning V - 53
 - 4.6.1 Pressure setting for the thrust cylinders V - 53
- 5. Operation V - 55**

TRANSLATION

4.1	Safety regulations	V - 40
4.1.1	General	V - 40
5.1.2	Hazards during operation	V - 56
5.1.3	Requirements placed upon the executing personnel	V - 57
3.4	Advance	V - 39
5.2.1	Start advance operation.....	V - 58
5.2.2	During advance operation.....	V - 58
5.2.3	Terminating advance operation.....	V - 58
5.3	Tunnel boring machine with four steering cylinders	V - 59
5.3.1	Prerequisites to steer the tunnel boring machine	V - 59
5.3.2	Steering movements in normal soil.....	V - 60
5.3.3	Steering movement in very hard soils.....	V - 61
5.3.4	Additional information about steering	V - 62
5.4	Cutting tool	V - 63
5.4.1	Sense of rotation and roll correction	V - 63
5.4.2	Releasing the cutting tool	V - 64
5.5	Interjack station	V - 65
5.6	Jacking frame	V - 66
4.1.1	General	V - 40
5.6.2	Extending and retracting the thrust cylinders	V - 67
	Controlling the thrust cylinders via the control panel.....	V - 67
	Controlling the thrust cylinders via the shaft panel	V - 67
6.	Fault elimination	V - 69
6.1	Fault analysis.....	V - 69
6.2	Troubleshooting.....	V - 70

TABLE OF CONTENTS

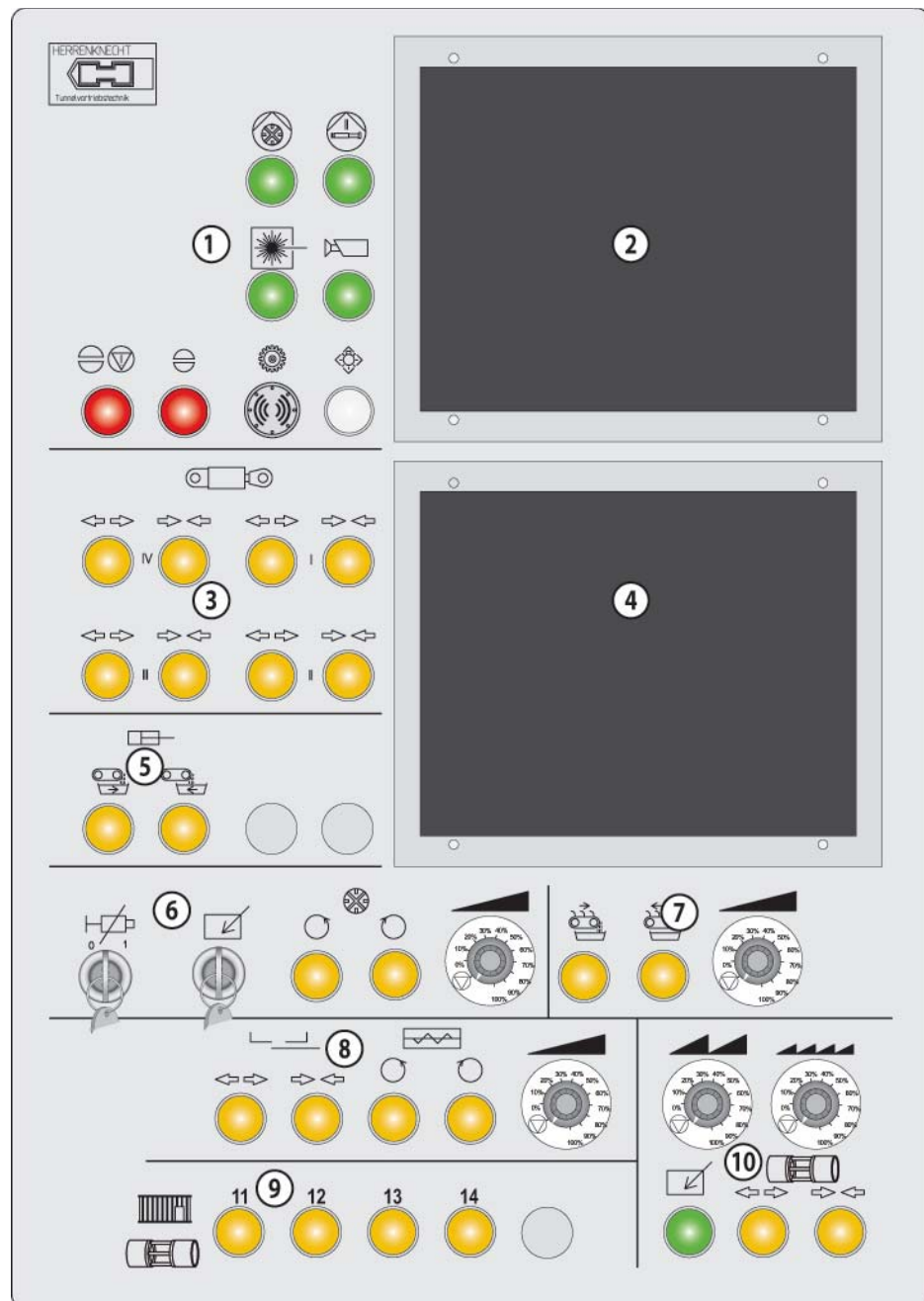
OPERATION

1. About this main chapter

- The main chapter describes and explains the following topics:
 - Control elements: Explanation and description of control elements.
 - Commissioning: Description of commissioning.
 - Operation: Typical operation of the tunnelling system.
 - Fault elimination: Description and elimination of frequently occurring faults.

2. Control elements

2.1 Control cabin



Overview control cabin

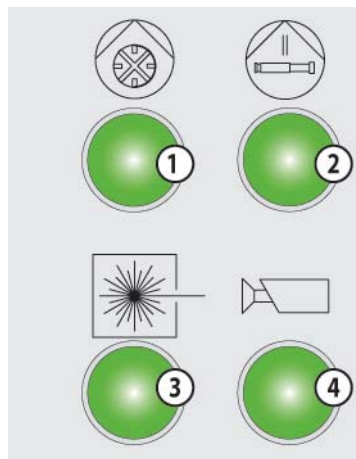
1	On/Off button	6	Control elements cutting tool
2	Measuring screen	7	Control elements belt conveyor
3	Control elements steering cylinder	8	Control elements screw conveyor
4	Visualisation screen	9	Control elements interjack preselection
5	Control elements thrust cylinder	10	Control elements interjack control

CONTROL ELEMENTS

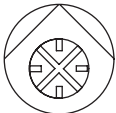
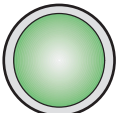
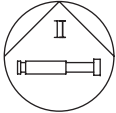
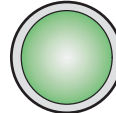
OPERATION

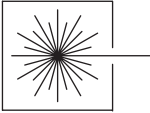
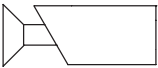
2.1.1 Button and switch assignments

Control area ON / OFF button



Area ON / OFF button

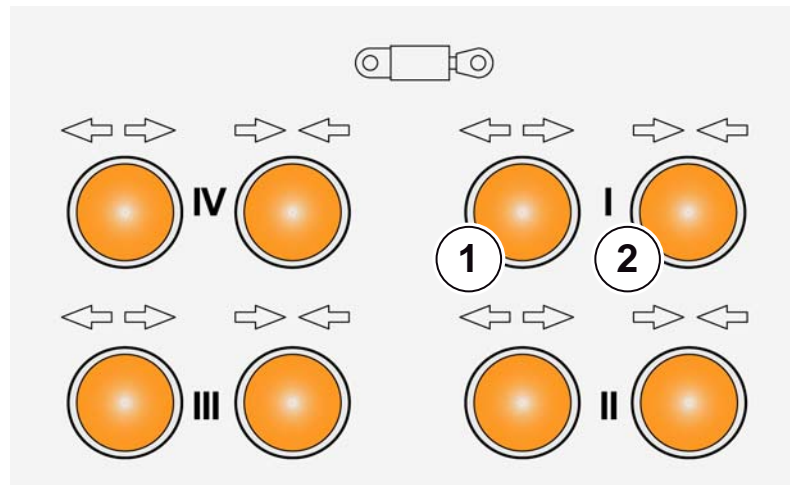
ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	 	Press the button. The lamp in the button is lit.	Actuated component / the component is switched on
		Press the button again. The lamp in the button is unlit.	Actuated component / the component is switched off
2	 	Press the button. The lamp in the button is lit.	Actuated component / the component is switched on
		Press the button again. The lamp in the button is unlit.	Actuated component / the component is switched off

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
3		Press the button. The lamp in the button is lit.	Actuated component / the component is switched on
		Press the button again. The lamp in the button is unlit.	Actuated component / the component is switched off
4		Press the button. The lamp in the button is lit.	Actuated component / the component is switched on
		Press the button again. The lamp in the button is unlit.	Actuated component / the component is switched off

CONTROL ELEMENTS

OPERATION

Steering cylinder control area



Steering cylinder control area

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
------	-----------------------------	----------	----------

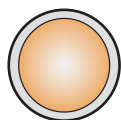


1 Extending the steering cylinders



Press and hold the button
 - The lamp in the button is ON

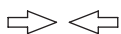
The controlled component is switched on



Release the button.
 - The lamp in the button is OFF

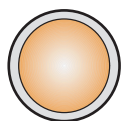
The controlled component is switched off

2 Retracting the steering cylinders



Press and hold the button
 - The lamp in the button is ON

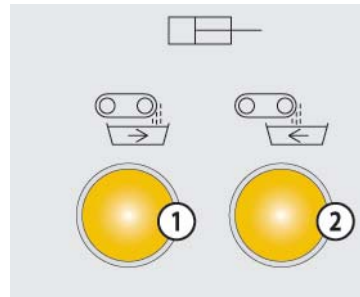
The controlled component is switched on



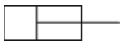

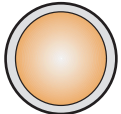
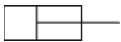

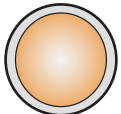
Release the button.
 - The lamp in the button is OFF

The controlled component is switched off

Operating area thrust cylinder



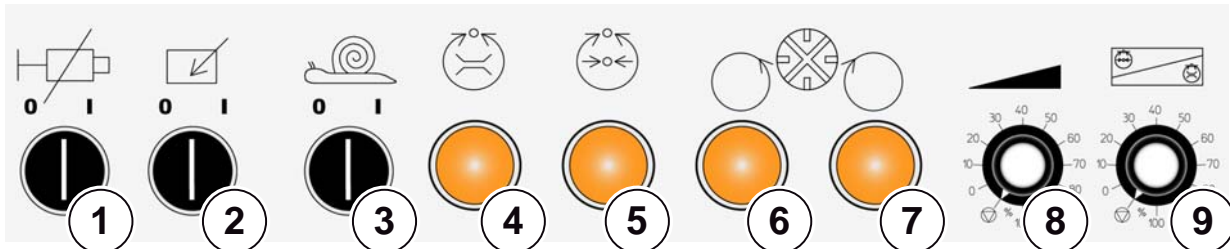
Operating area thrust cylinder

POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	  	Hold the button down. The lamp in the button is lit.	The thrust cylinder extends. The slurry carriage is moved in the direction of the tunnel.
2	  	Hold the button down. The lamp in the button is lit.	The displacement cylinder retracts. The slurry carriage can be dragged further under the belt conveyor.

CONTROL ELEMENTS

OPERATION

Cutting tool control area



Cutting tool control area

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	Grease bridging		
		Turn the key switch clockwise (towards I)	The tunnel boring machine is operated without grease lubrication - This function may only be used briefly
		Turn the key switch anticlockwise (towards 0)	Grease bridging is switched off

WARNING!

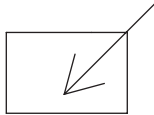
Using the machine with activated grease bridging for a longer time



- Damage to seals
- Damage to gear
- The activation of the grease bridging function must be agreed with the construction site manager or HERRENKNECHT AG.
- The key must be deposited with the construction site manager or a person responsible.

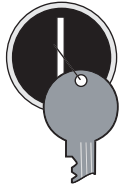
ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
------	-----------------------------	----------	----------

2 Cutting tool control priority



Turn the key switch in the operation container clockwise (towards I). Control priority is active at the operation container.

- To activate the control priority in the operation container you must turn the key switch on the control panel in the tunnel boring machine to 0.



Turn the key switch in the operation container anticlockwise (towards 0). Control priority is inactive at the operation container.

- To obtain the control priority at the control panel in the tunnel boring machine, you must turn the key switch on the control panel in tunnel boring machine to I.

DANGER!

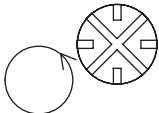
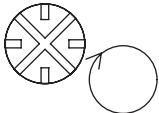
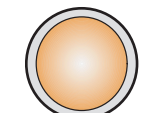
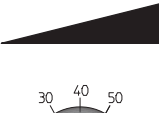
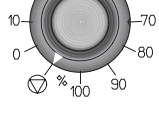
The key for the control priority of the cutting tool must be removed during maintenance and repair work on the machine / system.



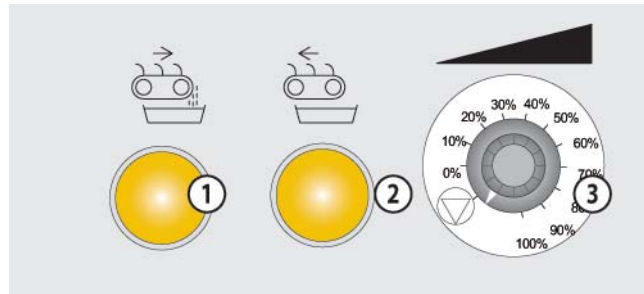
- Serious injuries or death
- Damage to the system
- Secure the system against being switched back on during maintenance and repair work.
- The key must be deposited with the construction site manager or a person responsible.

CONTROL ELEMENTS


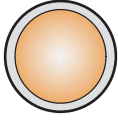
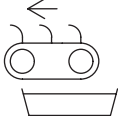
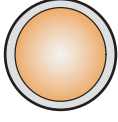
OPERATION

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
3		Press the button - The lamp in the button is ON	Preselection to rotate the cutting tool anticlockwise
		Potentiometer for the cutting tool speed must be at STOP.	
4		Press the button - The lamp in the button is ON	Preselection to rotate the cutting tool clockwise
		Potentiometer for the cutting tool speed must be at STOP.	
5		Press the „Preselect CW sense of rotation of the cutting tool“ button - The lamp in the button is OFF	Preselection of the sense of rotation is changed
		Potentiometer for the cutting tool speed must be at STOP.	
5		Press the „Preselect CCW sense of rotation of the cutting tool“ button - The lamp in the button is OFF	Preselection of the sense of rotation is changed
		Potentiometer for the cutting tool speed must be at STOP.	
5		Turn the potentiometer clockwise towards 100% - The speed of the cutting tool can continuously be regulated via the potentiometer.	The cutting tool starts rotating
		Turn the potentiometer anticlockwise towards 0%, and beyond the switching resistance - The cutting tool is stopped as soon as the potentiometer is turned beyond the switching resistance to STOP.	The cutting tool rotates slower

Control area belt conveyor



Control area belt conveyor

POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	 	Press the button. The lamp in the button is lit.	Preselection belt conveyor conveying is active. <hr/> The belt conveyor starts when the potentiometer is turned clockwise past the switch resistance.
2	 	Press the button. The lamp in the button is lit.	Preselection belt conveyor reversing is active. <hr/> The belt conveyor starts with a preset, non-changeable speed when the potentiometer is turned clockwise past the switch resistance.

CONTROL ELEMENTS

OPERATION

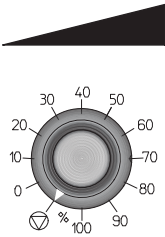
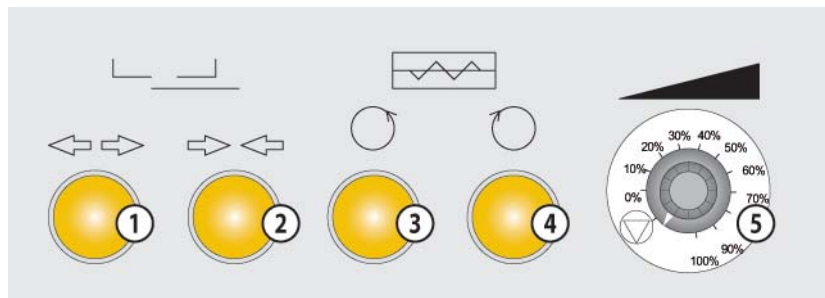
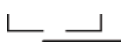
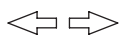
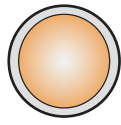
POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
3		Turn the potentiometer clockwise in the direction of 100%	The belt speed increases.
		Turn the potentiometer anticlockwise towards 0%, and beyond the switching resistance	The belt speed decreases.
		The belt conveyor stops when the potentiometer is turned past the switch resistance to STOP.	

Table V - 1: Control area belt conveyor

Control area screw conveyor



Control area screw conveyor

POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	  	Button in inching operation Press the button. The lamp in the button is lit.	The screw gate valve is open while the button is held down

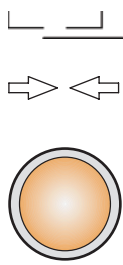
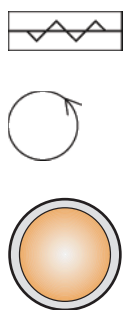
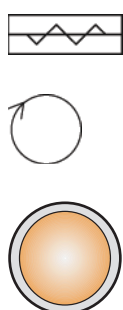
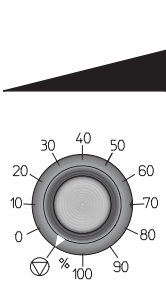
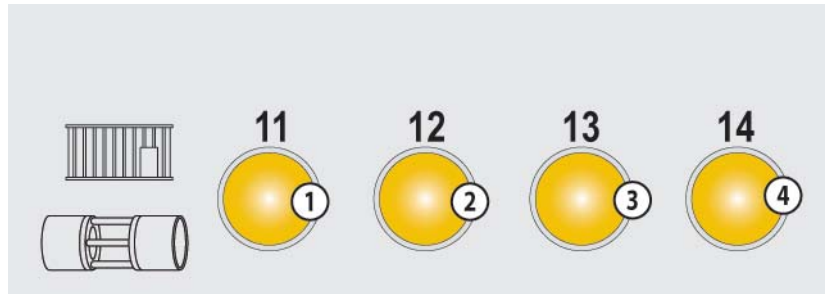
POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
2		Button in inching operation Press the button. The lamp in the button is lit.	The screw gate valve is closed while the button is held down
3		Press the button. The lamp in the button is lit. The screw conveyor starts with a preset, non-changeable speed when the potentiometer is turned clockwise past the switch resistance.	Preselection of screw conveyor reversing
4		Press the button. The lamp in the button is lit. The screw conveyor starts when the potentiometer is turned clockwise past the switch resistance.	Preselection screw conveyor rotate clockwise.
5		Turn the potentiometer clockwise in the direction of 100% Turn the potentiometer anticlockwise towards 0%, and beyond the switching resistance The screw conveyor stops when the potentiometer is turned past the switch resistance to STOP.	The screw conveyor speed is increased. The screw conveyor speed is reduced.

Table V - 2: Control area screw conveyor

CONTROL ELEMENTS

OPERATION

Control area interjack preselection



Control area interjack preselection


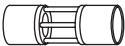
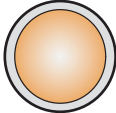
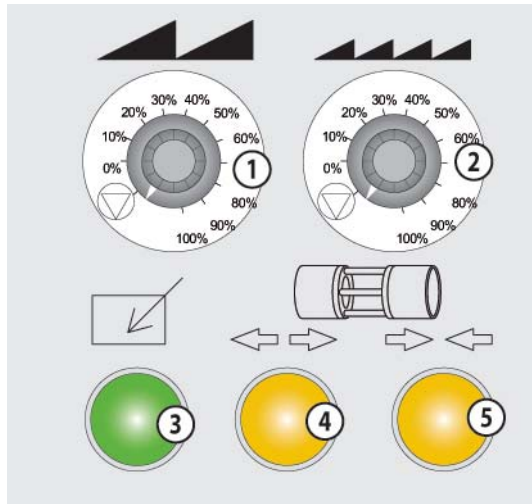

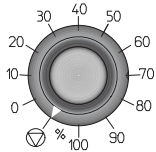

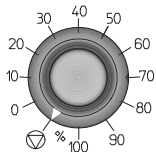
POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1 - 4	  	11-14 Press the button. The lamp in the button is lit.	The interjack station assigned to the button is activated.

Table V - 3: Control area interjack preselection

Control area interjack functions



Control area interjack functions

POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	 	Turn the potentiometer clockwise in the direction of 100%	Increase the rough presetting of the advance speed for the active interjack station.
		Turn the potentiometer anticlockwise towards 0%, and beyond the switching resistance	Reduce the rough presetting of the advance speed for the active interjack station.
		The active interjack station stops when the potentiometer is turned past the switch resistance to STOP. Advancing is interrupted.	
2	 	Turn the potentiometer clockwise in the direction of 100%	Increase the fine presetting of the advance speed for the active interjack station.
		Turn the potentiometer anticlockwise towards 0%, and beyond the switching resistance	Reduce the fine presetting of the advance speed for the active interjack station.
		The active interjack station stops when the potentiometer is turned past the switch resistance to STOP. Advancing is interrupted.	

CONTROL ELEMENTS

OPERATION

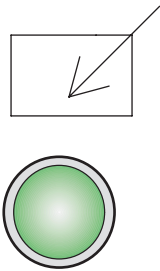
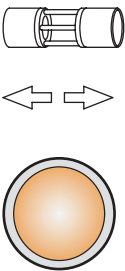
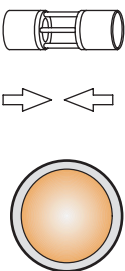
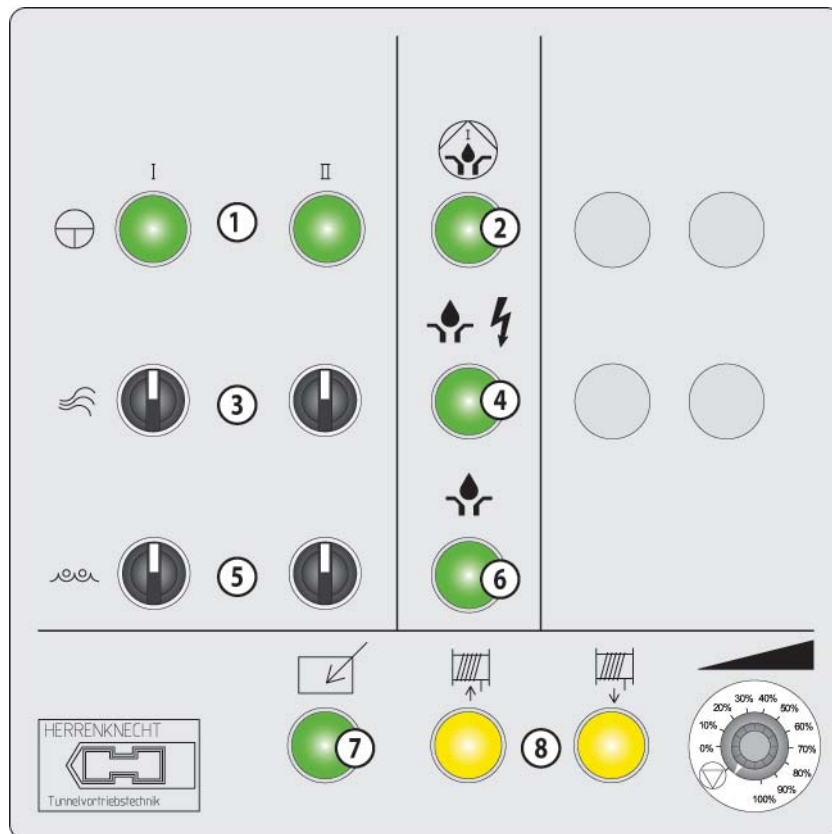
POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
3		Press the button. The lamp in the button is lit.	Control priority for the interjack station is assigned to the control cabin.
4		Press the button. The lamp in the button is lit.	Extend interjack station selected. The selected interjack stations are extended sequentially
5		Press the button. The lamp in the button is lit.	Retract interjack station selected.

Table V - 4: Control area interjack functions

2.2 Auxiliary control panel

2.2.1 Overview

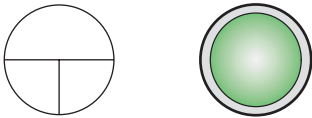

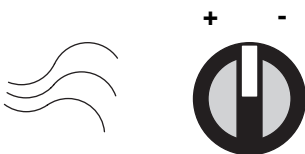
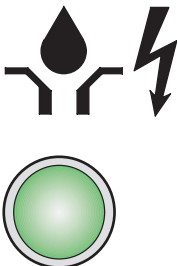





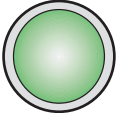
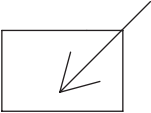
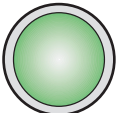
1	On/Off button	5	Liquid
2	Bentonite pump button	6	Tunnel boring machine bentonite lubrication
3	Compressed air	7	Control priority
4	Power supply bentonite pump	8	Winch control

CONTROL ELEMENTS

OPERATION


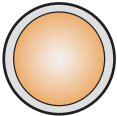

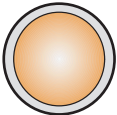

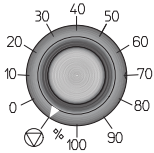
2.2.2 Button and switch assignments

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1		Press the button. The lamp in the button is lit.	The controlled component is switched on
		Press the button again. The lamp in the button is unlit.	Actuated component / the component is switched off
2		Press the button - The lamp in the button is ON	The controlled component is switched on
		Press the button again. - The lamp in the button is OFF	The controlled component is switched off
3		Turn the selector switch anticlockwise	Gradually increases the compressed air supply to the foam installation
		Turn the selector switch clockwise	Gradually reduces the compressed air supply to the foam installation
4		Press the button - The lamp in the button is ON	The controlled component is switched on
		Press the button again. - The lamp in the button is OFF	The controlled component is switched off

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
5	Foam installation liquid  	Turn the selector switch anticlockwise	Gradually increases the liquid feed to the foam installation.
		Turn the selector switch clockwise	Gradually reduces the liquid feed to the foam installation.
6	Tunnel boring machine bentonite lubrication  	Press the button - The lamp in the button is ON	The controlled component is switched on
		Press the button again. - The lamp in the button is OFF	The controlled component is switched off
7	Machine winch Release  	Press the button. The lamp in the button is lit.	Control priority winch - machine winch active.
		This button is only active when control priority has been assigned to the console shaft tableau.	
		Press the button again. The lamp in the button is unlit.	Control priority machine winch switched off.

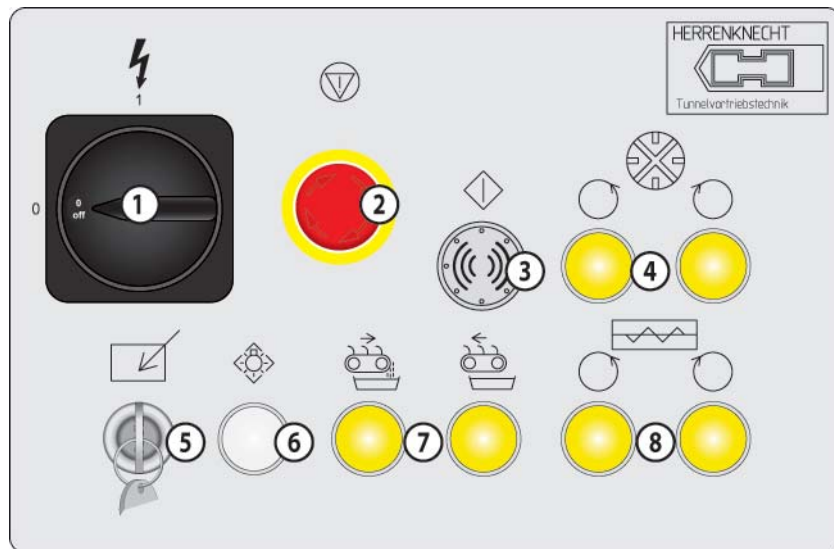
CONTROL ELEMENTS

OPERATION

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
8		Press the button - The lamp in the button is ON	Preselection wind off machine winch
		Press the button again. - The lamp in the button is unlit.	Switch off preselection wind off machine winch.
		Press the button - The lamp in the button is ON	Preselection wind up machine winch.
		Press the button again. - The lamp in the button is unlit.	Switch off preselection wind up machine winch.
		Turn the potentiometer clockwise in the direction of 100%	Switch on the machine winch and increase the winch pull speed
		Turn the potentiometer anticlockwise in the direction of 0%.	Reduce the pull speed of the winch.
		Turn the potentiometer beyond the switching resistance	Switch off the machine winch

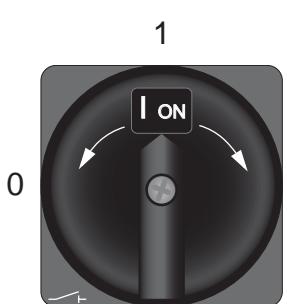
2.3 Cutting tool control panel

2.3.1 Overview





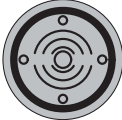
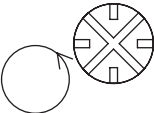
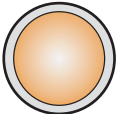
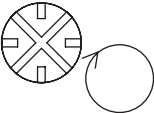
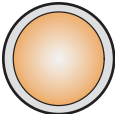
Cutting tool control panel

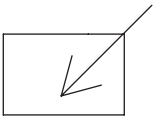
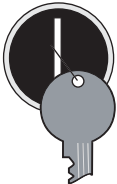
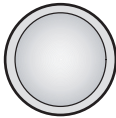
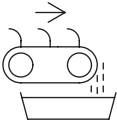
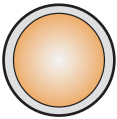
1	Maintenance switch	5	Control priority
2	EMERGENCY STOP	6	Lamp check
3	Start-up warning	7	Belt conveyor control
4	Cutting tool control	8	Screw conveyor control

POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION	
1	Maintenance switch		<p>Switch to position 0 - OFF</p> <hr/> <p>Switch to position 1 - ON</p>	<p>Predefined settings for the maintenance work are not active.</p> <hr/> <p>Predefined settings for the maintenance work are active. - The maintenance switch must be OFF (0) for maintenance and repair work.</p>

CONTROL ELEMENTS

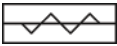

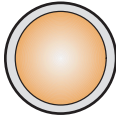

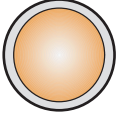
OPERATION

POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
2	EMERGENCY STOP 	Press the button: <hr/> Rotate the button in the arrow direction.	The whole machine/plant is switched off. - Safety components remain active - the machine/plant is at a standstill but still with live voltage <hr/> Emergency stop is unlocked - the machine / system can be put into operation again.
3	Start-up warning  	Audible warning before starting up the cutting tool.	
4	Cutting tool  	Press the button Inching operation: direction of rotation anticlockwise. - The lamp in the button is ON	The cutting tool rotates at low speed while this button is held down.
	 	Press the button Inching operation: direction of rotation clockwise. - The lamp in the button is lit.	The cutting tool rotates at low speed while this button is held down.

POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
5		Turn the key switch in the operation container clockwise (towards I). Control priority is active at the operation container.	- To activate the control priority in the operation container you must turn the key switch on the tunnel boring machine control panel to 0.
			Turn the key switch in the operation container anticlockwise (towards 0). Control priority is inactive at the operation container.	To obtain the control priority at the control panel in the tunnel boring machine, you must turn the key switch on the control panel in tunnel boring machine to I.
6		Hold the button down. The lamp in the button is lit.	The lamps are lit on all buttons in the control cabin - if this is not the case, eliminate the fault until all buttons are lit
		Release the button - the lamp in the button is unlit	The lamps in all buttons in the control cabin are unlit
Check the function daily!			
7		Press the button. The lamp in the button is lit.	

CONTROL ELEMENTS

OPERATION

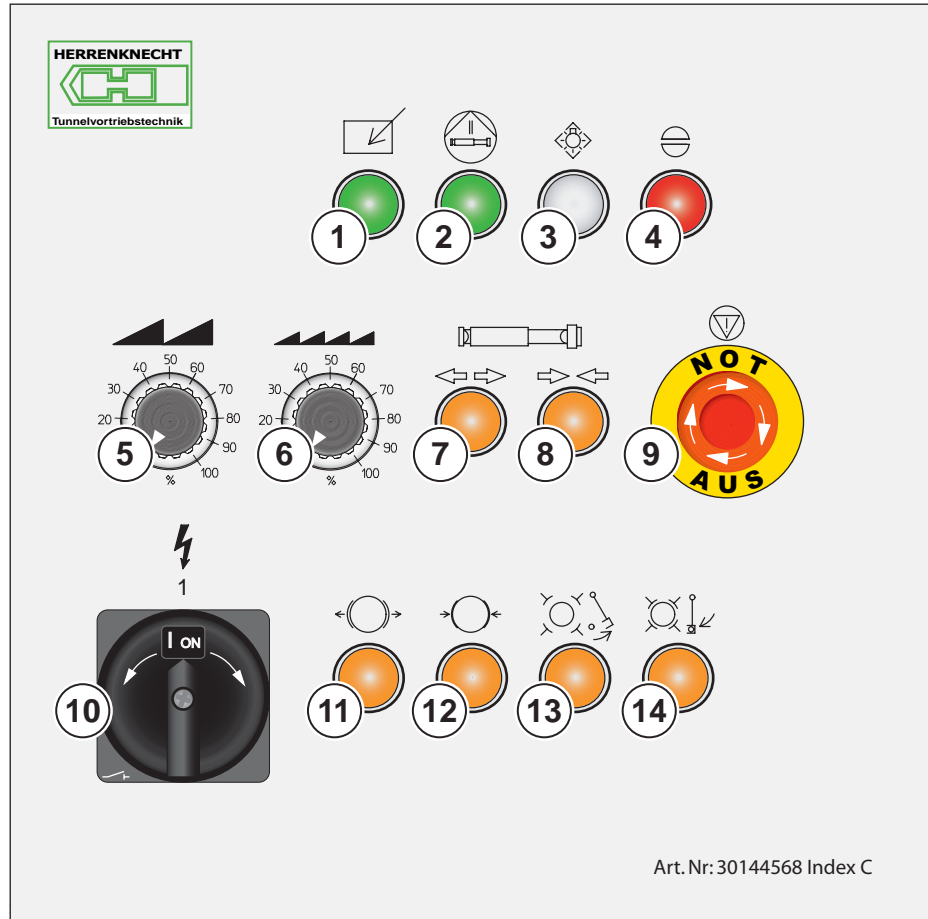
POS	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
8	Screw conveyor		
			
			
			
	<hr/>		
			
			

Press the button. The lamp in the button is lit.


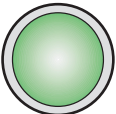
Press the button. The lamp in the button is lit.

Table V - 5: Cutting tool control area

2.4 Shaft panel

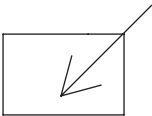
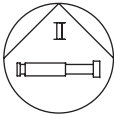
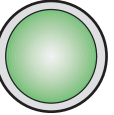

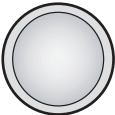
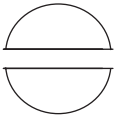
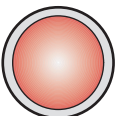



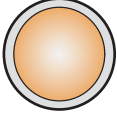

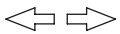
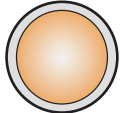
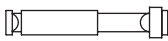
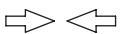
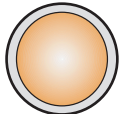
Shaft panel

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	Machine power supply		
		Press the button - The lamp in the button is ON	The power supply in the machine is switched on.
		Press the button again. - The lamp in the button is OFF	Control panel has the control priority

CONTROL ELEMENTS


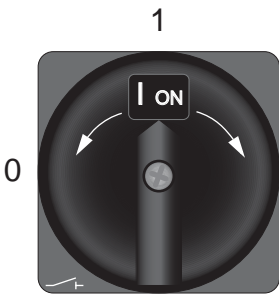
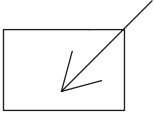
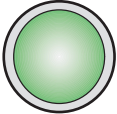
OPERATION


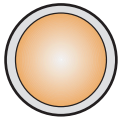

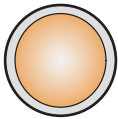

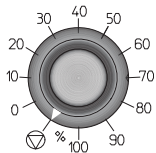
ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
2		Press the button. The lamp in the button is lit.	Shaft control panel control priority active
		<p>This button is only active when control priority has been assigned to the console cabin.</p>	
3		Press the button - The lamp in the button is ON	The controlled component is switched on
			Press the button again. - The lamp in the button is OFF	The controlled component is switched off
4		Press the button - The lamp in the button is ON	The lamps are all in all buttons in the control cabin. If this is not the case: Eliminate the fault until all buttons are illuminated.
			Release the button. - The lamp in the button is OFF
Check the function daily!			
5		Fault / warning / malfunction in the machine / system - The lamp in the button is ON	Fault / warning / malfunction are indicated
			Press the button - The lamp in the button is OFF	Fault / warning / malfunction are acknowledged

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
6	Speed level		
	 1, 2, 3 	Press the 1, 2 or 3 button. The lamp in the button is lit.	The thrust cylinders extend at the selected speed level
7	Preselection of thrust cylinders (extend)		
	  	Press the button - The lamp in the button is ON	Preselection is activated
		Press the button again. - The lamp in the button is OFF	Preselection is deactivated
	Preselection of thrust cylinders (retract)		
	  	Press the button - The lamp in the button is ON	Preselection is activated
	Press the button again. - The lamp in the button is OFF	Preselection is deactivated	

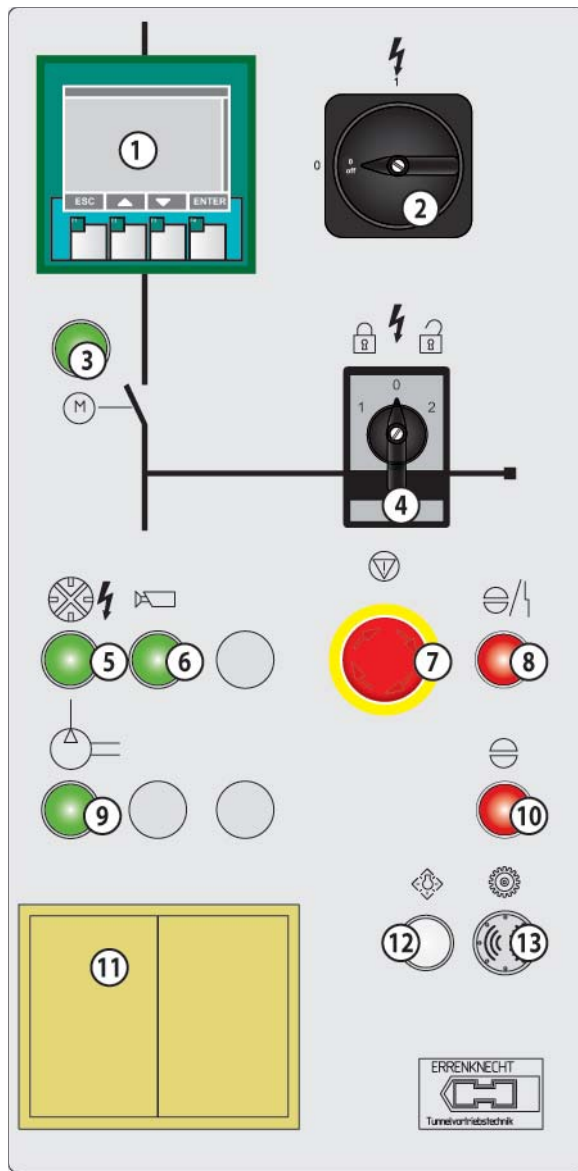
CONTROL ELEMENTS

OPERATION

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
8	EMERGENCY STOP 	Press the button	The complete machine / system is switched off. - Safety components remain active- machine / system is still energized
		Rotate the button in the arrow direction	Emergency stop is unlocked - the machine / system can be put into operation again.
Check the function daily!			
9	Maintenance switch 	Switch to position 0 - OFF	Predefined settings for the maintenance work are not active.
		Switch to position 1 - ON	Predefined settings for the maintenance work are active. - The maintenance switch must be OFF (0) for maintenance and repair work.
10	Control priority  	Press the button - The lamp in the button is ON	Control priority shaft winch active
		Press the button again. - The lamp in the button is OFF	Control priority shaft winch switched off

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
11	Unwind shaft winch  	Press the button - The lamp in the button is ON	Preselection wind off shaft winch active.
		Press the button again. - The lamp in the button is OFF	Preselection wind off shaft winch is switched off.
	Wind up shaft winch  	Press the button - The lamp in the button is ON	Preselection wind up shaft winch active.
		Press the button again. - The lamp in the button is OFF	Preselection wind off shaft winch is switched off.
	 	Turn the potentiometer clockwise towards 100% Turn the potentiometer anticlockwise towards 0% Turn the potentiometer beyond the switching resistance. The shaft winch is switched off.	Increase the pull speed of the shaft winch. Reduce the pull speed of the shaft winch.

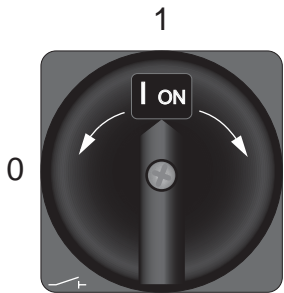
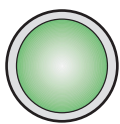

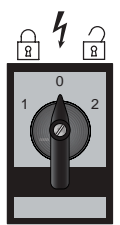
2.5 Performance panel



- | | |
|----|------------------------------------|
| 1 | Multifunction display |
| 2 | Switch control ON/OFF |
| 3 | Button main switch ON/OFF |
| 4 | Switch control voltage ON/OFF |
| 5 | Button power supply machine ON/OFF |
| 6 | Button camera ON/OFF |
| 7 | EMERGENCY STOP button |
| 8 | Reset malfunction |
| 9 | Button compressor ON/OFF |
| 10 | Reset |
| 11 | Sockets |
| 12 | Button lamp test |
| 13 | Audible error message |

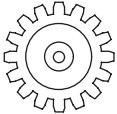
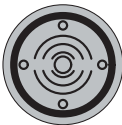
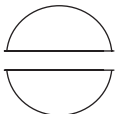
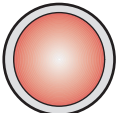

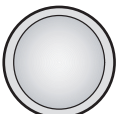




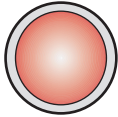
The control priority of a panel (control panel /shaft panel) is shown by the illuminated button.

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
1	Multifunction display		
		The multifunction display shows the performance data from the operation container. (Take the technical documentation from the manufacturer into account)	
2	Maintenance switch		
		Switch to position 0 - OFF	Predefined settings for the maintenance work are not active.
		Switch to position 1 - ON	Predefined settings for the maintenance work are active. - The maintenance switch must be OFF (0) for maintenance and repair work.
3	Main switch		
		Press the button - The lamp in the button is ON	The machine / system is switched on
		Press the button again. - The lamp in the button is OFF	The machine / system is switched off
4	Control voltage		
		Switch to position 0	Control voltage Switched off
		Switch to position 1	Control voltage Switched on INTERNAL
		Switch to position 2	Control voltage Switched on EXTERNAL

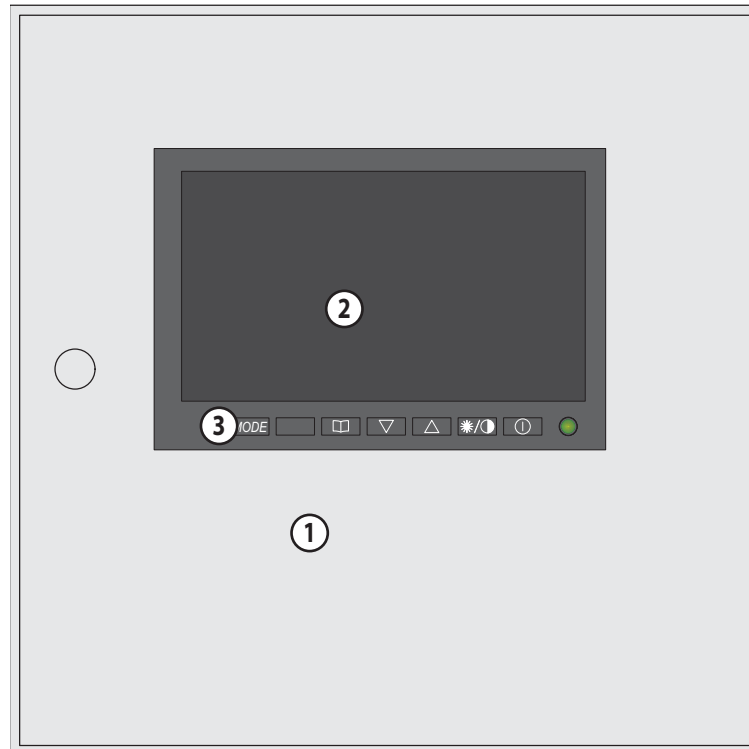
CONTROL ELEMENTS

OPERATION

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
13	Alarm signal		
			
			
		An audible alarm sounds in the event of a malfunction	
4	Reset		
			
		Fault / warning / malfunction in the machine / system - The lamp in the button is ON	Fault / warning / malfunction are indicated
			
		Press the button - The lamp in the button is OFF	Fault / warning / malfunction are acknowledged
5	Lamp check		
			
		Press the button - The lamp in the button is ON	The lamps are all in all buttons in the control cabin. If this is not the case: Eliminate the fault until all buttons are illuminated.
			
		Release the button. - The lamp in the button is OFF	The lamps in all buttons in the control cabin are OFF
		Check the function daily!	

ITEM	CONTROL / INDICATOR ELEMENT	ACTIVITY	FUNCTION
7	EMERGENCY STOP 	Press the button Rotate the button in the arrow direction	The complete machine / system is switched off. - Safety components remain active- machine / system is still energized Emergency stop is unlocked - the machine / system can be put into operation again.
Check the function daily!			
8	Reset for emergency stop / maintenance switch (acknowledge fault)  	When emergency stop or a maintenance switch is activated - The lamp in the button is ON Press the button - The lamp in the button is OFF	Fault / warning / malfunction are indicated Fault / warning / malfunction are acknowledged
9	Connections / socket outlet	There are various connections behind the two covers. For example: USB, keyboard, VGA, socket outlet, etc.	

2.6 Video monitoring



- | | | | |
|---|--------------------------|---|--------------------------|
| 1 | Switch Cabinet | 3 | Control elements monitor |
| 2 | Monitor video monitoring | | |

3. Basic functions

3.1 Switch on cutting tool

Procedure to start the cutting tool

1. Switch on the cutting tool hydraulic pump.
2. Set all cutting-tool-relevant potentiometers to 0.
3. Preselect the sense of rotation of the tool.
 - The preselection of the sense of rotation only works after the cutting-tool-relevant potentiometers have been set to 0.
4. Select the required speed of the cutting tool at the related potentiometer.

3.2 Switch on conveyor system

1. Switch on hydraulic pump for operating the conveying system.
2. Preselect sense of rotation for screw conveyor.
3. Turn the speed control clockwise to set the required speed. At the same time, open the screw conveyor discharge gate.
4. Switch on the belt conveyor
5. Use the control to set the required belt speed.

3.3 Position the muck skip under the muck discharge

1. Use the winch to drag the muck skip into the machine.
2. Extend/retract the positioning cylinder to position the muck skip so that the excavated material drops cleanly into the skip.

3.4 Advance

1. Transfer control priority to the shaft control panel
2. At the shaft control panel, switch on the hydraulic pump for the jacking cylinders.
3. Preselect extending the jacking cylinders.
4. As required, press the speed level 1, 2 or 3 button.

4. Commissioning

4.1 Safety regulations

4.1.1 General

Ensure that the following safety instructions are observed when you commission the machine / system. This prevents injuries, machine damage and other material damage.

- Only qualified personnel are allowed to commission the machine in accordance with the safety instructions.
- Ensure that only authorized persons are within the working area of the machine / system, and that nobody else is endangered when the system is put into operation.
- Check all electrical and hydraulic connections before the first start.
- Check the proper functioning of the entire safety equipment, and of all monitoring devices and guards.
- Prior to commissioning, check all connections, cables, hoses and lines for completeness and firm seating.
- Check whether all foreign bodies were removed from the working area of the system components.

WARNING!

Voltage!

Electric system, electric shock from voltage-carrying parts.



- Electric shock, severe paralytic symptoms or burns.
- Switch off the main switch of the system, and secure it against being switched back on.

-
- Check the special protective measures (e.g. earthing).
 - Also read the "General safety instructions".



CAUTION!

Machine damage!

Incorrect adjustment pressure values for cutterhead drive, kinematics, drawdown system and auxiliary hydraulics.

- System damage.
- Do not change the factory settings.



All parameters at the machine / system are set at the factory, and must not be readjusted.

Any change of the preset values without agreement of Herrenknecht AG releases the manufacturer from any liability.

4.1.2 Dangers during commissioning

The following special risks must be anticipated when the machine / system is commissioned:

- Incorrect connections can result in an accidental startup of the machine / system and uncontrolled machine movements.
- The hydraulic cylinders will move in the wrong direction when the connections are confused. This may result in severe machine damage.

4.1.3 Requirements placed upon the executing personnel

- For safety reasons, only staff who is directly involved in commissioning are allowed to be on site.
- It must be ensured that all persons who are on site during commissioning are aware of the potential risks!



WARNING!

Improper work during commissioning

- System damage, serious injuries.
- Ensure that all persons who are on site at the time of the first commissioning are informed about potential risks.
- Observe the safety instructions in the operating instructions.

4.1.4 Frequent commissioning mistakes

In addition to maintenance, commissioning is decisive for the service life and the functional reliability of the machine / system

Mistakes during commissioning should therefore be avoided.

The most frequent mistakes include:

- Liquid levels are not checked.
- The operating liquids were not filtered before they were filled in.
- Installations are not checked before commissioning. This leads to conversions with loss of liquid.
- No bleeding of system parts.
- The setting of the pressure limiting valves is too closely above the working pressure. The closing pressure difference is ignored.
- The setting of the hydraulic pump pressure controllers at the pressure side is higher than or at the same level as the setting of the pressure limiting valves.
- The recommended flushing time of servo systems is not observed.
- Abnormal pump noise is ignored. Cavitation or air in the operating liquid remains undiscovered.
- Transverse loads on rods; serious installation mistakes on rods are ignored.
- No cylinder bleeding (damaged seals!).
- Setting of limit switches is too tight.
- The switching hysteresis of the pressure switches is not taken into account for setting.
- Hydraulic pumps and hydraulic motor enclosures are not filled with operating liquid before commissioning is started.
- No documentation of the setting values.
- The setting spindles are not secured or sealed with lead.



Commissioning and maintenance have a large influence on service life and functional reliability of the machine / system.

Avoiding mistakes during commissioning and maintenance has a positive influence on service life and functional reliability.

4.2 Initial commissioning



Initial commissioning refers to any new construction site at which the machine / system is employed.

This chapter must therefore be observed whenever the machine / system is commissioned at a new construction site.

4.2.1 Power supply

Check whether:

- The required power supply for machine / system is ensured.
- The correct voltage is applied
- The required cable cross sections are installed
- All signal and supply lines are properly connected and undamaged.
- All fuses and emergency stop buttons are operational

4.2.2 Hydraulic system



All parameters at the machine / system are set at the factory, and must not be readjusted.

Any change of the preset values without agreement of Herrenknecht AG releases the manufacturer from any liability.

Check whether:

- The sense of rotation of the electric motors is correct (observe the arrow of the sense of rotation)
- Oil level and oil quality in the tanks are OK
- All screwed connections and lines are tight
- All hydraulic hoses are free from torsion and tension.

Hydraulic hoses



WARNING!

Explosion hazard!

Too high a pressure on the hydraulic hoses.

- Can cause hydraulic hoses to burst.
- Never adjust the pressure on the hydraulic system to a value that exceeds the maximum permissible pressure specified on the hose lines.

4.2.3 Gearbox

General

Gearboxes must be completely filled with oil for preservation purposes (e.g. for sea transport or extended storage).

Before starting up, the oil must be checked or adjusted to the correct fill level.



CAUTION!

Oil level too high or low.

- Damage to seals and bearings.
- Check the oil level before commissioning. If needed, top up with oil or drain oil

Correcting the oil level

Required tools / material

- Collecting container
- Flat spanner matching the oil filler and oil drain screws.

Procedure:

1. Place a sufficiently large collecting container below the oil drain screw.
2. Open the oil filler screw on the gearbox (breath the gearbox).
3. If the oil level is too high:
 - Remove the oil drain screw and drain the oil until the required fill level is reached (see the drawing for the drive in question).

4. If the oil level is too low:
 - Fill up with oil until the required fill level is reached (see the drawing for the drive in question).
5. After reaching the required oil level, replace the oil drain screw and the oil filler screw.

Oil level too high

Required tools / material

- Collecting container
- Flat spanner matching the oil filler and oil drain screws.

Correcting the oil level

1. Place a sufficiently large collecting container below the oil drain screw.
2. Open the oil filler screw on the gearbox (breath the gearbox).
3. Remove the oil drain screw and drain the oil until the required fill level is reached (see the drawing for the drive in question).
4. After reaching the required oil level, replace the oil drain screw and the oil filler screw.

Oil level too low

Required tools / material

- Flat spanner matching the oil filler and oil drain screws.
- Gearbox oil in line with gearbox drawing.

Correcting the oil level

1. Remove the oil filler screw on the gearbox.
2. Top up with gearbox oil until the required oil level is reached (see the gearbox drawing)
3. Replace the oil filler screw

4.2.4 Further checks

- Are the pipes adequately secured, also for changing pressure loads?
- Are the fastening points at the correct positions?
- Are all hoses routed in a way that excludes their abrasion under pressure loads?
- Does the entire communication at the construction site work properly? (Telephones, walkie-talkies, cameras)
- Do the electric motors rotate in the correct sense of rotation?
- Are all screwed connections and lines of the hydraulic power units tight?

4.3 Daily startup



The daily startup also includes a restart of the system after each pipe change.

The following checks are required before each system startup:

Power supply

Check whether:

- All signal and supply lines are correctly connected and in a proper condition. Damaged cables must be replaced.
- All fuses and emergency stop buttons are operational.

Hydraulic system

- Check the sense of rotation of the electric motors after extension cables have been installed.
- Check screwed connections and lines for leaks.

4.4 Commissioning of the hydraulic power unit

4.4.1 Test run

Prior to a test run you must ensure the following:

- All parts are clean and properly installed.
- All connections are tight, and all devices are properly connected in accordance with the electric and hydraulic diagrams.
- All gate valves are open.
- Drive motor and pump are properly connected (the sense of rotation of the pump must be correct).
- The pump suction valves are open. Fill up the pump housing with oil if necessary.
- The required filters are properly installed in flow direction.
- The filling with the specified oil is sufficient (upper edge of the oil level mark).

Observe the following points during the test run

- Execute the functions without load on machine / system.
- Do not operate the system under load before the operating temperature is reached.
- Monitor the control and measuring devices.
- Listen for noise.
- Check the oil level; top up if necessary.
- Put the system under load to check the settings of the pressure limiting valves.

Upon completion of the test run:

- Replace any lost oil.
- Bleed the system.
- Check all bolted connections for tightness. Refasten if required.

WARNING!

Machine damage!

Insufficiently filtered hydraulic oil.

- Damaged hydraulic components.
- Top up hydraulic oil only through the filler connection.



4.4.2 Leak test

1. Completely switch off and depressurize the machine / system.
2. Check the manometers to see whether the system is pressureless.
 - The manometer must read zero bars.
3. Look for any leaks or air bubbles on couplings.
4. Tighten all bolted connections.



Tighten screwed connections only when the system is depressurized.

4.4.3 Bleeding the hydraulic system

Operate the system components for approximately 10 ... 15 minutes without load after the hydraulic circuit has been opened somewhere (because of a defective cylinder, for example).

Indicators of air in the system:

- Foam in the container
- Abnormal noise
- Jerking movement

Carefully release a bolted connection at the top or a bleeding bolted connection. Tighten the bolted connection when the hydraulic fluid escapes without bubbles.



Check all flanges and bolted connections for leaks before you restart the system after bleeding.

Check whether there is air in the hydraulic system

1. Switch off and depressurize machine / system.
2. A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank.
 - Initial pressure see related fluid diagram
3. Open one of the bolted connections or a bleeding bolted connection at the top.
 - Hydraulic oil emerges.
4. Check whether the hydraulic oil escapes without air.
 - If hydraulic oil escapes without air, close and tighten the screwed connection. If the hydraulic oil contains air bubbles, change the hydraulic oil.

4.4.4 Temperature monitoring

The system is equipped with a permanent oil temperature monitor.

The temperature is measured at the hydraulic power unit. Excessively high temperatures (> +85 °C) are indicated as a group fault on the visualization monitor.

The oil cooler is automatically switched on at approximately +45° C. The entire machine / system is switched off automatically when the oil temperature exceeds +90°C. The machine / system can only be switched back on after the temperature has dropped to a lower value.

At the factory, the value are set as follows:

- +45°C cooler ON
- +40°C cooler OFF
- At least -5°C pump start
- 85°C warning in visualization
- 90°C stop of all functions except cooler

Cold start

During a cold start, the high viscosity can cause the differential pressure indicator to be activated.

This is shown as a fault in visualization.



Filter error messages are displayed with a delay of 30 seconds.

The filter fault messages are stored and evaluated in visualization and/or in the mensuration software. The fault message disappears automatically when the fault no longer exists.

Press the "RESET" button to switch off the audible signal. Press the "RESET" button to switch over from blinking light to continuous light.

The "RESET" button goes out when the differential pressure display returns to the normal range after the operating temperature has been reached.

WARNING!



The fault remains indicated after the operating temperature has been reached.

- Damage to gears and motors.
- Replace the filter element or the related filter.

4.4.5 Hydraulic oil level



A group fault message in visualisation shows when the oil level reaches the minimum level.

Change over to FAULT IMAGE to pinpoint the fault.

At the same time, all hydraulic pumps are switched off automatically.

Special notes

- During cold weather and frost periods, the hydraulic oil must be kept at a temperature above +5°C ... +10°C. Failure to do so could damage the hydraulic pumps.
- At low temperatures, the hydraulic system must be operated for approximately 10 ... 15 minutes without load.

Top up hydraulic oil

1. Switch off and depressurize machine / system.
2. Check the hydraulic components for leaks. Repair any defects.
3. Position the hydraulic oil filter at the tank.
4. Fill in new hydraulic oil via the filler neck at the tank.
 - Use the hydraulic oil specified on the tank label.
5. A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank.
 - Initial pressure see related fluid diagram

Changing hydraulic oil

1. Switch off and depressurize machine / system.
2. Check the hydraulic components for leaks. Repair any defects.
3. Drain the hydraulic oil completely.
4. Fill in new hydraulic oil via the filler neck at the tank.
 - Use the hydraulic oil specified on the tank label.
5. A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank.
 - Initial pressure see related fluid diagram

4.5 Commissioning the conveying system



DANGER!

Hand injury!

Risk of shearing limbs.

- Serious hand injuries
- Never reach through the ball valves / gate valves to check the position of the ball valves / gate valves.

4.5.1 Commissioning the belt conveyor

- Check the tightness of all hydraulic couplings.
 - Check the running direction and true running of the conveyor belt.
- If the belt is running in the wrong direction swap the A and B cables on the motor.

4.5.2 Commissioning the winches

- Check the tightness of all hydraulic couplings.
 - Check the running direction and true running of the conveyor belt.
- If the belt is running in the wrong direction swap the A and B cables on the motor.

4.6 Individual commissioning

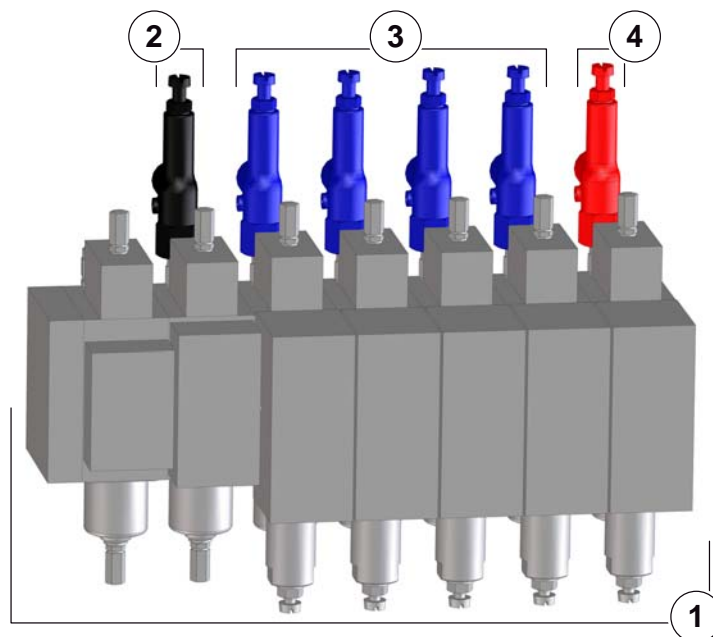
Depending on the tunnel boring machine, you must check and adjust the parameters and options in the visualization program. This is the only way to show correct values in the visualization and mensuration software.

4.6.1 Pressure setting for the thrust cylinders



All parameters at the machine / system are set at the factory, and must not be readjusted.

Any change of the preset values without agreement of Herrenknecht AG releases the manufacturer from any liability.



Typical thrust cylinder block

- | | | | |
|---|---|---|---|
| 1 | Thrust cylinder block | 3 | Pressure limiting valve (blue):
Extending the interjack stations |
| 2 | Pressure limiting valve (black):
Retracting the pipe brake | 4 | Pressure limiting valve (red):
Extending thrust cylinders |



The above diagram shows four interjack blocks (item 3 on the diagram - blue pressure limiting valve: Extending interjack station). The number of interjack blocks and thus the number of pressure limiting valves can vary.



CAUTION!

Set pressure too high.

- Risk of damaging product pipes and machine / system.
- The following adjustment work requires the pressures to be adjusted to 70% ... 80% of the press forces that are permissible for the advance pipe.
- The control pressure is set at the factory and must not be changed.
- The pressure limiting value for the entire hydraulic block is set at the factory. It must not be changed.

Procedure

1. Switch on the thrust pump.
2. Check the consumer (press station / interjack station).
 - a When a consumer (press station / interjack station) is connected, fully extend the related cylinders.
 - b When a consumer (press station/interjack station) is not connected, move against the quick couplings to build up pressure.
3. Depending on the consumer (press station / interjack station), control the required pressure with the related pressure limiting valve (see above diagram).
 - To increase the pressure, turn the pressure limiting valve clockwise.
 - To reduce the pressure, turn the pressure limiting valve anticlockwise.
4. If pressure setting was performed in step 2b, connect the consumer (press station / interjack station) after the pressure drop.

5. Operation

5.1 Safety regulations

5.1.1 General



The individual steps discussed in the Chapter "Operation" are merely suggestions. This Chapter merely gives recommendations for the machine control. Depending on the situation, the machine operator must take specific measures and make decisions.

Always observe the following safety instructions when you operate the machine / system. This is necessary to avoid life-threatening injuries, system damage and other material damage.

- Observe the operating instructions on the machine / system.
- Operating the machine / system is only permitted from the specified workplaces.
- Only the operating personnel are allowed to stay in the vicinity of the machine / system during operation.
- When a fault indicator lights up, the machine / system must be switched off immediately, and the cause of the fault must be located and eliminated.
- After an emergency stop, secure the machine / system against being switched back on inadvertently by somebody else.
- When the machine / system remains shut down and unattended for a longer time, you must remove all keys that are required for starting the system.
- The following steps must always be taken after the machine / system has been switched off: Switch the main switch to 'OFF' and lock it.
- Prior to starting advance operation you must switch off the tunnel light. This prevents incorrect measured values.
- Also read the "General safety instructions".

OPERATION

OPERATION

- Advance only when the cutterhead and the screw conveyor are rotating.
- The ground pressure in the excavation chamber and the ground pressure in the screw conveyor must be identical while advancing.
- Different ground pressures between the excavation chamber and the screw conveyor can lead to settling and uplift at the surface.

CAUTION!

Machine damage!



Advance operation with blocked cutterhead tool

- Bearing damage, gear damage and damage of hydraulic cylinders.
- Advance only with rotating cutterhead tool and activated conveyor.

5.1.2 Hazards during operation

When you operate the machine / system, you must anticipate the following specific hazards:

- Life-threatening injuries and machine / system damage may result if the machine / system is used in a way which is not in accordance with the intended use.

CAUTION!



Non-conforming pressure lines and connections.

- Severe injuries from leaking pressurized liquids.
- Use only undamaged lines and connections.
- Use only pressure lines and connections that are approved for the nominal pressure.

- Incorrect connections can result in an accidental startup of the machine / system and uncontrolled movements of machine / system.
- Severe injuries may result if the personal protective equipment is not used properly.
- Wrong reactions during a malfunction may cause severe injuries and material damage.

5.1.3 Requirements placed upon the executing personnel

- Appoint only experienced and instructed persons to operate the machine / system (see „General safety instructions“).
- The machine operator is responsible for the machine / system. Prior to starting advance operation, he must ensure that the following requirements are satisfied:
 - There is nobody in the danger areas.
 - All maintenance work was carried out.
 - All indicator lamps in the machine / system are OK.
 - All supply lines are connected correctly and sufficiently extended.
 - All key switches in the control cabin are set to local control priority.

5.2 Advance

5.2.1 Start advance operation.

Prerequisites

- The oil levels in the oil tanks of the hydraulic system and the gears are OK.
- The lamp check in the control cabin is OK.
- The safety elements (such as emergency stop buttons and limit switches) are OK.
- The main switch is switched on.

Procedure

1. Switch on the cutting tool, jacking pump, steering pump and any other existing hydraulic pumps.
2. Switch on the conveying system
3. Preselect the speed of the cutting tool. (Adjust the speed to match the geology.)
4. Open the screw conveyor discharge gate when the advance movement starts.
5. Start the advance movement at a low advance speed. Adjust the advance speed to match the geology.

5.2.2 During advance operation

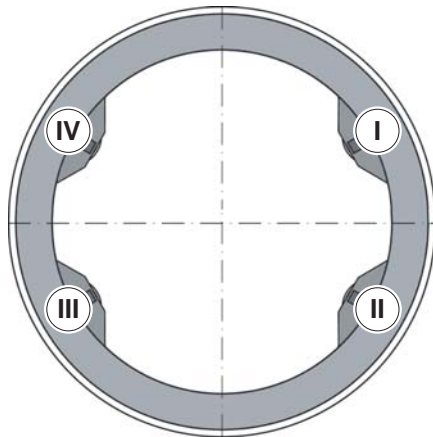
Monitor the ground pressure sensors carefully during the advance movement. The ground pressure must be selected to precisely match the ceiling and be kept constant via the screw conveyor

Select the advance speed so that the cutting wheel pressure is always at least 90 to 100 bar. The cutting wheel pressure guarantees that no cavities are washed out at the tunnel face because the cutting wheel always lies flush against the tunnel face in this case.

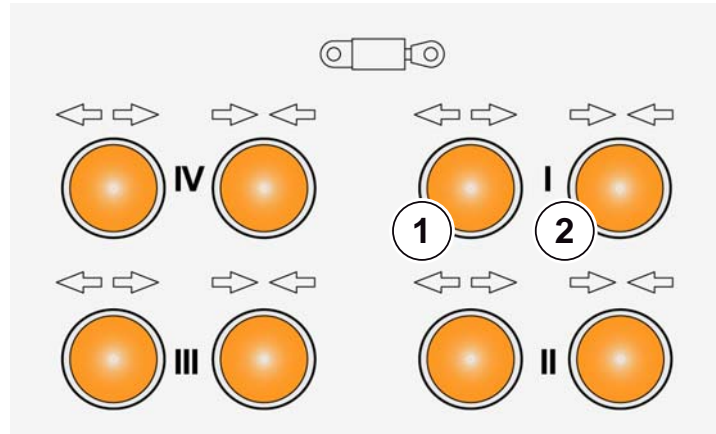
5.2.3 Terminating advance operation

1. Switch off the cutting tool.
2. Switch off the conveyor system.
3. Switch off the entire electric system.

5.3 Tunnel boring machine with four steering cylinders



Tunnel boring machine (seen in the direction of tunnelling)



Control panel - steering cylinder control area (in the diagram: Pos. 1 extend / Pos. 2 retract)

The cylindric machine body consists of two parts that are interconnected by three or four hydraulic cylinders (depending on the type of the tunnel boring machine). The front part is the steering head. The rear part is the machine pipe.

All steering cylinders have the same stroke. Experience shows that an extreme steering movement with maximum stroke difference is hardly ever needed. Visualization shows the extended stroke of the individual steering cylinders in mm.

5.3.1 Prerequisites to steer the tunnel boring machine

- Steering movements are only allowed when advance operation is in progress and the cutterhead tool is rotating.
- Strong and rough steering movements must be avoided.

5.3.2 Steering movements in normal soil

All steering movements can best be initiated from the normal position. In normal position, all steering cylinder are at mid-stroke.

Straight movement	Must be performed without steering movement. The strokes of all steering cylinders must be identical.
Steering upward	Initial position = normal position 1. Retract cylinders I and IV by the preselected steering stroke. 2. Extend cylinders II and III by the same steering stroke.
Steering downward	Initial position = normal position 1. Retract cylinders II and III by the preselected steering stroke. 2. Extend cylinders I and IV by the same steering stroke.
Steering right	Initial position = normal position 1. Extend cylinders III and IV . 2. Retract cylinders I and II by the same value.
Steering left	Initial position = normal position 1. Extend cylinders I and II . 2. Retract cylinders III and IV by the same value.
Steering about a 45° diagonal	Initial position = normal position 1. Extend cylinders II and III = steering movement upward. 2. Retract cylinders III and IV = steering movement to the right. – After this steering movement, cylinder III has moved by twice the stroke of cylinders II and IV . This steers the machine to the top right.

5.3.3 Steering movement in very hard soils

- Steering takes a bit more time.
- The achieved steering torque values are higher.
- To a certain extent, the steering movement must be supported by the advance movement.

Straight movement	Initial position = all steering cylinder must be fully extended.
Steering upward	Initial position = all steering cylinder must be fully extended. 1. With rotating tool and active advance movement, retract cylinders I and IV .
Steering downward	Initial position = all steering cylinder must be fully extended. 1. With rotating tool and active advance movement, retract cylinders II and III .
Steering right	Initial position = normal position 1. With rotating tool and active advance movement, retract cylinders III and IV by the preselected distance.
Steering left	Initial position = normal position 1. With rotating tool and active advance movement, retract cylinders I and II by the preselected distance.
Steering about a 45° diagonal	Initial position = normal position 1. Extend cylinders I and IV = steering movement upward. 2. Retract cylinders II and III = steering movement to the right. – After this steering movement, cylinder III has moved by twice the stroke of cylinders II and IV . This steers the machine to the top right.

5.3.4 Additional information about steering

Steering guidelines

- Larger course deviations must be returned to the nominal axis over a longer distance. Here, you must move in slight curves. Never steer sharp bends in the movement. This can cause the advance pipes to break.
- Never move in a curve when you traverse a concrete-covered intermediate shaft. The first steering movement may only be initiated after the machine has left the shaft by an entire advance pipe length.

Comments

- There is a fixed connection between the mensuration unit and the machine pipe. Each steering movement moves the machine pipe with the aiming device. This means that each steering movement causes the mensuration unit to modify its values slightly but perceptibly against the direction that is to be steered. Conversely, the mensuration unit will modify its value towards the currently steered direction when a steering position is reduced.

5.4 Cutting tool

The cutting tool works equally in both senses of rotation. Increasing the thrust force while the machine is operating at maximum torque reduces the tool speed. This can cause the tool to be blocked.



CAUTION!

Machine damage!

Change of sense of rotation of the cutting tool.

- Bearing damage, gear damage and damage of hydraulic cylinders.
 - The sense of rotation may only be changed after the speed at the speed regulator has been reduced to 0, and the cutting tool has been stopped.
-

5.4.1 Sense of rotation and roll correction

When the cutting tool rotates clockwise, the machine will react by rolling anticlockwise. The roll is shown on the mensuration display.

- To compensate for a left roll, you must advance with a cutting tool that rotates anticlockwise.
- To compensate for a right roll, you must advance with a cutting tool that rotates clockwise.

To prevent too high a roll of the tunnelling machine, changing the sense of rotation of the cutting tool after each stroke has proven useful. This method also helps to reduce an unbalanced wear of the tool.

5.4.2 Releasing the cutting tool

Use the following procedure when the cutting tool is blocked (as a result of excessive pressures, for example):

1. Set all cutting-tool-relevant potentiometers to 0.
2. Relieve the jacking cylinders.
3. If installed, relieve the interjack and telescopic stations.
4. Change the sense of rotation of the cutting tool.

Use the following procedure if the cutting tool cannot be released in this way:

1. Relieve the jacking cylinders. (STOP jacking cylinders)
 - Set all jacking cylinder-relevant potentiometers to 0 or STOP.
2. Switch off the screw conveyor and close the screw conveyor discharge gate
3. Fully retract the steering cylinders.
4. Change the sense of rotation to release the cutting tool.
 - Do not hold the maximum pressure for more than 10 seconds in this process. While the sense of rotation is changing, you can switch conveying to bypass operation, or switch it off completely.



The steps described above may only be carried out when the thrust cylinders are stopped.

5.5 Interjack station



Pressing the button of the related interjack station briefly switches the preselection to extending the related interjack station. OPTIONAL: Pressing the button of the related interjack station for a longer time switches over to relieving the related interjack station. (The lamp in the button blinks)

Procedure to extend the interjack station

1. Turn all potentiometers in the thrust cylinders / pipe thruster control area to STOP.
2. Press the button of the related interjack station (1 ... 6 or 11 ... 16) to activate the required interjack station.
3. Turn the potentiometer in the thrust cylinders / pipe thruster control area clockwise, towards 100%.
 - The preselected interjack station extends.



You can only extend one interjack station at any one time.
An interjack station can only be moved independently from the thrust cylinders.
While interjack stations are relieved, you may extend the thrust cylinders or another interjack station.

Procedure for relieving interjack stations

1. Press and hold the button of interjack station (1 ... 6 or 11 ... 16) until the button starts blinking.
 - The required interjack station is relieved.
2. Preselect extending the thrust cylinders.
 - The interjack station are compressed when you extend the thrust cylinders.

5.6 Jacking frame

5.6.1 General



DANGER!

Risk of crushing limbs!

While working on and around Jacking frame.

- Serious injuries from crushing and severing limbs.
- Staying inside the Jacking frame is not permitted during the entire advance operation.
- Never actuate the control elements of the thrust cylinders when you retract the thrust ring.



Prior to switching over from **Preselection extend thrust cylinders** to **Preselection retract thrust cylinders** you must turn both potentiometers of **Coarse thrust cylinder regulation** and **Fine thrust cylinder regulation** anticlockwise, towards 0% and beyond the switching resistance.



Once the thrust ring has reached the front position, you must disconnect all connections (slurry and feed line, electrical cables, hydraulic lines, etc.).

The thrust cylinders and thus the thrust ring may only be retracted after this has been done.

5.6.2 Extending and retracting the thrust cylinders

Initial position

At the beginning of the first advance stroke, the thrust ring is at the rearmost stop of the thrust cylinders. This means that the thrust cylinders are fully retracted.

Controlling the thrust cylinders via the control panel

Extending the thrust cylinders

1. Preselect the **Preselection extend thrust cylinders** button.
2. Slowly turn the potentiometers **Coarse thrust cylinder regulation** and **Fine thrust cylinder regulation** clockwise towards 100%. These potentiometers control the coarse and fine adjustment of the extend speed of the thrust cylinders.
 - The thrust cylinders fully extend; the thrust ring is pushed forward.
3. Slowly turn the potentiometers **Coarse thrust cylinder regulation** and **Fine thrust cylinder regulation** anticlockwise towards 0%, and beyond the switching resistance.

Retracting the thrust cylinders

1. Preselect the **Preselection retract thrust cylinders** button.
2. Slowly turn the potentiometers **Coarse thrust cylinder regulation** and **Fine thrust cylinder regulation** clockwise towards 100%. These potentiometers control the coarse and fine adjustment of the extend speed of the thrust cylinders.
 - The thrust cylinders fully retract; the thrust ring is pulled rearward.
3. Slowly turn the potentiometers **Coarse thrust cylinder regulation** and **Fine thrust cylinder regulation** anticlockwise towards 0%, and beyond the switching resistance.

Controlling the thrust cylinders via the shaft panel

Extending the thrust cylinders

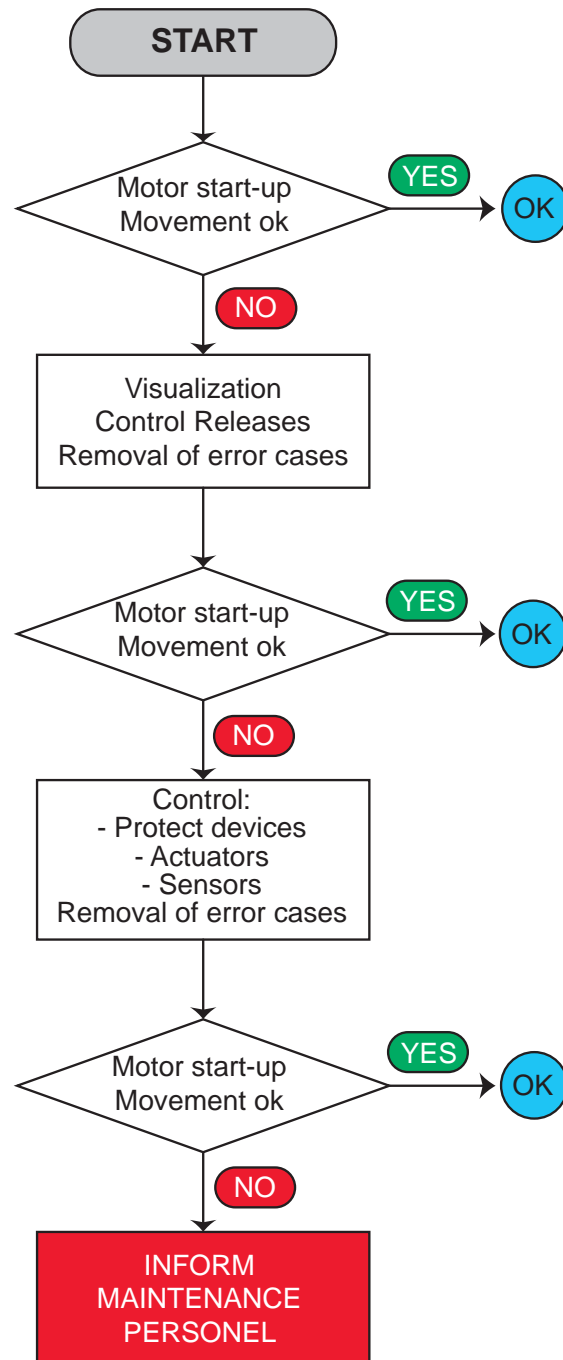
1. Preselect the **Preselection extend thrust cylinders** button.
2. Press the **Speed of the thrust cylinders** button. Depending on the button, the thrust cylinders extend as follows:
 Level control: Level 1: 25% / level 2: 50% / level 3: 100%
 - The thrust cylinders fully extend; the thrust ring is pushed forward.
3. Press the **Speed of the thrust cylinders** button to stop the thrust cylinders.

Retracting the thrust cylinders

1. Preselect the **Preselection retract thrust cylinders** button.
2. Press the **Speed of the thrust cylinders** button. Depending on the button, the thrust cylinders retract as follows:
Level control: Level 1: 25% / level 2: 50% / level 3: 100%
 - The thrust cylinders fully retract; the thrust ring is pulled rearward.
3. Press the **Speed of the thrust cylinders** button to stop the thrust cylinders.

6. Fault elimination

6.1 Fault analysis



Fault analysis

6.2 Troubleshooting

The following list does not claim to be complete. It contains the most common fault causes that occur in practical applications.

FAULT	CAUSE
<i>Steering cylinders can not be extended or retracted</i>	
Check via microphone / loudspeaker whether the solenoid valves switch.	
There is an electric problem if this is not the case.	Replace the electric control cable. Perhaps solenoid on valve defective.
There is a hydraulic problem if this is the case.	Control hose coupling defective. Hose burst. Cylinder defective (seal). Valve contaminated. Pump does not establish pressure.
<i>Bypass and slurry / feed gate valve do not switch</i>	
Check via microphone / loudspeaker whether the solenoid valves switch. Switch bypass in manual operation.	
There is an electric problem if this is not the case.	Replace the electric control cable. Perhaps solenoid on valve defective.
There is a hydraulic problem if this is the case.	Control hose coupling defective. Hose burst. Cylinder defective (seal). Valve contaminated.
Stone jammed	With running slurry pumps, switch repeatedly forward / backward to try to flush the lines.
<i>Obstruction in the slurry line / no material transport</i>	
	Flow rate too low. Bypass does not switch properly. Flushing as described under "Possibilities of removing obstructions".
<i>Steering cylinder stroke measuring reading incorrect or no value</i>	
	Defective or incorrectly connected electric control cable. Stroke measuring system in the cylinder is defective, or attached electronic housing is defective.

FAULT	CAUSE
<i>Thrust cylinders do not move correctly</i>	
	Check the solenoid valves on the hydraulic power unit. Check the hose lines. Pump does not establish pressure.
<i>Hydraulic pumps do not run</i>	
	Check the oil level in the tank. Check the electric power supply. Check contactors and fuses. Check the oil temperature.
<i>Control voltage on the control panel can not be switched on</i>	
	Unlock the emergency stop button. Switch on the main switch. Overvoltage or undervoltage or no clockwise phase sequence when the "Voltage monitoring" indicator lamp is ON. Control transformer defective.
<i>Main switch can not be switched on</i>	
	Overvoltage or undervoltage or no clockwise phase sequence of the power supply when the "Voltage monitoring" indicator lamp is ON. If this is not the case, the main switch is defective or emergency stop is activated.
<i>Slurry and feed pump do not run</i>	
	Check the circuit breaker. Using the troubleshooting instructions (frequency converter operating instructions), check whether there is a fault in the converter. Check the centrifugal pumps for obstruction or blockage. Check the thermal monitor of the electric motor.
<i>Oil temperature too high</i>	

FAULT ELIMINATION

OPERATION

FAULT	CAUSE
	<p>Check the oil cooler, whether the motor is switched on or defective. Check whether the switching points of the temperature meter are set correctly. 45° C > fan switches on 90° C > system stops</p>
<i>Cutting tool does not rotate correctly</i>	
	<p>Pump does not establish pressure. When the pump is not swung out, the control pressure must be approximately 25 bars. The control pressure drops when the pump is swung out. Connect a manometer to connection "G" of the pump to check. Electric control of the pump is defective. The amplifier card for the electric control is defective. Speed indicator is defective. Flow sensor is defective</p>
<i>Fault cutting tool pump</i>	
	<p>Circuit breaker tripped, then motor overload. Motor defective Pump blocked, resulting in overcurrent. Motor overload. Reduce speed of cutting tool.</p>

VI. Maintenance, repairs

1. About this main chapter	VI - 7
1.1 General	VI - 7
1.2 Safety Instructions	VI - 8
2. Maintenance schedule	VI - 10
2.1 General maintenance work	VI - 13
2.1.1 Mechanical system	VI - 13
2.1.2 Electrics	VI - 13
2.1.3 Hydraulics	VI - 15
2.1.4 Gas warning system	VI - 16
2.2 Maintenance work by plant component	VI - 17
2.2.1 Cutterhead / cutting wheel	VI - 17
2.2.2 Shield	VI - 18
Structural steelwork	VI - 18
2.2.3 Cutterhead/cutting wheel drive	VI - 19
2.2.4 Machine pipe 1	VI - 21
Foam installation	VI - 21
Target	VI - 21
2.2.5 Machine pipe 2	VI - 22
Foam installation	VI - 22
Dosing unit	VI - 22
Centrifugal pump	VI - 23
Machine winch	VI - 23
2.2.6 Conveyor system	VI - 24
Screw conveyor	VI - 24
Drive	VI - 24
Remaining screw conveyors	VI - 26
Belt conveyor	VI - 26
Machine winch	VI - 28
2.2.7 Jacking frame	VI - 28
Shaft winch	VI - 30
2.2.8 Operation container	VI - 31

TABLE OF CONTENTS

MAINTENANCE, REPAIRS

Steel structure/attachment parts	VI - 31
Hydraulic power unit	VI - 32
Compressor	VI - 34
Compressed air service unit	VI - 35
Bladder accumulator	VI - 36
Visualisation	VI - 36

3. Consumables VI - 39

3.1 General	VI - 39
3.1.1 Oil purity	VI - 40
3.2 Hydraulic oil	VI - 41
3.3 Motor oil	VI - 41
3.4 Compressed air lubricant	VI - 41
3.5 Removal	VI - 41

4. Cleaning work VI - 42

4.1 General safety regulations	VI - 42
4.2 Cleaning the screw conveyor	VI - 43
4.3 Cleaning agents	VI - 43

5. Maintenance work VI - 44

5.1 Safety Instructions	VI - 44
5.1.1 General safety regulations	VI - 44
5.1.2 Observe safety regulations when performing maintenance work . .	VI - 45
5.1.3 Dangers during maintenance work	VI - 45
5.1.4 Staff requirements	VI - 45
5.2 Maintenance work on the gearboxes	VI - 46
5.2.1 General	VI - 46
5.2.2 Safety Instructions	VI - 46
5.2.3 Gearbox maintenance	VI - 46
5.2.4 Changing the bearing oil	VI - 47
5.2.5 Changing the gear oil	VI - 48
5.3 Maintenance work on the hydraulic system	VI - 49

5.3.1	Before starting maintenance work on the hydraulic system	VI - 49
5.3.2	Replacing hydraulic hoses	VI - 50
5.3.3	Oil quality checks	VI - 51
5.3.4	Oil change	VI - 52
5.3.5	Cleaning the strainer	VI - 52
5.3.6	Replace the lost oil volume.	VI - 53
5.3.7	Bleeding the system	VI - 53
5.3.8	Leak tightness test	VI - 54
5.4	Changing the filter element	VI - 55
5.4.1	Changing the filter elements in the return/suction filter	VI - 56
5.4.2	Changing filter - high pressure filter elements.	VI - 58
5.5	Maintaining the bladder accumulator.	VI - 59
5.5.1	Preparations for working with the filling and testing device.	VI - 59
5.5.2	Check the gas pressure in the accumulator	VI - 60
	Check intervals	VI - 60
5.5.3	Reducing the gas pressure in the accumulator.	VI - 60
5.5.4	Increasing the pressure in the accumulator	VI - 61
5.6	Oil/air cooling system maintenance.	VI - 63
5.6.1	Cleaning the air side	VI - 63
5.6.2	Cleaning the oil side	VI - 63
5.6.3	Waste disposal	VI - 63
5.7	Switch cabinet ventilator maintenance	VI - 64
5.8	Compressor maintenance	VI - 65
5.8.1	Checking the oil level and topping up with oil.	VI - 65
5.8.2	Compressed air tank.	VI - 66
5.8.3	Oil change on the compressor block.	VI - 67
5.8.4	Clean or replace the air filter.	VI - 68
5.9	Maintenance work on the cutterhead tool	VI - 69
5.9.1	Safety instruction before and after changing the tool	VI - 69
5.9.2	Servicing the cutterhead and tool	VI - 70
5.9.3	Check list for tool service	VI - 71
	Disc cutter service.	VI - 71
	Servicing the slab cutters and buckets	VI - 71
5.9.4	Approach for service	VI - 71

TABLE OF CONTENTS

MAINTENANCE, REPAIRS

5.9.5	Tool service log	VI - 72
5.9.6	Cutting tool change	VI - 74
	Safety instructions	VI - 74
	Recommended equipment	VI - 75
	Preparation	VI - 75
	Changing the cutting tools	VI - 76
	Spare parts	VI - 76
	Illustration removing a slab cutter	VI - 77
	Removing discs or slab cutters	VI - 78
	Fit a new disk or slab cutter	VI - 79
5.9.7	Replacing the buckets	VI - 80
	Replacable parts, spare parts	VI - 80
5.9.8	Replacing the slab cutters	VI - 82
	Replacable parts, spare parts	VI - 82
5.9.9	Replacing the centre tool	VI - 83
	Replacing the centre tool	VI - 83
	Replacing the centre ripper	VI - 84
5.9.10	Welding, cutting and grinding work	VI - 85
	General notes	VI - 85
	Safety Instructions	VI - 85
	Preparation	VI - 85
5.10	Repair work to the cutterhead tool	VI - 85
5.10.1	Notes for use of Xuper Elasto Dur 8888	VI - 85
5.10.2	Processing instructions for hardfacing electrodes OK 8458	VI - 86
5.11	Bentonite/foam nozzles	VI - 87
5.11.1	Replacing the flat diaphragm	VI - 87
5.11.2	Replacing the conical diaphragm	VI - 88
5.12	Repair work on the conveying system	VI - 89
5.12.1	Replacing the conveyor belt	VI - 89
5.12.2	Changing the cable in the winch	VI - 90

6. Recurring tests VI - 91

6.1	Hydraulic operating equipment	VI - 91
6.1.1	Qualified staff	VI - 91
6.1.2	Mandatory documentation	VI - 91
6.1.3	Test periods for hydraulic hoses	VI - 92

6.2	Electrical operating equipment	VI - 94
6.2.1	Electrician	VI - 94
6.2.2	Preconditions for performing the tests	VI - 94
6.2.3	Mandatory documentation.	VI - 94
6.2.4	Fixed electrical operating equipment	VI - 95
6.2.5	Mobile electrical operating equipment.	VI - 95
6.2.6	Recurring tests on electrical systems	VI - 95
6.2.7	Test procedure for recurring tests on electrical equipment.	VI - 98
6.2.8	Measurement tasks and methods for recurring testing of electrical devicesVI - 99	
6.2.9	Wireless transmitters.	VI - 100
6.3	Lifting devices and lifting gear	VI - 101
6.3.1	Persons qualified to perform tests.	VI - 101
6.3.2	Tests	VI - 101
6.3.3	Instructions for performance	VI - 102

TABLE OF CONTENTS

MAINTENANCE, REPAIRS

1. About this main chapter

- The main chapter describes and explains the following topics:
 - Maintenance: General tips and safety warnings relating to maintenance.
 - Maintenance schedule: Table containing maintenance work recommended for maintaining the machine/plant.
 - Operating materials: Overview and description of operating materials used by the tunnelling system
 - Maintenance work: Description of the required maintenance and repair activities.

1.1 General

Operational safety and readiness are the requirements, a machine/plant must meet to ensure rational operating efficiency to the greatest possible extent.

Correct handling, sufficient lubrication and maintenance using suitable lubricants and careful observation of the machine/plant functions help to avoid faults.

These instructions contain all the explanations and guidelines required for correct handling of the machine/plant.

The maintenance work specified in these instructions must be carried out to ensure reliable and safe operation of the machine/plant and thus reduce downtime.

This manual only briefly lists most of the maintenance work, which is described in detail in the operating instructions for the individual installed equipment and machine components. In these cases, always adhere to the operating instructions for the installed equipment (supplier documentation on the CD), and perform maintenance work in accordance with the procedures described there.

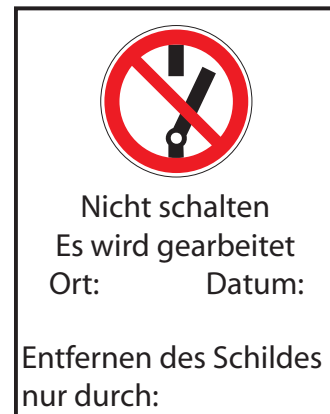
Details on implementing the work specified in the maintenance schedule are provided by the "Maintenance Work" and "Repair Work" chapters and the enclosed supplier documentation in the appendix (see CD-ROM). Additionally, always refer to supplier documentation in the appendix (see CD-ROM) for exact specifications of the maintenance intervals.



Herrenknecht AG does not accept any liability for damage caused by irregular performance of, or failure to perform, maintenance work.

1.2 Safety Instructions

- All maintenance, cleaning and repair work must be performed by authorized staff only while the machine/plant is at a standstill and switched off.
- Under exceptional circumstances some maintenance or repair work can require the machine/plant to be switched on (e.g. in order to determine the direction of rotation); in this case post a sign at the main switch and at the control cabin prohibiting switching any and all functions "ON" or "OFF" at the control cabin.
- Observe all instructions in the operating manual.
- Catch operating fluids in suitable containers.
- Immediately clean up any spilled operating fluids.
- Maintenance and repair work must be carried out by authorized and qualified staff only. These persons must have read and understood this operating manual.



DANGER!



Maintenance and repair work for the machine.

- Serious injuries, system damage.
 - Perform maintenance work only when the machine is stopped or the components/assemblies are stopped.
 - Disconnect the components/assemblies from the energy supply and secure them against being switched back on /started up.
 - Maintenance and repair work must be carried out by authorized and qualified staff only.
-



DANGER!

Maintenance and repair work on hydraulic systems.

- Serious injuries, system damage.
- Depressurize the system before you start working on the hydraulic system.



DANGER!

Maintenance work on electrical systems.

- Electric shock, severe paralysis or burns, **Danger of fatal injury.**
- Never touch live parts or damaged cables.
- Only qualified electricians are allowed to perform maintenance work on the electric system.



DANGER!

Improper approaches to performing maintenance. Ignoring safety instructions.

- Serious injuries, serious system damage.
- Maintenance work must be carried out by authorized and qualified staff only.
- These persons must have read and understood the operating manual.
- Observe all safety instructions.

2. Maintenance schedule

The maintenance schedule contains the maintenance work that must be performed regularly.

The maintenance work is listed in tables and sorted by assembly and subassembly.

Most maintenance and repair work is only briefly stated in the maintenance schedule; it is described in detail under "Maintenance Work" and "Repair Work". Details on implementing the work specified in the maintenance schedule are provided by the "Maintenance Work" and "Repair Work" chapters and the enclosed supplier documentation in the appendix (see CD-ROM). Additionally, always refer to supplier documentation in the appendix (see CD-ROM) for exact specifications of the maintenance intervals.

The stated maintenance intervals are recommendations that are valid for average operating conditions. Shorten the maintenance intervals under unfavourable ambient conditions (dusty atmosphere, for example) or heavy use. Adjust the maintenance intervals to reflect the local installation and operating conditions.

All maintenance and service work must be recorded in a logbook. This makes it possible to determine the individual maintenance work frequency and any deviations from the recommendations in the maintenance schedule.



All specified maintenance intervals including instructions concerning the replacement of subassemblies and components must be observed. Only original spare parts and original accessories approved by the manufacturer as well as the compulsory operating equipment and materials must be used.



Complete the maintenance schedules thoroughly and observe the schedules. All actions taken must be documented in writing.



These maintenance schedule only briefly lists most of the maintenance work, which is described in detail in the operating instructions for the individual built-in devices and machine components. In these cases, always adhere to the operating instructions for the installed equipment, and perform maintenance work in accordance with the procedures described there.



When carrying out maintenance work also perform any maintenance work designated for shorter intervals.



The maintenance intervals are recommendations that are valid for average operating conditions.

Shorten the maintenance intervals under unfavourable ambient conditions (dusty atmosphere, for example) or heavy use.

Adjust the maintenance intervals to reflect the local installation and operating conditions.

All maintenance and service work must be recorded in a logbook. This makes it possible to determine the individual maintenance work frequency and any deviations from the recommendations in the maintenance schedule.

MAINTENANCE SCHEDULE

MAINTENANCE, REPAIRS

2.1 General maintenance work

General maintenance work relates to the whole plant.

2.1.1 Mechanical system

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES	DONE DATE NAME
Monthly	Steel components	Check for damage and corrosion.	Repair all damage immediately. Replace defective components in line with drawings.	
	Bolted connections	Check torque. Tighten if needed.		

2.1.2 Electrics

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES	DONE DATE NAME
Prior to startup	Electrical connections	Check all bolts and connections for tight seating. Tighten if needed.	Replace defective components in line with schematics.	
	Limit switches	Check function.		
	Telephones			
Daily	Cables	Check for damage.		

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES	DONE DATE NAME
Weekly	Safety cut-offs	Check function.		
	Warning signals (horns, lamps)		Replace defective components in line with schematics.	
	Control cabinets	Check for moisture. Check bolts and connections for tight seating. Tighten if needed.		
Monthly	Battery emergency lighting	Check charge state.		
	FI residual-current-operated protective device	Check all bolts and connections for tight seating. Tighten if needed.		
	FI residual-current-operated protective device	Check function.	Replace defective components in line with schematics.	

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

2.1.3 Hydraulics

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES	DONE DATE NAME
Daily	Connections	Check for tight seating and seal. Tighten if needed.		
	Tank	Check fill level. Top up as needed.	Use the hydraulic oil specified on the tank label.	
	Pumps	Check for unusual noise. Check all connections for tight seal.		
500 hours of operation/annually	Hydraulic oil	Check quality. Replace as needed.	Required cleanliness class as per ISO 4406: 19 / 17 / 14 Shorten the intervals depending on the results.	
At every oil change	Tank	Clean.		
	Tank breather	Replace.	Replace defective components in line with schematics.	
	Tank strainers	Check fill level. Top up as needed.		
	Other filters	Replace filter elements.		
After a longer period without use	Tank	Drain any water that has collected at the base of the tank		
		Check fill level. Top up as needed.	Use the hydraulic oil specified on the tank label.	
If a malfunction is displayed	Related filters	Replace filter elements.	Replace defective components in line with schematics.	
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

2.1.4 Gas warning system

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES	DONE DATE NAME
Prior to starting	Gas warning system	Observe commissioning description	See supplier documentation	
Daily	Sensors	Check: Ready for operation		
		Cleaning		
Every 6 months		Calibration: Check: Zero point, sensitivity, signal transmission	Check by manufacturer's expert.	
Yearly	Gas warning system	Inspection, test		
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

2.2 Maintenance work by plant component

The maintenance work for the individual components must be listed here. Additionally, the general maintenance work listed above must be performed for the components.

2.2.1 Cutterhead / cutting wheel

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES	DONE DATE NAME
Before each start	Complete cutting tool	General visual check.	Repair all damage immediately. Replace defective components in line with drawings.	
Daily	Sprinkler	Functional test. Flush as needed.	Water	
	Structure, slab cutters, buckets, wear protection	General visual check. Check for wear.	Repair all damage immediately. Replace defective components in line with drawings.	
	Rotary coupling	General visual check. Check the tightness of all connections. Check the water circuit	Immediately stop advancing if the rotary coupling is not tight. Replace defective components in line with drawings.	
Weekly	Bolted connections equipment	Check torque. Tighten if needed.	Tightening torques as per spare parts drawing	
	Bolted connections drive cutting tool drive			

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

2.2.2 Shield

Structural steelwork

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES	DONE DATE NAME
Daily	Steel components	Visual check (e.g. welds) Clean if required	Repair damage immediately.	_____
	Measuring cylinder, all hydraulic cylinders	Visual inspection, check of all hydraulic connections		_____
	Hydraulic system: Hoses, lines, connections, distributors	Visual inspection: Leaks, abrasion spots Clean if required		_____
Weekly	Complete shield area	Cleaning, check the bolted connections	Observe tightening torque!	_____

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

2.2.3 Cutterhead/cutting wheel drive



If you discover swarf or contamination in the drive system, please contact Herrenknecht AG immediately!

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Bearing chamber Planetary gear	Check fill level. Top up as needed.	Gear oil as per list of lubricants.	
	Sealing gap, leakage chamber	Check: transparent hose, expansion tank		
	Grease pump	Check fill level. Top up as needed. Functional check minimum display, pressure	See supplier documentation	

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Weekly	Connecting bolts	Check torque. Tighten if needed.		
	Gear oil pump (if fitted)	Check gear oil. Clean pump	See supplier documentation	
	Gear oil circuit	Check filter. Replace filter element if needed.	Replace defective components in line with schematics.	
Check and clean magnetic filter.		If you discover swarf, please contact Herrenknecht AG immediately!		
In case of an empty signal	Grease pump	Top up	Ensure cleanliness.	
After the first 50 hours of operation	Planetary gear	First oil change.	Gear oil as per list of lubricants. See supplier documentation	
After the first 200 hours of operation	Main bearing	First oil change.	Gear oil as per list of lubricants.	
Monthly	Gear oil bearing chamber	Oil samples for analysis. Depending on results shorten or lengthen the intervals.		
	Gear oil planetary gear		See supplier documentation	
Every 500 operating hours	Main bearing, pinion, pinion bearing		If you discover swarf, please contact Herrenknecht AG immediately!	
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

2.2.4 Machine pipe 1

Foam installation

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Flange connections	Check for tightness.	Tighten leaking connections, or replace seal.	
	Pressure gauges	Clean		
Weekly	Flowmeter	External cleaning.		

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

Target

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Every 6000 operating hours	Laser target ELS 1, ELS 2 up to serial number 23000	Revision	Send laser target to Herrenknecht AG	
Every 10000 operating hours	Laser target ELS NTas of serial number 23001	Revision	Send laser target to Herrenknecht AG	

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

2.2.5 Machine pipe 2

Foam installation

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Flange connections	Check for tightness.	Tighten leaking connections, or replace seal.	
	Pressure gauges	Clean		
Weekly	Flowmeter	External cleaning.		

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

Dosing unit

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Metering device	Check settings.	Adjust metering if needed.	
Weekly	Filters	Check for soiling. Clean if needed.		
	Flange connections	Check for tightness.	Tighten leaking connections, or replace seal	

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

Centrifugal pump

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Prior to startup		Turn shaft.	See supplier documentation	
3 months		Turn shaft (only after extended period without use).		
1000 operating hours		Apply grease with grease gun, approx. 15 g grease.		
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

Machine winch

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Bearing	Listen for unusual noises		
	Hydraulic motor			
	Hydraulic connections	Check for leak tightness. Tighten leaking connections	Replace damaged lines.	
	Hydraulic pipework	Check for damage. Replace damaged lines.		

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Weekly	Bolted connections	Check torque; tighten if needed.		
	Winch bearings	Lubricate	See supplier documentation	
	Cable winding device	Lubricate		
Monthly	Wire-rope	Check for damage Replaced damaged wire-rope.	Wire-rope as per drawing	

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

2.2.6 Conveyor system

Screw conveyor

Drive



If you discover swarf or contamination in the drive system, please contact Herrenknecht AG immediately!

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Storage room	Check fill level. Top up as needed.	Gear oil as per list of lubricants.	
	Sealing gap, leakage chamber	Check:.		
Weekly	Bolted connections	Check torque. Tighten if needed.	Replace seal as necessary.	
	Leakage	Check		
After the first 200 hours of operation	Bearing chamber main bearing	First oil change.	Gear oil as per list of lubricants.	
Monthly	Gear oil bearing chamber	Oil samples for analysis.	Depending on results shorten or lengthen the intervals.	
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

Remaining screw conveyors

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Bentonite/foam nozzles	Flush	Water	
	Gate valve	Lubricate	3 grease nipples on each side.	
Weekly	Earth pressure sensor	Check for wear.	Replace defective components in line with schematics.	

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

Belt conveyor

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Motor, gearbox and bearings	Pay attention to unusual running noise. Check temperature.	See supplier documentation	
	Reel bearings and bearing lubrication	Check		
	Take-off points	Remove blockages in delivery medium.		

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Weekly	Reels, bearing pulleys	Remove caking.		
	Conveyor belt	Check for tears and grooves.		
	Gearbox	Check oil level. Top up as needed.		
	Scraper devices and material guides	Check. Adjust as needed.		
Weekly	Belt tension and true running	Check. Adjust as needed.		
	Conveyor belt	Remove caking.		
	Bearings drive and deflection pulleys	Lubricate. All grease nipples for each bearing.		
Monthly	Bolted connections	Check torque. Tighten if needed.		
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

Machine winch

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Bearing	Listen for unusual noises		
	Hydraulic motor			
	Hydraulic connections	Check for leak tightness. Tighten leaking connections	Replace damaged lines.	
	Hydraulic pipework	Check for damage. Replace damaged lines.		
Weekly	Bolted connections	Check torque; tighten if needed.		
	Winch bearings	Lubricate		
	Cable winding device	Lubricate		
Monthly	Wire-rope	Check for damage Replaced damaged wire-rope.	Wire-rope as per drawing	

The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.

2.2.7 Jacking frame

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
For each pipe change	Guide rails	Clean		
	Thrust cylinders	Before retracting clean piston rods		
Daily	Hydraulic connections	Check for leak tightness. Tighten leaking connections	Replace damaged lines.	
	Hydraulic pipework	Check for damage. Replace damaged lines.		
Weekly	Thrust plate	Lubricate	1 grease nipple per thrust plate	
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

Shaft winch

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE AND INSPECTION WORK	CONSUMABLES COMMENT	DONE DATE NAME
Daily	Bearing	Listen for unusual noises		
	Hydraulic motor			
	Hydraulic connections	Check for leak tightness. Tighten leaking connections	Replace damaged lines.	
	Hydraulic pipework	Check for damage. Replace damaged lines.		
Weekly	Bolted connections	Check torque; tighten if needed.		
	Winch bearings	Lubricate		
	Cable winding device	Lubricate		
Monthly	Wire-rope	Check for damage Replaced damaged wire-rope.	Wire-rope as per drawing	
The supplier documentation contains further details on maintenance intervals, which must always be observed for maintenance work.				

2.2.8 Operation container

Steel structure/attachment parts

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Daily/ Before each deployment	Check platforms, attachments, chassis, steel structures in general, welds, handrails for safety	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams Electrics diagrams	Water	Clean if needed Repair damages immediately.
	Check tightness of bolted and crimped contacts Visual check of all cables and lines incl. equipotential bonding			
	Check insulation on all cables and lines			
	Check tight seat and leak tightness of hydraulics couplings, water and bentonite lines			
	Check tightening torques of bolted connections, visual check for damage			
	Function test lamps and EMERGENCY OFF system			

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
After each deployment	Check sliding plates for wear and damage. Damaged sliding plates must be replaced; fit distance plates to worn sliding plates	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams Electrics diagrams	Water Wire electrode DIN 8555-MSG 6-GZ-60	Clean if needed Repair damage immediately.
	Check all points with hardfacing for damage; weld worn parts			
	Clean, flush and, if needed, replace high pressure nozzles, low pressure nozzles, suction box, rake, conveyor and feed lines			
	Clean machine/plant			

Table VI - 1: Steel structure/attachment parts

Hydraulic power unit

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Daily	Check oil level. Top up with oil as needed.	Manufacturer's documentation Herrenknecht documentation	Hydraulic oil	See the consumables section

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Every 50 operating hours	Check tank ventilation filter	Manufacturer's documentation Herrenknecht documentation		
After the first 100 hours of operation	Check the oil quality. Change the oil depending on the quality.	Manufacturer's documentation Herrenknecht documentation	Hydraulic oil	See the consumables section
	At every oil change:			
	All filters: replace the filter cartridge. Clean the filter casing.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Filter cartridge	See hydraulics diagram
All suction filters: clean filter, replace if needed.	Filters			

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Every 500 operating hours	Check the oil quality. Change the oil depending on the quality.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Hydraulic oil	
	At every oil change:			
	All filters: replace the filter cartridge. Clean the filter casing.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Filter cartridge	See hydraulics diagram
	All suction filters: clean filter, replace if needed.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Filters	See hydraulics diagram

Table VI - 2: Hydraulic power unit

Compressor

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Daily	Check the oil level in the compressor block. Top up as needed.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Motor oil	See the consumables section
	Drain condensate at the pressure vessel			

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Every 500 operating hours	Oil change.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Motor oil	See the consumables section
	Check and clean the air filter.			
	Check the non return valve			
	Check the safety valve			
Every 3000 operating hours	Check the function of the cylinder head and valves.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Motor oil	See the consumables section

Table VI - 3: Compressor

Compressed air service unit

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Daily	Check for condensate build-up. Drain if needed.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Oil	Oil - see the consumables section
	Check the oil level in the compressed air lubricator. Top up with compressed air lubricant if needed			

Table VI - 4: Compressed air service unit

Bladder accumulator

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
Daily	Check connections for tight seating, fittings and safety devices for orderly state; check fastening elements	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Oil Water	
After the first 50 hours of operation	Check the nitrogen filling pressure			
Every 3000 operating hours	Check the pretension pressure			

Table VI - 5: Bladder accumulator

Visualisation

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
The malfunction is displayed on the monitor.	Change the return line filter cartridge.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Return line suction filter	Replace the filter cartridge as per the high pressure filter hydraulics diagram
	Replace the high pressure filter cartridge.		High pressure filter	
	Check the function of the cylinder head and valves.		All suction filters	Filter according to hydraulic diagram

INTERVAL	MAINTENANCE WORK	INFORMATION/ DESCRIPTION	CONSUMABLES	COMMENT
After a longer period without use	Replace the return line filter.	Manufacturer's documentation Herrenknecht documentation Hydraulics diagrams	Return line suction filter	Change the filter cartridge as per the high pressure filter hydraulics diagram
	Replace the high pressure filter cartridge.		High pressure filter	
	Check the function of the cylinder head and valves.		All suction filters:	Filters as per hydraulics diagram

Table VI - 6: Visualisation

3. Consumables

3.1 General

When filling and refilling oils and greases, take care to use the same products as the original factory fill.

Before changing oil or grease types, always consult **Herrenknecht AG**.

CAUTION!



Damage to the machine/plant due to using different oil or grease types.

- Mixing different oil or grease types can change the physical properties of the oils and greases. This can cause severe damage.
- Use only the specified oil or grease types.

CAUTION!



Reduction of lubricating qualities due to different grease types.

- Danger of bearing and gearbox damage.
- Never mix different grease types.

3.1.1 Oil purity

To increase the service life of all plant components, an oil purity in line with ISO 4406 is required. The minimum required oil purity can be determined on the basis of the system pressure and the sensitivity of the system components, e.g. for a system pressure of 200 bar and hydraulic components with average sensitivity, the minimum required oil purity class is 19/17/14 in accordance with ISO 4406.Y

Oil purity class to ISO 4406

In addition to the particle size, the particle count is decisive for the wear behaviour of a system. The more particles there are in circulation, the higher the wear.

To classify the available system cleanliness, several methods can be implemented. However, mostly ISO 4406 and NAS 1638 are used. ISO 4406 is a globally recognised current standard.

Determine the number of particles with sizes > 4 µm, > 6 µm and > 14 µm in 100 ml fluid. The particles can be counted either with a microscope or an automatic particle counter (laser technology). The measured particle numbers are assigned to code numbers.

Oil purity to ISO 4406

NUMBER OF PARTICLES PER 100 ML			
PARTICLE SIZE	NUMBER OF PARTICLES	COUNT RANGE	PURITY CLASS
> 4 µm	354,800	250,000 - 500,000	19
> 6 µm	89,200	64,000 - 130,000	17
> 14 µm	15,400	8,000 - 16,000	14

Table VI - 7: Oil purity to ISO 4406

microscopic image100-times
magnification1 scale line: 10 µm

3.2 Hydraulic oil

LOCATION	ASSEMBLY	VOLUME IN L	TYPE	ART. NO.
Betriebscontainer C20	Hydraulic tank	1000	See tank stickers	

Table VI - 8: Hydraulic oil C20

3.3 Motor oil

LOCATION	ASSEMBLY	VOLUME IN L	TYPE	ART. NO.
Control container	Compressor	0.2	See supplier documentation	

Table VI - 9: Motor oil

3.4 Compressed air lubricant

LOCATION	ASSEMBLY	VOLUME IN L	TYPE	ART. NO.
Control container	Compressed air maintenance unit	See supplier documentation		

Table VI - 10: Compressed air lubricant

3.5 Removal

Make sure that all operating fluids and auxiliary materials as well as exchange parts are disposed of safely and with minimal environmental impact.

As a rule, never dispose of any operating fluids and auxiliary materials into the drains, soil or waters. Collect and dispose of all oils.



Collect operation media e.g. gear oil and greases in suitable containers and dispose of them in line with national environmental regulations. Recycle all reusable replacement parts.

4. Cleaning work

4.1 General safety regulations

- Prior to starting cleaning work, shut down the machine/system and secure it against being switched back on inadvertently.
- All cleaning work must be performed by authorized staff only while the machine/plant is at a standstill and switched off.
- Under exceptional circumstances some maintenance or repair work can require the machine/plant to be switched on (e.g. in order to determine the direction of rotation); in this case post a sign at the main switch and at the control cabin prohibiting switching any and all functions "ON" or "OFF" at the control cabin.
- Before cleaning with water and using high-pressure cleaners or other cleaning appliances, cover all openings which must not be exposed to liquids or cleaning agents for reasons of safety or function. This particularly applies to electric motors and control cabinets.
- After cleaning, the covers must be removed completely.
- Bolted connections which were released during maintenance work must be fastened with their specified torque values.
- If it is necessary to remove safety installations during the cleaning work, these safety installations must be reinstalled and checked or adjusted immediately after the work has been completed.
- Cleaning work must be carried out by authorized and qualified staff only.

4.2 Cleaning the screw conveyor

- Clean the screw conveyor by flushing with fresh water.
- Above ground or in the target shaft, the screw conveyor can also be cleaned from the front with a pressure cleaner.

WARNING!

Rotating helix during reversing operation.



- Severe injuries
- Never reach into the screw conveyor during cleaning.

- Loosen trapped stones by reversing the screw conveyor.



If possible, perform all cleaning in the target shaft after finishing tunnelling.

4.3 Cleaning agents

CLEANING AGENTS	POSITION
Water	Complete tunnel boring plant
Grease removing cleaning agents	Steps, platforms, hydraulic power unit
Acetone Solvents Paraffin	Strainers in the hydraulic unit tank

Table VI - 11: Cleaning agents

5. Maintenance work

5.1 Safety Instructions

5.1.1 General safety regulations

- Prior to starting the maintenance work, shut down the machine/system and secure it against being switched back on inadvertently.
- All maintenance, cleaning and repair work must be performed by authorized staff only while the machine/plant is at a standstill and switched off.
- Under exceptional circumstances some maintenance or repair work can require the machine/plant to be switched on (e.g. in order to determine the direction of rotation); in this case post a sign at the main switch and at the control cabin prohibiting switching any and all functions "ON" or "OFF" at the control cabin.
- Tools and aids required for maintenance work must always be in a fully operational and safe state.
- When replacing parts, always observe the correct order of the work steps.
- Never start fitting a part without completing assembly of the previous part.
- After completing maintenance, carefully check the work you have performed in order to ensure that you have performed it correctly.
- Repeated checking of settings by trial runs of the machine before it is returned to operational state.

DANGER!

Danger due to using incorrect fasteners and/or tightening torques!



- Failure to observe can lead to serious or fatal injury.
 - Use only original nuts and bolts!
 - Tighten nuts and bolts with the specified torque!
-

5.1.2 Observe safety regulations when performing maintenance work

- Professional servicing and maintenance prevent premature wear and keep the machine/plant in a functional state. Imminent damage can be identified at an early stage, thus helping the owner to avoid expensive repairs.
- Regular servicing and maintenance are basic preconditions for trouble-free and safe operation of the plant.
- In the owner's interest, all maintenance work must be performed with care at the specified intervals. The environment in which the maintenance work is performed must be clean.



If the operating hours stated in the maintenance schedule elapse before the specified period, perform the stated maintenance work on reaching the specified operating hour count.

When carrying out maintenance work also perform any maintenance work designated for shorter intervals.

5.1.3 Dangers during maintenance work

The following special risks must be anticipated during maintenance of the machine/system:

- Unintended switching on of the power sources can lead to severe injury to persons and damage to the machine.
- Danger of injury on accessible sharp edged machine parts and tools.
- Danger of slipping due to lubricants and other fluids escaping.
- Incorrect bolt tightening torques and/or incorrect nuts and bolts can cause severe injury to persons and damage to the machine.

5.1.4 Staff requirements

Only qualified personnel are allowed to perform maintenance work.

5.2 Maintenance work on the gearboxes

5.2.1 General

Appropriate servicing and maintenance can considerably extend the service life of machines and plants.

- Perform regular visual checks, oil level checks and noise checks
- Change the oil as stated in the maintenance schedule.
- All hour values relating to oil changes refer to motor operating hours.

5.2.2 Safety Instructions

WARNING!

Rotating parts.



- Danger of crushing.
- Prior to starting the maintenance work, disable the gearboxes and secure them against being switched back on.

CAUTION!

Gear oil spills



- Environmental hazard
- Catch used oil in suitable containers.
- Dispose of used oil in line with environmental protection rules.



5.2.3 Gearbox maintenance

Preparation

- Before starting work, interrupt the power supply to the gear motor and secure against inadvertent switching on.
- Before starting work, allow the gearbox to cool down sufficiently.
- Prepare sufficiently large catchment containers.
- Make sure you have the gear oil stated in the consumables list.

5.2.4 Changing the bearing oil



If you discover swarf or water in the used oil, contact **Herrenknecht AG** immediately to discuss further steps. Swarf or water can indicate damage to the drive system.

Before changing the oil, check the magnetic filter for any swarf:

Approach:

For machines with a filter circuit for gear oil:

1. Shut-off the ball valve upstream of the filter.
2. Open the filter; check the magnets and interior of the casing for swarf and contamination.
3. Close the filter.
4. Open the ball valve.

For machines without a filter circuit for gear oil, steps 1 to 4 of the procedure are omitted.

Changing the oil

1. Open the oil filler screw (to vent the bearing).
2. Open the oil drain screws and drain off the oil into a catchment container. Replace the oil drain screws.
3. Fill fresh oil into the bearing area via the oil filler opening or the maintenance cover.



Observe the fill height.

4. Close the maintenance hatch, if it exists
5. Replace the oil filler screw.

5.2.5 Changing the gear oil



If you discover swarf or water in the used oil, contact Herrenknecht AG immediately to discuss further steps. Swarf or water can indicate damage to the drive system.

Before changing the oil, check the magnetic filter for any swarf:

Approach:

For machines with a filter circuit for gear oil:

1. Shut-off the ball valve upstream of the filter.
2. Open the filter; check the magnets and interior of the casing for swarf and contamination.
3. Close the filter.
4. Open the ball valve.

For machines without a filter circuit for gear oil, steps 1 to 4 of the procedure are omitted.

Changing the oil.

1. Open the oil filler screw (to vent the gearbox).
2. Open the oil drain screws and drain off the oil into a catchment container. Replace the oil drain screws.
3. Fill fresh oil into the bearing area via the oil filler opening.



Observe the fill height.

4. Replace the oil filler screw.

5.3 Maintenance work on the hydraulic system

Ensure:

- that the environment in which the maintenance work is performed is clean.
- If it is necessary to uncouple lines to perform maintenance work, fit suitable caps at the line ends to avoid hydraulic oil escaping and soiling entering the lines.



CAUTION!

Fibres in the hydraulic oil.

- Clogging of filters and/or valves.
- Never use cleaning rags or other fibrous materials to seal hydraulic lines.

5.3.1 Before starting maintenance work on the hydraulic system



WARNING!

Pretensioned hydraulic systems.

- Risk of injury from hot, pressurized hydraulic oil escaping.
- Always relieve the tank pretension pressure before starting maintenance work.
- Wear safety goggles and protective gloves.

Switch off and depressurize the machine/system.

Follow these steps for pretensioned hydraulic systems:

1. Allow the hydraulic oil to cool down to approx. 30 - 40°C.
2. Turn the breather through approx. 2 turns clockwise.
 - The excess pressure escapes; the tank pretension pressure is relieved.
3. Check the manometers to see whether the system is depressurised.
 - The manometer (for oil and air in the return line suction filter) must read 0 bar.

5.3.2 Replacing hydraulic hoses



Hoses should not be used for more than 6 years, including a maximum storage time of 2 years. (See also "Recurring checks")

1. If ball valves are fitted in the hose (e.g. for tank hoses) shut off the ball valves before uncoupling the hose.
2. Unscrew the hydraulic hose. Catch any oil that escapes in a container.
3. Bolt on the new hydraulic hose.

CAUTION!



Danger of serious damage due to dry running hydraulic pumps.

- Before restarting the hydraulic pumps, make sure that all the ball valves in the hydraulic system are open.
- Open all the closed ball valves, except the oil drain valve on the hydraulic tank.



Catch any hydraulic oil that escapes in suitable and suitably large containers and dispose of the oil in line with the waste disposal laws of the country of use.

Never pour the collected hydraulic oil back into the oil tank.

5.3.3 Oil quality checks



An oil change is necessary after the first 50 hours of operation, and then every 500 to 1000 hours of operation.

An oil quality check is necessary every 100 hours of operation; if needed, the oil must be changed.

Follow these steps after an extended period without use:

1. Drain any water that has collected at the base of the tank
2. Replace the lost oil volume.
3. Flush the hydraulic lines.
4. Run the plant for approx. 1 hr. and check all functions.
5. Replace soiled filters (electr. display or malfunction message in the visualisation).
6. Replace the filters in the machine/plant.
7. Bleed the system.
8. Use the oil specified on the tank label. Always use water-free oil to avoid destroying pumps, valves and the measuring system in the hydraulic cylinders.

5.3.4 Oil change

CAUTION!



Soiled hydraulic oil.

- Damage to hydraulic pumps and valves.
 - Refilling with hydraulic oil or new filling of the unit through a 1...3 µm fine filter.
 - Use only the filling connector (quick coupling 28L size 6) to fill up or top up the unit with hydraulic oil.
-

1. Completely drain the hydraulic oil through the drain tap.
2. Open the container cover and clean the tank.
3. Clean and reinsert the strainers.
4. Replace the filter elements on the return line/suction filter.
5. Close the container cover again.
6. Pour in new oil via the filler neck on the tank.
7. Bleed the system.

5.3.5 Cleaning the strainer

The strainers in the tank must be cleaned at every oil change.

CAUTION!



Danger of damaging the strainer mesh.

- Damage to hydraulics components.
 - Do not use a wire brush for cleaning.
-

1. Unbolt the strainer.
2. Soak the strainer in cleaning bath for approx. 15 min.
3. Take the strainer out of the cleaning bath and blow clean with compressed air from the inside out.
4. Bolt the strainer back into the corresponding suction line in the tank.

5.3.6 Replace the lost oil volume.

Always fill up with new hydraulic oil via the filler neck on the tank. (Use the hydraulic oil specified on the tank label)

CAUTION!



Soiled hydraulic oil.

- Damage to hydraulics components.
- Refilling with hydraulic oil or new filling of the unit only through a 1...3 µm fine filter.
- Use only the filling connector (quick coupling 28L size 6) to fill up or top up the unit with hydraulic oil.

5.3.7 Bleeding the system

1. Stop the machine/plant.
2. For pretensioned machines/systems use compressed air to build up the pretension pressure in the hydraulic tank. (See the diagram for the pretension pressure)
3. Carefully open one of the higher screw connections and/or the bleed screw.
 - Hydraulic oil escapes.
4. Tighten the bolted connection when the hydraulic fluid escapes without bubbles.



Check all flanges and bolted connections for leaks before you restart the system after bleeding.

MAINTENANCE WORK

MAINTENANCE, REPAIRS

5.3.8 Leak tightness test

1. Switch off and depressurize plant.
2. Check the manometers to see whether the system is depressurised.
 - The manometer must read 0 bar.
3. Tighten all bolted connections.



Tighten the bolted connections only when the system is depressurized.

5.4 Changing the filter element

When the monitor (visualisation) indicates a malfunction, press the "F5" key in the "Malfunction messages" screen to change to the "Advance" screen. If one of the following displays is highlighted in red, the filter element must be replaced.

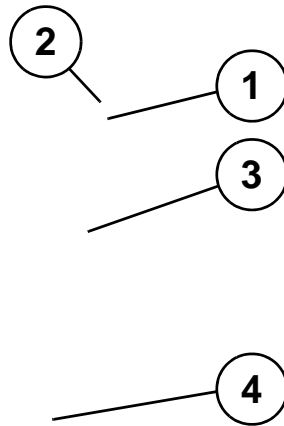
Error message filter change in visualisation



The filter elements in the filters described in the following cannot be cleaned and must be disposed of in line with environmental protection laws.

Always cleaning the filter casing when changing the filter element.

5.4.1 Changing the filter elements in the return/suction filter



1. Switch off the hydraulics system and relieve the pressure on the filter; if applicable, relieve the pressure in the tank.

2. Open the plug screw by approx. three turns. The filter casing can be bled via the play in the thread to equalise the oil level.

3. After waiting (for approx. 1 min.) remove the cover fastening bolts (2) and lift off the cover (1). No oil escapes beyond the edge of the casing at this step.

4. Pull the filter separator plate with the filter element attached to it, and the filter casing out of the filter bell. Some leverage is required here as the separator plate is seated in an o-ring seal seat.

5. Lifting out the complete unit.
6. After lifting out the complete unit, lower the oil level in the filter bowl by holding it over the filter head for a short while; oil drains through the 4 mm hole in the pretention or anti-cavitation valve on the clean side of the filter.
7. Place the complete unit in an oil catchment container and twist the separator plate off the filter element. The filter element remains in the filter casing for this step.
8. Twist the filter element to remove it from the filter casing. Check the surface of the element for contamination and larger particles. They can indicate damaged components.
9. Pour the residual oil out of the filter casing.
10. Perform the steps in reverse order to fit a new filter element and assemble the complete unit.
11. On restarting, you will need to bleed the return line/suction filter via the plug screw (5). Turn the plug screw (5) until a small quantity of oil escapes

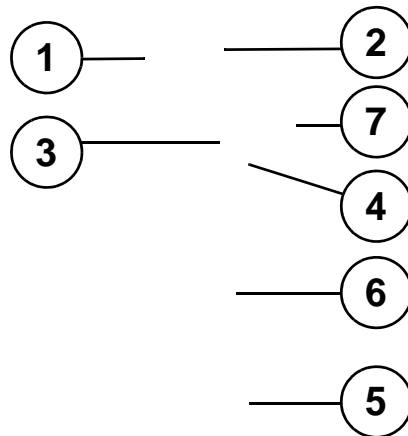


WARNING!

Danger due to oil squirting out during bleeding.

- Failure to observe can lead to severe injury.
 - Wear protective equipment during bleeding.
-

5.4.2 Changing filter - high pressure filter elements



1. Switch off the hydraulics system and relieve the pressure on the filter; if applicable, relieve the pressure in the tank.

2. Unscrew the filter bowl (5) and collect the hydraulic oil that escapes in a container. (Never pour the collected hydraulic oil back into the oil tank).

3. Remove the filter element (6) and check the element surface for visible contamination. (Visible particles can indicate an imminent failure of a system component).

4. Check the filter casing (2) and circulation valve for signs of damage. Damaged parts must be replaced.

5. Make sure that the o-ring (4) on the filter bowl is undamaged.

6. Lightly oil the o-ring element with clean hydraulic oil and slide the filter element (6) with the open side over the centring pivot in the filter casing.
7. Lightly oil the thread and o-ring (4) on the filter bowl (5) with clean hydraulic oil and screw into the filter head. Tighten the filter bowl to a maximum tightening torque of 100 Nm.
8. Pressurise the hydraulic system and make sure that the filter is leak tight.
9. Perform the steps in reverse order to fit a new filter element and assemble the complete unit.

5.5 Maintaining the bladder accumulator

5.5.1 Preparations for working with the filling and testing device

Before each check, or before you fill or top up with nitrogen, isolate the hydro-accumulator from the pressurised system via the shut-off valve, and relieve the pressure on the fluid side.

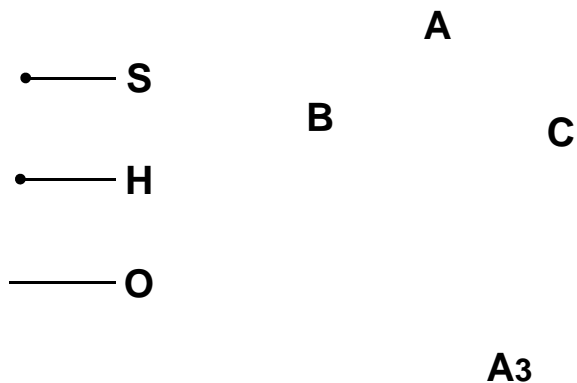
DANGER!



Danger of fatal injury due to defective bladder accumulator; i.e. nitrogen and operating fluids can escape from a leaking bladder accumulator during filling or testing.

- Never disassemble the non return valve. The valve has a safety function for the complete filling and testing device.
- Check all flanges and bolted connections for leaks before you restart the system after bleeding.

Perform the following steps before all test and filling activities:



1. Unscrew the dust protection cap (S) and the cap nut (H) from the bladder accumulator.
2. Remove the o-ring (O) from the bladder accumulator.
3. Assemble the filling and testing device.
4. Manually screw the filling and testing device and the union nut (A3) onto the stored gas valve. While doing so, make sure that the relief valve (B) on the filling device is closed.
5. Turn the filling device so that the manometer is in a position where you can easily read it.

5.5.2 Check the gas pressure in the accumulator

1. Open the accumulator valve by turning the spindle (A) clockwise.
2. When the needle on the manometer starts to move, turn the spindle another full turn clockwise.
 - The manometer now shows the prefilling pressure in the accumulator.
 - The non return valve (C) prevents the nitrogen escaping.

Check intervals

Nitrogen loss in hydro accumulators is typically very low. But to prevent the piston hitting the cover and/or excessive deformation of the bladder or diaphragm due to the gas fill pressure p_0 dropping excessively, regular checking of the gas fill pressure is recommended.

Set the prefilling pressure p_0 specified on the type plate or accumulator housing after installing or repairs, and then check at least once in the following week. If no nitrogen loss is detected, the next check should be performed after about four months. If you again do not detect any nitrogen loss, annual checks of the pretension will be sufficient.

5.5.3 Reducing the gas pressure in the accumulator

Perform the steps detailed in "Checking the gas pressure in the bladder accumulator". After doing so, then carefully open the relief valve (B) to allow nitrogen to escape into the atmosphere.

5.5.4 Increasing the pressure in the accumulator

- "Increasing the pressure in the accumulator" is equivalent to filling the bladder accumulator.
- To fill the hydro accumulator, use only nitrogen 99.995%.
- If the gas pressure in the nitrogen cylinder is higher than the max. operating pressure of the hydro accumulator, use an intermediate gas pressure reduction valve.

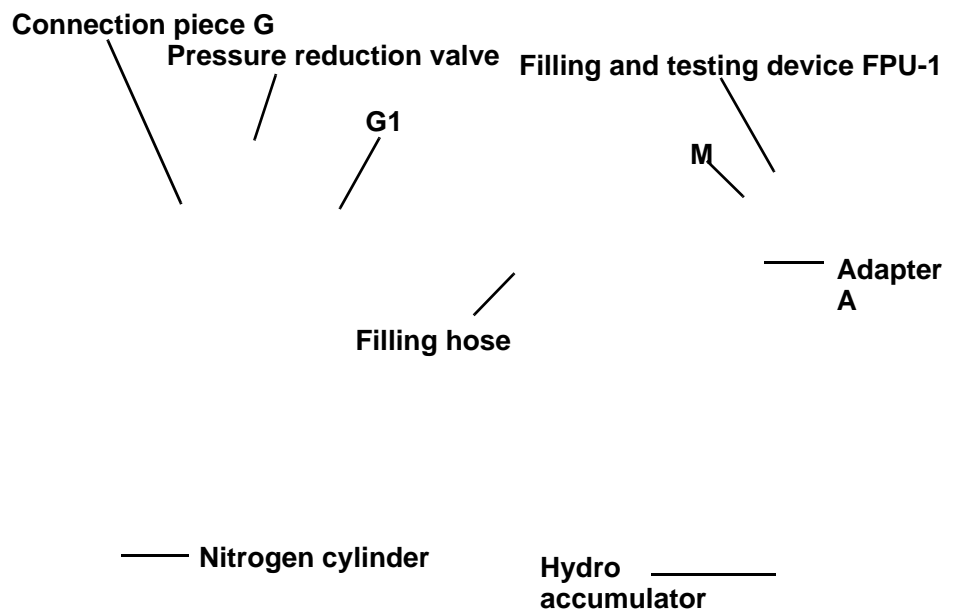


WARNING!

Explosion hazard!

Risk of explosion.

- Serious injuries due to parts being propelled.
- Never fill with oxygen or compressed air



1. Connect the union nut (G 1) on the filling hose to the pressure reduction valve on the nitrogen cylinder.
 - An adapter will be necessary for many international cylinders. The adapter must fit on a W24.32x1/14" thread.

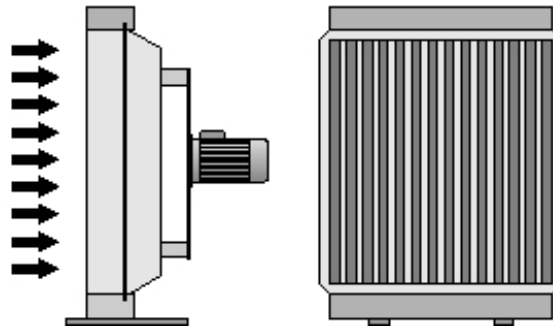
MAINTENANCE WORK

MAINTENANCE, REPAIRS

2. Connect the union nut (M) on the filling hose to the non return valve (C) on the filling and testing device.
3. Open the shut-off valve on the nitrogen cylinder and allow the nitrogen to slowly flow into the accumulator.
4. When a pressure of about 1 bar has been reached, but not sooner, you can open the shut-off valve further for faster charging.
5. Interrupt the filling procedure from time to time to check the prefill pressure that has been built up.
 - Repeat this procedure until the desired gas prefill pressure has been reached.
6. After accommodating to the ambient temperature, check the prefill pressure again, and adjust as needed.
 - If the prefill pressure is too high, you can relieve the pressure via the relief valve on the filling and testing device.
 - Once the desired gas prefill pressure has been reached, turn the spindle on the accumulator anticlockwise to shut off the gas valve.
7. Relieve the filling device via the relief valve and loosen the union nut to remove.
8. Screw off the adapter and replace the o-ring (O).
9. Check the tightness of the gas valve on the accumulator using a leak finding spray, or similar.
10. Screw the cap nut (H) and the dust protection cap (S) back onto the accumulator's gas valve and tighten.

5.6 Oil/air cooling system maintenance

The oil/air cooling systems do not need any special maintenance. However, regular cleaning must be performed when operated in environments with heavy soiling.



5.6.1 Cleaning the air side

Clean with compressed air in the direction of the arrow. The cleaning jet must be parallel to the fins to avoid damage to the fins.

Oily and greasy soiling can be washed off with a steam or hot-water cleaner. Again, pay attention to directing the jet parallel to the fins. The drive motor must be covered during cleaning.

5.6.2 Cleaning the oil side

The oil ducts are flushed with suitable cleaning agents in case of soiling. Adjust the flushing time to reflect the degree of soiling. After cleaning, the flushing medium must be purged without any residue using compressed air.

5.6.3 Waste disposal

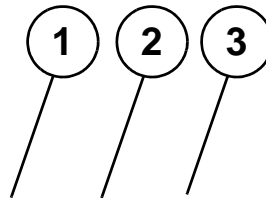
Use catchment containers when opening the cooling system. When choosing and disposing of operating fluids and cleaning agents, always observe legal requirements.

5.7 Switch cabinet ventilator maintenance

Fans are fitted to the switch cabinets to cool the electronic components. Replacing of the fan filters every 50 hours of operation is recommended.

To do so, follow these steps:

1. Pull the protective grid (3) off the fan housing (1).
2. Remove the filter (2) and replace with a new filter.
3. Push the protective grid (3) back onto the fan housing (1) and press into place.



Switch cabinet ventilator

- | | |
|---------------|-------------------|
| 1 Fan housing | 3 Protective grid |
| 2 Filter | |

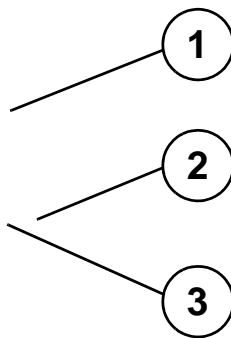
Article numbers for filters

FAN	FILTER	ART. NO.
SK 3150	SK 3160	26601400
SK 3151	SK 3161	26601401
SK 3152	SK 3162	26601402
SK 3153	SK 3163	26600314

5.8 Compressor maintenance

- Before starting any maintenance work on the compressor, interrupt the power supply by actuating the main switch and secure against switching on by pulling out the mains plug.
- Before working on pressurised lines, relieve the pressure in the lines first (relieve the accumulator pressure).
- Before switching back on, make sure that there are no maintenance employees working on the compressor system and that all covers have been correctly replaced.

5.8.1 Checking the oil level and topping up with oil.



- Check the oil level at the sight glass daily and before starting up the compressor.
- If the oil level drops to the low mark, top up with the recommended oil (see the enclosed operating manual). Never fill up with oil above the maximum oil fill level in the sight glass.
- When topping up with oil, use a screen or the original can.

Approach for topping up with oil:

1. Switch off the compressor at the switch provided, and unplug the mains plug to secure the compressor against switching on.
2. Remove the case breather (1) on the oil filler neck.
3. Top up with oil to the maximum fill level (2).
 - It takes a few minutes to reach the maximum oil fill level because the oil first needs to flow through the crank case.
4. Refit the housing breather.

5.8.2 Compressed air tank

DANGER!



Risk of fatal injury and damage due to failure to observe instructions.

- Observe the national legal requirements for pressure vessels.

Drain the condensate that collects in the compressed air tank daily via the drain tap (4).

Route the condensate to a collector tank and dispose of in line with environmental protection requirements.



5.8.3 Oil change on the compressor block

WARNING!



Danger of scalding and due to hot oil, danger of burns on hot parts.

- Severe burns.
- Wear personal protection while changing the oil.

-
- Change the oil while the system is at operating temperature.
 - The first oil change is due after 50 hours of operation. Further oil changes are due at intervals of 500 hours of operation, but at least once per year.
 - Change the oil immediately if you detect condensate in the oil in unfavourable operating conditions. Condensate in the oil is visible as a milky discolouration of the oil in the oil sight glass.

Approach for topping up with oil:



1. Switch off the compressor at the switch provided, and unplug the mains plug to secure the compressor against switching on.
2. Remove the case breather (1) on the oil filler neck.
3. Prepare an oil catchment container.
4. Loosen the oil drain screw (3) and allow the oil to drain into the oil catchment container.
5. Flush the crank housing with a small quantity of oil.
6. Fill up with fresh oil to the maximum oil fill level (2).

MAINTENANCE WORK

MAINTENANCE, REPAIRS



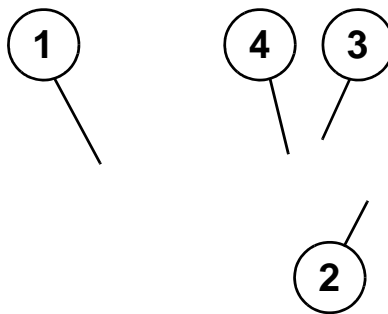
When filling up with oil, use a screen or the original can.



Collect the used oil and dispose of the oil in line with environmental protection rules.

It takes a few minutes to reach the maximum oil fill level because the oil first needs to flow through the crank case.

5.8.4 Clean or replace the air filter



Clean the filter element after 500 hours of operation at the latest. In case of heavy soiling, or if cleaning has been performed several times, fully replace the air filter.

Approach:

1. Switch off the compressor at the switch provided, and unplug the mains plug to secure the compressor against switching on.
2. Unscrew the air filter (1) from the cylinder head.
3. Push the clamping bar (2) off and open the filter casing.
4. Clean the filter casing (3), especially the sealing surfaces.
5. Wash out the air filter element with diesel fuel.
6. After cleaning the filter element slightly wet with oil.
7. Screw the air filter back on; fit the cover.



When screwing the air filter on, make sure that the suction inlet (2) is facing downward.

5.9 Maintenance work on the cutterhead tool

5.9.1 Safety instruction before and after changing the tool



DANGER!

Open the cover on the tunnelling machine to access the excavation chamber!

- Danger of fatal injury
 - Before opening the cover on the tunnelling machine, make sure that the tunnel face is stable and the excavation chamber depressurised, and empty.
 - If the tunnel face is not sufficiently stable, actions must be taken to achieve greater stability.
-



DANGER!

Gas deposits in the excavation/working chamber.

- Risk of explosion
 - Before starting work in the excavation/working chamber, always measure the gas concentration!
 - Ensure a sufficient exchange of air!
-



DANGER!

Cutting head rotation

- Danger of fatal injury
 - Never access the excavation chamber directly behind the cutterhead while the cutterhead is rotating.
-



DANGER!

Rock falls, collapsing tunnel face

- Danger of fatal injury
 - Before accessing the excavation chamber, make sure that the tunnel face is stable.
-

MAINTENANCE WORK

MAINTENANCE, REPAIRS



DANGER!

Blocked escape route

- Danger of fatal injury
- Escape routes and escape passages must be accessible for all staff and must be kept clear.
- Escape routes and escape passages must not be blocked by lines, cables or any other material.



Servicing of the tool must be performed behind the cutterhead only. Access to the front side of the cutterhead is prohibited.



Attach the required lifting gear to the intended load-bearing equipment and check to ensure safe operation.

5.9.2 Servicing the cutterhead and tool

The cutterhead must be serviced at regular intervals.



Prepare all required tools and materials before you start this task.

During servicing, check the cutterhead for damage. Check tools such as the discs, buckets, etc. for wear and log your findings in the service log. Additionally, check all fasteners for completeness and tighten to the recommended tightening torque.

Tunnelling with damaged or incomplete tool equipment can cause major damage to the cutterhead.

Geological conditions can substantially influence the service intervals. Performing regular servicing will help to determine the optimum tool change interval.

Servicing of the cutterhead is required whenever the geological conditions change.

5.9.3 Check list for tool service

Check all tools for signs of wear and perfect function at regular intervals. Replace damaged tools or tools that are not in perfect working condition.

Recommended tools for tool inspection

- Gauges
- Socket set
- Tape measure for measuring the blade circumference for disc cutters.
- Torque wrench for tightening bolts.

Disc cutter service

- For disc cutters with hardfacing, check the hardfacing for wear and damage.
- Check disc cutters with annular steel blades for damage and check for wear by measuring the circumference.

Servicing the slab cutters and buckets

Check slab cutters and buckets for wear and leaching between the carbide tips.

5.9.4 Approach for service

1. Use the conveying system to clear the excavation chamber.



DANGER!

Collapsing tunnel face

- Danger of fatal injury due to burying
- Before opening the cover on the tunnelling machine to access the excavation chamber, make sure that the tunnel face is stable.

-
1. After ensuring that the tunnel face is stable and the excavation chamber is empty, carefully open the cover on the tunnelling machine.
 2. Loosen the cover plate and place in safe position.
 3. Allow the cutterhead to rotate and check if the discs are turning.
 4. Stop the cutterhead at the required position.
 5. Check the wear on the tools.
 6. Check the bolt tightening torques.
 7. After completing the work, close the cover correctly.

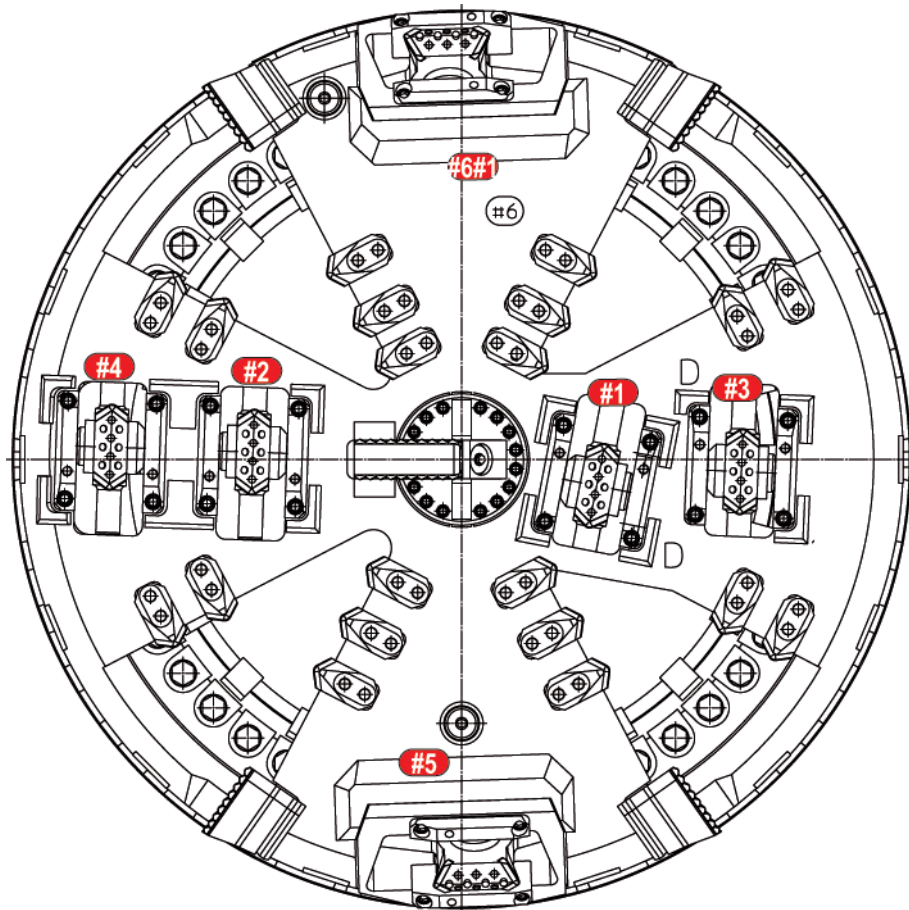
MAINTENANCE WORK

MAINTENANCE, REPAIRS

5.9.5 Tool service log

Project:	Advance length
Customer	Pipe no.
	Geology
	Date
	Signature

Table VI - 12: Service log



Service log: tooling plan

NO.	RIPPER	DAMAGE		COMMENT
	INSTALLATION	DISASSEMBLY		

#1

NO.	RIPPER		DAMAGE	COMMENT
	INSTALLATION	DISASSEMBLY		
#2				
#3				
#4				
#5				
#6				

Table VI - 13: Tool service discs/slab cutters

DAMAGE RIPPERS/BUCKETS/SLAB CUTTERS

- 1 = normal wear
- 2 = housing defective
- 3 = loose / faulty screw connection
- 4 = parts broken

Table VI - 14: Damage classification

MAINTENANCE WORK

MAINTENANCE, REPAIRS

5.9.6 Cutting tool change

Safety instructions



DANGER!

Moving machine parts, rockslides and landslides in front of the cutting tool.

- Danger of fatal injury
- Access to the space in front of the cutterhead is prohibited.
- All work must be performed from the area behind the cutting tool.



DANGER!

Water ingress

- Danger of fatal injury
- Close the doors so that the machine and tunnel are not flooded.
- Doors must not be blocked by lines, cables or any other material.



DANGER!

Falling

- Severe or fatal injury
- Wear a safety harness and secure it to the specified suspension points.



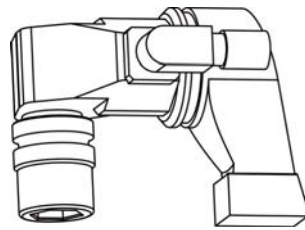
Attach all required platforms and load carriers at the respective fixing points.

Attach the required lifting gear to the intended load-bearing equipment and check to ensure safe operation.

Recommended equipment



Chain hoist
 Eye bolt M20



Hydraulic driving tool

Preparation



To replace all of the tools it is necessary to turn the cutterhead/cutting wheel multiple times. Before rotating, remove all equipment from the danger area

1. Remove the residual material from the excavation chamber.
2. Transport the tools to the working area using suitable gear.

DANGER!

Rotating cutting tool.

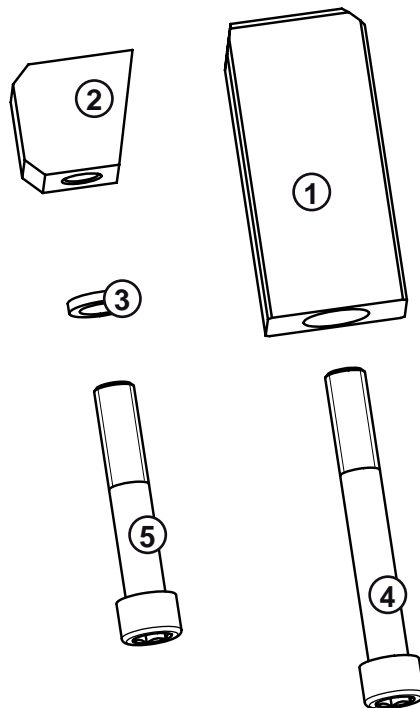


- Serious or fatal injury due to crushing limbs
- Never enter the cutting tool danger area when repositioning the cutting tool for a tool change

1. Use the control panel to rotate the cutting tool to the disc change position.
2. Attach suspended platforms, gratings and hoists at the intended attachment points.

Changing the cutting tools

Spare parts



1	Arrester
2	Clamping wedge
3	Disc
4	Bolt M 20 x 150 DIN912
5	Bolt M 20- x 110 DIN 912

Slab cutter Weight approx. 53.5 kg

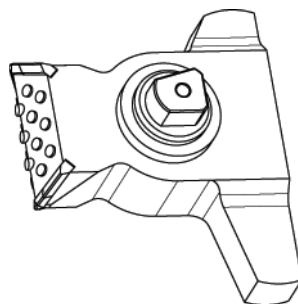
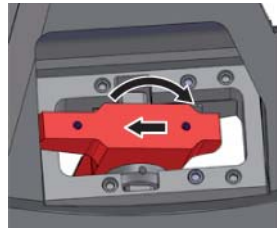


Table VI - 15: Spare parts



Follow the same steps for removing/installing the slab cutters as for removing/installing the discs.

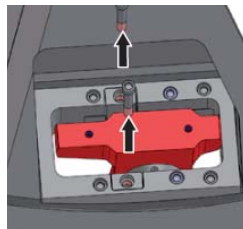
Illustration removing a slab cutter



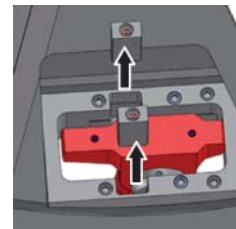
Step 01



Step 02



Step 03

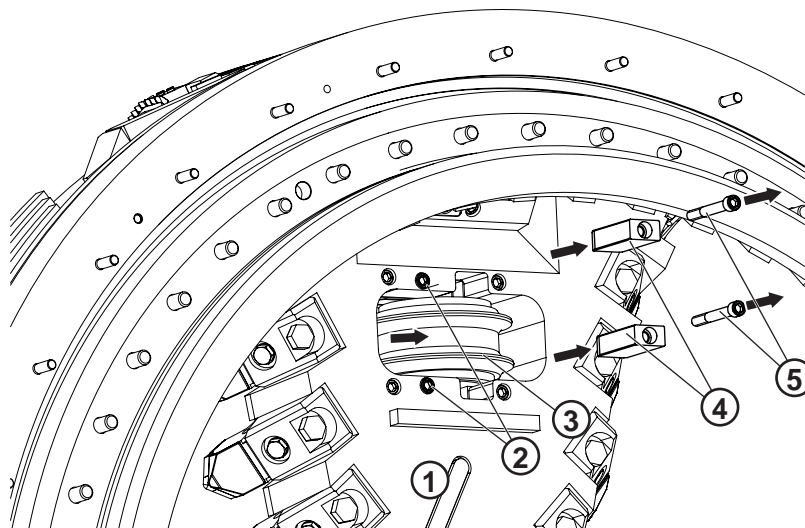


Step 04



Step 05

Removing discs or slab cutters.

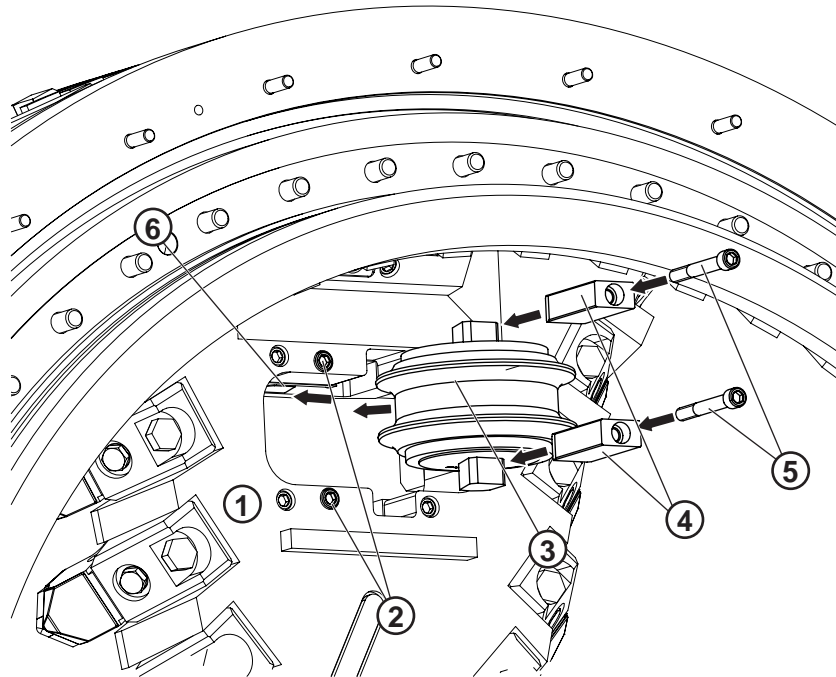


Example: Disc removal

1	Excavation tool	4	Arrester
2	Bolt M 20 x 110 DIN912	5	Bolt M 20 x 150 DIN 912
3	Disc		

1. Remove bolt (5).
2. Loosen bolts (2); do not remove.
3. Apply a bridge with hydraulic cylinders and bolt onto the arrestor (4).
4. Use the hydraulic pump to move out the hydraulic cylinders and thus pull the arrestor out of the disc holder.
5. If the maximum pressure is not sufficient, tap the loosened bolt (7) on the clamping wedge to support the process of loosening.
6. Push the disc (3) in the direction of the arrestor.
7. Remove the disc or slab cutter (3) from the holder.

Fit a new disk or slab cutter.



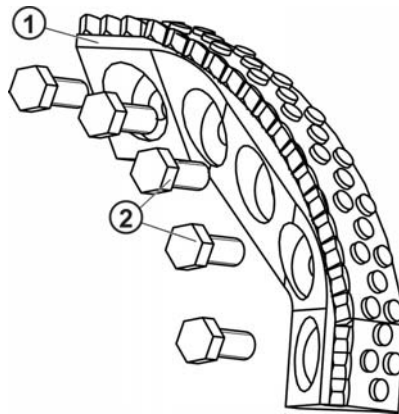
Example: Installing a disc

1	Excavation tool	4	Arrester
2	Bolt M 20 x 110 DIN912	5	Bolt M 20 x 150 DIN 912
3	Disc		

1. Clean all the contact surfaces and the space behind the clamping wedge.
2. Fit a new disc cutter or slab cutter into the disc holder.
3. Before installation, apply anti-welding lubricant to the bolt, e.g. GWF-GEWINDE-FREI (ART. NO. 29700744).
4. Bolt the arrester onto the holder and tighten the bolts to the recommended tightening torque.
5. Secure the disc and wedge by tightening the bolts (4) to the recommended tightening torque

5.9.7 Replacing the buckets

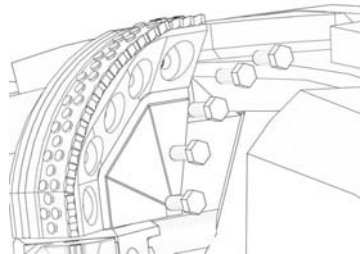
Replacable parts, spare parts



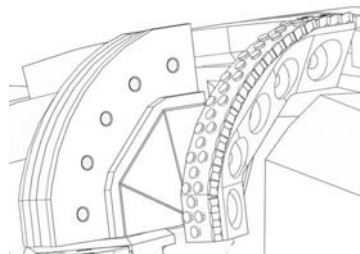
1	Buckets
2	Bolt M20x45 DIN 933

Procedure

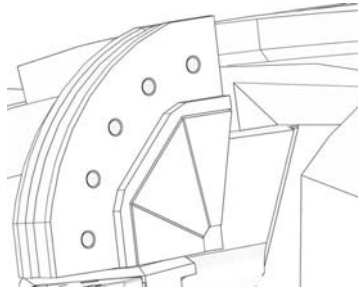
1. Remove the bolts.



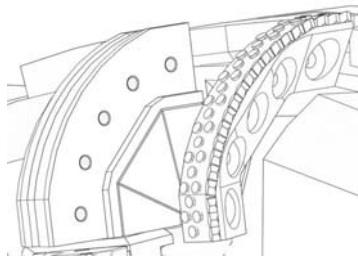
2. Take the bucket out of the holder.



3. Clean the contact surface.

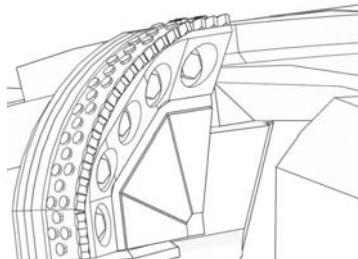


4. Fit a new bucket.



5. Before installation, apply anti-welding lubricant to the bolt, e.g. GWF-GEWINDE-FREI (ART. NO. 29700744).

6. Screw in the bolts and tighten to the required torque.



5.9.8 Replacing the slab cutters

Replacable parts, spare parts

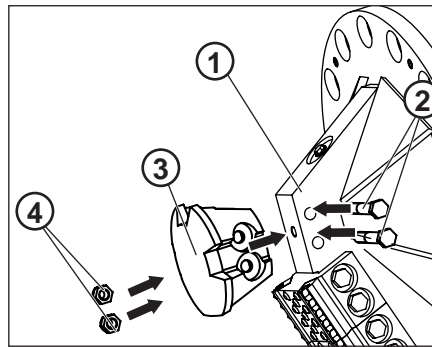
2	Slab cutter MH Art. No. 29600921
3	Threaded plate (not required)
4	Bolts

Procedure

1. Remove the retaining bolts (4).
2. Remove the slab cutter.
3. Clean the holder for the slab cutter.
4. Fit a new slab cutter.
5. Before installation, apply anti-welding lubricant to the bolts, e.g. GWF-GEWINDE-FREI (ART. NO. 29700744).
6. Screw in the bolts and tighten to the required torque.

5.9.9 Replacing the centre tool

Replacing the centre tool



Replacing the centre tool

1	Centre tool	3	Centre tool
2	Bolt	4	Self-locking nut

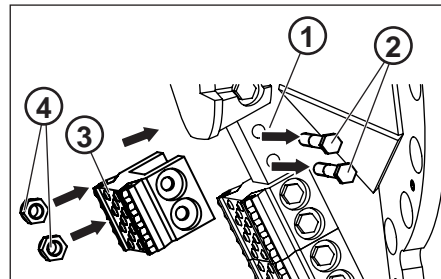
Table VI - 16: Replacable parts, spare parts centre tool

1. Remove the self-locking nut (4).
2. Remove the bolt (2).
3. Remove the centre tool (3).
4. Clean and grease the holder for the centre tool.
5. Fit a new or refurbished centre tool (3).
6. Before installation, apply anti-welding lubricant to the bolts, e.g. GWF-GEWINDE-FREI (ART. NO. 29700744).
7. Secure the centre tool (3) with a bolt (2) and self-locking nut (4).
8. Tighten the nuts to the required torque.



Always replace self-locking nuts after use.

Replacing the centre ripper



Replacing the centre ripper

1	Centre tool	3	Centre ripper
2	Bolts	4	Nuts

Table VI - 17: Replacable parts, spare parts centre ripper

1. Unscrew the nuts (4).
2. Remove the bolts (3).
3. Pull the centre ripper (2) off the centre tool (1) from the front.
4. Clean and grease the contact surfaces of the centre tool.
5. Fit a new centre ripper.
6. Before installation, apply anti-welding lubricant to the bolts, e.g. GWF-GEWINDE-FREI (ART. NO. 29700744).
7. Secure the centre ripper on the centre tool using nuts and bolts.
8. Tighten the union to the recommended tightening torque.



Always replace self-locking nuts after use.



Important:

Retighten all bolts after advancing for approx. 5 to 10 m.

5.9.10 Welding, cutting and grinding work

General notes

The vapours from welding/gas cutting are detrimental to your health. It is therefore necessary to install an extractor system in closed rooms. Alternatively, breathing apparatus with a controlled supply of fresh air can be used.

Safety Instructions

- Ensure that the ground cable is installed immediately next to the position to be welded when executing welding work. Never route the current via cylinders, bearing parts, particularly main bearings and guides.
- During welding, angle grinding and cutting, make sure that no flammable materials are stored in the vicinity of the workplace. Remove flammable materials from the danger area, or cover with a non-flammable cover

WARNING!

Welding/gas cutting without an extractor system.



- Danger to health due to breathing dust and vapours
- Install an extractor system prior to starting welding/gas cutting work.

Preparation

- Connect the hose to the media supply box gas/oxygen on the bulkhead (atmosphere side) and in the excavation chamber.
- Connect the power cables to the junction box.

5.10 Repair work to the cutterhead tool

5.10.1 Notes for use of Xuper Elasto Dur 8888

TYPE	MH ART. NUMBER
Hardfacing electrode	29900122

Table VI - 18: Hardfacing electrode Xuper Elasto Dur 8888

MAINTENANCE WORK

MAINTENANCE, REPAIRS

Clean the hardfacing area to the metal. Heat a wider area and locally to approx. 850 °C; avoid melting the carrier material. For wetting, keep the additional rod in contact with the workpiece. This promotes good coverage and even distribution of the DIAMAX particles. Weld on with a neutral, slightly acetylene-heavy flame

5.10.2 Processing instructions for hardfacing electrodes OK 8458

Replacement for 600

DESIGNATION AS PER DIN8555	DIMENSIONS IN MM	ITEMS PER PACKET	WEIGHT	ART. NO.
E 6 UM 55 G	Ø 3.2X450	40 pcs.	2.2 kg	22410076
E 6 UM 55 G	Ø 4.0X450	45 pcs.	3.7 kg	22410077
E 6 UM 55 G	Ø 2.5X350	150 pcs.	3.2 kg	22410075

Table VI - 19: Hardfacing electrodes OK 8458

Blank metal welding surfaces are required. Remove the existing hardfacing before applying new hardfacing.

During welding, the liquid hardfacing material mixes with the molten carrier material and thus reduces the hardness and the wear-resilience of the hardfacing.

Therefore:

- Do not weld with excess current; do not weld in one spot for too long; weld quickly.
- If possible, weld 2 - 3 layers.

Deposition welding of larger areas

Move the electrode in an oscillating movement to create beads with a width of approximately 15-20 mm. When applying the hardfacing, make sure that the gap between the beads is not too large.

5.11 Bentonite/foam nozzles

5.11.1 Replacing the flat diaphragm

1	Bentonite nozzle body
2	Washer
3	Diaphragm
4	Bolt

Table VI - 20: Bentonite nozzle with flat diaphragm

MAINTENANCE WORK

MAINTENANCE, REPAIRS

1. Remove the bolt (1).
2. Take out the bolt and washer (2), and replace the diaphragm.
3. Clean the contact surface.
4. Insert a new diaphragm.
5. Secure the diaphragm (3) with the washer and bolt. Make sure that the bevel on the washer points towards the diaphragm

5.11.2 Replacing the conical diaphragm

1	Steel structure bentonite nozzle
2	Conical diaphragm
3	Slotted nut

Table VI - 21: Bentonite nozzle with conical diaphragm

1. Remove the slotted nut (3).
2. Screw out the conical diaphragm (2).
3. Clean the thread.
4. Screw in a new conical diaphragm.
5. Secure the conical diaphragm by screwing in and locking the slotted nut.

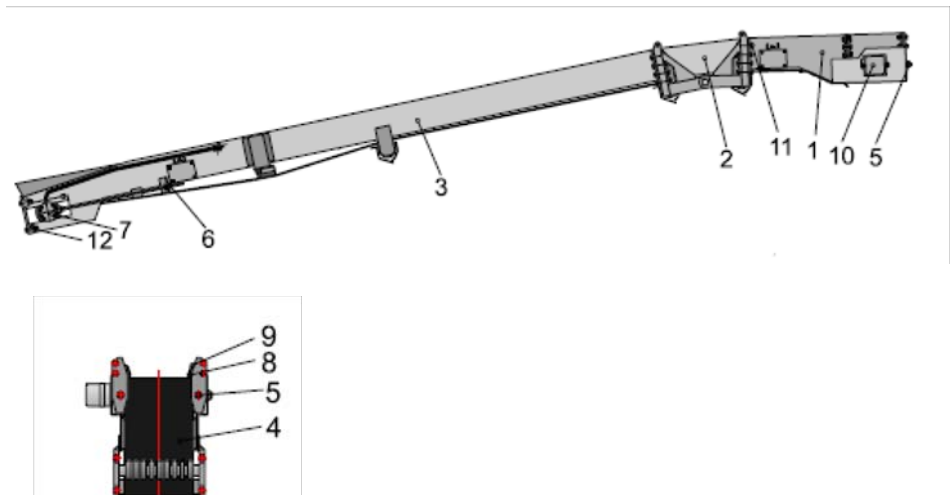
5.12 Repair work on the conveying system



Before you can perform maintenance work and repairs on a belt conveyor, you must actuate the EMERGENCY STOP mushroom head button, or the EMERGENCY STOP Andon cord switch on the belt conveyor.

5.12.1 Replacing the conveyor belt

Approach for replacing the belt based on the example of a conveyor belt with articulated joints



MAINTENANCE WORK

MAINTENANCE, REPAIRS

1. Remove the side deflectors (8 + 9) on one side, and loosen on the other side
2. Loosen the tensioning spindles (5 + 6) for the deflection pulley (7) and the belt drive (10) and pull the deflection pulley and drive as far back as possible.
3. Unbolt the drive box (1) from the belt and place it on the guide frame.
4. Unbolt the front cover (12) on the deflection box.
5. Unbolt the front cover (12) on the deflection box.
6. Check the bearing rollers and lateral guide rollers for signs of damage. Replace damaged rollers with new ones.
7. Fit a new belt.

5.12.2 Changing the cable in the winch

1. Fully unwind the wire-rope.
2. Remove the bolts [4] and cover plate [3].
3. Turn the reel until the washer [5] and bolt [6] are visible in the drill hole.
4. Remove the bolt [6] and take of the washer [5].
5. Push the wire-rope over the bolt on the reel and pull out to the front.
6. Push the new wire-rope through the slot in the reel and push the loop over the bolt.
7. Secure the wire-rope with a washer and nut.

6. Recurring tests

6.1 Hydraulic operating equipment

Tests must be performed by qualified and authorised staff.

6.1.1 Qualified staff

"Qualified staff" must fulfil at least the following requirements in terms of the special tests relating to the hydraulic hoses.

- Vocational training: The qualified person must have completed vocational training so that their professional skills are demonstrable. Demonstrable evidence of qualifications means professional certificates or similar documents.
- Professional experience: Professional experience means that the qualified person has handled the required equipment [i.e. hydraulic hoses] for a demonstrable period in their professional career. For this reason, the qualified person has experience of various reasons to initiate the required tests [i.e. have the tests performed], for example, as the result of risk analysis or observations during daily work.
- Recent professional activity: Recent professional activity in the field of the tests to be performed on the device under testing [i.e. the hydraulic hoses] and appropriate ongoing training are mandatory. The qualified person must have gained experience in performing the test to be performed, or comparable tests. The qualified person must have knowledge of the state of the art with respect to the equipment under testing and on the dangers that can be observed. Experts who have previously tested hydraulic hoses, and fulfil the three stated requirements, and are familiar with the content of occupational safety regulations, and the changes relating to them, are deemed qualified persons who can be commissioned with performing the tests



The qualified person is not subject to work instructions and must not be at a disadvantage due to work instructions.

6.1.2 Mandatory documentation

The test periods and the replacement intervals must be documented in writing along with other safety measures. The results of the tests must be added to this documentation.

RECURRING TESTS

MAINTENANCE, REPAIRS

Additionally, the results of the tests (e.g. with the test protocol for the equipment under testing) must be recorded and kept on site (until at least the date of the next test).

6.1.3 Test periods for hydraulic hoses

REQUIREMENTS FOR HYDRAULIC HOSES	TEST PERIOD	TESTED BY
Normal requirements	12 months	Qualified person
Extended use (e.g. multiple shift operation)	6 months	
Substantial external influences		
Intent to extend times of use		

Table VI - 22: Test periods for hydraulic hoses

Test criteria for hydraulic hoses

- Damage to the outer layer through to the insert (wear, cuts, tears),
- Brittleness of the outer layer (cracking of the hose material),
- Deformation that does not correspond to the natural shape of the hydraulic hose, in depressurised or pressurised state or when bent e.g. delamination, bubbling, crushing points, kinks,
- Leaks in the hose, line or fittings
- Hose protruding from the fitting
- Damage or deformation of the fitting that impairs the function and strength of the fitting or the hose/fitting joint,
- Corrosion of the fitting that impairs function and strength,
- Is free movement of the hydraulic hose still guaranteed, or has the installation of new plant components or units led to crushing, shearing or wear points?

- Is it certain that the hydraulic hoses do not protrude into traffic routes, even when the units connected to the hydraulic hoses are moved to their limit positions?
- Have hydraulic hoses been painted over (explanation: this makes it impossible to read the specifications and identify cracking!)?
- Have the storage and use times been exceeded?
- Have all covers (after testing, removal, redeployment) been reinstalled and are they working?
- Are additional tear-off safeguards in place, or required?



These tests must be documented. Defective hoses must be replaced immediately.

REQUIREMENTS FOR HYDRAULIC HOSES

REPLACEMENT INTERVAL

Normal requirements

6 years

Extended use (e.g. multiple shift operation)

2 years

Substantial external influences

6.2 Electrical operating equipment

Only qualified electricians are allowed to perform regular tests on the electrical systems or operating equipment.

6.2.1 Electrician

Professional qualification as an electrician is demonstrated by completing training e.g. as an electrical engineer, electrical technician, master electrician, trained electrician. It can also be demonstrated by multiple years of practical experience including theoretical and practical training following validation by a qualified electrician.

Qualifications must be documented.

6.2.2 Preconditions for performing the tests

Professional qualification as an electrician is demonstrated by completing training e.g. as an electrical engineer, electrical technician, master electrician, trained electrician. It can also be demonstrated by multiple years of practical experience including theoretical and practical training following validation by a qualified electrician.

Qualifications must be documented.

- The test equipment used for the tests must comply with DIN VDE 0413 or EN 61557 DIN 0404.
- Electrical technology rules that are applicable to the tests must be observed during the tests.

6.2.3 Mandatory documentation

Electrical systems and equipment must only be operated in perfect working order and must be maintained in this state.

The test periods and the replacement intervals must be documented in writing along with other safety measures. The results of the tests must be added to this documentation.

Additionally, the results of the tests (e.g. with the test protocol for the system, equipment under testing) must be recorded and kept on site (until at least the date of the next test).

6.2.4 Fixed electrical operating equipment

SYSTEMS/OPERATING EQUIPMENT	TEST PERIOD	TYPE OF TEST	TESTED BY
Electrical systems and fixed operating equipment	4 years	For orderly state	Electrician
Electrical systems and fixed operating equipment at/in "Operating sites, rooms and systems of special types"	1 year		
Residual current type safeguards - safeguards on non-stationary equipment.	1 month	For effectiveness (measure the residual current and the trip current, grounding resistance)	Electrician or person with appropriate training using suitable measuring and test equipment
Residual current, differential current, residual voltage circuit breakers on stationary systems	6 months	Test for perfect working order by actuating the test equipment	User
- on non-stationary equipment	Each working day		

Table VI - 23: Fixed electrical operating equipment

6.2.5 Mobile electrical operating equipment

SYSTEMS/OPERATING EQUIPMENT	TEST PERIOD	TYPE OF TEST	TESTED BY
Mobile operating equipment	3 months	For perfect working state (visual check – Test for mechanical damage – test the safeguards deployed for indirect touch protection and measure the insulation resistance, details as per DIN VDE 0702)	Electrician, also a person with appropriate training using suitable measuring and test equipment
Extension leads and equipment connection leads with connectors	If an error rate of < 2% is achieved during testing, the test period can be extended accordingly.		
Connection leads with plugs			
Mobile leads with plug and fixed connection	at 1 x per year.		

6.2.6 Recurring tests on electrical systems

Measurements, measurement methods and values/guideline values for measurements on systems with safeguards in the TN/TT system

RECURRING TESTS

MAINTENANCE, REPAIRS

MEASURING TASKS	MEASURING METHODS	VALUES
Main equipotential bonding and additional equipotential bonding	Low resistance measurement	< 1 W 2)
Insulation resistance of PE to neutral and conductors	Insulation resistance measurement	= 300 W/V with consumer= 1000 W/V without consumer at a mains voltage of up to 500 V and a measuring voltage of 500 V
Confusing of PE and conductor	Phase test or voltage measurement to earth	Mains voltage
Confusing of PE and neutral	Low resistance measurement	< 1 W 2)
In case or more than one residual current protection device for the entire system:		< 1 W 2)
<ul style="list-style-type: none"> • correct assignment of neutral line to the circuit covered by the residual current circuit breaker. 	Low resistance measurement	
<ul style="list-style-type: none"> • Short circuit between neutral lines on different residual circuit current breaker devices 	Insulation resistance measurement	See Insulation resistance measurement

2) Guideline value, not specified by the standard, depending on the diameter, length and material.

Additionally protective devices such as overcurrent protectors and residual current-operated devices must be evaluated. Testing of the protective measures in the TN system serves as an example.

SAFEGUARD	MEASURING TASKS	MEASURING METHODS
Overcurrent protection device	Schleifenimpedanz $Z_s = \frac{U_0}{I_a}$ <hr/> between conductor and PE and/ or PEN line (U_0 = nominal voltage to grounded conductor, I_a = switch-off current of overcurrent protection device)	Measure the loop impedance (short circuit current measurement) or computation and/or demonstrate by reference to grid model

SAFEGUARD	MEASURING TASKS	MEASURING METHODS
Residual current-operated protection device	1. $UB = UL$ $U = U_{\text{and}}(UL < 50$ $V, \text{ max. permissible touch}$ $\text{voltage})$ 2. Connec all other bodies to the central PE rail	Measure the trip current (I) and the touch voltage (UB) by creating a residual current and determine that the residual current-operated protection device trips at nominal residual current (In) at the latest. Low-resistance test of PE

Values for evaluating overcurrent and residual current-operation safeguards are stated in DIN VDE 0100 Part 610.

6.2.7 Test procedure for recurring tests on electrical equipment

The tests must be performed in a fixed order and each test must be passed before continuing with the next test.

* for connecting lines up to max. 5 m, plus 0.1 Ohm for each additional 7.5 m but to a max. of 10 Ohm.** Substitute measurement after successfully measuring the insulation resistance. If not technically feasible or if it cannot be ensure that all parts exposed to mains voltage are covered by insulation measurement. (e.g. electr. starter relays.) The measuring method can be freely selected. The measurement must be performed on touchable, conducting parts only that are not connected to physical earth.

Testing safety equipment
Testing device functions
Evaluation (appraisal)
Protocol if applicable label on device with next test date

6.2.8 Measurement tasks and methods for recurring testing of electrical devices

MEASUREMENT TASK	MEASUREMENT METHOD		
	PROTECTION CLASS I	PROTECTION CLASS II	PROTECTION CLASS III
PE conductor resistance	low resistance PE conductor measurement = 0.3 W for devices with connecting leads of up to 5 m length, plus 0.1 W for each additional 7.5 m	not applicable	not applicable
Insulation resistance	= 0.3 MW (devices with heating elements switched on)	= 2 MW (switches, temperature controllers, etc., on the devices must be closed)	= 250 kW (switches, temperature controllers, etc., on the devices must be closed)
	= 1 MW (other devices)		
Equivalent leakage current	Heating output = 3.5 kW = 3.5 mA Heating output > 3.5 kW = 1 mA/kW (only for protection class I devices with heating elements where the required insulation resistances is not achieved)	not applicable	not applicable
Protective conductor current	= 3.5 mA (only for protection class I devices with heating elements where the required insulation resistances is not achieved)	not applicable	not applicable
Touch current	= 0.5 mA (only for protection class I devices whose touchable, conducting parts are not connected to protective earth)	= 0.5 mA (only for protection class II devices where there are some reservations concerning measuring the insulating resistance)	not applicable

6.2.9 Wireless transmitters

Devices for wireless transmission of control commands must be tested by an expert at least once per year.

An expert is a person who, based on professional training and experience, possesses sufficient knowledge in the field of wireless transmission of control commands, and is familiar with applicable national occupational safety rules, accident prevention rules, guidelines and the accepted state of the art (incl. DIN standards, VDE policies, technical rules of other member states of the European Union or other contracting parties to the agreement on the European economic area) to the extent that said person can evaluate the operationally safe state of wireless devices for the transmission of control commands.

6.3 Lifting devices and lifting gear

6.3.1 Persons qualified to perform tests

Qualified expert

a person who, based on professional training and experience, possesses sufficient knowledge in the field of winches, lifting and pulling devices, and is familiar with applicable national occupational safety rules, accident prevention rules, guidelines and the accepted state of the art (incl. DIN standards, VDE policies, technical rules of other member states of the European Union or other contracting parties to the agreement on the European economic area) to the extent that said person can evaluate the operationally safe state of winches, lifting and pulling devices.

6.3.2 Tests

- The owner must ensure that devices including the supporting structure and wire-rope blocks are tested by a qualified expert prior to commissioning and prior to re-commissioning after major changes.
- The owner must ensure that devices including the supporting structure and wire-rope blocks are tested by a qualified expert at least once a year. The owner must additionally call in an expert to perform interim tests as required to reflect the conditions of use and operation.
- The test prior to initial commissioning in line with paragraph 1 also relates to correct installation and readiness for operation.

RECURRING TESTS

MAINTENANCE, REPAIRS

- a that technical measures are provided to prevent loads from dropping in case of component failure,
- b the devices are only used in cordoned off areas to which persons have no access,
- c by means of suitable test methods detect and remedy damage capable of causing loads to fall, or 4. in case of power-driven crane lifting gear which is not created in serial production and is regularly inspected by a qualified expert, provide state-driven maintenance to detect and remedy damage capable of causing loads to fall in good time. The type of maintenance capable of ensuring these requirements must be specified by the manufacturer or a qualified expert. The test interval for testing by an expert must not exceed four years.

6.3.3 Instructions for performance

The test primarily covers the completeness, suitability and effectiveness of the safety devices and the state of the device, the load-bearing equipment, the rollers, the equipment and the supporting structure. Safety devices include e.g. backlash safeguards, reverse running safeguards, braking devices, auxiliary brakes, cable winding equipment, devices for blocking the load shaft, safeguards against overloading, emergency stop equipment.

VII. Disassembly, storage, disposal

1. Bearing	VII - 2
1.1 General	VII - 2
1.2 Hydraulics components	VII - 3
1.2.1 Cylinders	VII - 3
1.2.2 Pumps and motors	VII - 3
1.2.3 Hoses	VII - 4
1.3 Electrical components	VII - 5
1.3.1 Control cabinets	VII - 5
1.3.2 Storing electrical cables	VII - 5
1.4 Hydraulic oil containers	VII - 6
1.4.1 Storage room and container requirements	VII - 6
1.4.2 Hydraulic oil stored outdoors - containers	VII - 6
1.5 Operation container	VII - 7
1.6 Tunnelling machine	VII - 7
1.7 Drive	VII - 8
1.7.1 Gearbox and main bearing	VII - 8
1.8 Cutting wheel/cutterhead	VII - 9
1.9 Screw conveyor	VII - 9
1.10 Belt conveyor	VII - 9
2. Disposal	VII - 10
2.1 Notes on disposal	VII - 10
2.2 Reusable parts	VII - 10
2.3 Non-reusable parts	VII - 10
2.4 Batteries, rechargeable batteries and electronics parts	VII - 10
2.5 Oils and greases	VII - 10
2.5.1 Disposal	VII - 10
2.5.2 Soiled packaging	VII - 11

TABLE OF CONTENTS

DISASSEMBLY, STORAGE, DISPOSAL

1. Bearing

1.1 General

- If you will be storing the machine/system for longer than 3 months, all hydraulic system parts (pumps, tanks, cylinders etc.) must be completely filled with a preservative oil.
- At least 1 x month check the state of the machine/system (corrosion, damage, condensate, etc.).



CAUTION!

Corrosion due to condensate

- Damage to seals, pistons and piston rods
 - Check the hydraulic system and hydraulics components for condensate every six months.
 - Drain condensate.
 - Replace lost oil volume by topping up with preservative oil.
-

1.2 Hydraulics components

1.2.1 Cylinders

- Fill the hydraulic cylinders with preservative oil. Leave a sufficient air-gap for heat expansion.
- Close pipe and threaded connections with plastic thread caps or plastic protective caps. Close flanges with soft plastic plugs that are secured with a metal plate.
- Store individual hydraulic cylinders upright in a dry room at approx. 10° -20° if possible.
- Protect piston rods that protrude out of the hydraulic cylinders against damage. Avoid the effect of aggressive media on the chrome layer of the piston rod.
- After the first six months, turn the hydraulic cylinders over at least once a year to displace any pockets of air and to re-oil these surfaces.
- Spray the piston rod before packing.
- Before reuse, remove the packaging and the wax.
- Do not store cylinders near heaters.

1.2.2 Pumps and motors

- Fill hydraulic pumps and motors that are disconnected from the hydraulics system with preservative oil. Keep a sufficient pocket of air for heat expansion.
- Close pipe and threaded connections with plastic thread caps or plastic protective caps. Close flanges with soft plastic plugs that are secured with a metal plate.



Check the hydraulic system and hydraulics components for condensate every six months. Drain off any condensate and replace the lost volume with fresh preservative oil.

Before reusing, drain the hydraulic system and refill with the specified hydraulic oil.

1.2.3 Hoses

Observe the following when storing hoses:

- Store in a cool, dry, dust-free place; avoid direct sunlight or UV radiation; shield heat sources in the vicinity.
- Avoid storage temperatures below -10 °C for elastomers; other values may apply for thermoplastics; do not use lighting that generate ozone, or electrical equipment that generates sparks in the immediate vicinity. Lighting that generates ozone includes fluorescent lamps and mercury evaporation lamps.
- Virtually dust-free storage can be achieved by wrapping in plastic foil.
- Favourable storage conditions means temperatures between +15 and +25 °C and a relative humidity below 65%.
- Hoses must in particular not be allowed to touch other materials that can cause damage.
- Store hose lines in a de-stressed state, flat and closed. When storing in loops observe the minimum bending radius specified by the manufacturer.

Labelling

Hoses and hose lines must be marked visibly and permanently with the following at distances of 50 cm at the most:

- **Manufacturer,**
- **Type,**
- **Nominal diameter,**
- **Date of manufacture (quarter and year of manufacture).**

For example "1 Q 83" designates a hose that was manufactured in the 1st quarter of 1983.

Hoses must be marked visibly and permanently with the following:



The storage time for hoses should not exceed 4 years; 2 years for hose lines.

1.3 Electrical components

1.3.1 Control cabinets

Pack control cabinets in watertight packaging. For protection against condensate caused by temperature fluctuations, fill switch cabinets with a desiccant in line with DIN 55473-A+B.



The volume of desiccant depends on the control cabinet volume.

1.3.2 Storing electrical cables

Observe the following when storing electrical cables:

- Store electrical cables in a cool and dry place; avoid direct sunlight or UV radiation. Shield heat sources in the vicinity.
- Avoid larger temperature fluctuations. Larger temperature fluctuations can cause condensate to build up in the cables.
- Only store electric cables with plugs and sockets in plugged state.
- For storage in loops observe a minimum bending radius $8 \times d$ (d = outer diameter of cable).

BEARING

DISASSEMBLY, STORAGE, DISPOSAL

1.4 Hydraulic oil containers

1.4.1 Storage room and container requirements

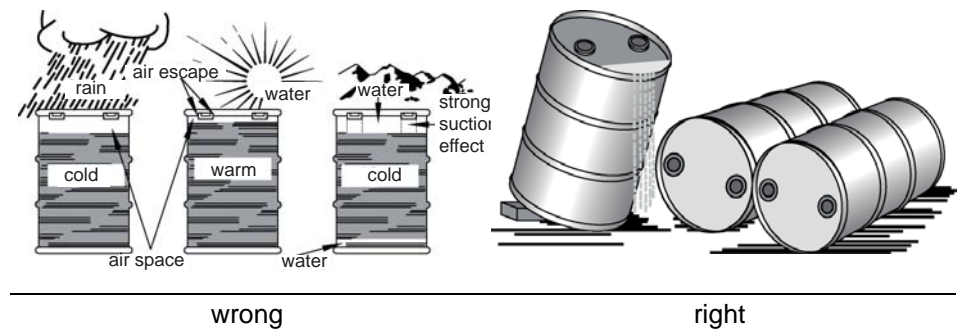
- Provide for sufficient room ventilation.
- Only use containers which are approved for the specific material / product.
- Keep the containers closed.
- Ensure that the material cannot penetrate the ground.

1.4.2 Hydraulic oil stored outdoors - containers

Hydraulic oil containers stored outdoors must not stand vertically. Store horizontally where possible.

If this is not possible, chock up the upright containers so that they slant.

This is the only way to keep the caps free of water.



wrong

right

1.5 Operation container

- Do not store the control container below 0° C.
- Store the control container in depowered state.
- Close the hydraulic connections.
- Remove all condensate; refill the control cabinets with desiccant.

1.6 Tunnelling machine

- Close the hydraulic connections.
- Clean the whole advance system thoroughly and completely drain (water tank and water lines, compressed air accumulators and lines).
- Protect piston rods that protrude out of the hydraulic cylinders against damage (see storing the hydraulic components).
- Grease blank metal parts or spray with preservative wax.



We recommend RESILAN M46 MH. Art. no. 29700012 as a preservative

-
- Cover all components with tarpaulins. Ensure sufficient ventilation to prevent against condensate caused by temperature fluctuations.
 - At least 2 x year check the state of the stored advance system (corrosion, damage, condensate build up).
 - Clean corroded surfaces thoroughly and re-grease or spray with preservative wax.
 - Remove all condensate; refill the control cabinets with desiccant.
 - Repair all damage before reusing the advance system, or replace damaged parts.

BEARING

DISASSEMBLY, STORAGE, DISPOSAL

1.7 Drive

1.7.1 Gearbox and main bearing

Completely fill all planetary gears and the main bearing with the specified gearbox oil. (See the oil fill volume list in the Operating and maintenance manual)



CAUTION!

Oil level too high

- Bearing damage and damage to seals
 - Before reusing the tunnelling machine, drain the gearbox oil to the specified level (See the oil fill volume list in the Operating and maintenance manual).
 - Catch the drained all in a sump and dispose of the oil in an environmentally friendly manner.
-

1.8 Cutting wheel/cutterhead

- If possible store the cutting wheel/cutterhead in a closed room at constant temperature.

In case of outdoor storage:

- Cover the cutting wheel/cutterhead with a tarpaulin; ensure adequate ventilation.
- For longer periods of storage (3 months or more) and in case of risk of corrosion due to high humidity (e.g. transport by sea), remove the tools (discs, bucket lips, scrapers, etc.).
- Preserve the tool fittings on the cutting tool and any bare metal parts on the tools.



CAUTION!

Corrosion forming on unpreserved parts

- Surface damage to bare surfaces
- Spray all bare metal parts to be stored outdoors with preservative wax to provide protection against corrosion.



We recommend RESILAN M46 Art. no. 29700012 as a preservative

1.9 Screw conveyor

- Thoroughly clean and drain the screw conveyor.
- Grease blank metal parts or spray with preservative wax.

1.10 Belt conveyor

- Grease bare metal parts or spray with preservative wax.
- Protect the conveyor belt against direct sunlight to avoid porosity and tearing.

2. Disposal

2.1 Notes on disposal

- Dispose / store in an officially admitted disposal site, taking all regional and national regulations into account. The system user is responsible for proper disposal.

2.2 Reusable parts

- Reusable parts such as undamaged steel components and bearings, hydraulic cylinders, hydraulic valves, hydraulic blocks and electrical parts can be reused on systems with the same function.
- Parts that can be repaired or refurbished can be deployed on systems with the same function after repairs.

2.3 Non-reusable parts

Non-reusable parts should be recycled.

2.4 Batteries, rechargeable batteries and electronics parts

- Electronic equipment and parts of it are hazardous waste. This applies in particular to rechargeable battery packs.
- Call in an expert waste management company for recycling and waste disposal tasks.

2.5 Oils and greases

2.5.1 Disposal

Oils, greases and other chemical substances must always be handed over to approved waste management companies

2.5.2 Soiled packaging

- Completely empty all containers.
- Hand over to an approved waste management company.



Refer to the manufacturer's safety data sheet for special information about handling and safety of all oils and greases used.

DISPOSAL

DISASSEMBLY, STORAGE, DISPOSAL

VIII. Appendix

1. Tightening torques	VIII - 3
1.1 Tightening torques for bolts in Nm.	VIII - 3
1.2 Tightening by applying pretensioning force.	VIII - 5
1.2.1 Assembly pretensioning force.	VIII - 5
1.2.2 Tightening tool.	VIII - 5
2. Carrying capacity table	VIII - 6
3. Colour table for pipe identification	VIII - 7
4. Ordering spare parts	VIII - 9
4.1 General instructions.	VIII - 9
4.2 Assembly matrix parts list	VIII - 10
4.3 Structure parts list	VIII - 11
5. Addresses of facilities	VIII - 12
5.1 Head office	VIII - 12
5.2 Subsidiaries	VIII - 12
5.3 Representatives	VIII - 14
6. Enclosed Herrenknecht CD	VIII - 17
6.1 Browsing the CD	VIII - 17
6.2 Overview of the CD	VIII - 17
7. Laser target data sheet	VIII - 18
8. Declaration of Conformity	VIII - 20

APPENDIX

1. Tightening torques

1.1 Tightening torques for bolts in Nm

There are a number of pitfalls which it is important to avoid when tightening bolts; always proceed with extreme caution. The following factors influence the pre-tension of the screw union:

- New bolts, smooth thread surface, thread and bearing surfaces lightly oiled.
- Material combinations steel/steel.
- No dirt, no paint residue or corrosion on the contact surfaces.
- No contact between the bolt shaft and the drill hole.
- Bolts tightened crosswise in two rounds.

THREAD	TIGHTENING TORQUE IN NM FOR STRENGTH			
	5.6	8.8	10.9	12.9
M5	2.5	5.7	8.1	9.7
M6	4.3	9.9	14	16.5
M7	7.1	16.5	23	27
M8	10.5	24	34	40
M10	21	44	64	75
M12	35	75	110	130
M14	56	120	175	205
M16	85	180	265	310
M18	120	260	370	430
M20	165	360	520	600
M22	220	485	690	810
M24	285	630	890	1050
M27	415	910	1300	1500
M30	570	1250	1800	2100
M33	780	1700	2400	2800
M36	980	2150	3100	3600
M39	1250	2800	3950	4650
M42	1550	3450	4900	5800
M45	1950	4300	6100	7100

TIGHTENING TORQUES

APPENDIX

THREAD	TIGHTENING TORQUE IN NM FOR STRENGTH			
	5.6	8.8	10.9	12.9
M48	2400	5200	7400	8700
M52	3000	6700	9500	11100
M56	3800	8300	11800	13900
M60	4630	10100	14400	17000

Note:

The bolt status "lightly oiled" means that the bearing surface/nut contact area and the engaged thread helixes are wetted with a thin film of oil.

- Approved oils are gearbox oils ISO VG 100 to ISO VG 220.
- Penetrating oils are not permissible.

The specified bolt tightening torques do not apply to HV bolts and HV nuts to DIN 6914 and DIN 6915 (large widths across flats). The table also does not apply to bolts and nuts secured with Loctite or similar.

1.2 Tightening by applying pretensioning force

The use of tensioning cylinders allows pretensioning forces of 90% of the minimum yield strength (0.2 - limit) to be leveraged because the torque is not overlaid. There is no need to consider friction. However, it is important to ensure cleanliness (e.g. soiling, weld spatter, paint), and perpendicularity to the bolt axis and planarity of the bearing surface nut contact surface.

1.2.1 Assembly pretensioning force

Set the following tensile forces in KN:

THREAD	TENSIONING FORCE IN KN FOR STRENGTH 10.9
M27	355
M30	430
M36	635
M42	875
M45	1020
M48	1150
M56	1600
M60	1850
M64	2100

1.2.2 Tightening tool

- Tensioning cylinders must only be used by trained staff.
- Observe the safety instructions in the manufacturer's instructions for use.
- Before setting the tensioning force, check whether you have the correct pressure/tensioning force table for the device you will be using.
- Refer to the operating instructions for positioning and use of the device.

CARRYING CAPACITY TABLE

APPENDIX

2. Carrying capacity table

Cargo chains to DIN 5688 - 8 quality class 8 (degree 80)

	2 strands		4 strands	
Angle of inclination beta	0° - 45°	45° - 60°	0° - 45°	45° - 60°
Load factor	1,4	1	2,1	1,5
Chains - nominal thickness in mm	The specified values refer to symmetrical loading			
6	1400	1000	2100	1500
7*	2200	1600	3300	2400
8	2800	2000	4250	3000
10	4500	3200	6700	4750
13	7100	5000	10000	7500
16	11200	8000	17000	11800
18	14000	10000	21200	15000
19*	16000	11300	24000	17000
20	18000	12500	26500	18000
22	21200	15000	32000	22400
26	28000	20000	40000	30000
32	45000	32000	63000	47000


















*chains - nominal thickness deviating from standard

Table VIII - 1: Carrying capacity table













Select the length of the cargo chains such that the angle of inclination beta is always in the range 0 ... 45°. An angle of inclination inside this area provides the highest safety.

3. Colour table for pipe identification

FLOW MATERIAL	GROUP COLOUR		ADDITIONAL COLOUR	
	EXAMPLE	RAL	EXAMPLE	RAL
Process water / sealing water		RAL6032		RAL5005 with white arrow
Coolant /Water/glycol mix		RAL6032		RAL9003 with black arrow
Dewatering /wastewater		RAL6010		
Water (high pressure water, drinking water)		RAL6032		
Sprinkler, water curtain		RAL6032		RAL3001 with white arrow
Water for foam unit		RAL6032		RAL4008 with white arrow
High pressure/process air/ vacuum		RAL7004		
Low pressure air (breathing air)		RAL7004		RAL5005 with white arrow
Foam installation		RAL4008		
Hydraulic oils/gearbox oils		RAL8002		
Greases/sealing compounds		RAL8002		RAL9003 with black arrow

COLOUR TABLE FOR PIPE IDENTIFICATION

APPENDIX

FLOW MATERIAL	GROUP COLOUR		ADDITIONAL COLOUR	
	EXAMPLE	RAL	EXAMPLE	RAL
Bentonite		RAL8017		RAL9003 with black arrow
Grout, component A		RAL8017		
Grout, component B		RAL8017		RAL4008 with white arrow
Oxygen		RAL5005		
Non-flammable gases		RAL1003		RAL9004
Flammable gases		RAL1003		
Acids		RAL2010		

4. Ordering spare parts

4.1 General instructions

For each order, please state the name and part number (article number) of the required part(s) as well as the required quantity.

Please send your order, quoting the keyword "**Spare parts service**" to the following address.

HERRENKNECHT AG
Schlehenweg 2
77963 Schwanau
Germany

Phone: +49 (0) 7824 302-0

Fax.: +49 (0) 7824 34-03

Electrical

Tel.: +49 (0) 7824 302-5260

Fax.: +49 (0) 7824 302-7000

E-mail: ASS-electro@herrenknecht.de

Technical

Tel.: +49 (0) 7824 302-9000

Fax.: +49 (0) 7824 302-7000

E-mail: ASS-technical@herrenknecht.de

Commercial

Tel.: +49 (0) 7824 302-1570

Fax.: +49 (0) 7824 302-7000

E-mail: ASS-commercial@herrenknecht.de

Operation

Tel.: +49 (0) 7824 302-1450

Fax.: +49 (0) 7824 302-7000

E-mail: ASS-operation@herrenknecht.de




Please refer to the parts lists, the spare parts drawing and hydraulics schematics for the article numbers for your order.

Article numbers for ordering electrical components are shown directly in the wiring diagram.

ORDERING SPARE PARTS

APPENDIX

4.2 Assembly matrix parts list


2011-11-28 STLDISP125		Baukastenstückliste Modular parts list					
Projekt Teilenummer		M-XXXX 30207923 MISCHBODENKOPF		Projekt Part Number		M-XXXX 30207923 MIXED CUTTING HEAD	
Zeichnungsnr.		3474-01-012-00 A		drawing number		3474-01-012-00 A	
①	②	③	④	⑤			
Pos	Part number	Bezeichnung	Designation	Quantity			
1	30207931	MISCHBODENKOPF	MIXED CUTTING HEAD	1,00 ST			
2	30030960	BEFESTIGUNGSSATZ SCHNEIDROLLE	FASTENING SET CUTTER DISC	6,00 ST			
4	30020031	ZENTRUMSSCHNEIDER	CENTRE CUTTER	1,00 ST			
5	29604975	RÄUMER BASIS	BUCKET BASIS	2,00 ST			
6	29604976	RÄUMER BASIS	BUCKET	2,00 ST			
7	30019915	VERSCHLUSSBOLZEN	BOLT	3,00 ST			
8	30020163	SIEDEROHR	PIPE	2,00 ST			
9	30021813	SCHAUMROHR	FOAM PIPE	1,00 ST			
11	30207992	DICHTUNGSKLEMMRING AUSSEN	SEAL CLAMPING RING OUTSIDE	1,00 ST			
12	30024466	MEMBRAN	MEMBRANE	3,00 ST			
13	25653542	SCHEIBE	WASHER	3,00 ST			
100	29603595	SCHNEIDROLLE BASIS 3-FACH D320/S55/3L/K	TRIPLE CUTTER DISC BASIC	2,00 ST			
101	29600660	SCHNEIDROLLE BASIS 2-FACH D250/2MB/S72/3.1/3SY	DISC CUTTER BASIC DOUBLE	4,00 ST			
102	28200173	RUNDSCHNUR ENDLOS	ROUND CORD	1,00 ST			

page 1 / 2

Example of an assembly matrix parts list

- | | | | |
|---|-----------------------------------|---|------------------------------------|
| 1 | Item number in drawing | 4 | Name of individual part in English |
| 2 | Article number of individual part | 5 | Number of parts used |
| 3 | Name of individual part in German | | |

4.3 Structure parts list

2011-12-06 STLDISPO68		Strukturstückliste Modular parts list					
Projekt Artikelnummer	M-XXXX 25268970	Project Part Number		M-XXXX 25268970			
Zeichnungsnr.	HYD.SCHEMA STEUERZYL/SCHIEBER 3475-45-001-00	drawing number		HYD.DIAGRAM STEERING/VALVE CYL 3475-45-001-00			
①	②	③	④	⑤	⑥	⑦	⑧
Pos	BMK	Path	Part number	Bezeichnung	Designation	drawing number	Quantity
20	01A001	1A2	20000697	STEUERZYLINDER+IMS	CONTROL CYLINDER	M01.2508-30	1,00 ST
20.1	*A1		20001165	STEUERZYLINDER	CYLINDER	577869	1,00 ST
20.1.1	**Z1		20901883	DICHTSATZ	SEALING KIT	577869/50	1,00 ST
20.2	*E1		26400864	WEGMESSSYSTEM IMS-A07	POSITION MEASURING SYSTEM	01.2451.0005	1,00 ST
21	01A002	1A3	20000697	STEUERZYLINDER+IMS	CONTROL CYLINDER	M01.2508-30	1,00 ST
21.1	*A1		20001165	STEUERZYLINDER	CYLINDER	577869	1,00 ST
21.1.1	**Z1		20901883	DICHTSATZ	SEALING KIT	577869/50	1,00 ST
21.2	*E1		26400864	WEGMESSSYSTEM IMS-A07	POSITION MEASURING SYSTEM	01.2451.0005	1,00 ST
22	01A003	1A3	20000697	STEUERZYLINDER+IMS	CONTROL CYLINDER	M01.2508-30	1,00 ST
22.1	*A1		20001165	STEUERZYLINDER	CYLINDER	577869	1,00 ST
22.1.1	**Z1		20901883	DICHTSATZ	SEALING KIT	577869/50	1,00 ST
22.2	*E1		26400864	WEGMESSSYSTEM IMS-A07	POSITION MEASURING SYSTEM	01.2451.0005	1,00 ST
23	01A004	1A4	20000697	STEUERZYLINDER+IMS	CONTROL CYLINDER	M01.2508-30	1,00 ST
23.1	*A1		20001165	STEUERZYLINDER	CYLINDER	577869	1,00 ST

page 1 / 5

Example of a structure parts list

- | | |
|---|---|
| <p>1 Internal Herrenknecht number</p> <p>2 Item number in schematic</p> <p>3 The part can be found at the following coordinates in the schematic</p> <p>4 Article number of individual part</p> | <p>5 Name of individual part in German</p> <p>6 Name of individual part in English</p> <p>7 Drawing number of the individual part</p> <p>8 Number of parts used</p> |
|---|---|

5. Addresses of facilities

5.1 Head office

COUNTRY	CONTACT DATA
Germany	Herrenknecht AG Schlehenweg 2; 77963 Schwanau; Germany Tel.: +49 (7824) 302 0 Fax: +49 (7824) 34 03 E-Mail: info@herrenknecht.de www.herrenknecht.de

5.2 Subsidiaries

COUNTRY	CONTACT DATA
China	Herrenknecht AG Beijing Office Room 1501A; CBD International Mansion; NO. 16 Yong'an Dongli; Chaoyang District; 100022 Peking; China Tel.: +86 (10) 6567 5088 Fax: +86 (10) 6567 6769 E-mail: hu.shengli@herrenknecht.com
Great Britain	Herrenknecht International Ltd. Wearfield; Southwick Riverside; SR5 2TA Sunderland; Great Britain Tel.: +44 (191) 54 89 191 Fax: +44 (191) 54 89 292 E-Mail: enquiries@herrenknecht.co.uk
Netherlands	Herrenknecht Nederland B.V. De Haag 14; 3993 AW Houten; Netherlands Tel.: +31 (30) 6000 333 Fax: +31 (30) 6000 955 E-Mail: info@herrenknecht.nl
Russia	Herrenknecht Tunnelservice Russia OOO ul. Derbenyovskaya d. 20; kor. 26; 115114 Moscow; Russia Tel.: +7 (495) 956 63 56 Fax: +7 (495) 956 63 57 E-Mail: info@herrenknecht.ru

COUNTRY	CONTACT DATA
Switzerland	Herrenknecht Schweiz AG Im Grund 52; 6474 Amsteg; Switzerland Tel.: +41 (41) 884 80 80 Fax: +41 (41) 884 80 89 E-Mail: info@herrenknecht.ch
Spain	Herrenknecht Ibérica S.A. Unipersonal Paseo de la Castellana 192-13Dcha; 28046 Madrid; Spain Tel.: +34 (91) 359 80 08 Fax: +34 (91) 359 20 32 E-Mail: herrenknechtiberica@herrenknecht.es
Thailand, Australia, New Zealand	Herrenknecht (ASIA) Ltd. 12/621 Moo 15 Soi Sornhirun; Bangna Trad Road; Bangplee; 10540 Samutprakarn; Thailand Tel.: +66 (2) 745 0843 Fax: +66 (2) 745 0845 E-Mail: McNally.Jim@herrenknecht-asia.com
Ukraine	TOV Herrenknecht Tunnel Systems Ukraine St. Shorsa 31; office 506-508; 01033 Kiev; Ukraine Tel.: +38 044 201 04 70 Fax: +38 044 494 25 67 E-Mail: htsu@svitonline.com
USA	Herrenknecht Corporation 1613 132nd Avenue East; Suite 200; 98390 Sumner; WA; USA Tel.: +1 (253) 447 2335; +1 (253) 353 6667 Fax: +1 (253) 863-9397 E-Mail: joconnell@herrenknecht-usa.com
United Arab Emirates	Herrenknecht Middle East P.O Box 61251; JAFZA View 18; 8th Floor; Office No.0809 Jebel Ali Freezone; Dubai; United Arab Emirates Tel.: +97 (14) 8857835; +97 (14) 8857832 Fax: +97 (14) 8857829 E-Mail: emirates@herrenknecht.com

5.3 Representatives

COUNTRY	CONTACT DATA
Egypt	ETCO Engineering+Trading Consultant Office 52 Mosadeq St. Dokki; Giza; 12311 Cairo; Egypt Tel.: +20 (2) 3748 3178 Fax: +20 (2) 3760 4556 E-Mail: etco1@link.net
Argentina	Hr. Hans G. Häntzsch Bmé Mitre 921 - piso 2 depto 27; 1036 Buenos Aires; Argentinien; Tel. +54 (11) 4394 3243 Fax +54 (11) 4394 3243 herrenknecht@gmail.com
Brazil	Herrenknecht do Brasil Av. Ellis Maas no. 740; Capão Redondo 05859-000 São Paulo; Brazil Tel. +55 (11) 5872 2161 Fax +55 (11) 5872 2161 assert@assert.com.br www.assert.com.br
Bulgaria, Macedonia, Montenegro, Bosnia	L&D Ltd. 26-28 Hristo Stanishew Street; 1225 Sofia; Bulgaria Tel. +359 2 9366 127 Fax +359 2 9366 036 lid@mbox.contact.bg
Greece	Tsekoura Icon S.A. Peristeri; 12136 Athens; Greece Tel. +30 (10) 3474 000 Fax +30 (10) 3462 198 info@tsekoura-icon.gr
India	Trikaus House M-26 Commercial Complex; Greater Kailash Part II (Market); 110 048 New Delhi; India Tel. +91 (11) 2921 7675 Fax +91 (11) 2921 1569 trikausch@eth.net tipl@vsnl.com

COUNTRY	CONTACT DATA
Iran	Tajhizat Novin Tunnel Ltd. Unit No. 6; Bldg. No. 5; In front of Shafayab Pharmacy; 12th St. (betw. Ghaem M. Farahani & Daryaye Nour Streets); Dr. Beheshti Ave.; Teheran; Iran Tel. +98 (21) 8874 6335; +98 (21) 887 344 31 Fax +98 (21) 8873 2116 tamizifar.mohammad@herrenknecht.de
Italy	Timeco S.r.l. Via Monza No. 87; 20060 Gessate; Italy Tel. +39 (02) 953 840 64 Fax +39 (02) 953 812 17 info@timecosrl.it www.timecosrl.it
Japan	Sanno International Co., Ltd. AIG Building; 9th floor; 1-3; Otemachi 1-chome; Chiyada-Ku; 100-0005 Tokyo; Japan Tel. +81 (3) 528 854 06 Fax +81 (3) 528 853 53 king@sanno-eng.com
Kolumbien, Venezuela, Puerto Rico	Hr. Juan Carlos Moreno Calle 7AA 30-244 Apto. 1904; Medellin; Columbia Tel. +57 4 266 62 27; +57 316 367 2000 morenoj@herrenknecht.de
Mexico	Coralmex S.A. de C.V. Texas 74-601; Col. Napoles; 03810 Mexiko-Stadt; Mexico Tel. +52 (55) 5523 2817 Fax +52 (55) 5543 0115 info@coralmex.com www.coralmex.com
Poland, Bulgaria, Romania, Slovakia, Czech Republic	Hr. Dymitri Petrow-Ganew N. Bonaparte 85; 04-965 Warsaw; Poland Tel. +48 (22) 872 40 37; +48 508 367 302 Fax +48 (22) 872 14 79 ganew.dymitri@herrenknecht.de
Portugal	Maquinter de Portugal Lda Quinta Olival das Minas; Rua C Lote 14; 2615-258 Vialonga; Lissabon; Portugal Tel. +351 (219) 52 76 00; +351 (917) 24 45 33 Fax +351 (219) 52 76 09 maqpor@maqpor.pt www.maqpor.pt

ADDRESSES OF FACILITIES

APPENDIX

COUNTRY	CONTACT DATA
Sweden, Finland, Denmark, Norway	Mineconsult Banérgatan 37; 11522 Stockholm; Sweden Tel. +46 (8) 662 20 60 Fax +46 (8) 662 50 02 info@mineconsult.se www.mineconsult.se
Serbia	International Engineering ul. Blagoja Parovica 120; 11030 Belgrad; Serbia Tel. +381 (11) 557 914 Fax +381 (11) 544 191 nenadlakicevic@hotmail.com
Singapore, Vietnam, Myanmar, USA	USAE Pte Ltd 27 Tech Park Crescent; Tuas Techpark; 638105 Singapore Tel. +65 68 653 962 Fax +65 686 324 41 daniel@usae.com.sg
South Korea	Daeseung International Co., Ltd. 1566-8 Seocho-dong-Ku; Seocho-gu; Seoul; South Korea Tel. +82 (2) 582 1907 Fax +82 (2) 582 2388 info@daeseung-intl.co.kr www.daeseung-intl.co.kr
Turkey	Penatrade Koza Sokak No. 59/6-7; Gaziosmanpasa; 06700 Ankara; Turkey Tel. +90 (312) 443 0070 Fax +90 (312) 443 0069 info@penatrade.com www.penatrade.com
Hungary	Bittmann GmbH Dorfener Straße 25; 84416 Taufkirchen; Germany Tel. +49 (8084) 7389 Fax +49 (8084) 7089 h.bittmann.ind@t-online.de
Vietnam	Openasia Heavy Equipment Ltd. 163 Ba Trieu Street; Hai Ba Trung District; Hanoi; Vietnam Tel. +84 (4) 978 2025 Fax +84 (4) 878 2027 ohe.vietnam@hn.vnn.vn

6. Enclosed Herrenknecht CD

6.1 Browsing the CD

1. Insert the enclosed CD into the drive.
 - Make sure that no ADOBE programs are running.
 - The CD starts automatically.
 - **The START screen is displayed.**
2. In the start screen, select the required language by clicking the button (flag or name).
 - **The CONTENT screen appears.**
3. Click supplier documentation, drawings, fluid diagrams or electric diagrams.
 - **Depending on your selection, a list will open.**
4. Select and click the supplier documentation, drawings, fluid diagrams or electric diagrams in the active list.
 - **This opens the desired supplier documentation, drawings, fluid diagrams or electric diagrams.**

6.2 Overview of the CD

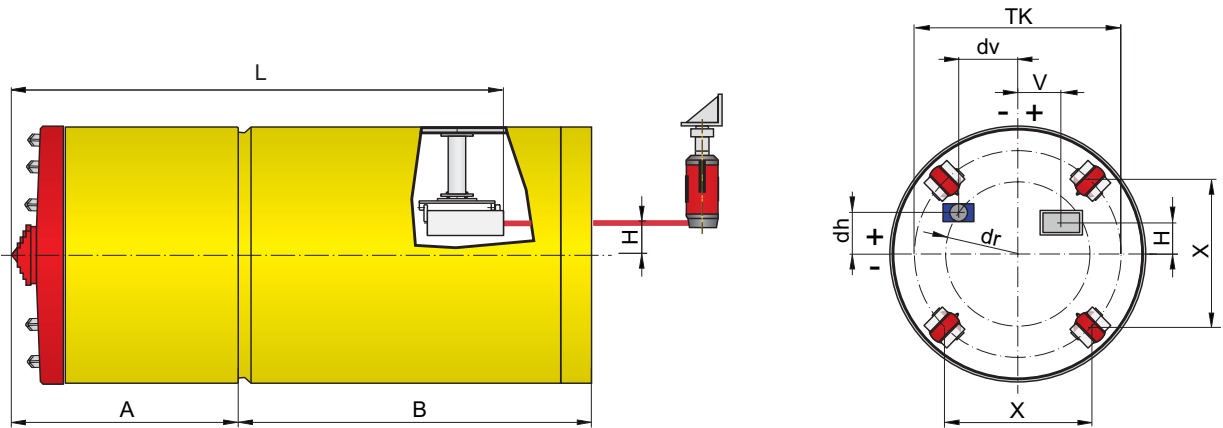
The directory tree on the enclosed CD is always in English.

The external technical documentation on the enclosed CD is organised as follows:

FOLDER NUMBER/ FOLDER NAME	TRANSLATION FOLDER NAME	DESCRIPTION
01_OperatingManual	Operating Manual	Operating Instructions HERRENKNECHT.
02_Internals-Accessories	Internals, Accessories	Technical documentation for components and accessories.
03_Drawings	Drawings	Drawings and parts lists
04_FluidDiagrams	Fluid Diagrams	Fluid diagrams with parts lists
05_ElectricDiagrams	Electric Diagrams	Electric diagrams.

Data Sheet Laser Target
Tunnelling machine **without** / extension kit

Parameter Visualisation



Height of laser over pipe axis (without power pack in the trailing tube)	H	465	mm
Height of laser over pipe axis (with power pack in the trailing tube)		---	mm
Horizontal offset distance laser target	V	430	mm
Distance target - cutting head	L	2629	mm
Length of steering head	A	1855	mm
Length of machine pipe 1	B	1215	mm
Number of steering cylinders with stroke measurement system		4	pcs.
Number of steering cylinders without stroke measurement system		---	pcs.
Diameter steering cylinders (piston)		140	mm
Stroke of steering cylinders		60	mm
Pitch circle steering cylinders	TK	1385	mm
Distance between steering cylinders	X	489,7	mm

HWL altitude sensor	Attachment radius	dr	---	mm
	Horizontal offset distance	dv	300	mm
	Vertical offset distance	dh	801	mm

Speed	Displacement 0% Step 1:	0 - 5,9	min ⁻¹
	Displacement 100% Step 2:	---	min ⁻¹

Maximum pressure cutting wheel drive	Pressure cut off	310	bar
	A4V HP - Valves	290	bar

TRANSLATION

EC DECLARATION OF CONFORMITY

IN ACCORDANCE WITH EC DIRECTIVE 2006/42/EC, ANNEX II
Translation of the original Declaration of Conformity



Manufacturer: **HERRENKNECHT AG**
Tunnelling Systems
Schlehenweg 2
77963 Schwanau
Germany

Person authorized to
compile the technical documents:
Reinhold Vogt
Schlehenweg 2
DE-77963 Schwanau

hereby declares that the Tunneling System:

Project number: M-1641M / M-1642C
Product type: TUNNELLING MACHINE /
OPERATION CONTAINER
Product number: 30207769 / 30208764

corresponds with the requirements of the Directives outlined below on the basis of its concept and design as well as the variant put into operation by us. The Operating Instructions must be observed.



We draw your attention to the fact that this Declaration becomes invalid in the event of any product modification, repair or maintenance which has not been agreed with us.

Applicable Directives: Machinery Directive (2006/42/EC)
 EMC Directive (2004/108/EC)
 Pressure Equipment Directive (97/23/EC)

Name: Thomas Studer, Member of the Executive Board Utility Tunnelling

Date: Schwanau, 17.01.2012

Signature:

IX. Assemblies, accessories

1. About this main chapter	IX - 3
2. Tunnelling machine	IX - 4
3. Operation container	IX - 5

MAIN TABLE OF CONTENTS

ASSEMBLIES, ACCESSORIES

1. About this main chapter

This section contains documentation (technical documentation) on the assemblies and accessory components integrated into the machine/system.

They are mainly sorted by manufacturer, and then by component. All components in the following list are actively linked to the respective folder (see navigation on the enclosed CD). The files are stored on the CD in the "DATEIEN\02_Internals-Accessories" folder.

TUNNELLING MACHINE

ASSEMBLIES, ACCESSORIES

2. Tunnelling machine

MANUFACTURER	COMPONENT
BOSCH	HYDRAULIC PUMP/HYDRAULIC MOTOR
BUCHER	WAY PROPORTIONAL VALVE
DOSATRON	FLUID METERING UNIT
ENDRESS & HAUSER	THERMAL MASS FLOWMETER T-MASS AT70 PROMAG 50 FLOWMETER
GEO	LASER VL80
HONEYWELL&BRAUKMANN	PRESSURE REDUCER
HYDAC	BLADDER ACCUMULATOR
KIEPE	ANDON CORD EMERGENCY SWITCHES
LINCOLN	GREASE PUMP P215
MOTEC	COLOR CAMERA MC3090
PARKER	GEAR PUMPS PGP500
POCLAIN	HYDRAULIC MOTOR
RITTAL	SWITCH CABINET A/C UNIT
ROLLSTAR	PLANETARY GEAR
SAMSON	MOTOR CONTROL VALVE
TACONOVA	BALANCING VALVE
VEM	MOTORS

Tabelle IX - 1: Assemblies, accessories, tunnelling machine

3. Operation container

MANUFACTURER	COMPONENT
BUCHER	WAY PROPORTIONAL VALVE
HERRENKNECHT	MEASURING SYSTEM UNS 4.26
	COMPRESSED AIR MAINTENANCE UNIT
	VISUALISATION
HAENY	BENTONITE PUMP
KAESER	COMPRESSOR KC 390
LINDE	HIGH PRESSURE CONTROL PUMP
MOTEC	MONITOR MD3072
MUD-DATA	BENTONITE MIXING SYSTEM
PARKER	GEAR PUMPS PGP 500
SCHNEIDER J	TRANSFORMER
SIEMENS	MULTIFUNCTIONAL MEASURING SYSTEMSENTRON PAC3200
STIEBEL ELTRON	HEATER
VEM	ELECTRIC MOTORS

Tabelle IX - 2: Assemblies, accessories, operation container

OPERATION CONTAINER

ASSEMBLIES, ACCESSORIES

X. Drawings

NO.	PART NO.	DESIGNATION	DRAWING NO.
1	30202631	START-UP SITUATION	3474-01-000-00
2	30207923	MIXED CUTTING HEAD	3474-01-012-00
3	30030960	FASTENING SET CUTTER DISC	809-90-201-13
4	30207769	TUNNELLING MACHINE	3474-01-002-00
5	30019153	CONVEYOR SCREW	1039-02-000-00
6	30018956	SCREW GEAR DRIVE	809-08-002-00
7	30019117	GATE VALVE	1039-02-010-00
8	30036283	EARTH PRESSURE SENSOR	809-01-050-02
9	30019454	EXCAVATION CHAMBER DOOR	809-12-005-00
10	25102954	BENTONITE NOZZLE	809-01-040-00
11	25101861	EARTH PRESSURE SENSOR	118-00-059-00
12	30045201	SPLASH GUARD	1437-01-026-00
13	30021245	LASER TARGET SUPPORT	208-07-023-160
14	30045288	FOAM GENERATOR	809-01-056-20
15	30207773	CUTTERHEAD DRIVE	809-04-022-00
16	30012390	TRANSMITTER	809-01-150-00
17	30207768	MACHINE PIPE 2	3474-01-006-00
18	30045287	DOSING UNIT	809-01-056-10
19	30219174	OPERATOR SEAT	3474-01-006-30
20	30208053	MOTOR PUMP UNIT	3474-01-006-20
21	30207983	OIL TANK	809-30-032-10
22	30115834	MACHINE WINCH+WIRE SPOOL DEV.	1450-70-012-00
23	30086359	WIRE	497-03-000-02
24	30086260	WIRE ROPE	497-03-000-01

DRAWINGS

NO.	PART NO.	DESIGNATION	DRAWING NO.
25	30045133	BELT CONVEYOR	1437-01-030-00
26	25100656	DRIVING STATION	462-00-002-00
27	25100658	DRUM	462-00-006-00
28	25100659	SCRAPER	462-00-008-00
29	25100655	RETURN STATION	462-00-001-00
30	30045550	ANGLE PIECE	462-00-060-10
31	25100657	ROLLER	462-00-005-00
32	25600569	SCRAPER	462-00-007-00
33	30045306	GUIDE ROLLER	1437-01-030-10
34	30209559	INTERJACK STATION LOST	809-61-422-00
35	30210577	CYLINDER SUPPORT RING	809-61-422-20
36	30210583	SEAL CARRIER	809-61-422-10
37	30209009	START-UP SEAL	809-70-791-00
38	30208502	JACKING FRAME	809-52-099-00
39	25102175	SHAFT WINCH	1450-70-010-00
40	30051555	WIRE ROPE	1450-70-019-02
41	30060369	WIRE ROPE	1450-70-019-05
42	30215654	WIRE ROPE	1450-70-019-10
43	25800193	INSTALLATION	497-04-100-20
44	25800192	INSTALLATION	497-04-100-10
45	30075481	LASER SYSTEM VL80 COMPLETE	809-63-100-25
46	30014270	LUBRICATION SYSTEM	809-63-002-10
47	30021191	FLOWMETER	809-63-002-30
48	30041085	T-PIECE	809-22-610-20

NO.	PART NO.	DESIGNATION	DRAWING NO.
49	30045321	SKIP	098-00-090-00
50	30045538	LIFTING BEAM	098-00-090-10
51	30208764	OPERATION CONTAINER	3478-04-000-00
52	30166188	HYDRAULIC POWER UNIT	2901-04-002-00
53	30166227	OIL TANK	2901-04-002-04
54	30179094	MOTOR PUMP UNIT	2901-04-004-40
55	30174968	HYDRAULIC BULKHEAD	2900-04-002-20
56	30174751	COATING SHEETS	2901-04-000-10
57	30175530	LABEL SET	2901-04-000-30
58	30180221	WINTER PACKAGE	2901-04-000-20
59	30149227	AIR CONDITIONER	2666-04-000-30
60	30144497	FIXING DEVICE	2606-06-030-20
61	30056464	DISPLACEMENT SENSOR	208-02-005-20
62	30138002	BASE COMPRESSOR	2584-04-002-10
63	30194953	STAND-ALONE UNIT	809-49-111-00

Table X - 1: Drawings

DRAWINGS

XI. Fluid diagrams

NO.	PART NO.	DESIGNATION	DRAWING NO.
1	25268970	HYDRAULIC DIAGRAM STEERING/VALVE CYLINDER	3475-45-001-00
2	25268971	HYDRAULIC DIAGRAM CUTTING WHEEL DRIVE	3475-45-002-00
3	25268972	HYDRAULIC DIAGRAM SCREW CONVEYOR DRIVE	3475-45-003-00
4	25268975	GREASE DIAGRAM MACHINE	3475-46-010-00
5	25268976	WATER DIAGRAM INDUSTRY/COOLING	3475-47-010-00
6	25268977	BENTONITE LUBRICATION	3475-47-030-00
7	25268978	FOAM SYSTEM	3475-47-060-00
8	25268973	HYDRAULIC DIAGRAM POWER UNIT	3475-45-010-00
9	25268974	HYDRAULIC DIAGRAM AUXILIARY HYDRAULICS MR	3475-45-015-00
10	25256138	HYDRAULIC DIAGRAM INTERJACK STATION	809-39-160-01
11	25257255	HYDRAULIC DIAGRAM JACKING FRAME	809-39-250-02
12	25268982	HYDRAULIC DIAGRAM CONTROL CONTAINER	3478-45-060-00

Table XI - 1: Fluid diagrams

FLUID DIAGRAMS

XII. Electric diagrams

NO.	PART NO.	DESIGNATION	DRAWING NO.
1	25186171	ELECTRIC DIAGRAM TUNNELLING MACHINE	3474-564-002
2	25186184	ELECTRIC DIAGRAM OPERATION CONTAINER	3478-562-002

Table XII - 1: Electric diagrams

ELECTRIC DIAGRAMS