HERRENKNECHT
Tunnelvortriebstechnik

OPERATING MANUAL

TRANSLATION OF THE ORIGINAL OPERATING MANUAL

D-881 55KW
TRAILING TUBE POWER UNIT

DOCUMENT: 81504-001

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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.

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I. General

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GENERAL

1. Product Identification

1.1 Machine / system data

IDENTIFICATION	DATA
Project number	D-881
Machine type	Trailing tube power unit 55kW
Order number	10000809

Table 1: Machine / system data

NOTE
Additional information:
Main chapter II product description / „Overall view“

1.2 Operating Manual

IDENTIFICATION	DATA
Edition dated:	30. May 2018
Version	001

Table 2: Operating Manual

1.3 Manufacturer address

HERRENKNECHT AG
Schlehenweg 2
77963 Schwanau
Germany
Phone: +49 7824 302 4444
Fax: +49 7824 302 7000

2. Information on the operating instructions/instruction manuals

2.1 General

Carefully read these operating instructions/instruction manuals before commissioning the machine/plant for the first time in order to operate the machine/plant safely, correctly and economically. This also applies for all manufacturer operating instructions that are included on the enclosed CD ROM under the section "Manufacturer operating instructions".

The operating instructions/instruction manuals contain all information and instructions for the operation and maintenance of the machine/plant.

These operating instructions/instruction manuals are a component of the complete documentation.

Before starting up the machine / plant each time, all conditions must be fulfilled that serve the safety of the personnel and the machine / plant.

In-hose regulations must be considered by the manufacturer instructions.

NOTE

The chapter dealing with safety must be observed in all cases in order to maintain the health and safety of the personnel and to ensure for the functionality of the machine / plant.

If these instructions are disregarded, this may impair the guaranty and warranty obligations of the manufacturer.

2.2 Availability of information

These operating instructions/instruction manuals as well as all corresponding manufacturer operating instructions must be kept available at the machine/plant. It must be ensured that all persons working on the machine/plant have access to these operating instructions/instruction manuals at all times.

In addition to these operating instructions/instruction manuals, the operating company must also provide instructions as per the labour protection act.

These operating instructions/instruction manuals are a part of the machine/plant. The complete set must be handed over to the purchaser when the machine/plant is sold.

2.3 Applicable documents for plant components

- Operating instructions/instruction manuals must be observed for all work on the machine/plant.
- Operating instructions/instruction manuals by third party component manufacturers are an integral part of these operating instructions/ instruction manuals and must be observed for all work on the machine/ plant.
- Please observe the corresponding national and international standards and directives.

2.4 Version

Only the documents pertaining to the respective order shall be applicable. Such documents are marked with the version, project number and the project name in the footer of the operating instructions/instruction manual.

2.5 Purpose

These operating instructions/instruction manuals contain information and instructions for operating the machine/plant purchased.

NOTE

These operating instructions/instruction manuals are intended to support the operator and his employees with the operation of the machine/plant.

Contractual agreements are not affected by the operating instructions/ instruction manuals.

2.6 Target group

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

- Operating instructions/instruction manuals
- the Safety Regulations
- the Safety Instructions of the individual chapters and sections

The operating instructions/instruction manuals must always be accessible for the operating personnel to avoid operating faults and ensure a fault-free operation.

The national regulations for accident prevention and environmental protection must be added to the operating instructions/instruction manuals by the operating authority.

2.7 Pictographs

The following symbols refer to information on and support with a proper handling of the TBM and its components.

	Note or tip
	NOTE Defines particularly useful information in the respective context which must be adhered to.
	Section
	NOTE Non-observance of this measure infringes the guidelines or legal regulations. Non-observance and resulting personal injuries or material damage may have legal effects or even be subject to prosecution.

2.8 Setup

2.8.1 Scope

The operating instructions/instruction manuals are each supplied in a printed version and as a digital version on CD ROM.

2.8.2 Main chapter

Main chapters represent the top, structural level. They feature all chapters and sub-chapters. Main chapter always start off with a table of contents.

2.8.3 Main chapter structure

The operating instructions/instruction manuals are subdivided into the following main chapters:

I. General aspects
II. Product description
III. Safety
IV. Transport, installation, connection
V. Operation
VI. Maintenance, repair
VII. Storage, disassembly, disposal
VIII. Appendix
IX. Installations, accessories
X. Drawings
XI. Fluid diagrams
XII. Electric diagrams

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

NOTE
The main chapter structure may differ, depending on the product.

2.8.4 Chapter

The corresponding main chapters are divided into individual chapters. They contain all sub-chapters.

2.8.5 Sub-chapters

Sub-chapters represent divided chapters. Regardless of the level, all chapters within the corresponding chapter are defined as sub-chapters.

2.8.6 Single pages

Single pages are numbered consecutively.

I	-2		
I		=	Main chapter
	-2	=	Page

Table 3: Description of the page number structure

2.8.7 Illustrations

The illustrations in the operating instructions/instruction manuals are used to describe the texts.

These may deviate from the version of the machine/plant without changing the objective information of the operating instructions/instruction manuals.

2.9 Disclaimer of warranty and liability

These operating instructions/instruction manuals contain important information and must be read prior to commissioning the machine/plant.

Basically, our terms and conditions of "General terms of sales and delivery" apply. These terms are provided to the operator on concluding the contract at the latest.

Herrenknecht AG shall not accept any liability for damage and malfunctions resulting from non-compliance with the operating instructions/instruction manuals.

Claims for damages have to be asserted immediately after the defect is detected.

Warranty may expire particularly in the following cases:

- Non-compliance with the operating instructions/instruction manuals.
- Damage by operator errors.
- Improper maintenance.
- Improper use.
- Non-utilization of genuine spare parts and genuine accessories.
- Accessories, spare parts and additional aids that may be the cause of damage and have not been approved by **Herrenknecht AG**. **Herrenknecht AG** assumes no liability whatsoever for subsequent damage resulting from this
- Modifications that were not agreed with **Herrenknecht AG**.
- Unauthorised constructional, electrical or control engineering modifications, repairs, manipulations and changes
- Disasters due to foreign bodies and force majeure.

NOTE

Wear parts are not subject to warranty.

2.10 Copyright

The operating instructions/instruction manuals must be handled confidentially. The operating instructions/instruction manuals must be handled confidentially.

NOTE

All documents of these operating instructions/instruction manuals are protected by copyright.

The disclosure and reproduction of documents (also in excerpts), utilisation and communication of their contents is prohibited unless expressly permitted.

Forwarding of such documents to third parties is only permissible with the express approval of **Herrenknecht AG**.

Contravention is a legal offence and may incur damages.

We reserve all rights arising from patents and other intellectual property.

2.11 Modifications

All technical information, data and advice on operation given in these operating instructions/instruction manuals correspond to the state of our knowledge at the time of going to press; **updated releases will not be provided**. All details take into account our previous experience and are provided to the best of our knowledge.

We reserve the right to make technical changes arising from further development to the subassemblies described in these operating instructions/instruction manuals. No claims may therefore be derived from the details, illustrations, and descriptions contained in these operating instructions/instruction manuals.

Important changes to the serial state of the machine shall each be included in the new edition of the operating instructions/instruction manuals.

2.12 Spare parts and Accessories / Technical Modifications

The installation or use of non-approved spare parts or accessories has to be refrained.

NOTE

For safety reasons, unauthorised conversions or modifications are impermissible. **Herrenknecht AG** excludes any and all liability for damage resulting from such unauthorised conversions or modifications.

2.13 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.

NOTE

The original operating instructions/instruction manuals are always used as the source texts for translations.

As a result, the translated operating instructions/instruction manuals represent a **translation of the original operating instructions/ instruction manuals**.

2.14 Specifications of direction

The positions **left** and **right,** as well as the directions **forward** and **backward** always refer to the advance direction.

II. Product Description

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PRODUCT DESCRIPTION

1. Overall view

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

DESIGNATION		PART NO.	DRAWING NO.
Designation 1	Trailing tube power unit		
Designation 2	DA1295-430L-55KW	40345835	5564-004-000-00
Cons. No.	23269		
Year of manufacture	2018		

Table 1: Overall view

2. Purpose

2.1 Intended use

The operational safety of the machine/system is only guaranteed if used as intended.

Only operate this machine/plant in geologies where no danger of explosion or hazardous materials is anticipated.

NOTE

Always refer and observe chapter "System description" on page!

This machine/plant was designed for driving a tunnel that matches the machine's diameter. It consists of the following components:

- The hydraulic power unit in the back-up tube is equipped with all hydraulic and electrical installations required for the cutting wheel drive and the steering and bypass cylinders. These are connected to the respective tunnelling and control assemblies and can only ensure safe operation in this combination.
- The trailing tube predominantly prevents the tunnelling machine from rolling that results from the rotating reaction of the cutterhead.
- The conveying system is used to transport material and is designed as a fluid circuit.

Any other or further use is considered to be improper use. This applies for both the complete machine/plant and for individual components of the machine/plant. The manufacturer accepts no responsibility for damage resulting from this. The operator alone bears the responsibility.

The machine/plant was constructed in line with the state of the art and recognised safety rules. However, its use can lead to risks of serious to fatal injury of operating staff or third parties, and/or to damage to the machine/plant and other property.

For this reason, the machine/plant must only be operated in technically impeccable condition, by trained operating staff, taking into consideration the valid safety and accident prevention regulations.

In particular, malfunctions that endanger safety must be resolved immediately. Do not restart the machine/plant until after resolving all malfunctions. All malfunctions must be documented and reported to **Herrenknecht AG**.

Intended use also includes observing the operating manual and all service and maintenance instructions.

The owner/operator is responsible, in cooperation with **Herrenknecht AG**, for checking whether the machine/system can be deployed at a location of use than intended at the time of its original design.

The owner/operator must ensure the overall conformity of the machine / plant. He must perform a conformity assessment for his machine / plant. This also includes a risk assessment / hazard assessment for the overall machine / plant in line with country-specific standards and guidelines. The responsibility lies with the operator of the machine / plant.

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.

NOTE

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".

3. Marking

Each machine / system is fitted with a type plate.

The type plate contains the following specifications:

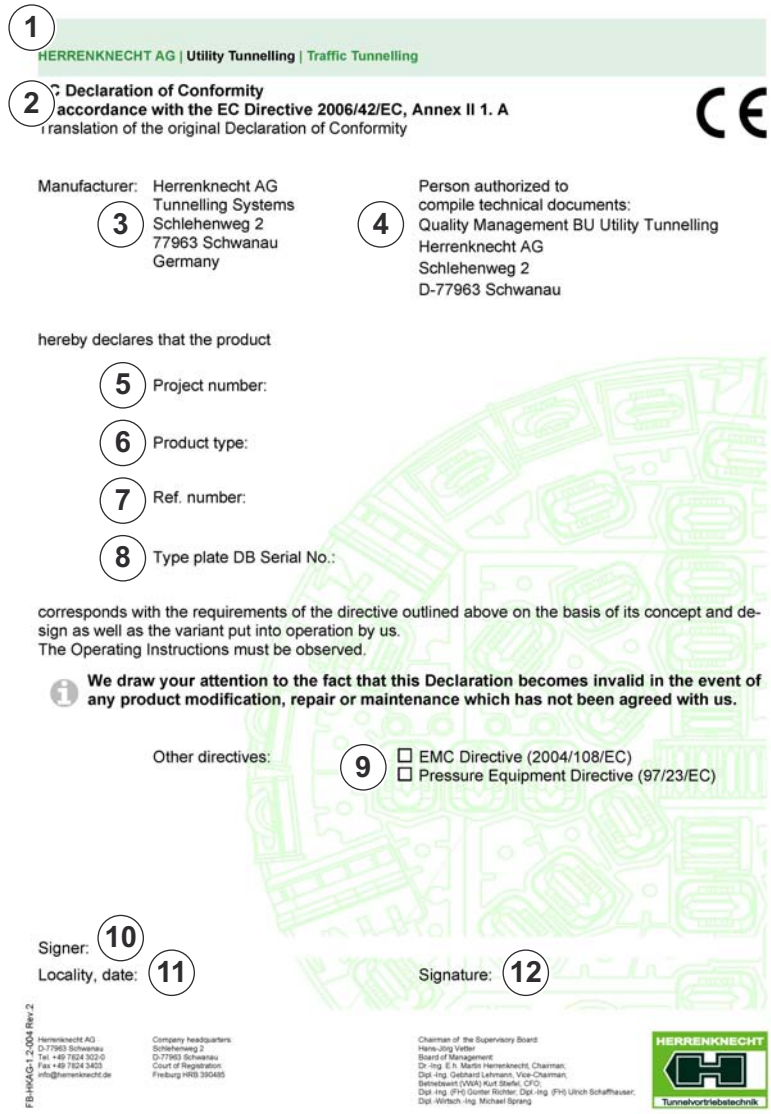
- Order number
- Type
- Part number
- Weight
- Year of manufacture
- Consecutive number (consecutive type plate number)

3.1 Type plate

Figure II - 1: 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. Explanation of the declaration of conformity or incorporation



(1) HERRENKNECHT AG | Utility Tunnelling | Traffic Tunnelling

(2) EC Declaration of Conformity
in accordance with the EC Directive 2006/42/EC, Annex II 1. A
Translation of the original Declaration of Conformity

CE

Manufacturer: (3) Herrenknecht AG
Tunnelling Systems
Schlehenweg 2
77963 Schwanau
Germany

(4) Person authorized to
compile technical documents:
Quality Management BU Utility Tunnelling
Herrenknecht AG
Schlehenweg 2
D-77963 Schwanau

hereby declares that the product

(5) Project number:

(6) Product type:

(7) Ref. number:

(8) Type plate DB Serial No.:

corresponds with the requirements of the directive outlined above 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.

Other directives: (9) ☐ EMC Directive (2004/108/EC)
☐ Pressure Equipment Directive (97/23/EC)

Signer: (10)
Locality, date: (11)
Signature: (12)

FB-HKAG-1-2-004 Rev.2

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Betriebswirt (VWA) Kurt Steffel, CFO;
Dipl.-Ing. (FH) Günter Richter; Dipl.-Ing. (FH) Ulrich Schaffhauser;
Dipl.-Wirtsch.-Ing. Michael Sprang

1	Business unit
2	Declaration of Conformity or Incorporation
3	Manufacturer's address
4	Person responsible for documentation
5	Project number
6	Product type
7	Part number/Article number
8	Serial number
9	Other principles
10	Signee and position
11	Place and date
12	Signature

Table 2: Sample Declaration of Conformity

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5. System description

5.1 Hydraulic power unit

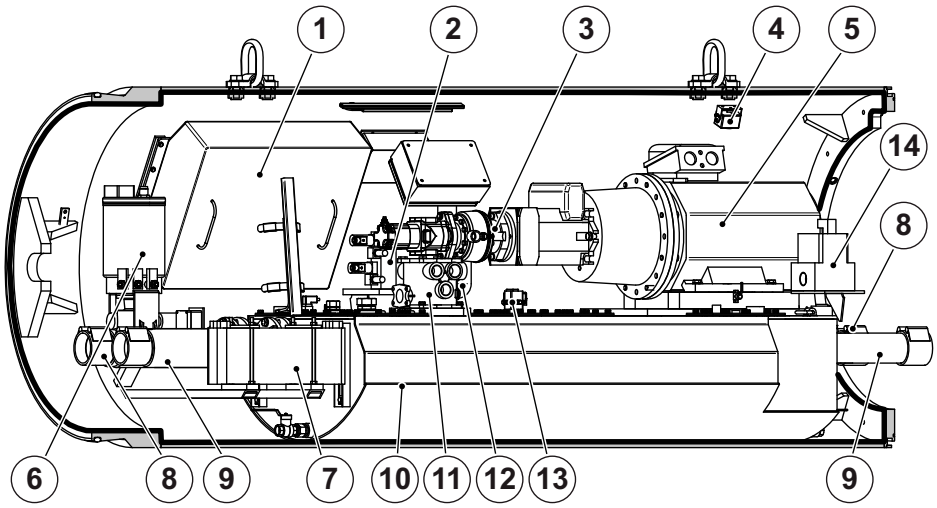

Figure II - 2: Example of hydraulic power unit

1	Terminal box	8	Feed line
2	Pressure limiting valve	9	Slurry line
3	Pump combination/cutting wheel drive/secondary circuit	10	hydraulic tank
4	Camera	11	suction filter
5	Electric motor	12	bladder accumulator
6	Grease pump	13	Level switch
7	Plate heat exchanger	14	Flowmeter

5.2 Trailing tube

During tunnelling, rolling may occur. The rolling that takes place as a reaction to the cutterhead is absorbed via the jacket friction of the trailing tube and is prevented to a large extent. A hydraulic power unit can optionally be installed in the trailing tube.

5.3 Hydraulic power unit in back-up tube

The hydraulic power unit for the cutting wheel drive and the steering and bypass cylinders with corresponding electrical installations is built into the back-up tube.

It is possible to operate the machine without the hydraulic power unit from a correspondingly equipped control container.

6. Technical specifications

NOTE

Project-specific data and pressures must be taken from the drawings and schematics provided.

6.1 Hydraulic power unit

CAUTION!

Machine damage!

If the hydraulic power unit in the trailing tube/machine pipe 2 is not deployed immediately behind the tunnelling machine.

Soiling of the hydraulic oil by coupling/uncoupling hydraulic lines for each pipe change.

- Damage to the hydraulic power unit and the flowmeter.

• Install and connect the high pressure filters and flowmeter intended for this purpose. Depending on the flowmeter, the flow rate may need to be adjusted at the variable displacement pump (see the fluid diagram).

DESIGNATION		DATA	
Back-up tube - power unit type		55	kW
Compatible machine types		AVN800 - AVN1000	
Cutting wheel pump		0 - 180	l / min
Control system pump		9	l / min
Filter / cooling circuit pump		75	l / min
Cooling circuit pump		88	l / min
Hydraulic tank	approx.	430	Litres
Laser elevation above roll axis	See drawing		

Table 3: Technical data of back-up tube - power unit

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6.1.1 Application limits

DESIGNATION			DATA	
Groundwater coverage (depth)	max.		30	m
Rise	max.		15°	
Drop	max.		15°	
Temperature range	-10	up to	+50	°C

Table 4: Application limits

7. Transport data

NOTE

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 Trailing tube with hydraulic power unit

DESIGNATION	DATA	
Back-up tube with hydraulic power unit		
Length	3330	mm
Diameter	1295	mm
Weight with hydraulic power unit approx.	4165	kg

Table 5: Trailing tube with hydraulic power unit

III. 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/instruction manuals and warning signs in hazardous machine/plant areas warn of residual risks which may occur during the operation of machine/plant in its individual operating states.

In these operating instructions/instruction manuals, safety instructions are structured as follows:

DANGER!

Danger type / danger cause!

Source

- Consequence
- Avoidance

STRUCTURE	CONTENTS
Warning sign	Exact definition of the danger
Signal word	Classification according to the severity of the danger (DANGER / WARNING / CAUTION)
Danger type / danger cause	Keyword for danger type / danger cause! (not always available)
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 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 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

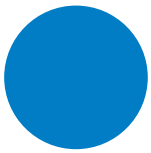
SIGNAL FORM	COLOUR	MEANING
	Yellow with a black frame	Warning signs
	Blue	Mandatory sign
	White with a red frame	Prohibitory sign
	Green	Rescue sign
	Red	Fire protection sign
	White with a blue frame	Note
	Orange	Hazard sign

Table 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.

NOTE

Any damaged or illegible warning signs must be replaced immediately.

The warnings signs on the machine/system must remain legible.

2.3.1 Warning symbol

ICON	MEANING	ICON	MEANING
	General danger		Hot surfaces
	Danger of falling		Noise hazard
	Caustic substances		Laser radiation
	Electrical voltage		Risk of crushing
	Risk of explosion		Radio-active substances
	Flammable substances		Rotating machine parts
	Hand injuries		Rotating rollers

ICON	MEANING	ICON	MEANING
	Risk of slipping		Falling objects
	Suspended loads		Rock fall
	Risk of tripping		System damage
	Gases that are hazardous to health		Cutting off / shearing of body parts
	Drowning		Environmental pollution
	Risk of impact Opens under spring pressure		

2.3.2 Prohibition signs

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

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2.3.3 Mandatory signs

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

2.3.4 Rescue and firefighting signs

ICON	MEANING	ICON	MEANING
	First aid		Fire detector
	Escape route		Fire hose
	Stretcher		ABC fire extinguishers
	Meeting point		CO_2 fire extinguishers
	Eye rinsing equipment		

2.3.5 Dangerous substances

ICON	MEANING	ICON	MEANING
	Hazards for the environment		Risk of fire

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2.3.6 Information signs

ICON	MEANING
	Note
	Note on directives and legal requirements

ICON	MEANING
	Observe the operating manual

3. Organisation and staff

NOTE

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 system operator

NOTE

The area of responsibility of the system operator depends on the national, regional and local regulations and laws.

NOTE

As part of his due diligence, the system operator must ensure that an explosion protection document is prepared and kept up-to-date for an Ex machine/plant.

- To monitor compliance with the safety measures, the system operator nominates a safety officer.
- The operator of the machine/system is responsible for providing the power supply, and the industrial and cooling water supply.
- The system operator has to ensure that only qualified, trained and specifically instructed personnel work on the machine/system.
- This Operating Manual must permanently be available at the place where the machine/system is used.
- In addition to this Operating Manual, the machine/system operator 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 Manual, and must be complied with.
- Safety instructions in the Operating Manual guaranteeing a higher degree of accident prevention than the national accident prevention regulations must be observed. The safety instructions must be supplemented by the system operator by instructions concerning the supervisory and reporting obligations, the different operating sequences or the operating personnel.
- Prior to starting work, the operating personnel must have read and understood the Operating Manual, in particular the chapter "General safety instructions". The system operator 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 system operator monitors these measures within the scope of his duties stipulated in the ordinance on industrial safety and health.
- The system operator must inform the personnel about all safety installations, their function and operation.
- The responsibilities of the operating personnel regarding operation, mounting, maintenance and repair must clearly be specified.
- The system operator must specify the responsibilities of the machine operator. He must be allowed to disregard instructions of third parties which are contrary to the safety code of practice.
- The operating personnel has to be regularly assessed by the system operator on its ability to work in compliance with this operating manual and the national regulations and to follow a safety- and risk-conscious work approach. If required, the system operator must implement corrective training measures for the personnel.
- The system operator 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 system operator initiates all recurring crane and chain hoist inspections. The results must be documented in the inspection and test logbook.
- The system operator must ensure that skilled electricians employed in areas subject to explosion hazards have know-how in the area of explosion protection.

3.2 Area of responsibility of machine operator

The machine operator is responsible for the following points:

- Designated use
- Compliance with the necessary safety precautions
- Occupational safety and prevention of accidents on the machine and in its environment
- Ordering any unauthorised person off the working area.
- Execution 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 at 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 machine application during its life cycle.

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. It is, however, imperative to comply with all general provisions on industrial safety and health protection.

Safety installations and protective guards must at no times be disassembled, bypassed or rendered useless.

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 worn at all times.
- 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.
- Safety installations must by no means be bridged, bypassed or rendered useless.
- The operating personnel must be familiar and comply with the instructions in the safety data sheets of the employed 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 is in automatic mode.

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.

NOTE

No access for unauthorized persons.

- 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.
- Cutting tool changes and repair work may only be carried out by expert personnel in compliance with work safety regulations.

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.

NOTE

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 analysed during machine/system design in accordance with applicable directives and standards, and documented within the scope of a risk analysis.

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

- Danger of fatal injury
- 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 manual.
- Observing the general safety instructions in this operating manual.
- Observing the applicable accident prevention regulations.
- Observing the manufacturer's instructions.
- Observing the ordinance on hazardous substances.

4.2.1 Danger of fatal injury

There is danger to life in the following cases:

- Unintended 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 the wrong choice of lifting devices
- Falling from large 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
- In case of use of additional units not discussed with and approved by Herrenknecht AG.
- Selecting an incorrect speed ratio between the driving and pushing units of the overall system.

  This consists of the HDD rig and the pipe thrusting unit (Pipe Thruster only).

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 mobile phones in the control cabin is not allowed.
- Never manipulate, disable or remove any safety devices.
- Maintain all safety and hazard information labels on the machine/ system in a complete and readable state.
- Never modify programs of programmable control systems be modified autonomously.
- Keep all handles, steps, handrails, platforms and ladders free of dirt.
- Always keep all escape routes clear (also for ambulance services).
- Use the machine/system only when all safety installations are fully operational.
- Avoid any and all safety-critical work methods.
- Observe procedures where units are switched on or off, and watch the control displays in accordance with 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.
- During operation, electric equipment has live, bare-metal and rotating parts. Removing the machine covers without authorisation, improper use of the machine, incorrect operation, incorrect commissioning, or insufficient maintenance can cause serious injuries or material damage.
- 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, shut down the machine immediately and look for the cause. Closely monitor the machine after switching it on again.
- When working on and with the machine, personal protective equipment, particularly protective gloves, hard hat, ear protectors and safety shoes, must be permanently worn.

- To avoid the risk of slipping 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.
- Cutting tool changes and repair work may only be carried out by expert personnel in compliance with work safety regulations.
- 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 must be performed by qualified persons with appropriate professional knowledge only.
- Never perform maintenance while the machine/plant is running.
- The deadlines and specifications for inspections, maintenance work, and replacement of assembly groups and components must be complied with and documented.
- Before starting non-standard work or maintenance, it is imperative to inform the operating staff and appoint a supervisor.
- Only use original spare parts and accessories approved by the manufacturer.
- Use the specified and approved consumables and operating materials (grease, oil, cleaning agents) only.
- If required, secure a wide area around the maintenance area.
- Once the machine/plant has been switched off for maintenance and repair work, it must be locked against inadvertent restarting.
- If a motor has been switched off for maintenance and repair work, it must be locked against being switched back on inadvertently.
- Always use the climbing aids and working platforms provided when you carry out maintenance work above body height.
- 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. Do not use aggressive cleaning agents and exclusively use lint-free cloths.
- Seal or cover any openings that must not come into contact with liquids or cleaning agents prior to cleaning the system using water, high-pressure cleaners or other cleaning agents. This particularly applies to electric motors and switch cabinets.
- After cleaning, covers or adhesive tape must be removed completely.
- Clean all handles, steps, handrails, platforms and ladders after completing maintenance work.
- 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 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 possibly pressurised line (slurry, air, water, hydraulic, vacuum or oxygen line), ensure that it is definitely depressurised. Switch off any units that create pressure, such as pumps or compressors prior to starting work and secure them against accidental re-activation.
- Pressure in lines may 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.
- Heavy parts must be protected against toppling or falling before screws are loosened or bolts removed.
- The maintenance switches must be used during maintenance or repair work. They are designed to accommodate up to three padlocks. 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 at all times. 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 safe and environmentally-compatible disposal of operating fluids, auxiliary materials and spare parts.

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 Storage

- 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

- All lines, hoses and screw connections must be regularly checked for leaks and externally visible damage. Damage must be remedied immediately.
- Access to the hydraulics/pneumatics area is strictly prohibited during operation.
- Before performing maintenance/repair work, completely de-pressurise the hydraulic/pneumatic system and interrupt the energy supply to the unit in question by turning the switch on the motor circuit breaker and locking against switching back on.
- Regular check of all components in the supply circuit.
- Always wear protective clothing for all cleaning/maintenance/repair work.
- When working on the machine/plant, never eat, drink, smoke or use snuff.
- Changes to the hydraulics/pneumatic system must not be made without contacting and receiving written approval from Herrenknecht AG.
- Before use, always check threaded joints, couplings and hoses.
- Never remove pipes, hoses and threaded joints under pressure.
- Observe national safety instructions

4.4.1 Hydraulics

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. The set pressures must not be changed.
- Damage to the hydraulic lines must be repaired immediately; oil spraying out can lead to injuries and fires.
- In case of a failure of the hydraulic supply, the hydraulic system is immediately shut down. The residual energy is gradually dissipated.
- Never exceed the maximum permissible pressure of the hydraulic system.

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 switching off the system or changing the operating mode (shift in pressure oil level).
- Additional risk is posed by the mechanical energy of electrical drives when the system is switched off or the operating mode changed (shift in pressure oil level).
- Hydraulic cylinders can execute fast piston movements even in "low pressure" situations.
- Do not enter the hydraulic area or open of safety covers until the residual energy in the oil pressure accumulator has been relieved (min. two seconds).
- Only persons with special know-how and experience in the field of hydraulics are allowed to work on hydraulic equipment.

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.

- 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.
- **In case of skin contact:**

  Minor skin irritation possible, repeated or extended 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 if highly pressurized oil penetrates your skin.
- **In case of contact with eyes:**

  Serious eye injuries possible. Spread the eye lids and rinse the eyes immediately with an eye rinsing device for 15 minutes.
- **After inhaling:**

  Risk of damage to the respiratory system, risk of fatality in in severe cases. Take affected persons out into the fresh air immediately, and place in a resting position.
- **After swallowing:**

  Do not cause the affected person to vomit (mucosal irritations).
- **If hydraulic oil escapes:**

  Thoroughly ventilate affected rooms.

  Take suitable sealing actions to prevent the substances entering the sewage system.

  The authorities responsible must be notified if harmful substances enter surface waters, the sewage system or the substrate.

  Only authorised maintenance personnel is allowed to clean up hydraulic oil spills.

4.4.2 Pneumatics

- Only persons with special know-how and experience in the field of pneumatics are allowed to work on pneumatic equipment.
- Never block compressed air lines manually.
- Never point compressed air at other people or your own body.
- Always use compressed air hoses and couplings that are approved for the working pressure.
- Before connecting pneumatic components, perform a safety check of the connections and hoses.
- When working with pneumatically powered tools, always use impact proof eye protection.

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 live parts or damaged cables.

- This can result in serious paralysis, burns and even fatality.

• Switch off the voltage before working on the electrical system or electrical components.

• Electrical work may only be performed by qualified electricians.

• Never touch live parts.

• Control cabinets may only be opened by qualified electricians.

NOTE

Prior to commissioning the system, check for tight fit of all contact screws.

NOTE

National regulations on the operation of electric systems valid in the respective operator country must be observed.

- Access to electrical equipment and devices is only allowed for authorized persons.
- Only qualified electricians are allowed to work on the electric systems or equipment.
- Cordon off the working area with a red / white safety chain and a warning sign. Use insulated tools only.
- When working on energised units, you must observe the applicable country-specific accident prevention measures.
- All electric cables and electric motors are protected against overload and short-circuit. The set values must not be changed.
- During operation, electric equipment has live, bare-metal and rotating parts. Removing the machine covers without authorisation, improper use of the machine, incorrect operation, incorrect commissioning, or insufficient maintenance can cause serious injuries or material damage.
- The electrical equipment must regularly be inspected and tested. Any defects, such as loose connections or burnt cables, must be remedied immediately.
- If you need to touch a device, avoid bending components and/or changing insulation gaps.
- Avoid touching electronic components (static discharge!).
- Operate the system only when all switch cabinets are closed.
- Use a suitable measuring instrument with an internal resistance of at least 10 kW to measure signal voltages.
- Only use genuine fuses of the specified tripping characteristics. Switch off the machine/system immediately in case of a fault in the electric power supply.
- Machine vibration or substantial oscillation can damage components or lines.
- 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.
- Main switches on control cabinets can be locked in their switch position with a safety lock to prevent unauthorised persons from switching on the power.
- Observe the warnings on the switch cabinet doors.
- Note the voltage and current specifications on peripheral units!
- Never modify the electrical system without consulting Herrenknecht AG and without prior written approval from Herrenknecht AG.
- When working on high-voltage assemblies, you must first disconnect the power supply. Next, connect the supply cable to ground and short-circuit the components (e.g., capacitors) with a ground 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 on which servicing, maintenance and repairs are performed must be de-energised. Always check the de-energised parts first to make sure there is no voltage.
- 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

NOTE

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.

4.6.2 Notes on safe handling of 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 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.

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

NOTE

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.

- When working in the vicinity of hot surfaces (gearbox, leakage oil lines, hydraulic tanks), wear protective clothing.
- Do not cover air-cooled motors. Clean them at regular intervals.
- Household appliances (coffee machines, microwaves, boilers) must not be operated on combustible surfaces and should be regularly inspected.
- Repair or replace defective bearings and mechanical clasp brakes.
- Unsuitable fire extinguishing agents: water, particularly a powerful water jet, must not be used for extinguishing.
- Keep inflammable liquids away from ignition sources.
- Welding, burning and grinding work pose 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.
- When performing welding, torch cutting or grinding work, always consider the fire hazard at the rear of the workplace, especially if this area cannot be seen easily.
- When selecting and positioning fire extinguishers, consider the various types of fire (electric fires/liquid fires).
- To secure the escape routes, fire extinguishers are distributed over the entire system, and installed wherever required.
- Prior to welding, torch cutting and grinding, clean the machine parts to be processed and the surrounding area to remove dust and other combustible materials. Furthermore, sufficient ventilation must be provided.
- Prior to welding, torch cutting 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.

NOTE

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.

WARNING!

Noise hazard!

Machine / system in operation.

- Receding attention, permanent hearing damage.

• Wear ear protection, even at low noise levels.

• Keep noise insulation housing closed.

4.11 Working in raised work zones

DANGER!

Falling hazard!

There is a danger of falling when working in raised work zones, standing and assembly places. People can fall, and objects can be dropped.

- This can cause severe injury and damage.
- Use appropriate personal protective equipment!
- Ensure adequate stability.
- Observe the permissible load bearing capacity of the substrate.
- Secure objects against falling.

5. Product-related safety instructions

5.1 Special dangers at the machine / system

- Access to tunnelling machines with a diameter of less than 1200 mm is prohibited.
- 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.
- Barriers of all kinds must not be crossed. 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.
- There is a risk of crushing limbs when cylinders are extended or retracted.
- Nobody is allowed to stay under a suspended load.

- The hydraulic systems of the machine / system are equipped with pressure limiting valves. The set pressures must not be changed.

  - Exception: The pressure settings for Jacking frame and interjack station must be adjusted to the permissible load of the employed pipe type. The pressure settings for the „Cutting tool drive“ pump must be adjusted according to the data sheet of the employed machine.

WARNING!

Risk of tripping!

Insufficient lighting.

- Serious injuries from tripping, falling.
- Always ensure adequate lighting in the work area.
- Carefully route hoses and cables.
- Assure tidiness/cleanliness.

WARNING!

Machine components at head height.

- Injuries due to knocks.

• Wear a safety helmet!

WARNING!

Hot surfaces (e.g. motors, gearboxes, heat exchangers, electrical and hydraulic components).

- Burns.

• Do not touch hot surfaces!

5.2 Working in the shaft

- The operator is responsible for shaft safety.
- 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.
- All shafts must be accessible via a fixed access ladder.
- Where non-fixed ladders are used, they must be captively connected to the shaft side guard and protrude at least 1m above the railing.

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.

WARNING!

Risk of crushing limbs!

Moving heavy parts (e.g., segments, product pipes, machine/plant parts, etc.) and accessing the thrust cylinders.

- Risk of severe injury due to crushing or severing limbs.
- Deploy only trained and authorised staff.
- Avoid accessing the area between heavy parts and the shaft.
- Always maintain visual contact with the crane operator.
- Use mounting aids for aligning and moving heavy parts.

WARNING!

Dropping objects!

Danger due to objects falling (e.g., metal parts, tools, or assembly aids) during work on multiple levels.

- System damage.
- Personal injuries.

• Wear personal protective equipment!

• Secure loose objects against falling.

DANGER!

To drown!

Danger due to water ingress in the tunnel / shaft.

- Drowning.
- Damage to the system

• The operator must ensure that sufficient escape routes exist in all areas.

• The operator must install sufficient water detents (dewatering) in the tunnel/shaft.

5.3 Pipe thrusting

5.3.1 General

- On machines / systems with suspended air lock pipe, it has to be ensured that the air lock pipe is attached to the machine fixed and safe.
- The thrust ring of the jacking frame must always rest tight against the tube sheet of the final production pipe.
- Preselection tunnelling press must **not** be on tunnelling.
- If the interjack station is to be used with the function "relief" then during the air locks procedure no interjack station must be preselected on operation mode relief.

5.3.2 Safety information

DANGER!

The product pipes and / or machine pipes can be pushed out of the existing product pipe.

- Severe to fatal injuries.
- During the entire air lock operation, the thrust ring of the jacking frame must always push against the product pipe or the machine pipe to create counterpressure.

DANGER!

Vehicle traffic in the area behind the tunnelling machine.

- Severe to fatal injuries.
- Do not stay in the rear area of the tunnelling machine while the transport vehicle is moving.
- Do not enter the area behind the tunnelling machine during operations!

DANGER!

Hand injury!

Positioning the product pipes in the pipe drive.

- Severe hand injuries.
- Do not intervene in the positioning process of the product pipes.

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.

NOTE

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 4: Danger areas and working areas

- The area of the jacking frame/jacking station, thrust cylinders and the complete working area in and around the shaft must be treated as particularly dangerous areas during tunnelling operation.

Hazards are to be anticipated in the following areas, in particular:

- Pipe Thruster
- Pipeline
- Jacking frame
- Shaft

NOTE
Never enter danger areas!
Never modify closed-off areas.

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 mounted and how they work.
- Prior to each operation and at regular intervals you must check the functioning of the safety devices.
- 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.

NOTE

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

NOTE

Electrical safety components must be replaced after 20 years!

NOTE

The bridging, disabling, removal or manipulation of safety devices is prohibited!

If safety installations must be removed during setup, maintenance or repair work, these safety installations must be reinstalled immediately after the work has been completed, and be checked for their presence and correct setting.

6.2.2 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).

6.2.3 Illumination

- Lamps must be maintained and cleaned regularly.
- Open flame is not permissible.

6.2.4 Emergency stop and maintenance equipment

Various emergency stop devices, key switches and maintenance switches are installed on the machine / plant.

The overview of emergency stop and maintenance devices is to be found in **Section: Appendix**.

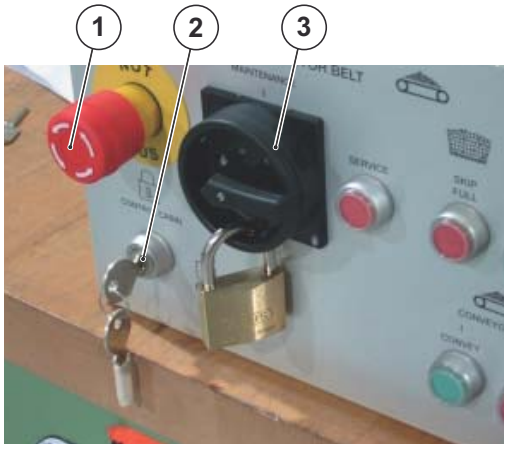


Figure III - 1: Emergency stop device on control panel

1	Emergency stop button	3	Maintenance switch
2	Key switch		

EMERGENCY STOP device

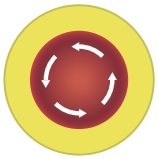


Figure III - 2: Emergency stop button

EMERGENCY STOP button for shutting down the machine/system are located 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 by pressing the nearest emergency stop button.

Enabling the emergency stop device leads to an immediate stop of a machine movement in order to avoid any risk emanating from this movement.

NOTE

EMERGENCY STOP equipment must only be actuated in case of immediate danger!

Emergency stop devices must not be used for regular switching off.

Emergency stop devices are located:

- In the control cabin
- on the locally installed control panels

Emergency stop devices are implemented as:

- Mushroom head buttons

EMERGENCY STOP device in shaft

Two EMERGENCY STOP buttons are available in the shaft. One button is located 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.

EMERGENCY STOP device for additional components

NOTE

The operator must integrate all emergency stop devices of the additional components into the entire emergency stop system (with mutual direction of action).

The maintenance switches of the additional components act only locally on the respective component installed in the unit.

Maintenance switches

Maintenance switches secure energy sources against being switched back on inadvertently. They ensure safety during commissioning and maintenance work.

Always use maintenance switches during:

- Maintenance
- Commissioning / Decommissioning
- Assembly / Disassembly

NOTE

Working with the safety padlock of another person is prohibited!

Only the person who fitted the padlock is allowed to remove it!

Using the control panel maintenance switch:

1. Turn the maintenance switch to position "0".
2. Secure the maintenance switch with your personally marked safety padlock against being switched back on. This must also be done when the maintenance switch has already been secured with the padlock of another person.

Figure III - 3: Maintenance switch with padlock

Using the hydraulic system maintenance switch:

1. Turn the maintenance switch to the "closed" position.
2. Secure the maintenance switch with your personally marked safety padlock against being switched back on. This must also be done when the maintenance switch has already been secured with the padlock of another person.

Figure III - 4: Hydraulics maintenance switch

6.2.5 Motor protection switch

Motor circuit breakers interrupt the power supply to the plant components in case of overload.

6.2.6 Main switch, key switch

- Various key switches are installed for releasing control panels.
- 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.

6.3 Gas measurement

DANGER!

Explosion hazard!

Danger due to occurrence of gas and/or formation of explosive air/gas mix.

- Serious injuries, system damage.
- Observe the building regulations.
- Measure gas concentration at all times.

NOTE

The national rules and regulations of the operator country on gas monitoring at tunnel construction sites are applicable.

The gas sensors must be calibrated at regular intervals. Calibration may only be performed by authorised staff.

6.3.1 Gas measurements after extended operation interruptions

After extended operation interruptions, Herrenknecht AG recommends taking the following measures prior to entering the tunnel:

- ventilate the tunnel sufficiently.
- Measure the gas concentration with a mobile gas measuring device

6.3.2 Gas measurement in the shaft

The operator must perform continuous gas measurements in the shaft in line with national regulations. The gas monitoring system must be equipped with an audible and visual alarm system.

The gas monitoring system must be mounted in the immediate vicinity of the tunnel entrance.

The plant operator must ensure the proper function, regular functional tests, and regular servicing of the gas monitoring system.

At the start of the shift/before starting work perform measurements at significant points as indicated by the plant operator's risk assessment.

6.4 Fire fighting

6.4.1 Fire prevention

NOTE

Smoking is prohibited on the plant.

To prevent fire on the plant, you must observe the following safety instructions:

- Prior to welding, torch cutting and grinding, clean the machine parts to be processed and the surrounding area to remove dust and other combustible materials. Furthermore, sufficient ventilation must be provided. Cover flammable parts with a fire blanket.
- Welding, burning and grinding work pose a risk of fire and explosion. It is therefore imperative to provide the necessary fire fighting equipment and appoint a supervisor who will, if required, immediately take appropriate action.
- When working in small rooms and when using open flames or fire, the national regulations must be observed.
- Do not cover air-cooled motors. Clean them at regular intervals.

6.4.2 Fire protection

The plant owner is responsible for the completeness and functionality of the fire protection installations. Additionally, the plant owner is responsible for maintaining the fire protection installations, especially for observing inspection and maintenance intervals.

6.4.3 Hand-held fire extinguishers

When selecting and positioning hand-held fire extinguishers, consider the various types of fire (electric fires/liquid fires).

There are two types of hand-held fire extinguishers: ABC and CO_2 fire extinguishers.

ABC FIRE EXTINGUISHERS	CO2 FIRE EXTINGUISHERS
	
• Solid matters • Liquids • Gases	• Liquids • Electric fires

Table 5: Symbols hand-held fire extinguishers

- The plant owner must install hand-held fire extinguishers and mark their locations.
- The plant owner must ensure the proper function of the fire extinguishers and that they are serviced within the required intervals.
- In the vicinity of electrical systems and generators, manual CO_2 fire extinguishers must be used to extinguish electric fires.
- In areas designed for positive pressure, the operator must provide manual fire extinguishers approved for the maximum permissible positive pressure.
- The installation positions of the manual fire extinguishers must be taken from the escape and rescue plan.

NOTE

Never block access to the hand-held fire extinguishers.

6.5 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

DOCUMENT: 81509-001

1. About this main chapter

- The main chapter describes and explains the following topics:
  - Transport:

    Transporting the machine / plant and its components to the installation site.
  - Construction site structure:

    Selecting the location and preparing for assembling the separation plant.
  - Assembly:

    Installing the machine / plant-
  - Connection:

    Connecting the machine / plant.

NOTE

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).

NOTE

The supplied drawings fluid diagrams and electrics diagrams must be consulted for this main chapter.

2. Transport

2.1 Safety

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.

2.2 General

NOTE

For more details of transportation, see also *section "Transport data" in main section II "Product description"*. Additionally observe the drawings, which can be found on the enclosed CD or in printed form in the drawings folder.

NOTE

Please refer to the drawings for details of the suspension points. The drawings can be found on the enclosed CD or in a printed form in the drawings folder.

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

- Lift and transport the components with suitable and appropriately dimensioned load lifting equipment only.
- Always transport the components in a horizontal position.
- Always keep the doors and maintenance openings closed during the transport.
- The coupling points of the hydraulic and electric lines must be closed with caps during the transport.

CAUTION!

Danger from leaking liquids and lubricants

- Environmental damage.
- Always transport the components in a horizontal position.
- Use only load handling equipment of sufficient carrying capacity.

Suspension points for crane

Lifting points for forklift truck

2.3 Special risks

2.3.1 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.

2.3.2 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.

2.3.3 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.

2.4 Transport regulations

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

NOTE

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 abrupt movements.
5. Transport the load to the final site and stabilise it.
6. Position and lower the attached load without abrupt 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.

2.5 Suspension points

2.5.1 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 separate 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.

NOTE

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.

NOTE

Please refer to the drawings for details of the suspension points. The drawings can be found on the enclosed CD or in a printed form in the drawings folder.

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

DANGER!

Suspended loads!

Damaged bolts and threaded holes.

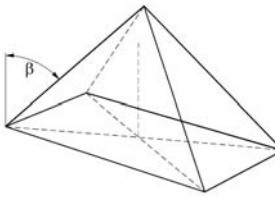
- Serious of fatal injuries from dropping parts.

• 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.

2.5.2 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 1: Carrying capacity table

NOTE

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.

2.6 Transporting the components

2.6.1 Hydraulic power unit

CAUTION!

Danger from leaking liquids and lubricants

- Environmental damage.

• Always transport the components in a horizontal position.

• Use only load handling equipment of sufficient carrying capacity.

2.6.2 Pipes after the tunnelling machine

- Machine pipe 2
- Trailing tube
- Air lock pipe
- Telescopic station
- Interjack station (all-steel interjack station)

These pipes differ in terms of function but are handled identically.

Product pipes are excluded from this approach.

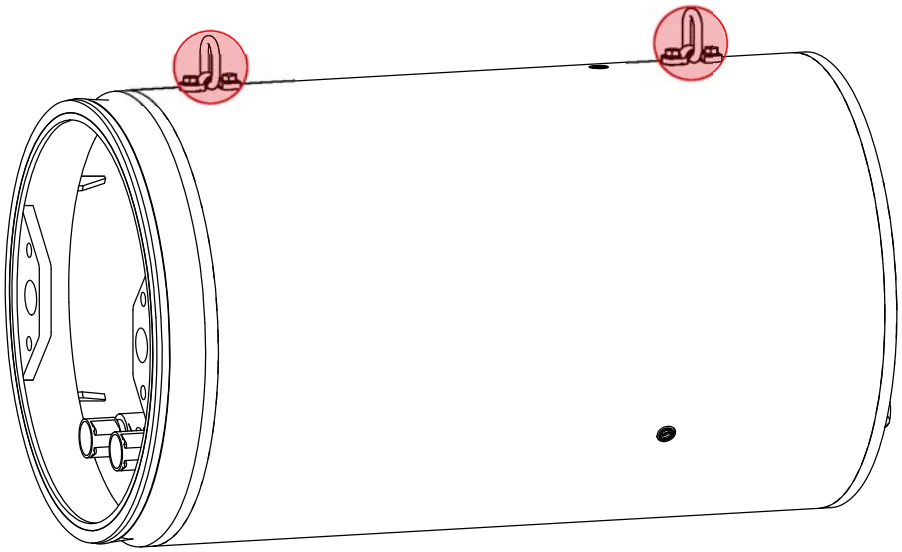


Figure IV - 1: Pipe suspension points

Follow the same approach as for the tunnelling machine for lifting and lowering into the launch shaft as well as for recovering from the target shaft.

DANGER!

Danger due to inadvertent moving apart of the telescopic station/ interjack station.

- Serious or fatal injuries from falling parts.

- The cylinders must be fully retracted.
- The telescopic station/interjack station must be secured against moving apart.

3. Construction site structure

3.1 General notes

- The tunnel and shaft linings must be professionally implemented by the customer.
- The launch shaft must be perpendicular as problems with installing the jacking frame/jacking unit can otherwise occur.
- 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 shaft must well be compacted. Insufficient soil-mechanical boundary conditions may require additional measures (e.g. injections outside the shaft) that contribute to stabilising the shaft.
- Sufficient clearance for the launch/reception seal must be provided in the shaft (recess in the concreted to be able to fold back the sealing lip)
- The 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.

DANGER!

To drown!

Danger due to water ingress in the tunnel / shaft.

- Drowning.
- Damage to the system

- The operator must ensure that sufficient escape routes exist in all areas.
- The operator must install sufficient water detents (dewatering) in the tunnel/shaft.

3.2 Selection of the site

A good selection of the site is therefore very important for the prevention of accidents.

- The place of installation must be able to withstand the minimum loads, and satisfy the requirements of statics and soil properties.
- The components must be supported equally and securely. They must not sink. Any unevenness that prevents a full-surface contact of the components must be removed.

NOTE

Installing the machine / system on a ground of sufficient pressure bearing capacity is the basis of a safe operation. This requires an individually calculated foundation to be erected.

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.

3.3 Surveying the shaft

Suggested approach for surveying the shaft

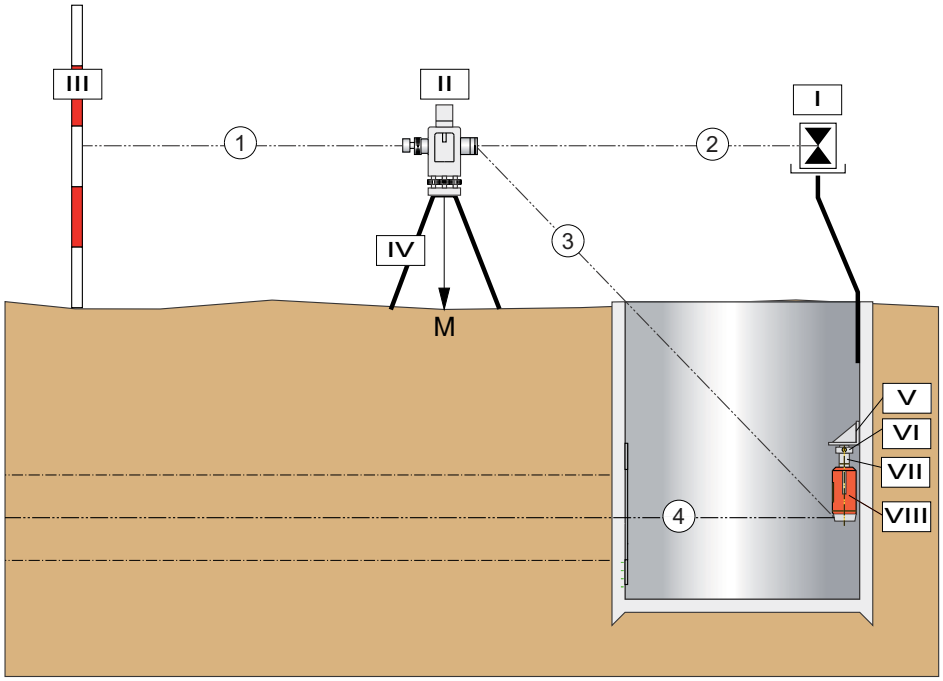


Figure IV - 2: Surveying the shaft 1

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 2: Legend shaft surveying

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.

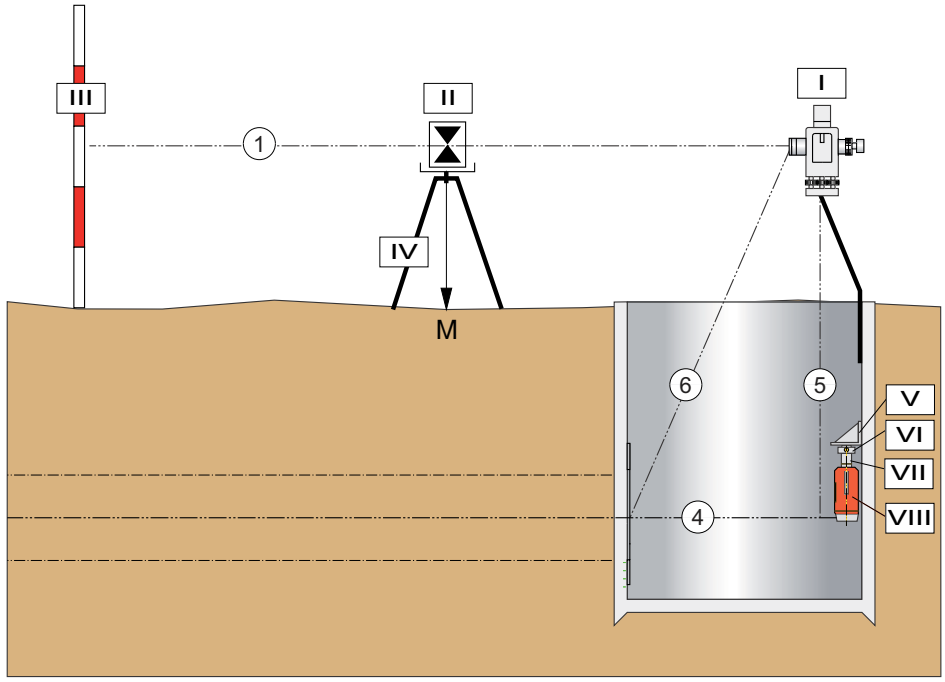


Figure IV - 3: Surveying the shaft 2

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.

4. Installation

4.1 Safety

Ensure that the following safety instructions are observed when you assemble the machine / system. This avoids potentially fatal injuries, damage to the system and other assets.

- 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.
- Wear personal safety equipment during installation working and observe the safety instructions.
- Use only load carrying devices of a sufficient size.

4.2 Target unit

Correct assembly, version 1

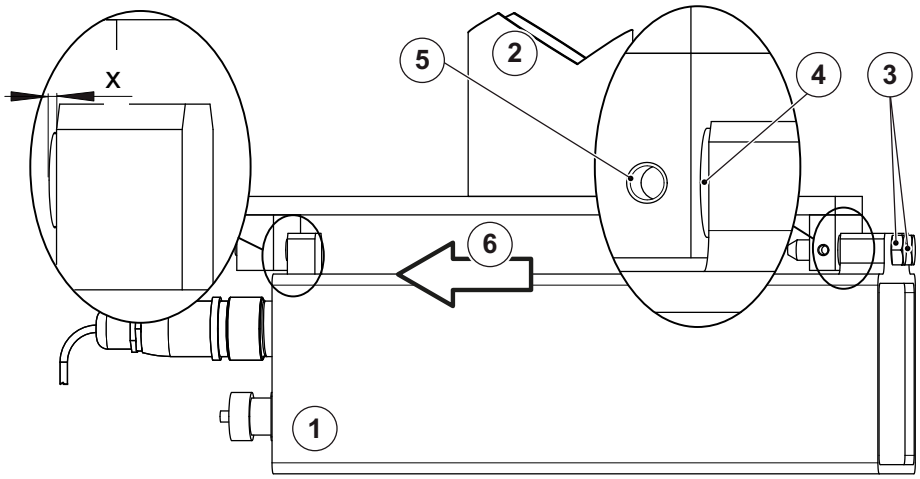


Figure IV - 4: Mounting from the rear

1	Laser target	5	Threaded bore for lock bolts
2	Laser target support	6	Direction of drive
3	Hexagon head bolt	X	Distance
4	Spacer		

The fastening of target unit with two hexagon head bolts when using a spacer washer. Fix with the locking bolts of the target unit.

Correct assembly, version 2

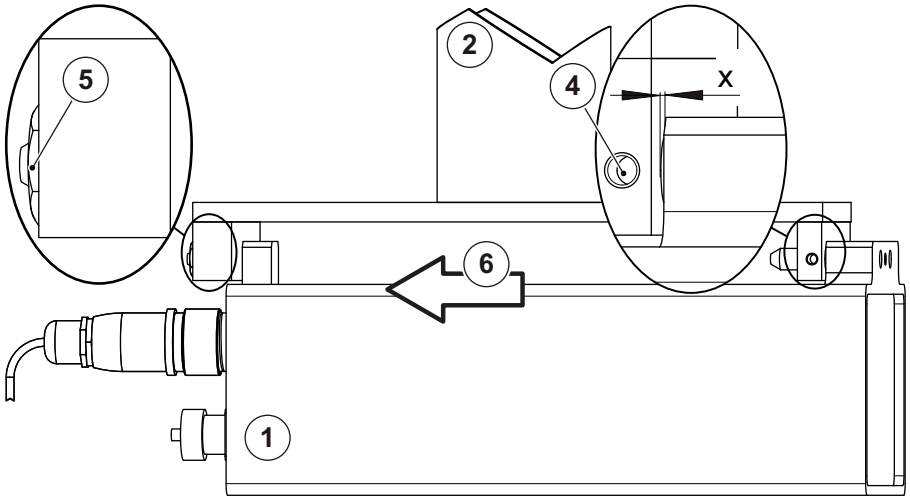


Figure IV - 5: Assembly from the front without spacer washer

1	Laser target	5	Nut
2	Laser target support	6	Direction of drive
3	Hexagon head bolt	X	Distance
4	Threaded bore for lock bolts		

The assembly with a nut, no spacer washer must be used in doing so. Fix with the locking bolts of the target unit.

Incorrect assembly

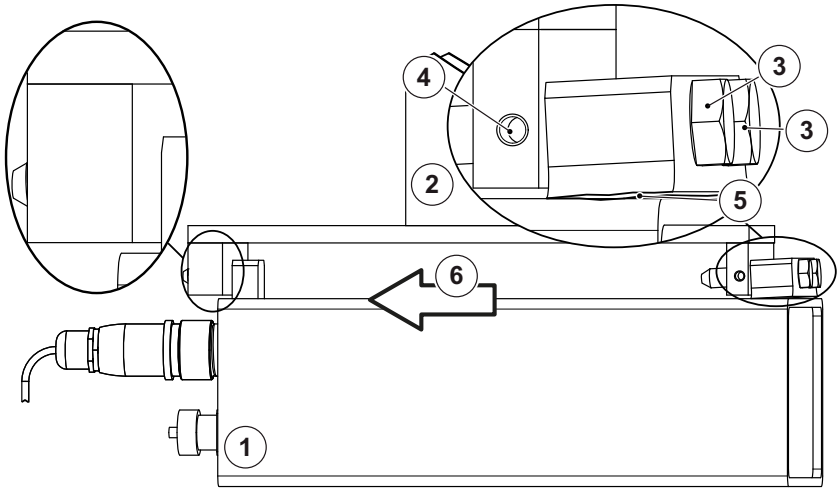


Figure IV - 6: Assembly from the front without spacer washer

1	Laser target	4	Threaded bore for lock bolts
2	Laser target support	5	Target unit frame
3	Hexagon head bolt	6	Direction of drive

This type of assembly leads to damage to the target unit and to damage to the target unit on the front window.

4.3 Tunnelling machine

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

4.4 Components downstream of the tunnelling machine

- Machine pipe 2
- Back-up tube
- Air lock pipe
- Gantry

These components differ in terms of function but treated in the same manner in their handling.

Product pipes are excluded from this approach.

NOTE

Once the tunnelling machine (shield and machine pipe 1) has drilled a sufficient distance to accommodate the components, you can start assembling the individual components.

Procedure:

1. De-energise and de-pressurise the system.
2. Disconnect all lines (for machine pipe 2, see chapter page).
3. Attach the component at the suspension points. Always use a cross-beam to transport the gantries; see section on page)
4. Locate the component in the jacking frame.
5. Grease the seal rubber.
   – If an adjustable seal is installed in this part of the machine, release the tension.

6. Clean the tailskin of the already advanced machine part. Grind any dents to avoid damage to the rubber seal.
7. Insert the component carefully into the tailskin of the already advanced machine part by using the jacking frame.
   – Make sure that the rubber seal is not damaged by this.

DANGER!

Risk of crushing limbs!

Risk of shearing/jamming body parts

- Serious injury.

• Do not enter the area between component and jacking frame.

   – Note the torque support device.
8. Connect all supply lines.
9. Test all machine functions.

When operating the air lock pipe, the individual pipes first need to be securely connected.

4.5 Slurry circuit

Connecting the feed pump

1. Install the feed pump between the shaft and the sedimentation tank (or separation plant) and connect it to the power supply.
2. Connect the suction side to the water supply hose on the sedimentation tank of the separation plant.
3. Connect the the feed side to the flowmeter hose. From the flowmeter, connect to the tunnelling machine with further hoses.

Connecting the slurry pump

1. Deposit the slurry pump in the shaft and connect to the electrical system.
2. The slurry hose from the tunnelling machine must be connected to the suction side of the slurry pump.
3. Connect the shaft hose to the flowmeter and route it from there to the sedimentation tank (or the separation plant).

NOTE

When connecting the flowmeter, always observe the flow direction of the flowmeter (see the marking on the flowmeter). An incorrect flow direction will give you incorrect measured values.

5. Connection

5.1 General

NOTE

The system operator must provide all supply lines, route them professionally, and secure them against uncontrolled movements.

5.2 Electrical connection

CAUTION!

Incorrect direction of rotation for drives, motors and pumps.

- Wiring up the cables incorrectly will change the direction of rotation, thus destroying the drive in question.
- Always check the direction of rotation for all drives, motors and pumps.

NOTE

Before commissioning the machine / plant check all contact screws for tight fit.

5.2.1 Information about the electrical connection

- An authorised 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 machine, test the insulation of the main distributor feeder!
- VDE regulations and the regulations of the country concerned must be observed.
- Observe the applicable national and international regulations for all electrical supply lines.
- Observe the minimum bending radii of the respective cables.
- Connect the EMERGENCY STOP cable as per the wiring 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. Prior to separating the plug-in connections you must switch off the electrical power on the control lines.
- In all cases, a qualified electrician must connect the wiring. Observe the pertinent, country-specific regulations.

5.2.2 Trailing tube with hydraulic power unit

Connecting the tunnelling machine to the back-up tube with hydraulic power unit

- Connect the machine/system to the appropriate tunnelling machine as per the electric diagram.
- Connect the earth cable.
- Connect the data transmission cable for the machine using the 24-pin plug. Clean the coupling and the plug thoroughly, then connect. Close both latches to lock in place.
- The power supply to machine is provided by a mid-voltage cable (12.6 kV).

back-up tube with hydraulic power unit in direction of launch shaft

- Connect the machine/system to the appropriate operation/control container as per the electric diagram.
- Connect the earth cable.
- Connect the data transmission cable for the machine using the 24-pin plug. Clean the coupling and the plug thoroughly, then connect. Close both latches to lock in place.
- Patch the supply cable for the cutting wheel drive in the terminal box. Observe the colour coding of the cables.

  The cable with the plug connector must only be connected to the appropriate socket, marked in RED, in the launch shaft.
- The power supply for the machine/system is implemented with a CEE plugged connection. This is secured with a union nut and sealed.

5.3 Hydraulic connection

5.3.1 Information about the hydraulic connection

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

- **Commissioning and maintaining hydraulic equipment (VDI 3027)**
- **German standards "hydraulic equipment" DIN 24346**
- **ISO standards 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.

NOTE

Effect the connection as per the fluid diagram. Fluid diagrams are stored in Section XI "Fluid Diagrams".

- When connecting the lines, be sure to avoid confusing the couplings.
- Observe hose diameters.
- Before coupling, clean the couplings well and perform a visual check for damage.
- Make sure that the seals (O-rings and thrust rings) are seated correctly in the couplings and that the check valve disks are undamaged.

NOTE

To ensure correct functionally all couplings must fully screwed together.

Preparing the connection

Observe the following points for each hydraulic connection:

- 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

Connecting hose lines

- To avoid tension and transverse forces on 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.

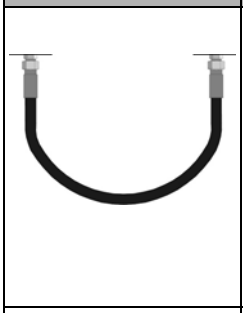
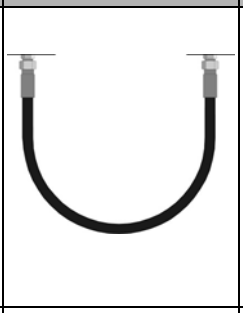
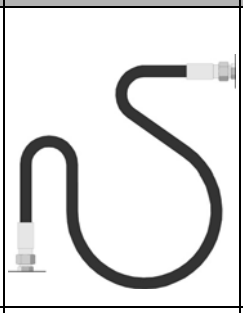
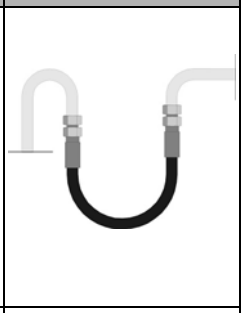
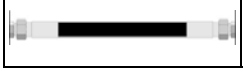
INCORRECT	CORRECT	INCORRECT	CORRECT
			
		twisted 	

Table 3: Hose lines

Hose lines connect connection points which move in realtion to one another. The following advice on laying hose lines must always be observed:

- 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 respective hoses.
  (The minimum bending radii apply for fixed routing of the hose lines. If a movement of the hose in a tight bending radius must be repeated very often, then it is recommended to select as large a bending radius as possible.)
- 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.

Laying hydraulic hoses

NOTE

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. Lay hydraulic hose between the hydraulic power pack and the consu-mer. Do not open the hose caps.
2. Open the cap of the hydraulic hose at the side of the hydraulic power pack. Leave the other end of the hydraulic hose closed.
3. Screw off the plug at the connection port of hydraulic power pack and screw on the hydraulic hose. Collect hydraulic oil and dispose in accor-dance with environmental regulations.
4. Open the sealing cap of the consumer or the next hose.
5. Open the cap of the installed hydraulic hose and screw it onto the consumer or the next hydraulic hose.
6. Check whether all hoses have been properly fastened and all bolted connections are tight.
7. Check the oil level of the hydraulic power pack. Top up if necessary.
8. Operate the hydraulic power pack without load, until the air has escaped from the hydraulic system. If necessary, open a plug at the top and bleed the circuit.

CAUTION!

Risk of slipping!

The hydraulic hoses are filled with hydraulic oil.

- Risk of skidding and damage to the environment from escaping hydraulic oil.
- Never open hydraulic hoses at both sides simultaneously.
- Collect escaping hydraulic oil and dispose of it in accordance with environmental regulations.
- Remove spilled hydraulic oil immediately.

SAE flange joint for pipe end or hose end

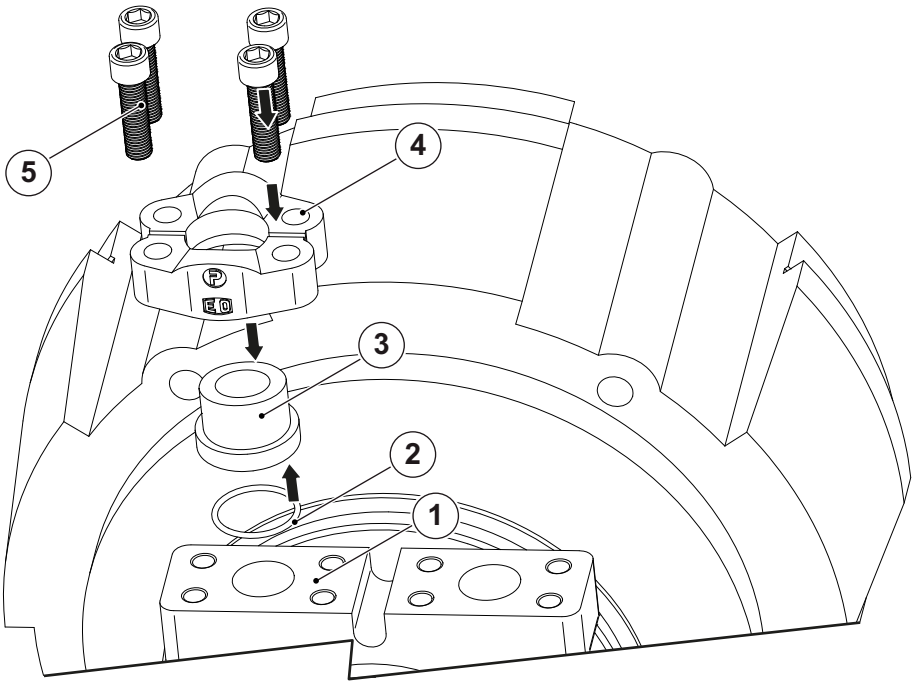


Figure IV - 7: SAE flange joint

1	Fixed half	4	Flange half
2	O-ring	5	Screw
3	Pipe end or hose end		

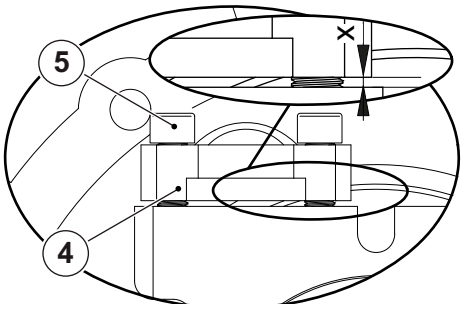
Requirement:

- Sealing surface [1] must be free from burrs, notches, scratches, and foreign particles.

Required tools / material

- Torque spanner with hex socket that matches the screws used.
- Spring lock washer matching the screws used.

Procedure:

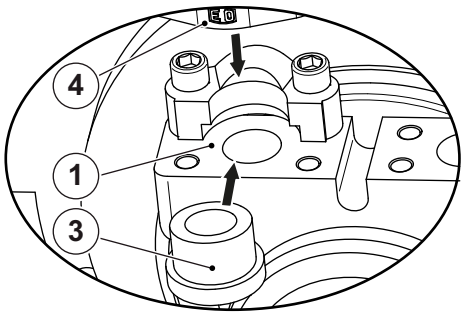


1.Screw on one flange half [4] to the sealing surface [1].

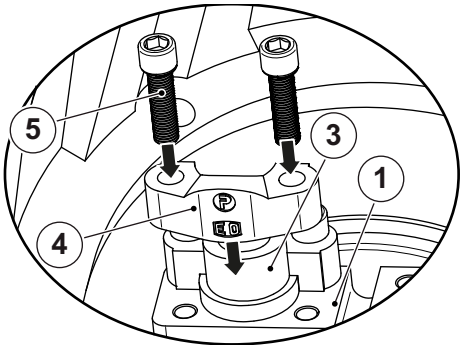
NOTE

The flange half [4] must have about 3 to 4 mm play [**X**].

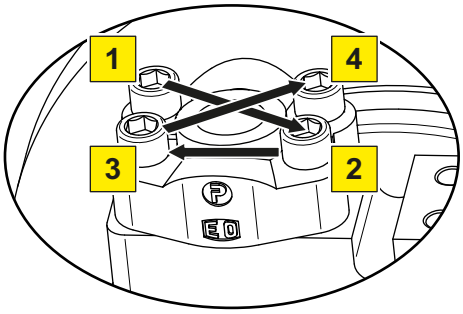
2. Lubricate the O-ring [2] with system fluid and put it in the notch of the pipe or hose [3] to be mounted



3.Push pipe end or hose end [3] into the reception of the screwed on flange half [4].



4.Secure the pipe end or hose end [3] with the second flange half [4].



5.Tighten the screws [5] in a cross bolt tightening pattern.

6.Tighten screws [5] to the required torque.

Torque tables according to manufacturer's instruction

3000 PSI series (code 61) flange: recommended torque for screws

DN SERIES	FLANGE SERIES	IMPERIAL SCREW (J518)	TORQUE (NM[1])	METRIC SCREW (ISO 6162)	TORQUE (NM[1])
13	1/2	5/16-18	24	M8	24
19	3/4	3/8-16	43	M10	50
25	1	3/8-16	43	M10	50
32	1-1/4	7/16-14	70	M12[2]	50
38	1-1/2	1/2-13	105	M12	92
51	2	1/2-13	105	M14[2]	135
64	2-1/2	1/2-13	105	M12	92
76	3	5/8-11	210	M16	210
89	3-1/2	5/8-11	210	M16	210
102	4	5/8-11	210	M16	210
127	5	5/8-11	210	M16	210

6000 PSI series (code 62) flange: recommended torque for screws

DN SERIES	FLANGE SERIES	IMPERIAL SCREW (J518)	TORQUE (NM[1])	METRIC SCREW (ISO 6162)	TORQUE (NM[1])
13	1/2	5/16-18	24	M8	24
19	3/4	3/8-16	43	M10	50
25	1	7/16-14	70	M12	92
32	1-1/4	1/2-13	105	M14[2]	130
38	1-1/2	5/8-11	210	M16	210
51	2	3/4-10	360	M20	400

1. Tolerance: min 0% max 10%
2. Not specified in ISO 6162

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.

Figure IV - 8: 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.

5.3.2 Trailing tube with hydraulic power unit

Connecting the tunnelling machine to the hydraulic power unit with back-up tube

- Connect the machine/system to the appropriate tunnelling machine as per the hydraulic diagram.
  - 1 line for steering cylinders
  - 2 lines for the motors
  - 1 line for leakage oil

Tank filling connection

Figure IV - 9: Tank filling connection

1 Filler on the hydraulic tank

The tank must be filled with oil via the filler [1]

NOTE
Refer to the "Operating materials" chapter for the oil grade and volume

Oil drain on oil tank

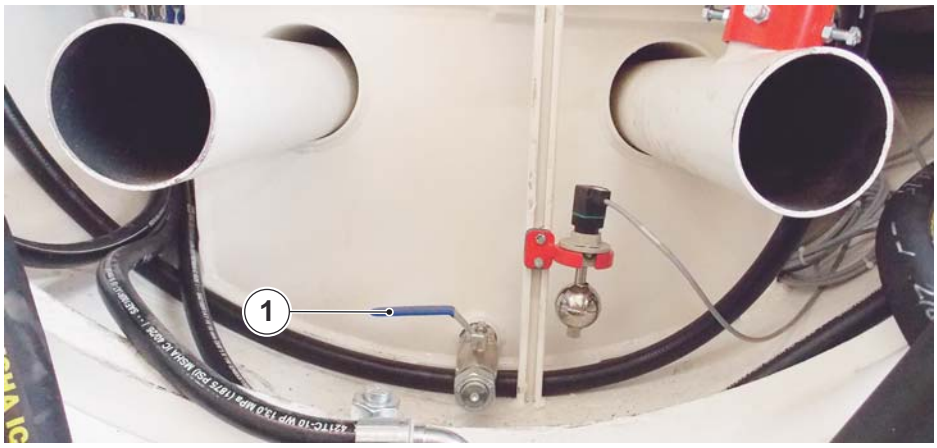


Figure IV - 10: Oil drain on oil tank

1 socket ball valve

Opening the ball valve [1] drains the oil from the tank.

5.4 Slurry circuit

5.4.1 Coupling system

VICTAULIC quick-release coupling system

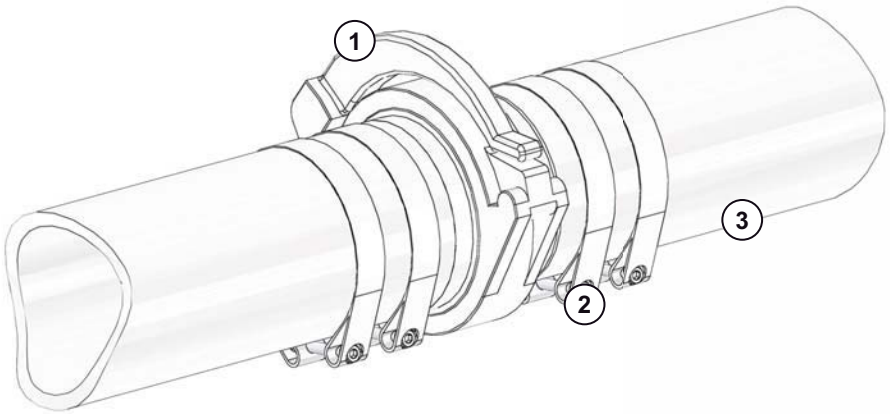


Figure IV - 11: VICTAULIC quick-release coupling system

1	Quick-release coupling	3	Line
2	Clamp		

Table 4: Quick-release couplings

When assembling quick-release couplings make sure that:

- the pipe surface between the pipe end and groove is undamaged and that the pipe end is free from burrs.
- the sealing surface is free from loose dirt and grease.
- the groove root is clean.

Assembling the quick-release coupling system

Place the sealing ring over the pipe ends and lightly grease the outside diameter. Then place the coupling piece over it and close.

VICTAULIC screw-type coupling system

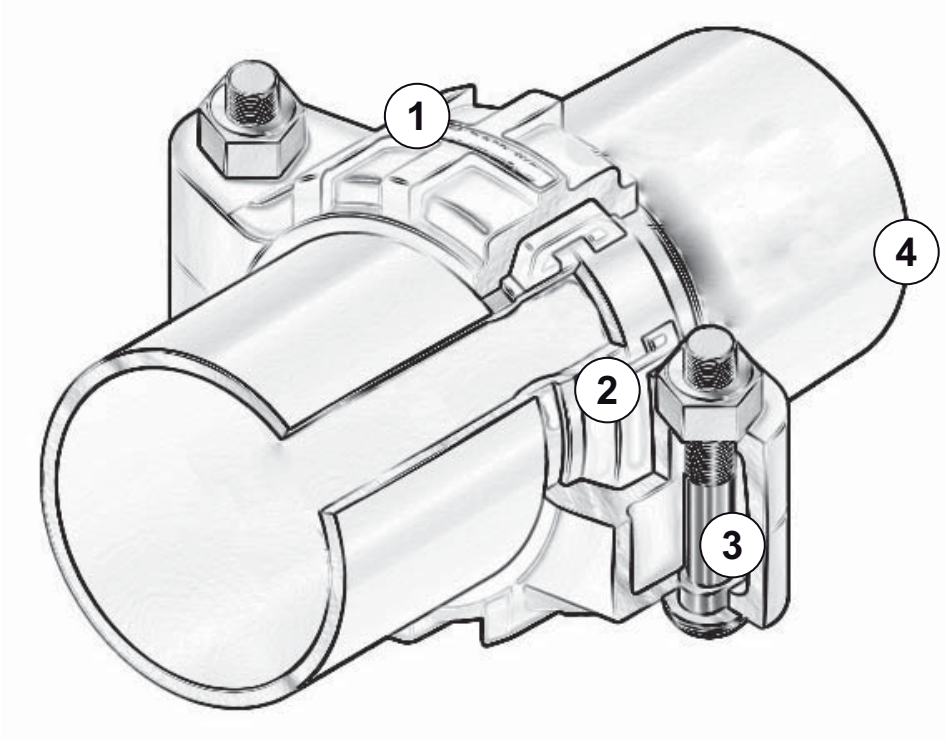


Figure IV - 12: VICTAULIC screw-type coupling system

1	Screw-type coupling	3	Bolt and nut
2	Seal	4	Line

Table 5: Screw-type coupling

When assembling screw-type couplings make sure that:

- the pipe surface between the pipe end and groove is undamaged and that the pipe end is free from burrs.
- the sealing surface is free from loose dirt and grease.
- the groove root is clean.

Assembling the screw-type coupling system

Place the sealing ring over the pipe ends and lightly grease the outside diameter. Then place the coupling piece over it and close.

PERROT quick coupling system

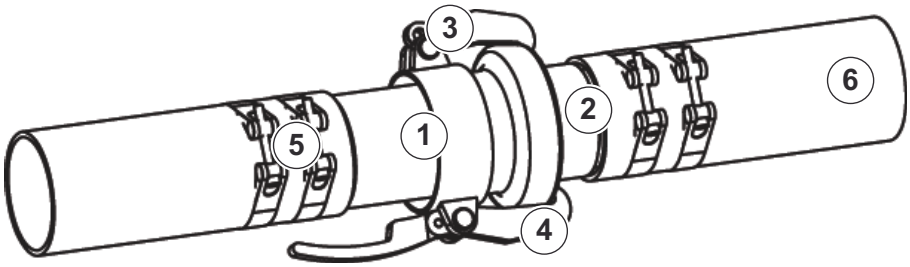


Figure IV - 13: PERROT quick coupling system

1	Female part	4	Clamping hook
2	Male part	5	Clamp
3	Hook	6	Line

When assembling quick-release couplings make sure that:

- both coupling parts are not damaged
- the sealing surface is free from loose dirt and grease
- new seal rings are used

Assembling the quick-release coupling system

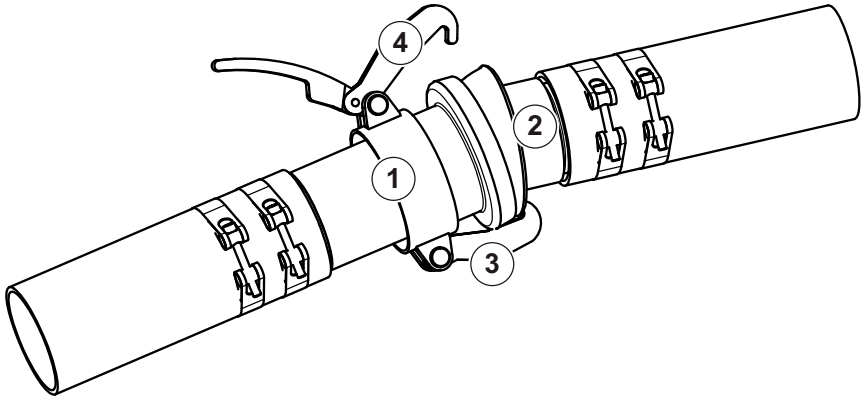


Figure IV - 14: Assembly of PERROT quick coupling system

1	Female part	3	Hook
2	Male part	4	Clamping hook

1. Insert a new seal ring in the female part [1].
2. Place the male part [2] in the female part [1] at an angle.
3. Attach the hook [3] to the male part [2].
4. Pull the male part [2] straight.
5. Secure the male part [2] with the clamping hook [4].

MH sleeve type coupling system

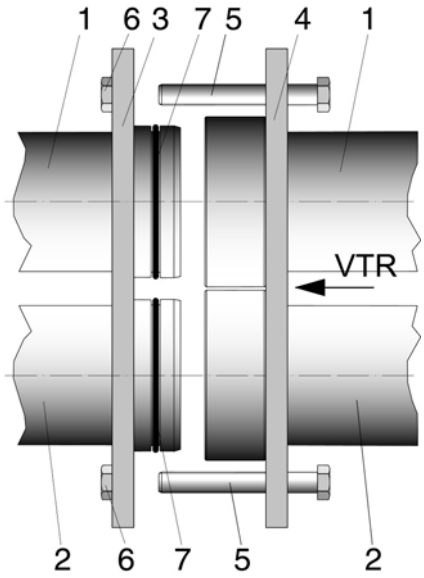


Figure IV - 15: MH sleeve type coupling system

1	Line	5	Screw
2	Line	6	Nut
3	Movable plate	7	Seal
4	Fixed plate		

Table 6: STRAUB-GRIPP pipe coupling system

When assembling screw-type couplings make sure that:

- Before coupling the nipple ends with the sleeve ends, check the sleeve for roundness with the test piece provided.
- Clean the nuts thoroughly before pushing in the nipple ends.
- Check O-rings for damage. Replace any damaged O-rings immediately!
- Before coupling in the pipeline, lubricate O-rings with silicone grease. When coupling the slurry line, take care to avoid damaging the O-rings.
- After pushing the pipe ends together, only lightly tighten the screws to allow for some flexibility in the pipelines.
- Use only spare parts in perfect working order.

STRAUB-GRIPP pipe coupling system

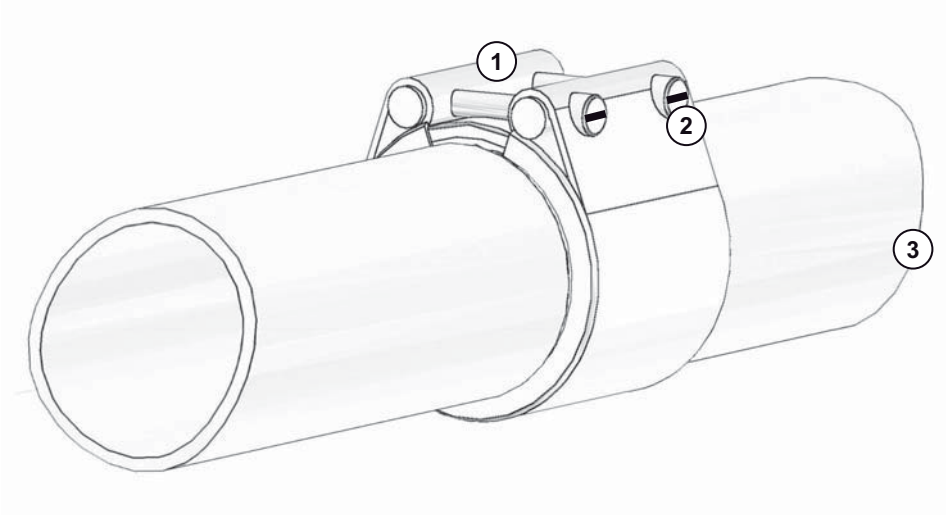


Figure IV - 16: STRAUB-GRIPP pipe coupling system

1	Pipe coupling STRAUB-GRIPP	3	Line
2	Clamping screws		

Table 7: STRAUB-GRIPP pipe coupling system

Preparing assembly:

Clean the pipe ends thoroughly in the area of half the coupling width and remove any damage that could endanger the function. Remove sharp edges and burrs.

CAUTION!

Twisting of pipe couplings.

- Pipes and other components can be destroyed by liquids escaping.
- The pipe couplings must not be twisted while the anchoring teeth are gripping the pipe.

NOTE

Clean pipe couplings immediately in case of soiling.

Always keep clamping screws well greased.

Assembly:

1. Mark off half a coupling width on both pipe ends.
2. Push the coupling over the pipe end (never twist).
3. Push the pipes flush against one another.
4. Centre the coupling over the pipe joint (the mark is visible on both sides).
5. Tighten the clamping bolts alternately and evenly to the required torque using a torque wrench.

Disassembly:

1. Release the clamping screws until the thread end is in the transverse bolt.
2. Expand the housing opening.
3. Using a screwdriver, release the toothed rings from their anchor points at several points on the circumference.
4. Pull the coupling out of the pipe ends axially (do not twist).

V. 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 machine / system.
  - Fault elimination:
    Description and elimination of frequently occurring faults.

2. Control elements

2.1 General

NOTE

For an overview of the controls, warning indicators and displays, see the operating manual for the operation container deployed.

3. Commissioning

3.1 Safety

3.1.1 General

Always observe the following safety instructions when commissioning the machine/plant. This helps to avoid injuries, machine damage and other damage to property.

- Only qualified personnel are allowed to commission the machine in accordance with the safety instructions.
- Make sure that only authorised persons are in the machine/plant's work area and that no one persons our endangered by starting up the machine/plant.
- 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.
- The "General safety instructions" must be read.

WARNING!

Voltage!

Electric system, electric shock from live parts.

- Electric shock, severe paralysis 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).

CAUTION!

Machine damage!

Incorrect set pressure of the machine / system.

- System damage.

• Do not change the factory settings.

WARNING!

Set pressure too high.

- Serious injuries due to parts being propelled.

• Wear personal protective equipment while working.

NOTE

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.

3.1.2 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.

3.1.3 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.

3.1.4 Common mistakes during commissioning

Besides maintenance, commissioning is decisive for the service live and functional safety of the machine/plant.

This is why commissioning faults should be avoided.

The most frequent mistakes are:

- Liquid levels remain unchecked.
- 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 pressure limiting valves are set to a value 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 piston rods; serious installation mistakes on piston 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 during 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.

NOTE

Commissioning and maintenance have a major influence on the service live and functional safety of the machine/plant.

By avoiding mistakes during commissioning and maintenance, you can exert a positive influence on service life and functional safety.

3.2 Initial commissioning

NOTE

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.

3.2.1 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

3.2.2 Hydraulics

CAUTION!

Machine damage!

If the hydraulic power unit in the trailing tube/machine pipe 2 is not deployed immediately behind the tunnelling machine.

Soiling of the hydraulic oil by coupling/uncoupling hydraulic lines for each pipe change.

- Damage to the hydraulic power unit and the flowmeter.

- Install and connect the high pressure filters and flowmeter intended for this purpose. Depending on the flowmeter, the flow rate may need to be adjusted at the variable displacement pump (see the fluid diagram).

NOTE

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.

3.2.3 Further checks

Check whether:

- all pipe fasteners are adequate for changing pressure loads.
- all fastening points are at the correct positions.
- all hoses are routed so as to exclude abrasion even under pressure load.
- overall communication on the jobsite is working properly.
- the sense of rotation of the electric motors is correct (observe the rotation indicator arrow on the motor housing).
- all screwed connections and lines on the hydraulic power units are tight.
- all transport locks have been removed.

3.3 Daily startup

NOTE

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

The following checks are required before each system startup:

3.3.1 Energy 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.

3.3.2 Hydraulics

Check whether:

- After installing the extension cables, check that the rotational direction of the electric motors is still OK.
- All screw unions and pipes must be tight.
- Check that the oil level and quality in the tanks is OK.
- The hydraulic hoses must not be twisted or stressed.

3.4 Commissioning of the hydraulic power unit

3.4.1 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.

3.4.2 Temperature monitoring

The machine/system is equipped with a permanent oil temperature monitor. The temperature is measured on the hydraulic power unit. Temperatures that are too high or too low are displayed on the visualisation monitor as messages or warnings.

At the factory, the value are set as follows:

TEMPERATURE	FUNCTION
< - 10°C	Fault message: temperature too low
> - 5°C	Start hydraulic pumps functions not ready for operation
< 10°C	Warning: Low temperature
> 10°C	Machine/system ready for operation
> 45°C	Cooler on
< 40°C	Cooler off
> 85°C	Warning: Increased temperature
> 90°C	Fault message: High temperature
100 °C	Fault message: Temperature too high Machine/system shuts down

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.

NOTE

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.

3.4.3 Hydraulics

- During maintenance work, pay attention to cleanliness in the machine/ system area and environment.
- If you need to cut hydraulic lines, the open ends must be sealed with suitable caps. This prevents fluid escaping and dirt entering the lines.
- 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.

CAUTION!

Fibres in the hydraulic/gearbox oil.

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

NOTE

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

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

Hydraulics pre-tensioned

Always depressurise the hydraulics during maintenance and repair work on the hydraulic system.

WARNING!

Pre-tensioned 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.

Depressurise the hydraulics

1. Switch off the machine / plant to depressurise the hydraulics
2. Allow the hydraulic oil to cool down to approx. 30 - 40°C.
3. Slowly open the ball valve for the air coupling on the tank (see fluid diagram) or turn the ventilation filter on the hydraulic tank approx. 2 turns anticlockwise.
   – The excess pressure escapes; the tank pretension pressure is relieved.
4. 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. Relieve the pressure on the return line suction filter (see return line suction filter manufacturer's operating instructions).

Pressurise the hydraulics

A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank. Check the fluid diagram to see if the machine/plant needs to be pressurised.

1. Switch off the machine / plant.
2. Connect the air hose to the air coupling.
3. Slowly open the ball valve on the air coupling.
4. Slowly pressurise the hydraulic tank.
   Refer to the fluid diagram for precise values.
5. Close the ball valve on the air coupling and remove the air hose.

Oil quality checks

NOTE

Analyse the hydraulic oil in the machine/plant at regular intervals and improve as needed. Hydraulic oil analysis must be performed by an independent laboratory. Only operate the machine/plant if the hydraulic oil is within the defined laboratory values. To file claims in the warranty period, you must submit evidence of all laboratory analysis and maintenance work. All maintenance work performed must be documented and archived.

Oil sample

1. Identify the oil sampling point on the fluid diagram. (Mini-measuring point on the filter circuit, see fluid diagram, marked in yellow).
2. Heat the hydraulic oil up to operating temperature.
3. Fill the hydraulic oil through the oil sampling point into a container.
   – Use only containers that are approved for hydraulic oils.
4. Close the oil sampling point.
5. Send the container with the oil sample to an independent laboratory to have the oil tested in line with Herrenknecht AG specifications.
6. Act as dictated by the laboratory values.

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/unfiltered 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.

• Topping up hydraulic oil or refilling the power unit only via the filler connection

Ventilate hydraulic component

CAUTION!

Do not ventilate the hydraulic component (hydraulic pumps)

- Damage to hydraulics components especially to hydraulic pumps.
- Before restarting after maintenance/repair work, all hydraulic components, especially hydraulic pumps must be ventilated.

1. Stop the machine/plant.
2. A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank. Check the fluid diagram to see if the machine/plant needs to be pressurised.
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.

NOTE

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

Leak tightness test

1. Completely switch off and depressurize the machine/plant.
2. Check the hydraulic system for leaks and lack of tightness.
3. If leaks or lack of tightness is observed in the hydraulic system, identify and remedy the problem.
   – Replace defective parts and tighten all bolted connections on the hydraulic system.

NOTE

Tighten the bolted connections only when the system is depressurized.

3.5 Commissioning the conveying system

WARNING!

Machine damage!

The maximum grain diameter is too large.

- System damage.

• Install a suction strainer in the sedimentation tank that limits the maximum grain diameter to 5 mm.

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.

• Look into the feed and slurry lines to check the conveying system on the tunnel boring machine.

• Use the switching curve of the bypass manometer to check the conveying system.

• Use the indicator lamps of the proximity switch to check the conveying system.

3.6 Individual commissioning

Whenever a tunnelling machine is commissioned, the parameters and options must be checked in the visualisation program and changed if necessary. Only correct parameters and options will ensure that the correct values are displayed in the visualisation and surveying software.

3.6.1 Test the machine / plant

Excavation tool

- Test direction of rotation anti-clockwise / clockwise.
- Test the maximum speed and maximum torque.
- Check the pressure displays.

Steering cylinder

- maximum pressure
- Geometric location and extension / retraction position correspond
- • Maximum and zero position
- cylinder lift position

Microphone (optional)

- Check the microphone

Tunnel light (optional)

- Check the tunnel light

Feed pressure

- Set the maximum feed pressure

NOTE

The feed pressure must be obtained from the hydraulic diagrams. Setting the feed pressure, see the operation container operating manual

Check the surveying system

- editor values
- Date, time
- Plausibility check for measured values

4. Operation

4.1 Safety

4.1.1 General

NOTE

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 operating the machine/plant. This helps to avoid serious of fatal injuries to persons, damage to the plant and other damage to property.

- Observe the operating instructions on the machine/plant.
- The machine/plant must only be operated from the designated workplaces.
- In unmanned tunnelling machines, **no one** is allowed to be in the tunnelling machine during advance/operation of the machine/system.
- Control areas (control cabins, control panels, remote controls, etc.) may only be accessed by operating personnel.
- For maintenance work, the entire machine/system must be shut down.
- If a malfunction indicator lights up, the machine/plant must be switched off immediately, the malfunction identified and remedied.
- After an emergency stop, secure the machine / system against being switched back on inadvertently by somebody else.
- If the machine/plant is switched off and left unattended for an extended period of time, always remove all keys that are needed to start the plant. Turn battery key to position 0.
- After switching off the machine/plant, always perform the following steps: turn the main switch to "OFF" position and lock.
- Always observe the "Safety" section.

- Prior to starting tunnelling you must switch off the tunnel light. This prevents incorrect measured values.

CAUTION!

Machine damage!

Tunnelling with a blocked cutting tool and/or blocked components.

- Bearing damage, gear damage and damage of hydraulic cylinders.

• Advance only with the cutting tool rotating and the conveying system switched on.

WARNING!

Machine damage!

The maximum grain diameter is too large.

- System damage.

• Install a suction strainer in the sedimentation tank that limits the maximum grain diameter to 5 mm.

4.1.2 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.
- Incorrect response during a malfunction may cause severe injuries and material damage.

4.1.3 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.

4.2 Advance

4.2.1 Start advance operation.

Prerequisite

- 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 cutting tool, thrust pump, steering pump and any other existing hydraulic pumps.
2. Open the bypass.
3. Start the water circuit.
4. Adjust feed pump and slurry pump to the desired flow rate.
5. Preselect the speed of the cutting tool. (Adjust the speed to the geology.)
6. Close the bypass when the advance movement starts. Feed and slurry gate valve are opened automatically in this step.
   – Press the "Close bypass" button until the required characteristic curve sequence has been completed at the pressure manometer (time approximately 15 ... 20 seconds).
7. Start the advance movement at a low advance speed. Adjust the advance speed according to the geology.

4.2.2 During tunnelling operation

During advance operation, you must control the water flow via the speed sensors to the required flow value. (see "Conveying speed" diagram). The general rule is to keep the water throughput as low as possible. The advance rate must be selected such that the cutting wheel pressure is always above 90 ... 100 bars. 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. To avoid cavities at the tunnel face, the water flow should be reduced to the lowest permissible flow limit if the highest advance rate is used without approximately 80 bars pressure being applied to the cutting wheel.

4.2.3 Terminating advance operation

1. Switch off the cutting tool.
2. Switch the water circuit to bypass operation. This permits the material components in the slurry line to be flushed out.
   – As soon as the advance operation is terminated (to relocate the press, or for other reasons), you must immediately switch over the water circuit to bypass operation.
3. Switch off the water circuit.
   – The water circuit must be shut down after the slurry line has been flushed out.
4. Switch off the entire electric system.
   – The electric system may only be switched off when the pumps are stopped and the water in the line system is no longer flowing.

4.3 Conveyor system

Whenever you interrupt operation, you must switch the water circuit to bypass operation. This must be done, for example, when

- the cutterhead is blocked
- you reverse the presses
- you change pipes

When you open and close the bypass you must watch the manometer and check whether the pressure follows the required characteristic curve. This is the only way to ensure that the ball valves in the machine switch properly.

4.3.1 Flow rate of the water circuit

NOTE

The flow rate of the water circuit must always be adjusted to the geological conditions.

- With a loosely deposited sand soil, you must set the flow rate of the water circuit to approximately 50%. This avoids washing out.
- With a gravel soil, the flow rate of the water circuit must be set to approximately 70 ... 80%.
- With clayey soil (homogenous), the flow rate of the water circuit must be set to approximately 100%.

Characteristics of too low a flow rate

Reduced flow rate in the slurry line at an unchanged speed of the slurry pumps, with a slight change on the flow indicator. This behaviour will result in an obstruction within a short time.

Characteristics of too high a flow rate:

The pressure of the cutting tool is too low (idling pressure of cutting wheel). Too much material is washed out. This leads to cavities since the cutting wheel is not in full contact with the tunnel face.

The sedimentation tank or the slurry treatment plant contains more conveyed material that is appropriate for the pipe volume.

Water pressure at the intake

The water pressure is measured at the intake in the machine, and displayed in the control cabin.

4.3.2 Water circuit in bypass operation

The groundwater pressure is indicated when the bypass is open end the slurry and feed gate valves are closed. A reading of 0.6 bars, for example, corresponds to 6 m of groundwater above the machine.

The slurry gate valve and the feed gate valve are closed in bypass operation. The reading must therefore be constant. This shows at the same time that slurry gate valve and feed gate valve are properly closed.

4.3.3 Water circuit in advance operation

During advance operation, the water pressure should be approximately 0.05 ... 0.2 bar higher than is required by the groundwater pressure above the machine. This is adjusted at the speed controllers of the pumps. According to experience, this action results in an operation with a water output per advance pipe that corresponds to the volume of the excavated soil. The water level in the sedimentation tank thus remains constant.

NOTE

The reading usually changes by approximately 0.1 ... 0.2 bar during advance operation.

4.4 Reception situation of tunnelling machine

4.4.1 Disconnect tunnelling machine

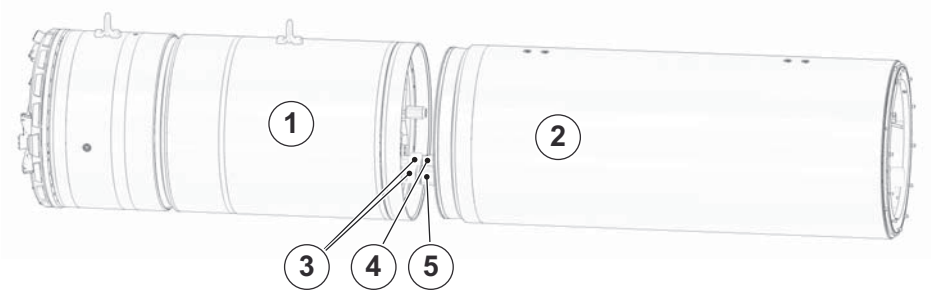


Figure V - 1: Disconnect tunnelling machine

1	Tunnelling machine	4	Feed line
2	Back-up tube	5	Slurry line
3	Line coupling STRAUB-GRIPP		

Requirement:

- Tunnelling has been completed and the tunnelling machine is in the target shaft.
- Tunnelling machine is depressurized and de-energized.

Required tools / material

- Crane and lifting accessories with sufficient load-bearing capacity.

Procedure

1. Attach the tunnelling machine [1] at the corresponding lifting points.
2. Tension lifting accessories without lifting the attached load.
3. Use a crane to move the tunnelling machine[1] to the front by max. 500 mm.

CAUTION!

Machine damage!

Moving the tunnelling machine too far forward.

- Damage to the machine/system.

• Move tunnelling machine forward by max. 500 mm.

---

4. Fix tunnelling machine and trailing tube and secure them against collision.

DANGER!

Risk of crushing limbs!

Accidental lifting/moving of tunnelling machine.

- Risk of shearing/jamming body parts when the machine is pushed together.

• Deploy only trained and authorised staff.

• Secure tunnelling machine against being pushed together accidentally.

---

5. Remove pipe coupling STRAUB-GRIPP [3].
   – Feed line [4] and slurry line [5] are disconnected.
6. Disconnect all supply lines.

DANGER!

Falling loads due to cranes and hoisting devices with insufficient load-bearing capacity.

- Severe or fatal injury.

• Only use cranes/hoisting devices with sufficient load-bearing capacity to recover the machine/system.

• Make sure that there are no persons in the danger zone.

• Do not step under suspended loads.

---

7. Move tunnelling machine [1] forward and lift it out of the shaft.

5. Fault elimination

5.1 Fault analysis

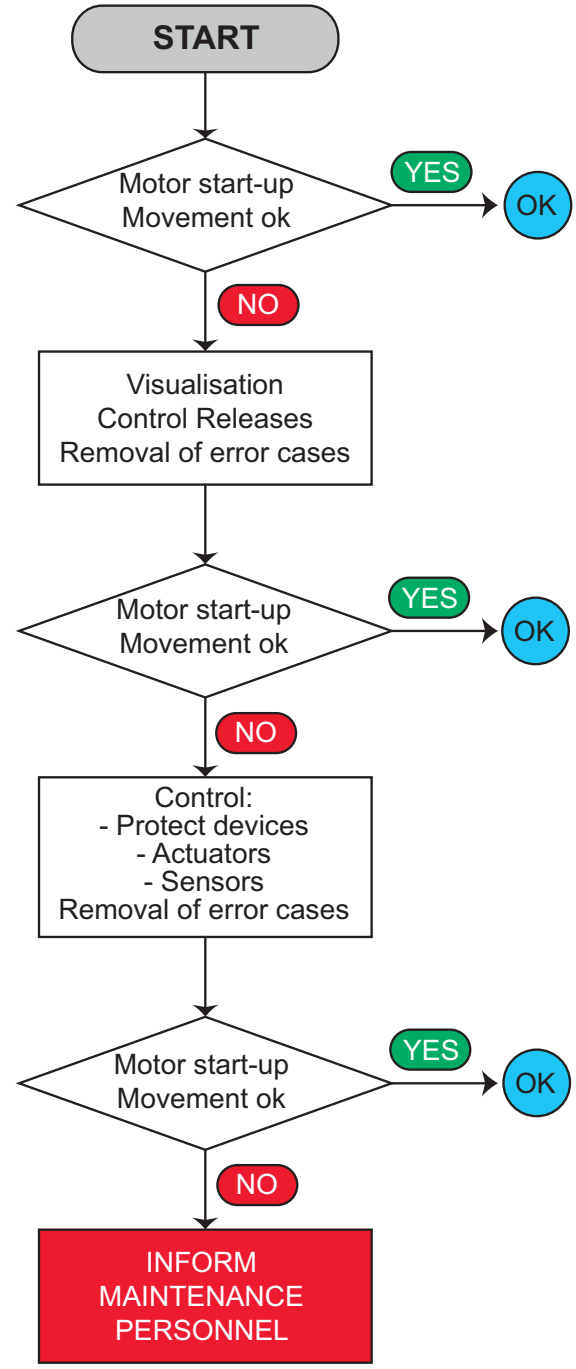


Figure V - 2: Fault analysis

5.2 Troubleshooting Information

5.2.1 General information

As all components are subject to wear, components may fail.

Here, the sources of the malfunctions can be grouped in two main categories:

- Hydraulic components
- Electrical components

5.2.2 Differentiation of Fault Sources

There can be an electric or a hydraulic malfunction when a function is not initiated after a control element has been actuated.

Use the manual emergency function on the hydraulic valve to narrow down the cause of the fault.

5.3 Troubleshooting

The following list does not claim to be exhaustive. It contains the most common causes of malfunction in practical applications.

FAULT	CAUSE
Steering cylinders can not be extended or retracted	
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.
Bypass and slurry / feed gate valve do not switch	
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.
Obstruction in the slurry line / no material transport	
	Flow rate too low. Bypass does not switch properly. Flushing as described under "Possibilities of removing obstructions".
Steering cylinder stroke measuring reading incorrect or no value	
	Defective or incorrectly connected electric control cable. Stroke measuring system in the cylinder is defective, or attached electronic housing is defective.

FAULT	CAUSE
Thrust cylinders not moving correctly	
	Check the solenoid valves on the hydraulic power unit. Check the hose lines. Pump does not establish pressure.
Hydraulic pumps do not run	
	Check the oil level in the tank. Check the electric power supply. Check contactor and fuses. Check the oil temperature.
Control voltage on the control panel can not be switched on	
	Unlock the emergency stop. Switch on the main switch. Overvoltage or undervoltage or no clockwise phase sequence when the "Voltage monitoring" indicator lamp is ON. Control transformer defective.
Main switch can not be switched on	
	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.
Slurry and feed pump do not run	
	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.

FAULT	CAUSE
Oil temperature too high	
	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
Cutting tool does not rotate correctly	
	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
Fault cutting tool pump	
	Circuit breaker tripped, then motor overload. Motor defective. Pump blocked, resulting in overcurrent. Motor overload. Reduce speed of cutting tool.
No braking effect	
Hydraulic hoses confused during assembly	Connect the hydraulic hoses correctly
Hydraulic pump running backwards	Switch the electrical connections on the hydraulic pump
Support frame not relieved	Adjust the support frame.
Product pipe too small	Replace the brake
Brake lining worn	Replace the brake lining

VI. Maintenance, repair

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:
    Tabular list of maintenance work recommended for maintaining the machine/plant.
  - Operating materials:
    Description of operating materials used by the machine/plant
  - Maintenance work:
    Description of the required maintenance and repair activities.

2. General

Operational safety and readiness are the requirements that a machine / plant must meet as part of sensible operating efficiency.

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 and reduce downtime of the machine/system.

This manual only briefly lists most of the maintenance work, which is described in detail in the operating manuals for the individually installed equipment and machine components. In these cases, always adhere to the operating manual 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 in the "Maintenance Work" and "Repair Work" chapters and the supplier documentation enclosed with the appendix (see CD-ROM). Additionally, always refer to supplier documentation in the appendix (see CD-ROM) for exact specifications of the maintenance intervals.

NOTE

Herrenknecht AG accepts no liability for damage caused by irregular performance of, or failure to perform, maintenance work.

All maintenance and repair work must be documented and filed.

When performing maintenance work, only operating resources, operating materials, original spare parts and original accessories released by Herrenknecht AG may be used.

2.1 Replacing heavy components

DANGER!

Lifting heavy components.

- Heavy components must be properly attached to and secured on hoisting devices when being replaced.
- Use only suitable hoisting devices that are in perfect working order and load handling equipment with sufficient load-bearing capacity.

If repair work necessitates removing heavy components, always use suitable lifting gear.

- Never store heavy components in unstable places.
- Secure heavy components reliably even for short-term storage.
- Use only suitable hoisting devices that are in perfect working order and load handling equipment with sufficient load-bearing capacity.
- When using lifting gear, always observe the manufacturer's specifications on maximum permissible loads.
- Never work or linger under suspended loads.
- When installing/removing components, always observe the work sequence order.
- Never start installing/removing a part without finishing installing/ removing the previous part.

After completing the assembly work, 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 / plant before it is returned to operational state.

2.2 Information on maintenance and repairs

2.2.1 Differences between maintenance and repair

Maintenance and repairs are both parts of maintenance work, which also includes servicing and improvements. Correct maintenance of the machine/system can prevent system failure and breakdowns. Maintenance objectives also include:

- Enhancing and ensuring optimum use of service life of the machine/ plant.
- Improving operational safety.
- Increasing system availability.
- Optimising operational procedures.
- Reducing malfunctions.
- Forward-looking cost planning.

2.2.2 Maintenance

Maintenance is carried out at regular intervals and by trained specialists. This helps to ensure the longest possible service life and low wear of the maintained parts of the machine/system.

Maintenance includes readjustment, lubrication, preservation, top-ups or replacement of operating materials or consumables and scheduled replacement of parts subject to wear.

2.2.3 Repairs

Repairing means restoring a faulty item to its original and functional condition. Repair work is all work that involves replacing (or repairing) damaged components.

NOTE

When exchanging damaged parts, please consult Herrenknecht AG. Failure to consult means that the guarantee/warranty is voided.

2.2.4 Before starting maintenance and repair work

Complete the following steps before starting maintenance/repair work:

1. Stop the machine/system.
2. Make sure that the machine/system is depressurised and de-energised.
3. Depressurise the complete hydraulic system and switch off all existing hydraulic power units.
4. Secure the hydraulic system against undesirable re-activation.
5. De-energise the entire electrical system. (If it exists, set the battery switch to OFF.)
6. Secure the electrical system against undesirable re-activation.
7. Lock the control cabinets. Keep the keys in a safe place.
8. For hydraulic tanks with pretension pressure, aerate the hydraulic tank to relieve the pretension pressure.
9. Interrupt the power supply to the plant by switching off the main switch.
10. Padlock the main switch to prevent it being switched back on. Keep the keys in a safe place.

WARNING!

Hot surfaces on the hydraulic power unit, engine and exhaust system

- Burns

- Wear personal protective equipment
- Do not enter the power unit room during operation
- Before entering the power unit room, allow the hydraulic power unit, engine and exhaust system to cool down.

NOTE

Parts of the plant such as the hydraulic power unit, motor and exhaust gas system become hot duration operation; do not stand on them.

2.3 Consumables

NOTE

Herrenknecht AG does not recommend using alternative lubricants other than those stated in the lists of consumables.

Using other consumables requires written approval by Herrenknecht AG.

Herrenknecht AG accepts no liability for damage resulting from the use of non-approved lubricants.

NOTE

Gearbox oil quality check
The oil sample has to be checked by a suitable laboratory for:

- Lubrication oil quality:
- Contamination of the lubricating oil by external influences (water, sand, etc.)
- Wear particles produced during operation (metal, etc.)

An oil change is required in case of maximum contamination of 19/17/14 per 100ml as per ISO 4406

CAUTION!

Degradation of lubrication and running properties due to different grease or oil types.

- Bearing damage and gearbox damage.
- Do not mix different grease and oil types.
- Clean all parts lubricated with the previously used grease or oil type prior to using a different grease or oil type.

2.3.1 Cleaning agents

CLEANING AGENTS	CITY
Water	Complete machine/plant (see „Water quality requirements“)
Grease removing cleaning agents	Steps, platforms, hydraulic power unit
Acetone Petroleum ether Paraffin	Strainers in the hydraulic unit tank

2.3.2 Waste disposal

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.

NOTE

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.

3. Safety

- Observe all instructions in the operating manual.
- All maintenance, cleaning and repair work must be carried out on time, correctly and completely.
- Always move all moving components, mainly hydraulic cylinders to a safe stop position or position.
- All maintenance, cleaning and repair work must be performed only while the machine/plant is at a standstill and switched off.
- Prior to starting any repair work, shut down the machine/system and secure it against being switched back on inadvertently.
- Escape routes and escape passages must be accessible for all staff and must be kept clear. Doors must not be blocked by lines, cables or any other material.
- For disassembly of heavy machines/plant parts, use suitable lifting gear. Heavy machine/plant parts must be properly attached and secured on the hoisting devices when being replaced. Use only suitable hoisting devices that are in perfect working order and load handling equipment with sufficient load-bearing capacity. After completing the work, check to ensure that it has been carried out correctly. Repeat checking of settings by trial runs of the machine before it is returned to operational state.
- Safeguard maintenance and repair zones to over a wide area.
- 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" (see Table „Switching prohibited template“ on page 13).

SWITCHING PROHIBITED	
	**Do not operate switch!** **Work in progress!** **This sign must not be removed except by:** **Name:** _____ **Date:** _____ **Location:** _____

Table 1: Switching prohibited template

DANGER!

Maintenance and repair work on the machine/plant.

- 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!

Explosion hazard!

Maintenance and repair work on the hydraulic system. Explosive expansion of hydraulic oil.

- Serious injuries to the body, eyes and skin.
- Machine/system damage.

• Wear safety gear.

• Depressurise the entire machine/plant before you start working on the hydraulic system.

DANGER!

Voltage!

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.

3.1 Qualification and training

- Before starting maintenance, cleaning and repair work, all staff must be notified.
- Only qualified electricians are allowed to perform maintenance work on the electric system.
- Only qualified hydraulics specialists are allowed to perform maintenance work on the hydraulics system.
- Maintenance, cleaning and repair work must be carried out by authorized and qualified staff only. These persons are required to have read and understood the entire technical documentation.

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 are required to have read and understood the entire technical documentation.
- Observe all safety instructions.

3.2 Maintenance switches

Maintenance switches secure an energy source against being accidentally switched. It allows staff to work safely during commissioning and maintenance.

Always use maintenance switches during:

- Maintenance
- Commissioning / Decommissioning
- Assembly / Disassembly

NOTE

Working with the safety padlock of another person is prohibited!

Only the person who fitted the padlock is allowed to remove it!

Various emergency stop devices, key switches and maintenance switches are installed on the machine / plant.

The overview of emergency stop and maintenance devices is to be found in **Section: Appendix**.

Using the control panel maintenance switch:

1. Turn the maintenance switch to position "0".
2. Secure the maintenance switch with your personally marked safety padlock against being switched back on. This must also be done when the maintenance switch has already been secured with the padlock of another person.

Figure VI - 1: Maintenance switch with padlock

Using the hydraulic system maintenance switch:

1. Turn the maintenance switch to the "closed" position.
2. Secure the maintenance switch with your personally marked safety padlock against being switched back on. This must also be done when the maintenance switch has already been secured with the padlock of another person.

Figure VI - 2: Hydraulics maintenance switch

4. Maintenance plan

The maintenance schedule contains the recurrent 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 in the "Maintenance Work" and "Repair Work" chapters and the supplier documentation enclosed with 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 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.

NOTE

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.

NOTE

Complete and observe the maintenance schedules with care.

All actions taken must be documented in writing.

NOTE

When carrying out maintenance work also perform any maintenance work designated for shorter intervals. The maintenance intervals are defined on the basis of the absolute value of the hours of operation meter on the system.

4.1 General

NOTE

The general maintenance schedule defines the work that is valid for the entire machine/plant.

4.1.1 Steel structure / attachment parts

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Daily / before starting work	Check platforms, ladders, attachments, chassis, steel structures in general, welds, handrails	for safety		Manufacturer's documentation (see CD) Herrenknecht AG documentation Drawings Fluid Diagrams Electric Diagrams
	Bolted and crimped contacts	check tightness		
	All cables and lines including equipotential bonding	Visual check for damage Insulation check		
	hydraulic couplings, water and bentonite lines	Check strength and leak tightness, tighten as needed		

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Daily / before starting work	Blue Globe screw unions (if in place)	Check all screws for tight seating, tighten loose screws Visual check for damage		Manufacturer's documentation (see CD) Herrenknecht AG documentation Drawings Fluid Diagrams Electric Diagrams
	Lamps and EMERGENCY STOP system	Check function		
	Machine / plant	clean and keep clean	Water	
	Steel components	Check for damage and corrosion. Repair damage immediately. Replace faulty parts as per drawings		
	Lubricating nipple	Lubricate all of the lubricating nipples on the machine / plant.		

Table 2: Maintenance – steel structure / attachment parts

4.1.2 Hydraulic and lubricating oil

General

WARNING!

Etching substances!

Danger due to contact with hydraulic and gear oil

- Skin and eye injuries and injuries of the respiratory system.

• When working with hydraulic and gear oil, always use personal protective equipment. In case of danger of splashes, always wear goggles and protective gloves. Protective gloves made of PVC or nitrile rubber are not permitted.

Hydraulic oil

DANGER!

Explosion hazard!

Maintenance and repair work on the hydraulic system. Explosive expansion of hydraulic oil.

- Serious injuries to the body, eyes and skin.
- Machine/system damage.

• Wear safety gear.

• Depressurise the entire machine/plant before you start working on the hydraulic system.

NOTE

Analyse the hydraulic oil in the machine/plant at regular intervals and improve as needed. Hydraulic oil analysis must be performed by an independent laboratory. Only operate the machine/plant if the hydraulic oil is within the defined laboratory values. To file claims in the warranty period, you must submit evidence of all laboratory analysis and maintenance work. All maintenance work performed must be documented and archived.

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Every 500 operating hours/after longer periods of standstill	Hydraulic oil	Have hydraulic oil analysed by an external laboratory. If the laboratory values are not within the limits specified by Herrenknecht AG, you must improve, clean or change the hydraulic oil following the recommendation by the laboratory.	see list of operating materials, fluid diagram, drawings, tank label	Do not take a hydraulic oil sample until the hydraulic oil has reached operating temperature. Take the hydraulic oil sample at the intended sampling point (Mini-measuring point on the filter circuit, see fluid diagram, marked in yellow). Use only containers that are approved for hydraulic oils. Only top up with hydraulic oil via a filter.

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Every 2000 operating hours/once per year	Hydraulic oil	Change hydraulic oil	see list of operating materials, fluid diagram, drawings, tank label	Only change the hydraulic oil when the hydraulic oil has reached a temperature of 30°C - 40°C. Drain the hydraulic oil at the intended drain point. Dispose of hydraulic oil according to expertise and standards. Only top up with hydraulic oil via a filter.

Table 3: Maintenance – hydraulic oil

Lubricating oil

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
After the first section/ the first 50 hours of operation	Lubricating oil Gear oil Bearing oil	Change the lubricating oil	see list of operating materials, fluid diagram, drawings, tank label	Change the lubricating oil only when the lubricating oil has reached operating temperature. Drain the lubricating oil at the intended drain point. Dispose of lubricating oil according to expertise and standards. Clean the housing from the outside and tighten the ventilation screw to the required torque.
After each section/ every 50 operating hours	Lubricating oil Gear oil Bearing oil	Check the lubricating oil level on all existing gearboxes, bearings and drives. Top up with lubricating oil as necessary.	see list of operating materials, fluid diagram, drawings, tank label	The sight glass or the oil fill hose show the precise lubricating oil level
		Check the fastening screws on the gearbox, bearing and drive for tight seating, tighten loose screws		

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Every 500 operating hours/after longer periods of standstill	Lubricating oil Gear oil Bearing oil	Have the lubricating oil analysed by an external laboratory. If the laboratory values are not inside the manufacturer's limits, you must clean or change the lubricating oil.	see list of operating materials, fluid diagram, drawings, tank label	Do not take a lubricating oil sample until the lubricating oil has reached operating temperature. Drain the lubricating oil at the intended drain point. Use only containers that are approved for lubricating oils. Clean the housing from the outside and tighten the ventilation screw to the required torque.

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Every 1500 operating hours/at least once per year	Lubricating oil Gear oil Bearing oil	Change the lubricating oil	see list of operating materials, fluid diagram, drawings, tank label	Change the lubricating oil only when the lubricating oil has reached operating temperature. Drain the lubricating oil at the intended drain point. Dispose of lubricating oils according to expertise and standards. Clean the housing from the outside and tighten the ventilation screw to the required torque.

Table 4: Maintenance – lubricating oils

Hydraulic circuits

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Daily / before starting work	All circuits, connections, piping	Visual check Repair damage immediately.		Manufacturer's documentation (see CD) Herrenknecht AG documentation Drawings Fluid Diagrams Electric Diagrams
		Check: Leaks, wear, chafe marks Repair damage immediately.		
	Miscellaneous filters	Check		
After each section/ every 50 operating hours	General	Cleaning		

Table 5: Maintenance - hydraulic circuits

4.2 Back-up tube with hydraulic power unit

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Daily / before starting work	Hydraulic couplings	Check strength and leak tightness, tighten as needed		• Repair damage immediately. • Replace faulty parts as per drawings
	tank	Check fill level Top up as necessary.	see list of operating materials, fluid diagram, drawings, tank label	• Only top up with hydraulic oil via a filter.
	Pumps	Listen for unusual noises Check tightness of all connections		
After each section/ every 50 operating hours	Bentonite nozzles	Clean and flush free	Water	– Herrenknecht AG documentation – Drawings – Fluid Diagrams
In case of malfunction display	Related filters	Replace filters/filter elements	Replace defective components in line with drawings or fluid diagram	

4.2.1 Bladder accumulator

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
Daily / before starting work	Bladder accumulator	Check connections for tight seating, fittings and safety devices for orderly state; check fastening elements	Oil as per list of lubricants Grease as per list of lubricants Water Repair damage immediately	Manufacturer's documentation (see CD) Herrenknecht AG documentation Drawings Fluid Diagrams Electric Diagrams
After the first section/ the first 50 hours of operation		In case of new installation or repair Check the prefill pressure		
Every 50 operating hours / at least once a week		Check the nitrogen filling pressure		
Every 400 operating hours/after longer periods of standstill		Check the prefill pressure	In case of pressure loss, refill with nitrogen.	
Before each use		Check the gas fill pressure, Top up as needed	Bladder accumulators must be refilled with nitrogen only.	

Table 6: Maintenance - bladder accumulator

4.2.2 Grease pump

INTERVAL	ASSEMBLY/ COMPONENT	MAINTENANCE WORK AND CHECKS	CONSUMABLES	NOTE/INFORMATION
After each section/ every 50 operating hours	Grease pump	Check the filling of the grease tank. Top up with grease as necessary.	see list of operating materials, fluid diagram, drawings, tank label	Top up with grease only when the grease pump is shut down.

Table 7: Maintenance - grease pump

5. Consumables

5.1 General

When filling and refilling oils and greases, it must be ensured that the same products are used that were originally in the system upon delivery.

Prior to changing oil or grease types, always consult Herrenknecht AG.

CAUTION!

Use of unsuitable hydraulic oils with Hägglunds motors.

- Damage to drive motors

• Only used hydraulic oils with a viscosity of 68 cSt.

• Never mix hydraulic liquids.

• When changing the oil type, the complete hydraulic system must be cleaned. The same applies to hose and conduits.

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. Serious material damage can occur.

• 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.

5.2 Laboratory limits hydraulic oil

NOTE

Analyse the hydraulic oil in the machine/plant at regular intervals and improve as needed. Hydraulic oil analysis must be performed by an independent laboratory. Only operate the machine/plant if the hydraulic oil is within the defined laboratory values. To file claims in the warranty period, you must submit evidence of all laboratory analysis and maintenance work. All maintenance work performed must be documented and archived.

Wear behaviour

To increase the service life of all plant components, an oil purity in line with ISO 4406 is required. The hydraulic components used by Herrenknecht requires an oil purity class of at least 19/17/14 as per ISO 4406.

The particle size and count determine the wear behaviour of the hydraulic system. The more particles there are in circulation, the higher the wear.

Laboratory sample

Several methods can be used to classify the existing system cleanliness. However, mostly ISO 4406 and NAS 1638 are used. ISO 4406 is a globally recognised current standard.

A qualified laboratory analyses the hydraulic oil sample with a calibrated particle counter. The particles are counted in a hydraulic oil sample of one millilitre. The particle count is expressed as a code: 19/17/14, this means that the sample contains 2500 - 5000 particles with a size great or equal to 4 µm(c), 640 - 1300 particles with a size greater than or equal to 6 µm(c) and 80 - 160 particles with a size greater than or equal to 14 µm(c).

Oil purity class to ISO 4406

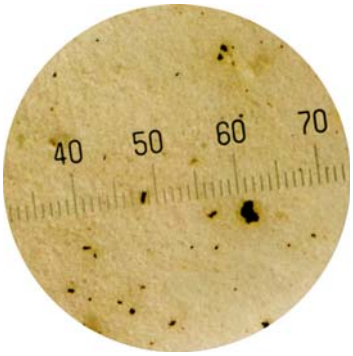


Figure VI - 3: microscopic image, 100-times magnification, 1 scale line: 10 µm

CRITERION	VALUE
Particle size and count	Oil purity class 19 / 17 / 14
Water content	max. 1000 ppm
Viscosity deviation (40°C)	max. +/- 15% from viscosity of new hydraulic oil
Additives	Good or bad
Oil aging	Good or bad

5.3 Water quality requirements

Adequate water quality is paramount. This ensures reliable operation of the components and prevents damage to the cooling circuit.

- Type of water: Fresh water
- Inlet temperature max.: 25°C / 77°F

ANALYSIS	VALUES
Total hardness	< 11°dH
Carbonate hardness	< 8°dH
Non-carbonate hardness	< 3°dH
ph value	= 6-8
electrical conductivity	< 2,500 µS/cm
pKs 8.2	< 3 mmol/l
pKs 4.3	< 25 mmol/l
Iron content (Fe)	< 0.2 mg/l
Manganese content (Mn)	< 0.05 mg/l
Calcium content (Ca)	< 400 mg/l
Magnesium content (Mg)	< 50 mg/l
Sodium content (Na)	< 200 mg/l
Chloride content (Cl)	< 250 mg/l
Sulphate content (SO_4)	< 240 mg/l
Nitrate content (NO_4)	< 50 mg/l
Free carbon acid (CO_2)	< 10 mg/l
Dissolved organic carbon	< 1.7 mg/l
Settable substances after 0.5 h	< 0.1 mg/l

5.3.1 Remarks

Any cleaning of the cooling circuit with descaling agents or cleansing agents that becomes necessary in the course of work requires previous agreement with **Herrenknecht AG**.

Unsuitable decalcification or cleaning agents may cause severe damage to individual machine/plant components.

The water must not be cloudy.

NOTE

For machines/plant with internal cooling circuit, the cooling circuit has to be filled with 30% antifreeze and anticorrosive agents.

Herrenknecht AG recommend the use of **Aral Antifreeze Extra** as anti-freeze and anti-corrosion agent.

5.4 List of consumables

5.4.1 Trailing tube power unit

CONSUMABLES	COMPONENT	AMOUNT (LITRES)	TYPE	PART NO.
Hydraulic oil	Hydraulic tank	450	TELLUS S2 MX-ISOVG68	40241705
coolant	coolant tank	16	EUROLUB ANF	40118703
Lubrication grease	Grease pump	10	PLANTOGEL 2-N	29700746

5.5 Waste disposal

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.

NOTE

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.

6. Cleaning work

6.1 Safety information

- 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.
- Seal or cover any openings that must not come into contact with liquids or cleaning agents prior to cleaning the system using water, high-pressure cleaners or other cleaning agents. This particularly applies to electric motors and switch cabinets.
- After cleaning, covers or adhesive tape 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.
- The piston rods must be retracted for hydraulic cylinders.

Document: 81511-001

6.2 Cleaning agents

CLEANING AGENTS	CITY
Water	Complete machine/plant (see „Water quality requirements“)
Grease removing cleaning agents	Steps, platforms, hydraulic power unit
Acetone Petroleum ether Paraffin	Strainers in the hydraulic unit tank

7. Maintenance works

7.1 General

- 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 operating company 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.

NOTE

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.

7.2 Staff requirements

Only qualified personnel are allowed to perform maintenance work.

7.3 Safety information

- Before starting maintenance or repair 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 or repair 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.
- Incorrect bolt tightening torques and/or faulty nuts and bolts can cause severe injury to persons and damage to the machine.

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 to the specified torque!

7.3.1 Dangers during maintenance work

The following special risks must be anticipated when carrying out maintenance on 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 posed by accessible sharp edged machine parts and tools.
- Danger of slipping due to lubricants and other fluids escaping.

7.4 Hydraulics

- During maintenance work, pay attention to cleanliness in the machine/ system area and environment.
- If you need to cut hydraulic lines, the open ends must be sealed with suitable caps. This prevents fluid escaping and dirt entering the lines.
- 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.

CAUTION!

Fibres in the hydraulic/gearbox oil.

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

NOTE

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

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

7.4.1 Hydraulics pre-tensioned

Always depressurise the hydraulics during maintenance and repair work on the hydraulic system.

WARNING!

Pre-tensioned 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.

Depressurise the hydraulics

1. Switch off the machine / plant to depressurise the hydraulics
2. Allow the hydraulic oil to cool down to approx. 30 - 40°C.
3. Slowly open the ball valve for the air coupling on the tank (see fluid diagram) or turn the ventilation filter on the hydraulic tank approx. 2 turns anticlockwise.
   – The excess pressure escapes; the tank pretension pressure is relieved.
4. 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. Relieve the pressure on the return line suction filter (see return line suction filter manufacturer's operating instructions).

Pressurise the hydraulics

A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank. Check the fluid diagram to see if the machine/plant needs to be pressurised.

1. Switch off the machine / plant.
2. Connect the air hose to the air coupling.
3. Slowly open the ball valve on the air coupling.
4. Slowly pressurise the hydraulic tank.
   Refer to the fluid diagram for precise values.
5. Close the ball valve on the air coupling and remove the air hose.

7.4.2 Replacing hydraulic hoses

NOTE

Hydraulic 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.

NOTE

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.

7.4.3 Oil quality checks

NOTE

Analyse the hydraulic oil in the machine/plant at regular intervals and improve as needed. Hydraulic oil analysis must be performed by an independent laboratory. Only operate the machine/plant if the hydraulic oil is within the defined laboratory values. To file claims in the warranty period, you must submit evidence of all laboratory analysis and maintenance work. All maintenance work performed must be documented and archived.

Oil sample

1. Identify the oil sampling point on the fluid diagram. (Mini-measuring point on the filter circuit, see fluid diagram, marked in yellow).
2. Heat the hydraulic oil up to operating temperature.
3. Fill the hydraulic oil through the oil sampling point into a container.
   – Use only containers that are approved for hydraulic oils.
4. Close the oil sampling point.
5. Send the container with the oil sample to an independent laboratory to have the oil tested in line with Herrenknecht AG specifications.
6. Act as dictated by the laboratory values.

7.4.4 Oil change

CAUTION!

Soiled/unfiltered 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.
- Topping up hydraulic oil or refilling the power unit only via the filler connection

1. Identify the oil drain in the fluid diagram and on the tank.
2. Completely drain the hydraulic oil through the oil drain.
3. Open the container cover and clean the tank.
4. Clean and reinsert the strainers.
5. Replace the filter elements on the return line/suction filter.
6. Close the container cover again.
7. Fill with new hydraulic oil via the filler neck on the tank.
8. A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank. Check the fluid diagram to see if the machine/plant needs to be pressurised.
   – Before restarting after maintenance/repair work, all hydraulic components, especially hydraulic pumps must be ventilated.

7.4.5 Clean the strainers

The strainers in the tank must be cleaned, and possibly replaced, at every oil change.

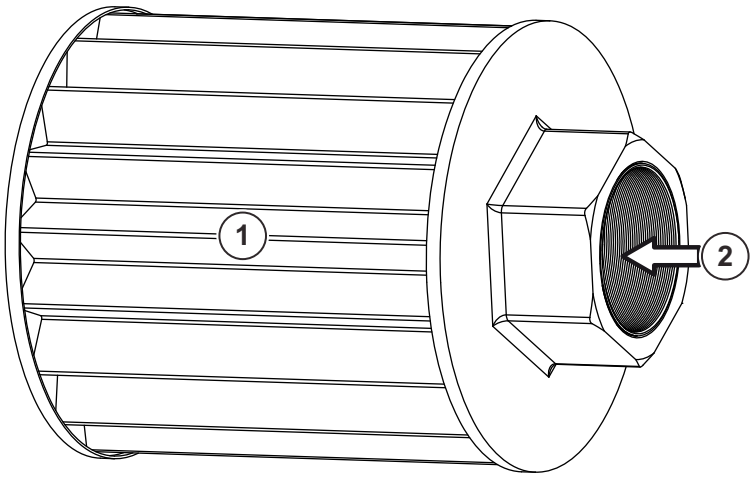


Figure VI - 4: Strainer

1	Strainer	2	Purging direction

CAUTION!

Cleaning the strainers with a solid object or wire brush.

- Damage to wire mesh on strainer and to hydraulic components.

• Do not use hard objects such as wire brushes or similar to clean the strainers.

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

7.4.6 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/unfiltered 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.
- Topping up hydraulic oil or refilling the power unit only via the filler connection

7.4.7 Ventilate hydraulic component

CAUTION!

Do not ventilate the hydraulic component (hydraulic pumps)

- Damage to hydraulics components especially to hydraulic pumps.
- Before restarting after maintenance/repair work, all hydraulic components, especially hydraulic pumps must be ventilated.

1. Stop the machine/plant.
2. A machine / system with initial pressure requires compressed air to be applied to build up an initial pressure in the hydraulic tank. Check the fluid diagram to see if the machine/plant needs to be pressurised.
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.

NOTE

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

7.4.8 Leak tightness test

1. Completely switch off and depressurize the machine/plant.
2. Check the hydraulic system for leaks and lack of tightness.
3. If leaks or lack of tightness is observed in the hydraulic system, identify and remedy the problem.
   – Replace defective parts and tighten all bolted connections on the hydraulic system.

NOTE

Tighten the bolted connections only when the system is depressurized.

7.5 Filters

The filter element concerned must be replaced when the fault indicator (LED) lights up on the control panel or when the fault is indicated on the visualization monitor. After an extended period of standstill, the filter elements must also be replaced.

NOTE

Some filter elements cannot be cleaned and must be disposed of in line with environmental protection laws. Always clean the filter casing when changing the filter element.

7.5.1 Safety information

- Only replace filter elements when the hydraulic system is depressurised.
- Keep the workplace and working environment clean at all times. Remove spilled oil, grease and liquid immediately.
- Wear safety goggles and protective gloves.
- Observe the safety datasheets of all manufacturers.
- Do not use a pipe wrench or a hammer.

NOTE

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

7.5.2 High pressure filter

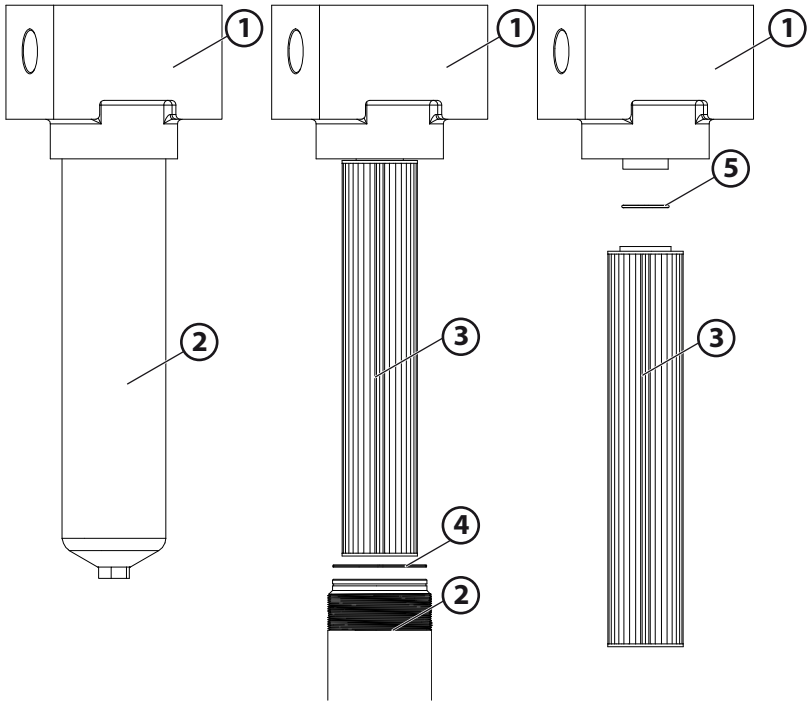


Figure VI - 5: Replacing the filter element on the high pressure filter.

1	Filter head	4	O-ring
2	Filter bell	5	O-ring (optional)
3	Filter element		

Remove the filter element

Requirement:

- The hydraulic system is switched off and secured against being switched back on.
- Hydraulic oil has cooled down
- Hydraulic system is depressurised
- Depressurised state and temperature have been checked

Required tools / material

- Allen key to match screw sizes
- Flat spanner
- Catchment container
- Filter element as per Herrenknecht AG bill of materials

Approach

1. Make sure the hydraulic system is depressurised and has cooled down to a low temperature.

WARNING!

Hot hydraulic oil escaping at pressure

- Burns and scalds
- Make sure that the hydraulic system is depressurised and that the hydraulic oil has cooled down.
- Always use personal protective equipment!

---

2. Place the catchment container below the filter.

DANGER!

Spilled hydraulic oil.

- Severe or fatal injury
- Remove spilled hydraulic oil immediately.

---

3. Open the exhaust ventilation plug (if one exists).
4. Unscrew the oil drain screw (if one exists).
5. Remove the filter bell
6. Remove the filter element

– Check the filter element for soiling and visible particles.

NOTE

Visible particles may be a warning signal of a forthcoming failure of a machine/plant component.

7. Dispose of the filter element and o-ring

NOTE

Observe national environmental protection rules for disposal.

Fit a new filter element

Approach

1. Clean the filter casing
2. Check o-rings and circulation valves for damage.

NOTE

Damaged parts must be replaced. Always use new o-rings, dispose of used o-rings responsibly.

3. Lightly wet the o-ring with clean hydraulic oil and push the filter element with the open side over the nipple in the filter head.
4. Lightly oil the thread and o-ring on the filter bell with clean hydraulic oil.
5. Screw filter bell manually into the filter head up to the stop.
6. Screw in the oil drain screw (if one exists).
7. Switch on the hydraulic system and ventilate the hydraulic component.
8. Pressurize the hydraulic system, and check the filter for leaks.

7.6 Bladder accumulator

7.6.1 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:

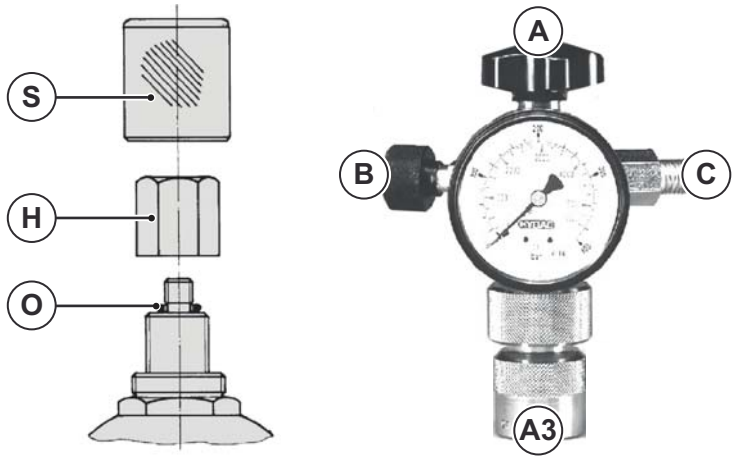


Figure VI - 6: Filling and testing device FPU-1

S	Protective cap	B	Relief valve
H	cap nut	C	Non-return valve
O	O-ring	A3	Union nut with adapter
A	Spindle		

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 test 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.

7.6.2 Check the gas pressure in the accumulator

1. Open the bladder 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 prefill 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 p0 dropping excessively, regular checking of the gas fill pressure is recommended.

Set the prefill pressure p0 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.

7.6.3 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.

7.6.4 Increasing the pressure in the accumulator

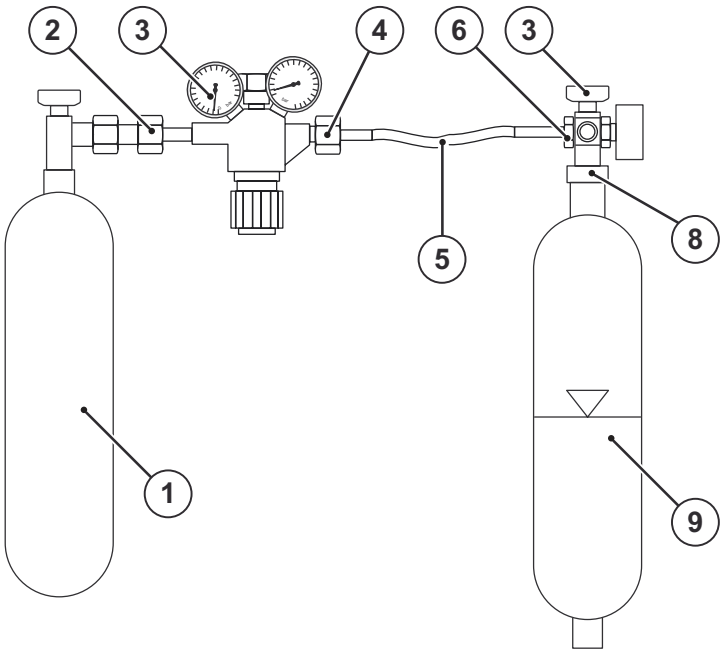
- "Increasing the pressure in the accumulator" means filling the bladder accumulator.
- To fill the hydro accumulator, use only nitrogen 99.995%.
- If the gas pressure in the nitrogen cylinder is higher than the max. operating pressure of the hydro accumulator, use an intermediate gas pressure reduction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

WARNING!

Explosion hazard!

Risk of explosion.

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



1	Nitrogen cylinder	6	Union nut M
2	Connection piece G	7	Filling and testing device FPU-1
3	Pressure relief valve	8	Adapter A
4	Union nut G1	9	Hydro accumulator
5	Filling hose		

1. Connect the union nut [4] on the filling hose [5] to the pressure reduction valve [3] on the nitrogen cylinder [1].
   – An adapter will be necessary for many international cylinders. The adapter must fit on a W24.32x1/14" thread.
2. Connect the union nut [6] on the filling hose [5] to the non return valve [C] on the filling and testing device (see figure „Filling and testing device FPU-1“ on page 53).
3. Open the shut-off valve on the nitrogen cylinder [1] and allow the nitrogen to slowly flow into the hydro-accumulator [9].
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 [B] on the filling and testing device (see figure „Filling and testing device FPU-1“ on page 53).
   – Once the desired gas prefill pressure has been reached, turn the spindle [A] on the bladder accumulator anticlockwise to shut off the gas valve (see figure „Filling and testing device FPU-1“ on page 53).
7. Relieve the filling and testing device via the relief valve [B] and loosen the union nut [6] to remove.
8. Screw off the adapter [A3] and replace the o-ring [O] (see figure „Filling and testing device FPU-1“ on page 53).
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 (see figure „Filling and testing device FPU-1“ on page 53).

8. Repair work

8.1 Safety

- Prior to starting repair 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.

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!

WARNING!

Suspended loads!

Damaged or insufficiently dimensioned lifting gear, unsafe attachment of loads.

- Serious or fatal injuries due to dropping loads.
- Heavy machine parts must be properly attached to and secured on hoisting devices when being replaced.
- Use only suitable hoisting devices that are in perfect working order and load handling equipment with sufficient load-bearing capacity.

- If repair work necessitates removing heavy machine parts, always use suitable lifting gear.
- Never store heavy parts in an instable position.
- Secure heavy parts reliably even for short-term storage.
- Use only suitable hoisting devices that are in perfect working order and load handling equipment with sufficient load-bearing capacity.
- When using lifting gear, always observe the manufacturer's specifications on maximum permissible loads.
- Never work or linger under suspended loads.
- When replacing parts, always observe the correct order of the work steps.
- Never start installing/removing a part without finishing installing/ removing the previous part.
- After completing repair work, 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.
- Cleanliness of the environment in which the repair work is performed.
- 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.

8.1.1 Dangers during repair work

The following special risks must be anticipated during repairs to the system:

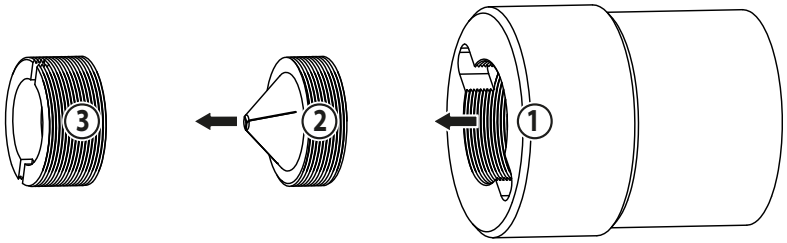
- Installing the wrong spare parts or wear parts can cause severe damage to the machine.
- Unintended switching on of the power sources can lead to severe injury to persons and damage to the machine.
- Danger of injury posed by accessible sharp edged machine parts and tools.
- Incorrectly routed lines (e.g. bending radius too small) can cause smouldering and burning cables.
- Danger of slipping due to lubricants and other fluids escaping.
- Confusing the connections will cause the motor to run in the wrong direction - this can cause severe damage to the machine.
- Incorrect bolt tightening torques and/or incorrect nuts and bolts can cause severe injury to persons and damage to the machine.

8.1.2 Staff requirements

Only qualified personnel are allowed to perform repair work.

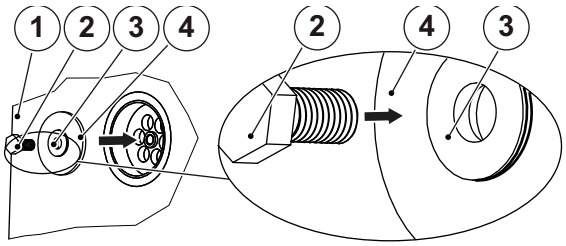
8.2 Bentonite/foam nozzles

8.2.1 Replacing the conical diaphragm



1. Remove the slotted nut [3].
2. Unscrew and remove 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.

8.2.2 Replacing the flat diaphragm



1. Remove the bolt [2].
2. Remove the bolt and washer [2,3] and remove the diaphragm [4].
3. Clean the contact surface.
4. Insert a new diaphragm.
5. Secure the diaphragm [4] with the washer and bolt.

NOTE

During installation, make sure that the bevel on the washer points towards the diaphragm

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8.3 Fatigue in welds

Check the machine / plant regularly for signs of fatigue in welds. The frequency of these checks depends on the age of the machine / plant, the degree of use, and the experience of the machine driver and maintenance staff.

If you detect fatigue or cracking in welds, they must be repaired immediately by staff with appropriate training.

CAUTION!

Risk of fire during welding work.

- Fire can break out on the machine/system and cause severe injuries.
- Always keep a filled and working fire extinguisher at hand for welding work on the machine.
- The contact points of welding gun and ground must be on the same component and as closely together as possible to prevent the current flowing over bearing points.

9. Recurring tests

9.1 Hydraulic operating equipment

Tests must be performed by qualified and authorised staff.

9.1.1 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 continue to be commissioned with performing the tests

NOTE

The qualified person is not subject to work instructions and must not be at a disadvantage due to work instructions.

9.1.2 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.

Additionally, the results of the tests (e.g. with the test report for the equipment under testing) must be recorded and kept on site (until at least the date of the next test).

9.1.3 Test periods for hydraulic hoses

REQUIREMENTS FOR HYDRAULIC HOSE G	TEST PERIOD	CONTROLLER
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 8: 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
- Can the hydraulic hose lines freely be moved or did the installation of new system components or units provide crushing, shearing or abrasion spots?
- 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, modification) been reinstalled and are they working?
- Are additional tear-off safeguards in place, or required?

NOTE

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	

9.2 Electrical operating equipment

Only qualified electricians are allowed to perform regular tests on the electrical systems or operating equipment.

9.2.1 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.

9.2.2 Preconditions for performing the tests

- 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.

9.2.3 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).

9.2.4 Fixed electrical operating equipment

SYSTEMS/OPERATING EQUIPMENT	TEST PERIOD	TYPE OF TEST	CONTROLLER
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 in stationary systems	6 months	Test for perfect working order by actuating the test equipment	User
- on non-stationary equipment	Each working day		

Table 9: Fixed electrical operating equipment

9.2.5 Mobile electrical operating equipment

SYSTEMS/OPERATING EQUIPMENT	TEST PERIOD	TYPE OF TEST	CONTROLLER
Mobile electrical operating equipment	3 months If an error rate of < 2% is achieved during testing, the test period can be extended accordingly.	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			
Connecting cables with plugs			
Movable lines with plugs and fixed connections	at least 1x annually.		

9.2.6 Recurring tests on electrical systems

Measurements, measurement methods and values/guideline values for measurements on systems with safeguards in the TN/TT system

MEASURING TASKS	MEASUREMENT METHOD	VALUES
Main equipotential bonding and additional equipotential bonding	Low resistance measurement	< 1 Ohm *)
Insulation resistance of PE to neutral and conductors	insulation resistance measurement	= 300 Ohm/V with consumer = 1000 Ohm/V without consumer at a mains voltage of up to 500 V and a measuring voltage of 500 V
Confusing of PE and external conductor	Phase test or voltage measurement to earth	Mains voltage
Confusing of PE and neutral	Low resistance measurement	< 1 Ohm *)
In case or more than one residual current protection device for the entire system:		< 1 Ohm *)
• correct assignment of neutral line to the circuit covered by the residual current circuit breaker.	Low resistance measurement	
• Short circuit between neutral lines on different residual circuit current breaker devices	insulation resistance measurement	See Insulation resistance measurement

*) Practical value, not specified by the standard, depending on the cross-section, length and material.

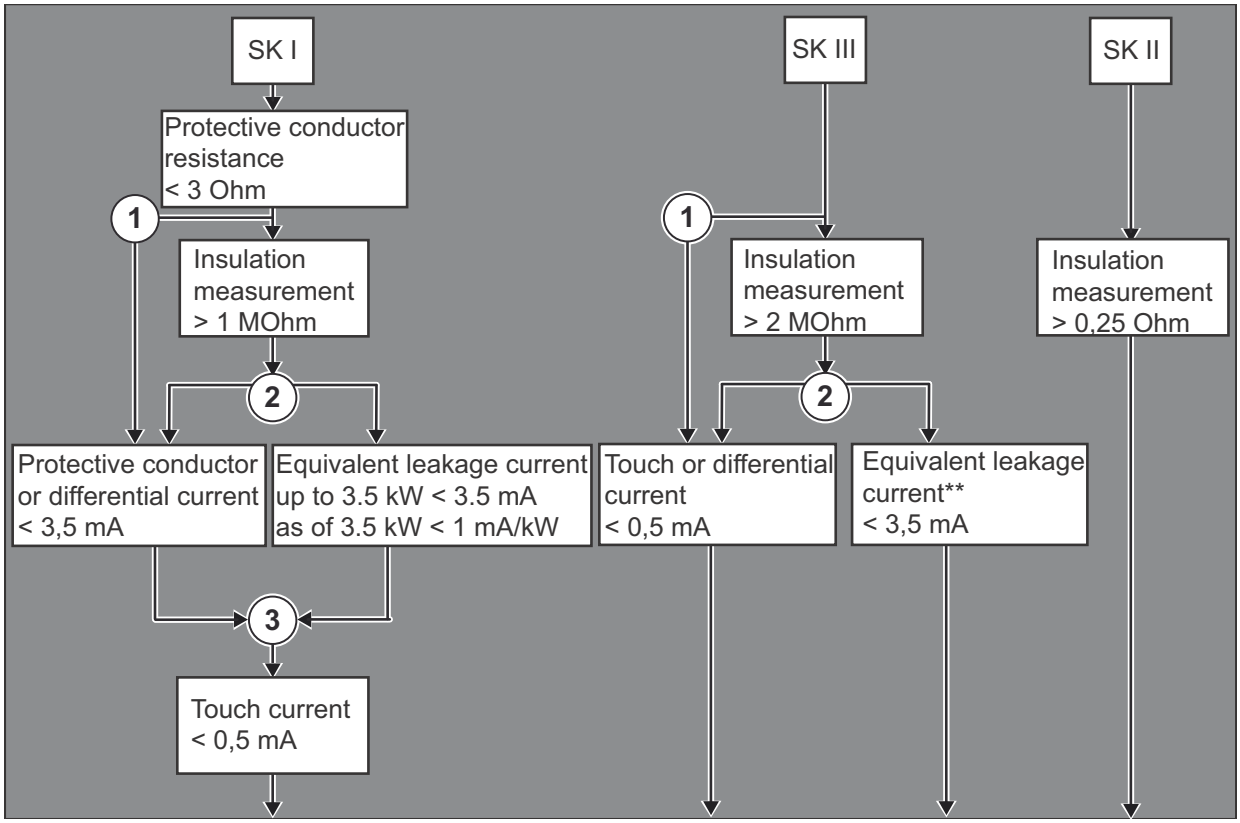
Additionally protective devices such as overcurrent protectors and residual current-operated devices must be evaluated. Testing of the protective measures in the TN system serves as an example.

PROTECTIVE DEVICE	MEASURING TASKS	MEASUREMENT METHOD
Overcurrent protection device	Between conductor and PE and/ or PEN line (U0 = nominal voltage to grounded conductor, Ia = 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
Residual current-operated protection device	1. UB = UL U = Un and (UL < 50 V, max. permissible touch voltage) 2. Connection of 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.

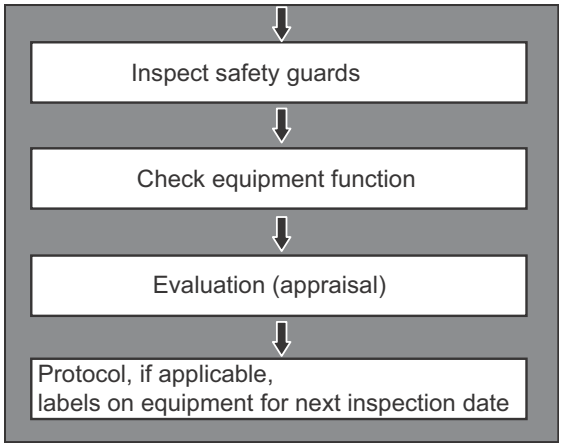
9.2.7 Test procedure for recurring tests on electrical equipment

The tests must be performed in a fixed order and each test must be passed before continuing with the next test.



* for connection lines up to max. 5 m, plus 0.1 Ohms for every additional 7.5 m but to a max. of 10 Ohms.

** Substitute measurement after passed measurement of insulation resistance. If not technically feasible or if it cannot be ensured that all parts exposed to mains voltage are covered by insulation measurement (e.g. electrical start relay). The measurement method can be selected freely. The measurement must be performed on touchable, conducting parts only that are not connected to physical earth.



9.2.8 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 measurement of PE conductor = 0.3 Ohm for devices with connection lines up to max. 5 m length plus 0.1 Ohm for every additional 7.5 m	not applicable	not applicable
Insulation resistance	= 0.3 MOhm (devices with heating elements switched on)	= 2 MOhm (switches, temperature controllers, etc., on the devices must be closed)	= 250 kOhm (switches, temperature controllers, etc., on the devices must be closed)
	= 1 MW (other devices)		
Equivalent leakage current	Heating capacity = 3.5 kW = 3.5 mA heating capacity > 3.5 kW = 1 mA/kW (only for protection class I devices with heating elements, where the required insulation resistance 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 resistance 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

9.2.9 Wireless transmitters

Devices for wireless transmission of control commands must be tested by a qualified expert at least once per year.

A qualified expert is a person who, based on professional training and experience, possesses sufficient knowledge in the field of the 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 devices for the wireless transmission of control commands.

9.3 Lifting devices and lifting gear

9.3.1 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.

9.3.2 Testing

- 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.
- In the scope of testing power-operated wire and chain hoists for lifting loads and of power-operated crane hoists, the owner-operator must determine the used part of the theoretical service life. If needed, a qualified surveyor must be called in to perform this work.
- The test prior to initial commissioning in line with paragraph 1 also relates to correct installation and readiness for operation.
  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.

9.3.3 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. Storage, disposal

STORAGE, DISPOSAL

1. Storage

1.1 Hydraulics components

1.1.1 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.

1.1.2 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.
- Seal pipes and threaded connections with plastic thread caps or plastic protective caps.
- Close flanges with soft plastic plugs that are secured with a metal plate.

NOTE

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.

1.1.3 Hoses

- Store hoses in a cool, dry and dust-free environment.
  - Virtually dust-free storage can be achieved by wrapping in plastic film.
- 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.
- Favourable storage conditions means temperatures between +15 and +25 °C and a relative humidity below 65%.
- Hoses must 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.
- Hoses must not be stored for more than two years.

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.

NOTE

The storage time for hoses should not exceed 4 years;
2 years for hose lines.

Document: 81512-001

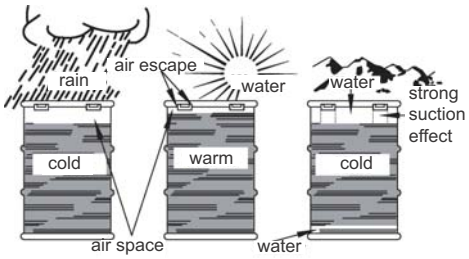
1.1.4 Hydraulic oil container

Storage room and container requirements

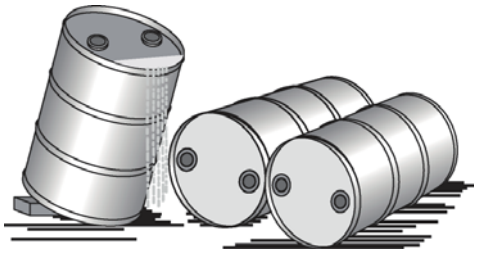
- Provide for sufficient room ventilation.
- Only use containers which are approved for the specific material / product.
- Keep the containers closed.
- Ensure that the material cannot penetrate the ground.

Hydraulic oil containers stored outdoors

- 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

1.2 Electrical components

1.2.1 Control cabinets

Switch cabinets must be packed in watertight packaging. For protection against condensate caused by temperature fluctuations, the switch cabinets must be filled with a desiccant in line with DIN 55473-A+B.

NOTE

The volume of desiccant depends on the control cabinet volume.

1.2.2 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.
- Observe bending radii.
  - Observe a minimum bending radius of 8 x d.
    (d = outer diameter of cable).

1.3 Machine / plant

1.3.1 General

- Thoroughly clean and drain the all parts of the plant/machine.
- If possible store the machine/plant in a closed room at constant temperature.

CAUTION!

Corrosion and frost.

- Material damage and impact to service life.
- Store the machine/system in fully dewatered state only.
- Avoid formation of condensation.

NOTE

If you have any questions regarding preserving agents, please contact **Herrenknecht AG**.

Outdoor storage

- Grease all bare metal parts to be stored outdoors or spray with preservative wax to provide protection against corrosion.
- For outdoor storage, the machine/system must be covered with tarpaulins. Provide for adequate ventilation.
- Completely fill all gearboxes and bearings with the specified lubricants.
- Before re-commissioning the machine/system, drain the lubricants to the required levels. Catch the drained oil in a container and dispose of the oil in an environmentally-friendly manner.

1.3.2 Hydraulic power unit

- Close the hydraulic connections.
- Clean the whole machine/plant 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 bare metal parts or spray with preservative wax.
- 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 condensate, refill switch cabinets with desiccant.
- Repair all damage before reusing the advance system, or replace damaged parts.
- Clean articulated joints and fill entirely with grease (if possible).
- Due to memory chips in the laser target, the machine/system must not be exposed to temperatures below 0° C.

1.3.3 Bladder accumulator

- Store in a cool dry atmosphere without direct sunlight exposure.
- In case of storage for more than 3 months, relieve the pressure to 2 bar.

1.3.4 Slurry and feed lines

- Remove the o-rings from the nipples on the slurry lines and store in a dark, dry and frost-free place.
- Grease blank metal parts (nipples and sleeves) or spray with preservative wax.
- Remove seals from couplings and store in a dark, dry and frost-free place, or store the fitted couplings in a dark, dry and frost-free place.
- Grease blank metal parts on the slurry pipe (nipple ends) or spray with preservative wax.

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.

NOTE

Refer to the manufacturer's safety data sheet for special information about handling and safety of all oils and greases used.

STORAGE, DISPOSAL

VIII. Appendix

DOCUMENT: 81513-001

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

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.

- Usable 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 MDB bolts and MDB nuts to DIN 6914 and DIN 6915 (large widths across flats). The table also does not apply to nuts and screws 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:

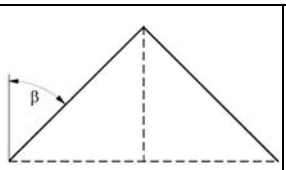
THREADS	TENSIONING FORCE IN KN FOR STRENGTH 10.9
M27	355
M30	430
M36	635
M42	875
M45	1020
M48	1150
M56	1600
M60	1850
M64	2100

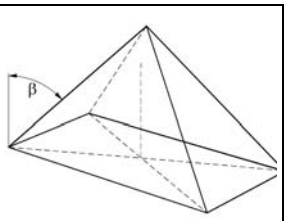
1.2.2 Tightening tool

- 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.

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

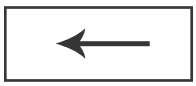
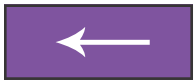
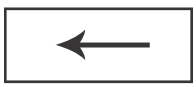
*chains - nominal thickness deviating from standard

Table 1: Carrying capacity table

NOTE

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 SAMPLE	GROUP COLOUR RAL	ADDITIONAL COLOUR SAMPLE	ADDITIONAL COLOUR RAL
Process water / sealing water		RAL6032		RAL5005 with white arrow
Cooling water/ 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 system		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	
	SAMPLE	RAL	SAMPLE	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		

Document: 81513-001

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 7824 302 4444
Fax: +49 7824 302 7000

Electrical
Phone: +49 7824 302 4445
Fax: +49 7824 302 7000
E-mail: ASS-electro@herrenknecht.de

Technical
Phone: +49 7824 302 4446
Fax: +49 7824 302 7000
E-mail: ASS-technical@herrenknecht.de

Commercial
Phone: +49 7824 302 3640
Fax: +49 7824 302 7000
E-mail: ASS-commercial@herrenknecht.de

Operation
Phone: +49 7824 302 4447
Fax: +49 7824 302 7000
E-mail: ASS-operation@herrenknecht.de

NOTE

Please refer to the parts lists, the spare parts drawings and hydraulics diagrams for the article numbers for your order.

Article numbers for ordering electrical components are shown directly in the electrics diagram.

4.2 Assembly matrix parts list

2011-11-28
STLDISP125

Baukastenstückliste
Modular parts list

833223

Projekt	**M-XXXX**	**Project**	**M-XXXX**
Teilenummer	**30207923**	**Part Number**	**30207923**
	MISCHBODENKOPF		**MIXED CUTTING HEAD**
Zeichnungsnr.	**3474-01-012-00 A**	**drawing number**	**3474-01-012-00 A**

Pos (1)	Part number (2)	Bezeichnung (3)	Designation (4)	Quantity (5)
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

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Figure VIII - 1: Example of an assembly matrix parts list

1 Item number in drawing

2 Article number of individual part

3 Name of individual part in German

4 Name of individual part in English

5 Number of parts used

Document: 81513-001

4.3 Structure parts list

2011-12-06
STLDISPO68

Strukturstückliste
Modular parts list

839230

Projekt	**M-XXXX**	**Project**	**M-XXXX**
Artikelnummer	**25268970**	**Part Number**	**25268970**
	HYD.SCHEMA STEUERZYL/SCHIEBER		**HYD.DIAGRAM STEERING/VALVE CYL**
Zeichnungsnr.	**3475-45-001-00**	**drawing number**	**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

Figure VIII - 2: Example of a structure parts list

1	Internal Herrenknecht number	5	Name of individual part in German
2	Item number in schematic	6	Name of individual part in English
3	The part can be found at the following coordinates in the schematic	7	Drawing number of the individual part
4	Article number of individual part	8	Number of parts used

5. Addresses of facilities

5.1 Head office

COUNTRY	CONTACT DATA
Germany	Herrenknecht AG Schlehenweg 2; 77963 Schwanau; Germany Tel.: +49 7824 3020 Fax: +49 7824 3403 E-Mail: info@herrenknecht.de www.herrenknecht.com

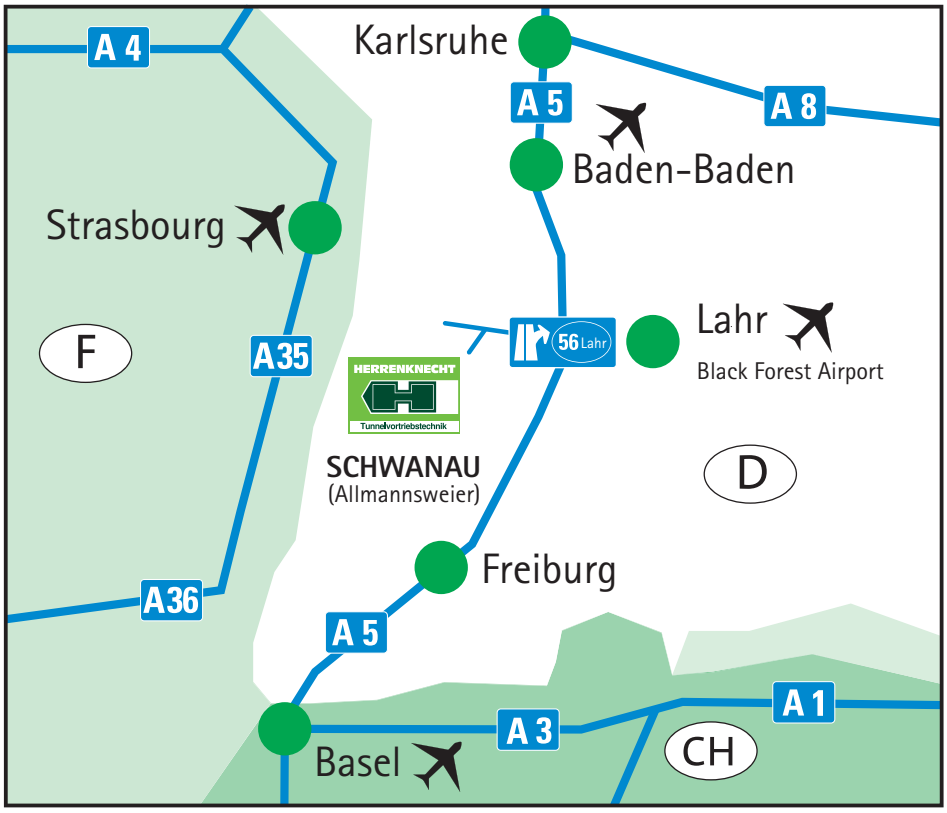

Figure VIII - 3: Route to Herrenknecht AG

Document: 81513-001

5.2 Subsidiaries

NOTE

See:

https://www.herrenknecht.com/en/company/herrenknecht-world-wide.html

5.3 Representatives

NOTE

See:

https://www.herrenknecht.com/en/company/herrenknecht-world-wide.html

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 electrics diagrams.
   – **Depending on your selection, a list will open.**
4. Select and click the supplier documentation, drawings, fluid diagrams or electrics diagrams in the active list.
   – **This opens the desired supplier documentation, drawings, fluid diagrams or electrics diagrams.**

6.2 Overview of the CD

The directory tree on the enclosed CD is always in English.

The folder structure of the CD can vary depending on the product.

The external technical documentation on the enclosed CD is organised as follows:

FOLDER NUMBER/ FOLDER NAME	TRANSLATION FOLDER NAME	DESCRIPTION
01_OperatingManual	Operating Manual	HERRENKNECHT operating manual
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

7. Glossary

7.1 General

DESIGNATION	DEFINITION
Atmosphères Explosibles ATEX	The term ATEX stands for the French abbreviation of ATmosphères EXplosibles. ATEX is a synonym for the ATEX directives of the European Union. These directives comprise regulations regarding explosion prevention.
Bentonite	Clay with a high swelling capacity used in tunnelling for fluid-supported methods as a bentonite suspension: during tunnelling it also serves as the transport medium for the excavated material in the slurry circuit and as a support medium for the tunnel face (thixotropic fluid).
Bentonite mixing plant	The bentonite mixing plant uses a mixing pump to mix the drilling fluid from water and additives in the desired consistency. The mixed drilling fluid is then pumped into a transfer tank or directly to the consumer.
Control cabin	This is the place where the machine operator works; either a background in the control container (in case of remote control) or directly in the machine.
CSC	International agreement regarding safe containers.
Feed line	A pipeline through which the feed medium is pumped through the tunnel and the machine into the excavation chamber.
Feed pump	A centrifugal pump which pumps the feed medium into the machine.
Fitting	Fittings are devices for controlling the flow rate in the pipe system. Fittings can be operated manually (hand levers) or by means of an electrical or hydraulic actuator. Compensators, filters and screens are also referred to as fittings.
Geothermal	Geothermal refers to the heat stored below the surface of the Earth which can be accessed as an energy source. As a regenerative energy source, it is becoming increasingly important as the heat is continually available. Heat can be extracted by drilling to depths of 6000 m; it can then be used for generating electric power, or in cogeneration systems. Near surface drilling up to depths of 250 m can be used to heating and cooling buildings in combination with a heat pump circuit.

DESIGNATION	DEFINITION
Guidance system	System for determining the actual positioning coordinates of the tunnelling machine. Depending on the diameter, these are either systems with a gyro compass (interval measurement) or laser technology (permanent measurement).
Gyro compass	A gyro compass is a compass that a light itself parallel to the Earth's direction of rotation and thus shows the North/South direction.
Hose fittings	Hose fittings are connecting core jointing elements of hoses.
Hose lines	Hose lines are hoses which are functionally connected with hose fittings.
Hoses	Hoses are flexible, tubular semi-finished products which comprise multiple layers and inserts.
Inclinometer	Determines the current roll angle of the laser station and transfers these data via the control unit in the switch cabinet to the control PC.
Lifting accessories	Lifting accessories are used to directly attached loads to the crane hook of the lifting gear. Lifting accessories include cables, hook chains, lifting straps, ropes, chains links and span sets.
Load handling equipment	Load handling equipment (e.g., cranes winches) is used to lift loads with lifting accessories through a friction locking (grab, pipe clamp, clamp) all positive locking (C hook, compensator) connection.
Material Safety Data Sheets (MSDS)	Material Safety Data Sheets (MSDS) provide safety instructions for handling hazardous substances and explain both the risks related to the product and the measures to be taken to mitigate these risks. The material safety data sheets must be laid out or posted at locations where hazardous substances are kept and stored. It must be possible for employees to read the material safety data sheets at any time.
Operating fluids/ consumables	Operating fluid/consumables include all materials required for the additional equipment to function. Hydraulic fluid, coolants, and lubricants are all operating fluids/consumables.

DESIGNATION	DEFINITION
Operating instructions	Operating instructions are provided to staff in a brief and intuitive form with the required information on the risks and protective measures for the activity in question; they are only binding with the signature of the owner/operator or their agent. The operating instructions must be discussed with employees in the scope of documented training and laid out or posted at suitable locations. It must be possible for employees to read the operating instructions at any time.
Operating resources	Operating resources include tools, equipment, machines or plant that support staff in performing their tasks. Tools (drills, electric saws) and additional assembly aids (work platforms) are designated as operating resources.
Overcut	The difference between the bore diameter and the diameter of the shield skin or pipe string.
Pipe system	The pipe system comprises pipes, pipe line parts (fittings, bends), connecting elements (threaded joints, flanges) and hoses. A pipeline is comprised of pipes and pipeline components.
PPE	Personal protective equipment (PPE) is used to prevent and mitigate dangers. Personal protective equipment includes head, eye, face, hearing, breathing, body, arm, hand, leg and foot protection as well as protection against falling and general protection for persons working alone.
Replacement criteria	Criteria defined in the ISO4309 standard that mandate the replacement of a cable.
Replacement state of wear	Cable technology term. Designates the level of damage of a cable at which it must be replaced by a new cable on inspection as per ISO4309.
Rotary coupling	Pressure-tight interface from a fixed to a rotating component. This is typically used for multiple media, e.g., for hydraulic oil for various consumers, bentonite suspension or foam. The largest rotary coupling on the tunnelling system are located at the transition between the shield and the cutting wheel.
Rotary pump	A centrifugal pump pumps the excavated material along with the conveyed material through the machine. The medium to be conveyed enters the centrifugal pump via the suction pipe, is taken in by the rotating pump wheel, and is pressed outwards on a spiral path.

DESIGNATION	DEFINITION
Slurry line	A pipeline through which the excavated material is pumped along with the conveyed material through the machine back to the separation plant.
Slurry pump	A Centrifugal pump which pumps the excavated material along with the conveyed material through the machine back to the separation plant.
Solid matter pump	Piston pump for conveying viscose, pappy media, e.g., grout, bentonite, concrete or condition soil; suitable for high delivery pressures.
Suspension	A mixture of liquid and a solid very finely distributed in it; in mechanical tunnelling this is used as a support and transport medium and/or a flushing liquid.
Target unit	The electronic laser target is used to steer the tunnelling machine. Its four sensors detect the position of the laser beam and transmit the value to the computer in the control cabin. This allows the precise position of the machine to be verified at all times.
Transfer tank	The transfer tank is a container in which the drilling fluid is collected. The transfer pump connected to it is used to pump the drilling fluid to the consumer.
Transport equipment	Transport equipment (fork lifts, lifting carts) is used for transporting loads on a flat surface.
Visualisation	The representation of the values acquired by the sensors in the machine.

7.2 Tunnelling

DESIGNATION	DEFINITION
Annular gap	The cavity between the surrounding soil and the pipe string or the tunnel construction; it is caused by these slightly greater diameter of the cutting wheel or cutterhead compared with the pipe string or tunnel construction.
AVN	Automatic, wet tunnelling machine
AVN machine	Tunnelling machine with hydraulic slurry circuit.

DESIGNATION	DEFINITION
AVND	Automatic, wet tunnelling machine with pneumatic support
AVND machine	Tunnelling machine with additional, pneumatic safety features.
Breathing air	Compressed air treated to achieve a high degree of purity for breathing air quality. This is needed in the man locks for locking in maintenance staff in the excavation chamber and for maintenance work.
Bypass	A ball valve/slide valve through which the water from the feed line can be fed directly into the slurry line.
Compressed air lock	A device for locking in and locking out persons and/or material from the atmospheric area of a tunnel to the area of the tunnel exposed to compressed air. This allows access to the tunnel face for cutting tool changes or removing obstacles. it is typically installed in the front part of the tunnelling machine.
Cone crusher	The cone crusher is located in the steering head/shield on the tunnelling machine. The excavated material is broken down to conveyable grain size between the crusher gibs on the cone crusher and the crusher arms on the cutting wheel/cutterhead.
Cutterhead	In large diameter applications, this is a term for a tool carrier mainly equipped with disc cutters for full-surface hard rock removal in the case of Hard Rock TBMs; when it rotates, it picks up the excavated material and conveys it through integrated channels to the muck ring; in small diameter applications this is a general term for the rotating head on the tunnel boring machine which is equipped with cutting tools; the distinction is made between standard, mixed ground and rock cutting heads.
Cutting tool	The term cutting tool designates all cutters used on a cutterhead/cutting wheel, for example: disc cutters, cutting knives, buckets, centre cutters, etc.
Cutting wheel/ cutterhead	The rotating part of the tunnelling machine which holds the cutting tools.
Drive	A typically annular drive with a freewheeling centre for the cutting wheel and/ or cutterhead on the tunnelling machine; a large annular bearing with inner gearing has multiple sprockets on its circumference which are hydraulically or electrically driven by a planetary gear.
Drive	The drive is the part of the tunnel between the starting and target points.

DESIGNATION	DEFINITION
Erector	A holding device for moving concrete segments during ring building.
Excavation chamber	The space between the cutter head and the cone crusher in which the excavated material is mixed with the feed material.
Excavator	A universal excavator for removing partial surfaces. Depending on the soil characteristics, it can be fitted with a shovel, a bucket or a hydraulic hammer drill.
Extension	Extension means attaching an additional shield skin to the tunnelling machine to achieve a greater outer diameter. It can thus typically be used to excavate the standard pipe diameter and the next largest pipe diameter.
Face support pressure	The positive pressure builds up in the excavation chamber to compensate the existing ground or (ground) water pressure.
Interjack station lost	The interjack station lost is an auxiliary thrust unit which is installed between the product pipes in the tunnel. After the advance the cylinder and the cylinder bearing being removed. The interjack casing remains in the tunnel.
Interjack station (All-steel interjack station)	The reusable interjack station (all-steel interjack station) is an auxiliary thrust unit which is built into the tunnel between the product pipes. After an advance, the interjack station can be reused.
Jacking frame	The thrust unit of the system. The jacking frame is installed in the launch shaft. See also main jacking station.
Machine pipe	As steel tube in which the steering cylinder is actuated and hydraulic valves and electrical components are installed for operating the tunnelling machine.
Main jacking station	A jacking device installed in the launch shaft; also commonly referred to as the jacking frame (pipe driving).
Man lock	A device for locking in and locking out persons and/or material from the atmospheric area of a tunnel boring machine to the area of the tunnel boring machine exposed to compressed air. This allows access to the tunnel face for cutting wheel inspection, cutting tool changes or removing obstacles.

DESIGNATION	DEFINITION
Material lock	A material lock is installed on the tunnelling machine for locking in tools or other materials. To facilitate handling of heavy objects, the lock is equipped with a moving carriage that runs on rails.
Microtunnelling	Tunnelling method during which an unmanned tunnel boring machine is controlled remotely in pipe jacking from a control container on the surface.
Operational compressed air	Compressed air for operating compressed air consumers such as tools, winches, cranes, pumps.
Overburden	The distance between the top edge of the pipeline and the service of the terrain, or the waterway bed above the pipeline. Often referred to as overburden.
Pipe lubrication	A process for reducing the sleeve friction between the pipe string and the surrounding soil and for supporting the annular gap by means of injected bentonite suspension.
Pipe thrusting	Pipe thrusting is a tunnelling method in which prefabricated product pipes are pushed into the excavated tunnel directly downstream of the tunnel boring machine. At the same time these pipes served to propel the tunnel boring machine.
Product pipe	A pipe made of concrete, steel or stoneware which remains in the ground at the end of the drive and thus forms the raw structure of the tunnel.
Refraction	The deflection of the laser target beam caused by changes in the air density along the beam path.
Sea outfall	Generic term for creating pipelines from the coast into the open sea.
Segment lining	Tunnel lining method which uses individual prefabricated concrete parts; the individual segments are transported through the finished part of the tunnel and connected using and erector to form closed rings directly downstream of the tunnelling machine; the tunnelling machine has hydraulic cylinders which support the last tunnel ring to be built during the drive.
Segmental lining	Segmental lining describes a tunnel building method in which the excavated tunnel is lined with concrete or steel segments directly downstream of the tunnel boring machine.

DESIGNATION	DEFINITION
Shield skin	The outer steel shell and at the same time the basic construction of a tunnelling machine; its provides protection against the surrounding soil and the (ground) water; tunnelling machines without a closed shield (gripper tunnelling machines) are only deployed in rock.
Shield/steering head	The moving part of the tunnelling machine or changing direction.
Slab cutters	Special excavation tools which are equipped with a carbide-tipped blade are used as cutting knives. They are screw-attached to cutting knife supports and can be replaced from the rear. Slab cutters are deployed in mixed soil.
Slurry machines	Tunnelling machine with hydraulic slurry circuit.
Tailskin	The rear part of the shield skin; it can be articulated or fixed on the shield skin.
TBM	Tunnel boring machine
Trailing tube	An empty steel tube for absorbing the talk generated by the cutterhead.
Tunnel face	Surface on which material excavation takes place.
Tunnelling	A general term for the process of mechanically creating tunnelling works.
Ventilation	A general term for a supply of fresh air and the extraction of exhausted air in the tunnel.

IX. 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 "DATA\02_Internals-Accessories" folder.

2. Trailing tube power unit

MANUFACTURER	COMPONENT
EMOD	ELECTRIC MOTOR
HYDAC	BLADDER ACCUMULATOR
	PLATE HEAT EXCHANGER
LINCOLN	GREASE PUMP P215
MOTEC	CAMERA

Table 1: Assemblies, accessories

X. Drawings

NO.	PART NO.	DESIGNATION	DRAWING NO.
1	40345835	TRAILING TUBE POWER UNIT	5564-004-000-00
2	40345860	OIL TANK, 430L	5564-004-000-20
3	40234047	55 KW MOTOR PUMP UNIT	5039-004-000-20
4	30096616	MOUNTING KIT	1970-01-005-40
5	30144497	FIXING DEVICE	2606-06-030-20
6	25100831	LASER TARGET HOLDER	208-07-023-32
7	40029762	PIPE BUNDLE HEAT EXCHANGER	809-29-006-11
8	40351312	TELESCOPIC PIPE	809-25-001-10
9	30039981	ANTI-ROLL SYSTEM	809-01-000-20
10	25102954	BENTONITE NOZZLE	809-01-040-00

Table 1: Drawings

XI. Fluid diagrams

NO.	PART NO.	DESIGNATION	DRAWING NO.
1	40345783	HYDRAULIC DIAGRAM TRAILING TUBE	5564-45-010-00
2	40345785	WATER DIAGRAM TRAILING TUBE	5564-47-000-00
3	40345784	LUBRICATION PLAN TRAILING TUBE	5564-46-010-00
4	40048936	WATER DIAGRAM TUNNEL/SHAFT	3939-47-070-30

Table 1: Fluid diagrams

FLUID DIAGRAMS

XII. Electric diagrams

NO.	PART NO.	DESIGNATION	DRAWING NO.
1	40347188	ELECTRICS DIAGRAMS HYDRAULIC POWER UNIT	5564-564-002

Table 1: Electric diagrams