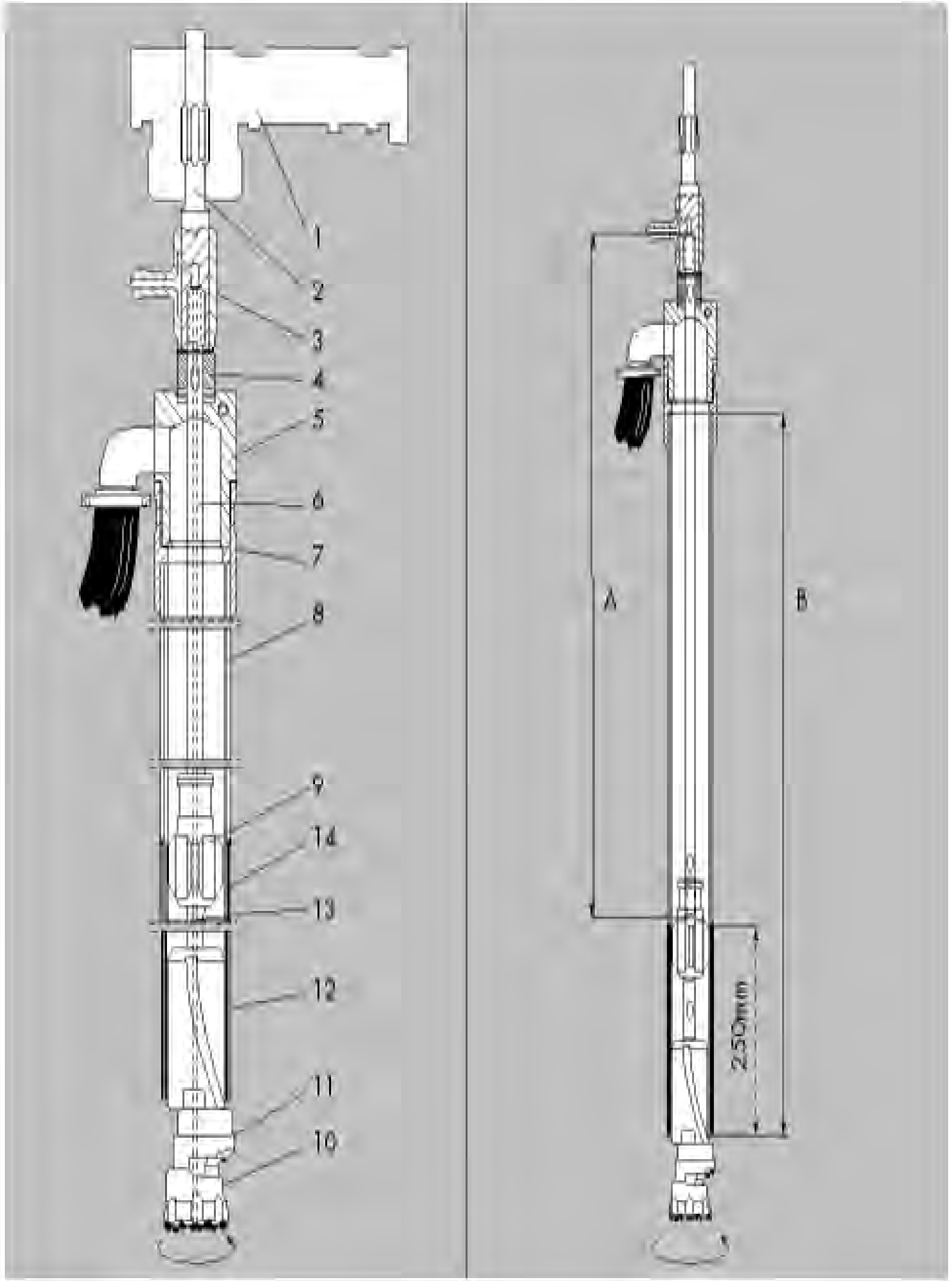
Vedlegg A

Eksempel Topphammer, Odex og OD



Hallingdal Bergboring

Überlagerungsbohren mit Hydraulikhammer
Overburden drilling with top drifter

Ø 114,3 / T45

kegeliges Linksgewinde / *conical left hand thread*

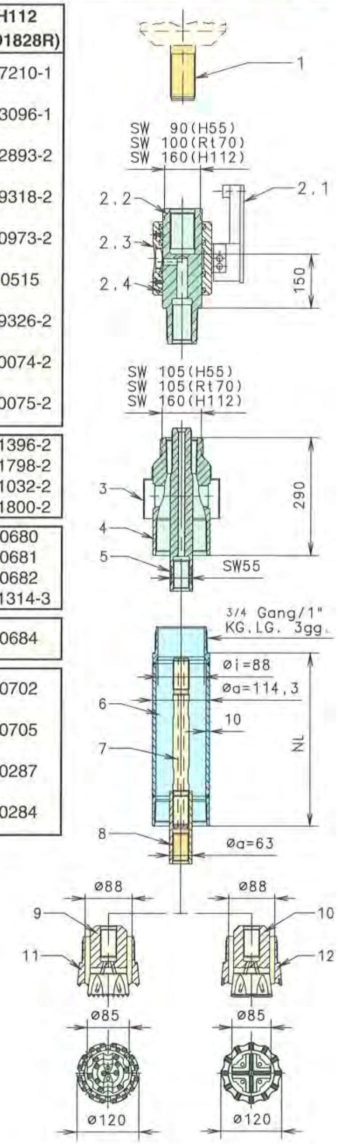
Pos. *pos.*	Bezeichnung *description*	H55	Rt70	H112 (KD1624)	H112 (KD1828R)
1	Einsteckende *shank adapter*	011981-2	067360-1	066141-1	067210-1
2	Spülkopf kpl. *flushing head cpl.*	083973-2	091733-2	093095-1	093096-1
2.1	Spülkopfhalter *flush. head holder*	093150-3	093160-2	080199-1	092893-2
2.2	Spülwelle *flushing rod*	082041-2	091629-2	019318-2	019318-2
2.3	Spülring *flushing ring*	093143-4	093159-4	080973-2	080973-2
2.4	Nutring 4x *seal 4x*	11215	10718	10515	10515
3	Spritzschutz *dirt protector*	019498-3	019498-3	019326-2	019326-2
4	Auswurfglocke *ejection bell*	019512-2	019512-2	020074-2	020074-2
5	Ausgleichstange *balancing rod*	092877-3	092877-3	020075-2	020075-2

6	Drehschlagbohrrohr mit Gewindeverbindern aus Vergütungsstahl *percussion casing with tempered steel thread connectors*	NL 1000	091396-2
		NL 1500	091798-2
		NL 2000	091032-2
		NL 3000	091800-2

7	Bohrstange *drilling rod*	NL 1000	80680
		NL 1500	80681
		NL 2000	80682
		NL 3000	091314-3

8	Verbindungsmuffe *coupling*	80684

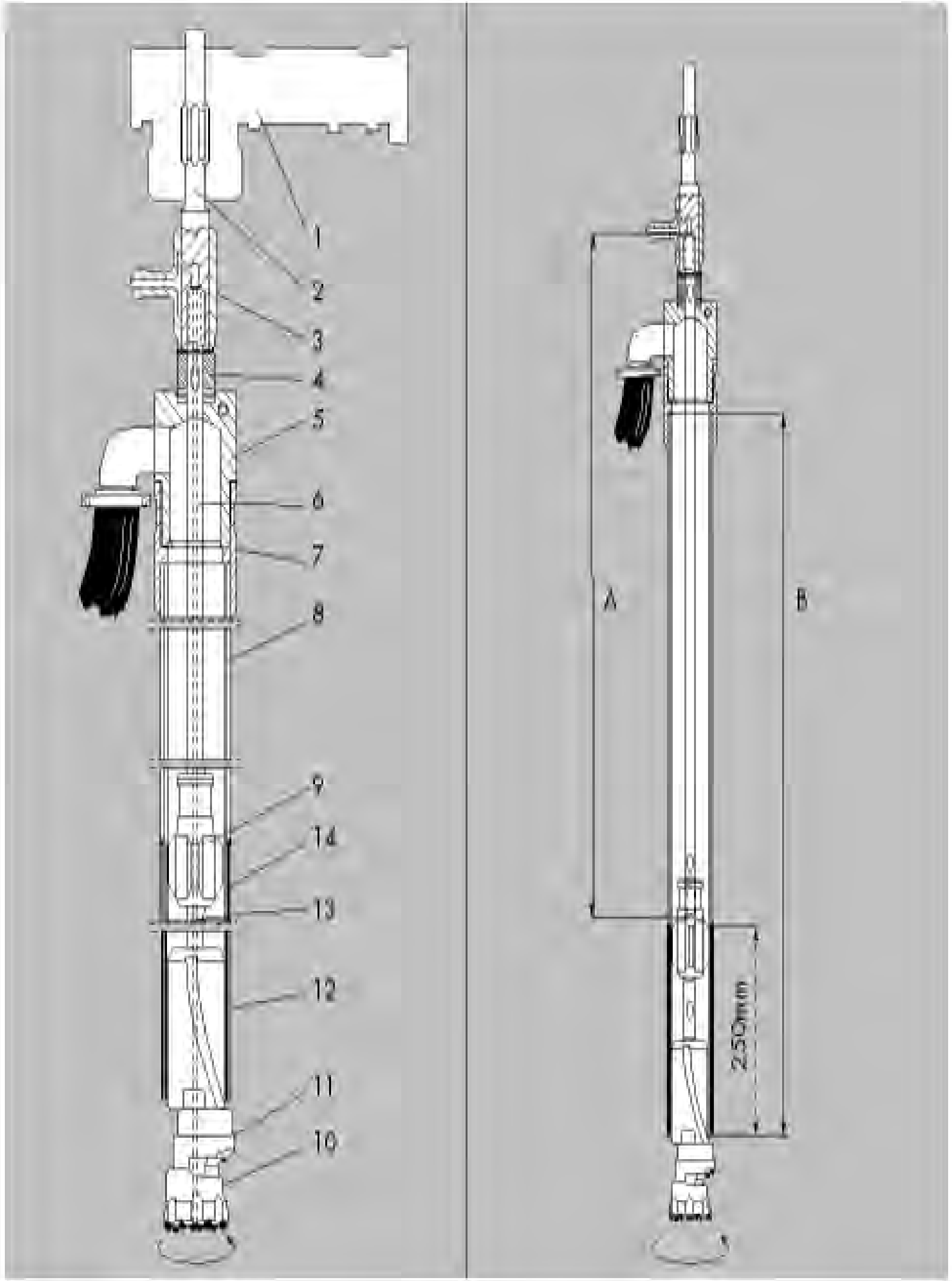
9	Schlagbohrkrone mit HM-Stiften *full face percussion bit with TC-buttons*	80702
10	Schlagbohrkrone (Kreuzschneide) mit HM-Platten *full face cross-cut percussion bit with TC-plates*	80705
11	Ringbohrkrone mit HM-Stiften *casing ring bit with TC-buttons*	80287
12	Ringbohrkrone mit HM-Platten *casing ring bit with TC-plates*	80284



weitere adaptierbare Kronen - siehe gesonderte Übersicht

more adaptable drill bits please refer to extra sheet in this catalogue

Hallingdal Bergboring



Überlagerungsbohren mit Hydraulikhammer
Overburden drilling with top drifter

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3	Spritzschutz *dirt protector*	019498-3	019498-3	019326-2	019326-2
4	Auswurfglocke *ejection bell*	019512-2	019512-2	020074-2	020074-2
5	Ausgleichstange *balancing rod*	092877-3	092877-3	020075-2	020075-2

Pos.	Bezeichnung / *description*	NL	Nr.
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		NL 1500	091798-2
		NL 2000	091032-2
		NL 3000	091800-2
7	Bohrstange *drilling rod*	NL 1000	80680
		NL 1500	80681
		NL 2000	80682
		NL 3000	091314-3
8	Verbindungsmuffe *coupling*		80684
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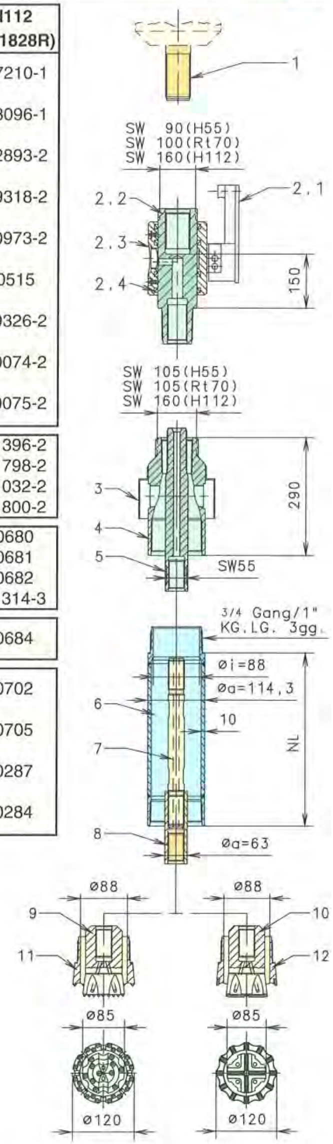


weitere adaptierbare Kronen - siehe gesonderte Übersicht

more adaptable drill bits please refer to extra sheet in this catalogue

KLEMM Bohrtechnik

Rückschlagventile für alle Bohrkronen sowie Schlagbohrkronen als verlorene Vollbohrkronen auf Anfrage. Technische Änderungen vorbehalten.

Non-return valves for all bit types and lost full face percussion bits on request. Specification subject to change without prior notice.

Vedlegg B

Eksempel Senkhammer

Atlas Copco Geotechnical Engineering Products

Terranox DTH hammers

Sustainable Productivity

Terranox
– DTH hammers for geotechnical applications

DTH drilling is gaining increased interest in geotechnical applications all around the world. With advantages such as improved hole straightness and reliable performance in challenging ground conditions, this method is turning into the number one choice for many construction companies and well drillers. Atlas Copco offers a wide range of geotechnical drilling equipment and by introducing the Terranox DTH hammer we create a package with full focus on your application and your demands.

Challenges in urban development
Atlas Copco offers a wide range of high performing drilling equipment designed for percussive drilling. In fact, we offer the most productive DTH hammers in the world. DTH drilling as a method is growing in popularity in both foundation works and in well and geothermal drilling. As the global redevelopment of urban areas continues, this trend comes with a challenge - accessing and drilling in populated areas without damaging the existing structures around the work site. It is obvious that our customers in geotechnical operations have very different demands on the equipment than those working with high production drilling in for example quarrying. The demand for application tailored solutions is increasing.

Low pressure drilling
In production drilling, especially in hard rock, the use of high pressure air is vital in order to flush the drill bit efficiently. In overburden ground conditions, air from DTH drilling might unconsolidate the ground, decreasing the capacity of existing foundations. Construction companies and well drillers are frequently operating in urban areas where existing foundations are sensitive to any kind of disturbance in their immediate surroundings. In geotechnical applications lower air pressure (in the range of 12-18 bar) is therefore recommended. Focus is on reliable and safe operations along with minimal environmental impact.

With focus on your operations
With your operations in mind, we are now proud to present Terranox - a range of DTH hammers dedicated to cost efficient and reliable geotechnical drilling. The Terranox DTH hammers are designed for optimum performance in low pressure operations.

Reliable, well proven technology
The Terranox hammer is based on well proven technology and over 30 years of successful operations in the industry. When working in urban areas, drilling

must usually be accomplished during restricted drilling hours. Reducing down time is critical. Terranox hammers are rugged, reliable and when damaged, easily repaired or replaced. Together with Atlas Copco's worldwide service network, assuring availability of parts, services and support, you can trust this cost efficient product to do the job for you.

A dedicated package

The Terranox DTH hammers are very well suited for use together with our well proven casing advancement systems Symmetrix, Odex and Elemex, the Mustang drilling rigs and Unigrout grouting equipment, all committed to reliable and safe geotechnical drilling. With Atlas Copco you get a unique in-house turnkey solution for your geotechnical drilling operation.

The Terranox product range

The Terranox DTH hammer comes in five sizes. Choosing the right hammer is largely determined by hole size and type of ground conditions. Ideally, the size of the hammer should match the required hole dimension as closely as possible, leaving just enough space for cuttings to evacuate the hole.

Terranox DTH hammers

Description	Thread connection	Outside diameter		Rec. hole size		Shank style	Length without bit*		Weight wihout bit		Part number
		mm	inch	mm	inch		mm	inch	kgs	lbs	
Terranox 3	API 2 3/8 Reg PIN	79	3 1/8	88 - 105	3 7/16 - 4 1/8	DHD	902	35 1/2	30	66	**8393 0826 35**
Terranox 4	API 2 3/8 Reg BOX	92	3 5/8	105 - 127	4 1/8 - 5	DHD	1049	41 5/16	39	86	**8393 0826 40**
Terranox 5	API 3 1/2 Reg PIN	115	4 1/2	130 - 152	5 1/8 - 6	DHD	1166	45 7/8	69	152	**8393 0826 50**
Terranox 6	API 3 1/2 Reg PIN	137	5 3/8	152 - 216	6 - 8 1/2	DHD	1255	49 7/16	103	227	**8393 0826 60**
Terranox 8	API 4 1/2 Reg PIN	181	7 1/8	200 - 270	7 7/8 - 10 5/8	DHD	1443	56 13/16	177	390	**8393 0826 80**

* shoulder to shoulder

Service and tuning kits

In abrasive drilling conditions, partly external components of the DTH hammers are subject for excessive flush blasting and is wearing out before the internal parts reaches their fatigue limits. Wear often appears on the chuck itself or on the cylinder at the chuck-end. For this reason many of the Terranox hammers are designed with reversible cylinders. With help of defined **service kits** the hammers can be rebuilt and most internal parts re-used for another run. Use of service kits, extends the total hammer life and substantially reduces the total drilling cost, as the cost for service kits is only approximately 10% of a new hammer

Terranox hammers are, for optimized drilling performance and hole cleaning, fitted with choke plugs to enable a ultimate tuning of the hammer for each occasion and use. Replacement choke plugs are included in the Terranox **tuning kits**.

For easy logistics defined kits containing the vital parts are available for each hammer as to below table.

Terranox service and tuning kits

	Part number		
	Hammer	Service kit	Tuning kit
Terranox 3	8393 0826 35	8393 0827 23	8393 0827 28
Terranox 4	8393 0826 40	8393 0827 24	8393 0827 29
Terranox 5	8393 0826 50	8393 0827 25	8393 0827 30
Terranox 6	8393 0826 60	8393 0827 26	8393 0827 31
Terranox 8	8393 0826 80	8393 0827 27	8393 0827 32

A rule of thumb for use of service kits

Rock formation	Hammer life	Action
Highly abrasive	< 5 000 m	Use service kit to rebuild the hammer 1-2 times
Medium abrasive	5 000 - 10 000 m	Consider service kit to rebuild the hammer 1 time
None abrasive	> 10 000 m	Rebuilding not recommended, risk that internal parts might fail before the service kit is worn out

Matching hammer and casing diameter

For proper selection of Terranox hammer to match casing diameter, please use cross reference table below. Casing size and drilling conditions will be decisive factors when selecting casing advancement system.

Hammer description	Casing diameter range	
	mm	inch
Terranox 3	114.3	4 1/2
Terranox 4	139.7 - 152.4	5 1/2 -6
Terranox 5	168.3 - 177.8	6 5/8 - 7
Terranox 6	193.7 - 244.5	7 5/8 - 9 5/8
Terranox 8	244.5 - 323.9	9 5/8 - 12 3/4

Selecting compressor capacity

The Terranox hammer range is designed for a maximum working pressure of 25 bar. In overburden drilling applications the air pressure is normally recommended to be kept in the range of 12-14 bars. However, for proper hammer performance throughout the entire drilling operation, the compressor model should be selected to match the corresponding maximum hammer air consumption, shown below.

Drill rig requirements

For proper hammer performance, the geotechnical drilling rig should be equipped with a rotation unit providing minimum torque as per the table shown below.

Hammer description	Minimum torque	
	Nm	lb ft
Terranox 3	600	440
Terranox 4	1 500	1 020
Terranox 5	2 000	1 480
Terranox 6	3 000	2 210
Terranox 8	8 000	5 900

Hammer description	Air consumption (at 24.1 bar)	
	l/s	scfm
Terranox 3	239	506
Terranox 4	292	618
Terranox 5	358	760
Terranox 6	459	973
Terranox 8	725	1 538

Above specifications/ratings are based on initial factory setting

A complete package from Atlas Copco

Casing advancement systems

Atlas Copco offers three casing advancement systems: Symmetrix, Elemex and Odex. With these systems a casing pipe is installed simultaneously as the hole is drilled. The casing prevents the hole from collapsing. Using the Atlas Copco casing advancement systems is particularly advantageous for foundation works or well drilling in urban areas. The systems offer high productivity even if the ground contains boulders, concrete blocks or old foundations which are hard to penetrate and they can easily drill a rock socket into the bedrock if required. When used for micropiling, cased piles can accommodate large load concentrations also from lateral forces.

The drilling principle is based on a pilot bit and a reamer bit, which together drill a hole larger than the external diameter of the steel casing. This enables the casing pipe to follow the drill bits down the hole. Odex has an eccentric reamer bit while Symmetrix and Elemex feature a concentric reamer called ring bit.

Symmetrix

The concentric drill bit design gives Symmetrix plenty of benefits: incomparable hole straightness, deep drilling capability and incredible quick pile setting. Symmetrix is ideal tool for all kind of ground conditions and superior when there are big obstacles in the ground or sloping bedrock exists. For well drilling, the Symmetrix range offers drill-through systems. When the surface portion is cased and sealed in the overburden layer, the pilot bit can drill further into the bedrock without having to change drilling equipment. Symmetrix is also capable for all types of micropiling work whether there is an end-bearing or friction pile to be drilled.

Elemex

The Elemex system design is based on the Symmetrix concentric system but is especially designed for DTH drilling in urban areas or sensitive ground. The unique concept behind the Elemex design is built on redirection of the air flow. Once the air reaches the bit face, it is blown against the extended ring bit walls which redirects the flow across the face. This way, the air pressure is decreased just enough to allow an efficient flushing of the bit face without escaping to the surrounding ground. Elemex is gentle on the surrounding but tough on the boulders that might come in its way.

Odex

The eccentric, retrievable Odex system is ideal for short holes up to 273 mm (10 3/4") in diameter. Well drillers often have an Odex drill bit at hand for simultaneous casing of water and geothermal wells. Odex offers quick and cost efficient drilling. When a casing has been installed, the complete drill bit is retrieved – ready to drill the next hole. Odex system was originally developed, in the late 1960's, as a reliable method for micropiling with steel core piles, as is today still very popular when drilling in basic ground conditions.

Vedlegg C

Eksempel Vannhammer

WATER-POWERED DRILLING
IN GROUND ENGINEERING

"When drilling in formation close to buildings and other constructions, it's crucial that the drilling operation itself doesn't undermine any buildings. We always use Wassaras water-powered DTH hammer in sensitive areas to ensure a benign drilling."

Björn Biller, Drilling Manager for Ground Engineering at Veidekke, Sweden

STRAIGHT FORWARD DRILLING

The Wassara technology uses water to power the hammer. This makes it the ideal choice for most drilling applications in ground engineering – for drilling in sensitive areas as well as for drilling long straight holes. The water-powered DTH hammer is capable of penetrating any formation while maintaining speed and straightness. Hard rock, boulders, concrete, lime stone, granite, till, water rich formations and dense clay. The jet grouting hammer also enables jet grouting in one single pass.

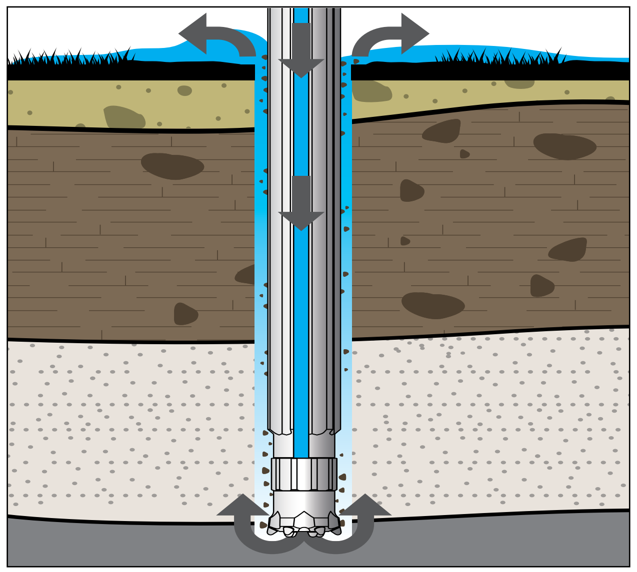
Suitable for most ground engineering applications

When drilling in the ground, there are several aspects that affect the work: Type of formation (till, dense clay, water-rich formations, boulders, etc.), requirements on the borehole (length, accuracy, etc.) and environmental concerns (drilling in sensitive areas, noise restrictions). Wassaras drilling technique meets basically all the challenges that might arise due to these different aspects. Wassaras water-powered DTH hammer is developed to handle any formation, and is suitable in numerous applications:

- Drilling in sensitive areas
- Casing advancing
- Geo energy / geothermal drilling
- Jet grouting
- Maritime drilling

How Wassara works

The Wassara technology uses high-pressure water to power the DTH hammer. Water enables a high frequency and high power output. When the water leaves the hammer it has a sufficient velocity to bring the cuttings and debris to the surface and clean the hole. Besides clean and straight holes with a minimum of deviation, Wassara offers superior benefits like high productivity, borehole quality and minimum impact on the formation you are drilling in.



The principles of water-powered drilling

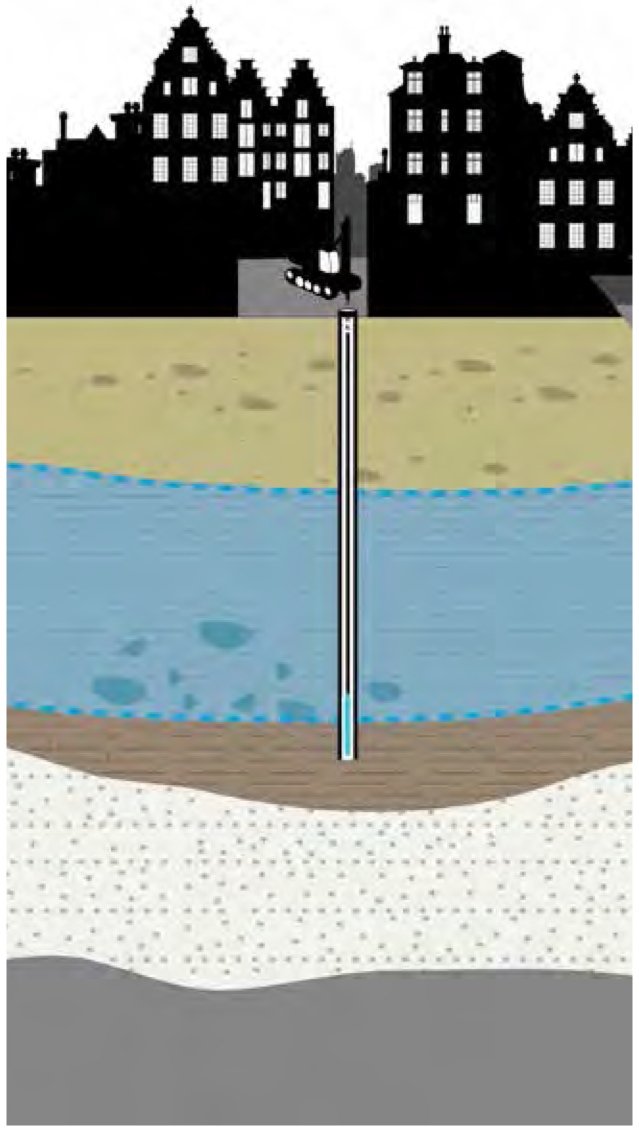
DRILLING IN SENSITIVE AREAS

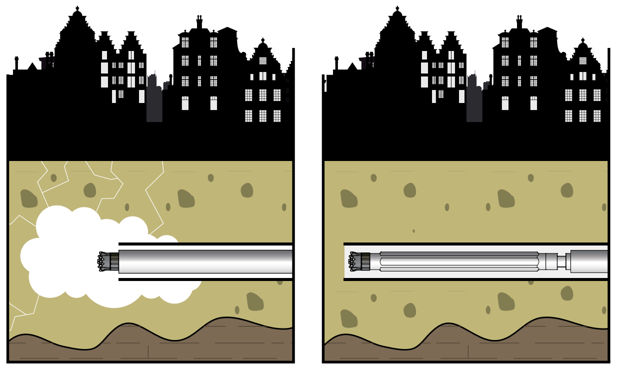
Foundation work and ground engineering with Wassara

Minimal impact on ground water table
Urban areas are often considered as sensitive and must not be affected by side effects from a drilling operation. This means that no impact is allowed on the ground water level, or any injection of oil or air to the formation.

No risk of harming buildings
When drilling with Wassara, the risk of pressurising the formation is minimised as the water quickly lose pressure when leaving the hammer. When drilling with air-powered equipment, there is always a risk of pressurising the formation. If the formation is filled with cracks or cavities, the expanding air may cause hazard to adjacent structures.

Better work environment
Air-powered drilling in urban areas often face environmental restrictions in terms of allowed noise level and injection of oil or dust to the air. Wassaras water-powered drilling gives no injection of oil or dust in the formation, and is far quieter than top hammers since the percussion takes place down in the borehole.





Wassara (right image) minimises the risk of pressurising the formation

THE BANCO HOUSE IN OLD TOWN, STOCKHOLM, SWEDEN

Mission: Re-enforcing of a cultural monument in Stockholm, an old bank house from 1734. The house was once built on a formation comprised of old wooden piles, old filling material and clay. A total of 400 holes with casings were to be drilled.

Result: The benign drilling with Wassara proved a great success since the difficult formation didn't affect the drilling. Drilling indoors was no problem as the water could be discharged by a separate system.

CASING ADVANCING

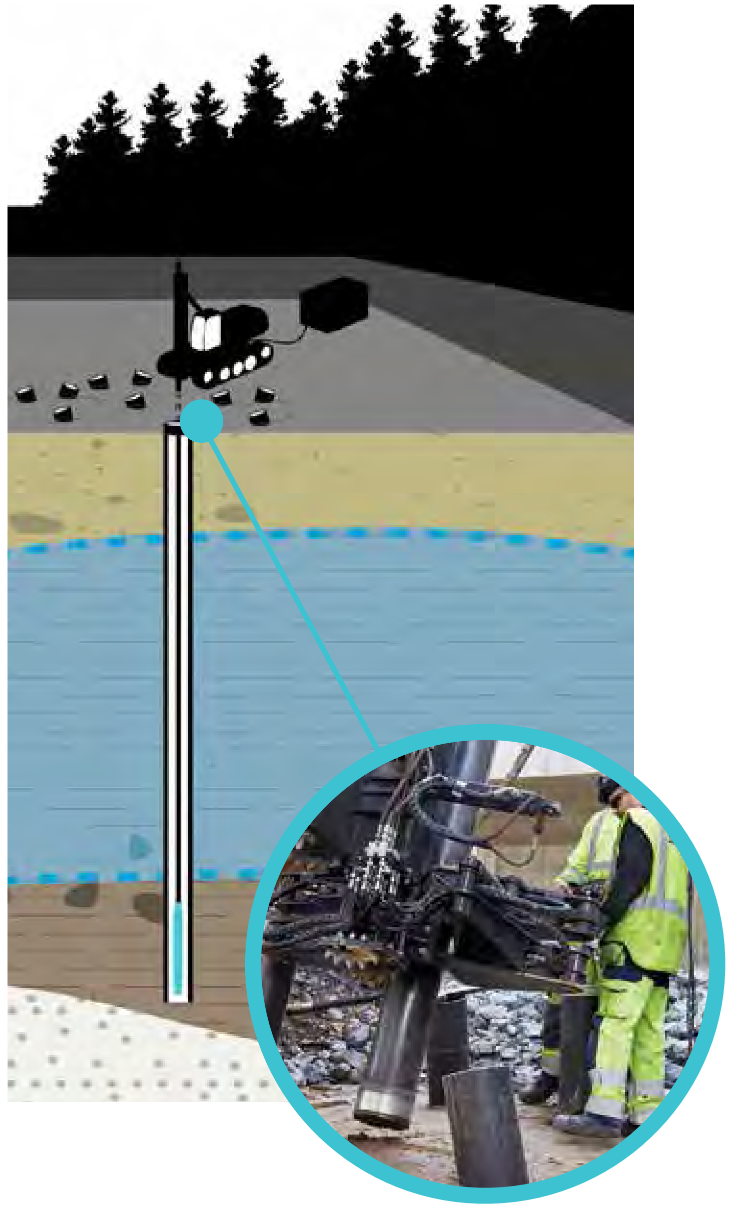
Foundation and reinforcement work with Wassara

High drilling performance
Wassara is proven to be a reliable method for casing advancing. The water lubricates the casing, which enables a smoother drilling operation. When casing advancing in longer holes, Wassara is often the only feasible method. Wassara offers drill bits and casing shoes developed for the water-powered drilling technique.

Drills through any formation
As Wassara is a water-powered percussion system, it's able to drill through complex formations, from soft clays and sands to harder rock, boulders and even through old wooden piles! The Wassara system is unaffected by water in the formation, even at high back pressure.

Safer and more benign drilling
Because water is an incompressible medium, the risk of causing damage to the surrounding services or adjacent structures when drilling is minimised. Air-powered drilling always faces a much higher risk of pressurising the formation, leading to hazard for adjacent structures.

More environmental-friendly
No dust or oil mist is created by the drilling operation, which leads to a safer, cleaner environment for both site personnel and the general public. When drilling with Wassara, it is possible to place the water pump well away from the drilling area, enabling a quieter and healthier workplace.



THE CITYBANAN RAIL LINK PROJECT AT THE CENTRAL STATION IN STOCKHOLM, SWEDEN

Mission: Preparing the ground for building a work tunnel. As the main line was only five meters away, subsidence was strictly forbidden. The formation comprised a thin layer of till on top of soft clay, making drilling with air-powered equipment both impossible and forbidden.

Result: The whole drilling operation was smooth and easy. No subsidence was detected.

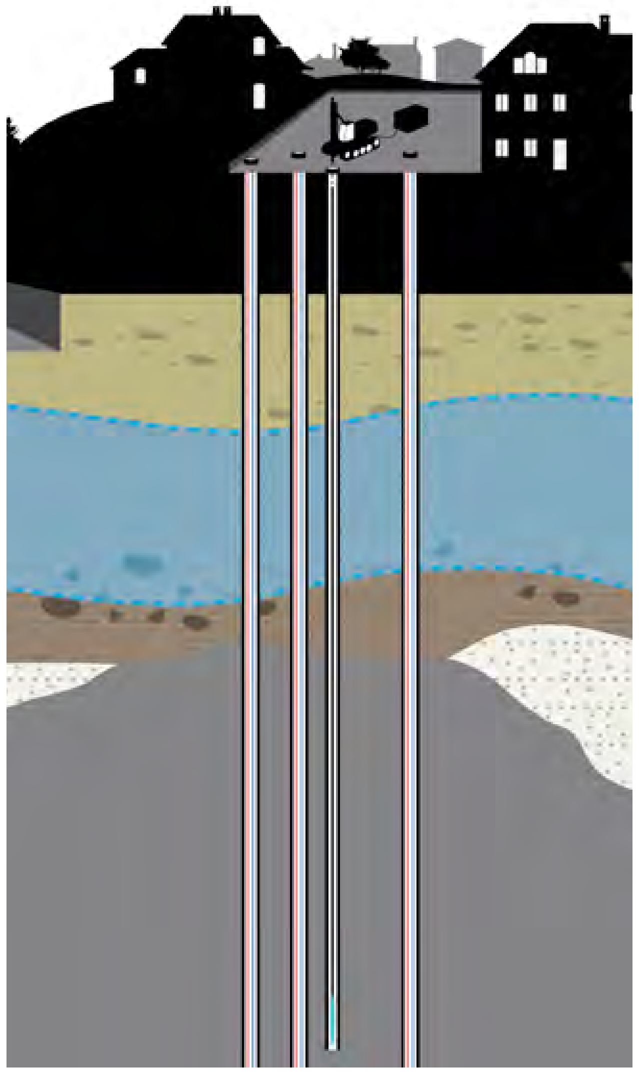
GEO ENERGY AND GEOTHERMAL DRILLING

Drilling long holes with Wassara

Long straight holes
When drilling several long holes, minimised borehole deviation is crucial as the holes might collide otherwise. Wassara has proven its capability to drill long straight holes that are not affected by the water table. The ability to drill fewer holes to larger depths is also one of the advantages of the water-powered drilling technology – especially in restricted areas where space is limited.

Drills through different formations
Drilling in areas with layers of different formations can be tricky. Dense clay is one of the more troublesome formations for conventional equipment to handle, while Wassara penetrates it with maintained speed and straightness. The water-powered DTH hammer is capable of penetrating any formation.

Efficient and secure in water rich formations
To drill in water rich formations with air-powered equipment is hazardous; the air wants to push the water to the surface. This gives far reduced, if any, drilling efficiency. With Wassara, water in the formation is not a problem. The surrounding water will not affect the drilling at all. Nor does the drilling affect the water in the formation.



GEO ENERGY STORAGE TO A LARGE CONFERENCE CENTRE IN MALMÖ, SWEDEN

Mission: Drilling 75 holes of 280 meters length in very water-rich formation. Maximum allowance of water fed to sedimentation system: 190 m³ per day. Earlier drilling with air-powered DTH gave 100 m³ every hour.

Result: Wassara kept the tight time schedule without exceeding the allowed amount of water fed to the sedimentation system.

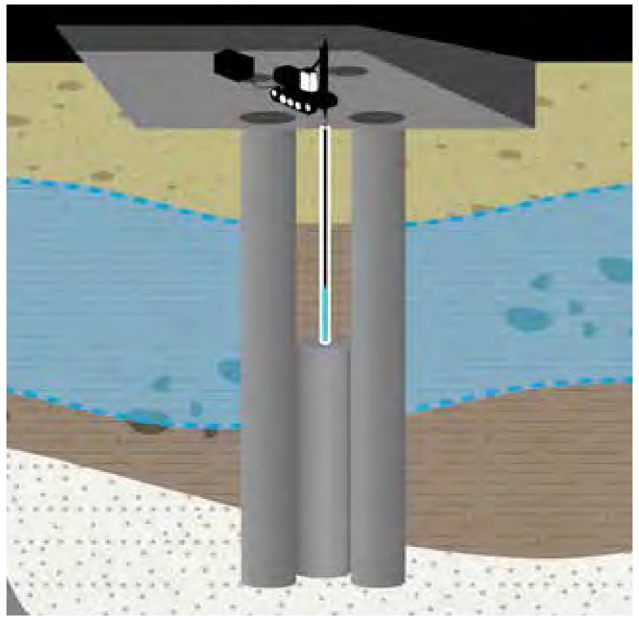
JET GROUTING

Enabling single pass jet grouting

Drills through any formation
Wassara Jet grouting hammer enables single pass jet grouting in difficult formations. This eliminates the need for more than one drill rig and jet grouting equipment. As the hammer and jet monitor are powered by separate pumps, they can be controlled independently of each other.

No changing of equipment
Where stones, boulders and other obstacles have made jet grouting complicated, Wassaras patented Jet grouting hammer makes the procedure easier. As the drill string is complete with all necessary tools, no changing of equipment is required during the whole operation.

Performance
By pre-cutting with water or air through the nozzles during the drilling phase, it's possible to produce larger diameter columns than with conventional single fluid jet grouting systems.



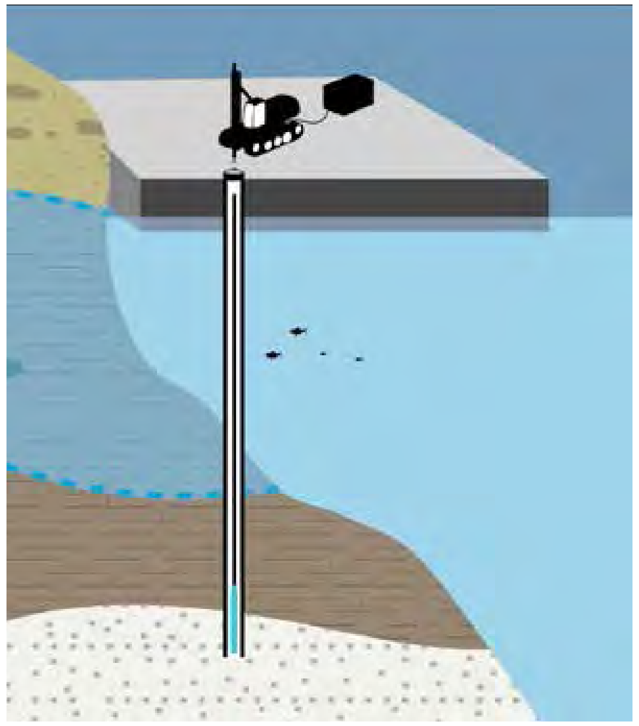
MARITIME DRILLING

Foundation and reinforcement work under water with Wassara

Highly efficient
In maritime projects, like drilling in harbours, the Wassara technique offers superior efficiency compared to conventional drilling methods. The capacity is falling quickly when drilling with air-powered DTH hammer. With Wassara the capacity and speed is maintained during the whole operation, the surrounding water does not affect the drilling.

No oil in the water
Another benefit with the Wassara technique is that it uses no oil, which eliminates the risk of any oil polluting the water. This is often a strict requirement when drilling in maritime areas.

Minimised risk of pressurising the formation
The likelihood of pressurising the formation is very low with Wassara. This is always a risk when drilling with air-powered DTH equipment. Cracks and cavities in the formation will be at risk of expanding drastically with the expanding air.



THE KEY BENEFITS WITH WASSARA

Safer and more benign drilling

The Wassara drilling technique minimises the risk of pressurising the formation, which ensures a minimum of disturbance to the surrounding services and adjacent structures. The ground water table is not impacted – and neither does the ground water table impact the drilling work.

Better borehole quality and accuracy

With Wassara you get straight and stable boreholes, thanks to the tight clearance between drill string and borehole. The stability is maintained by the water column's hydrostatic pressure. Also, the low up-hole velocity of the water prevents creation of cavities, which means cleaner and smoother holes.

High and versatile performance

Since the Wassara technique itself uses water, it drills through water-rich formations without problems. The high penetration rate also provides very efficient and fast drilling through almost any material, from boulders and wood to dense clay and old foundations.

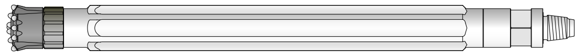
Cost effective

The energy consumption with Wassara is normally 50–80% less than with air-powered drilling systems. Another cost saving factor is the minimum wear on the equipment, due to the low up-hole velocity of the water.

Less environmental impact

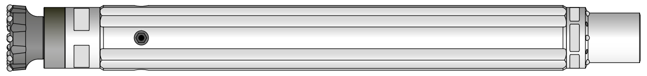
The water-powered technique gives no pollution as no oil is used to lubricate the hammer, only pure water is used. You get no injection of air or oil in the formation, no influence of oil in the ground water and no oil mist or dust distribution in the air – all important benefits, not least for the work environment.

Hammer range



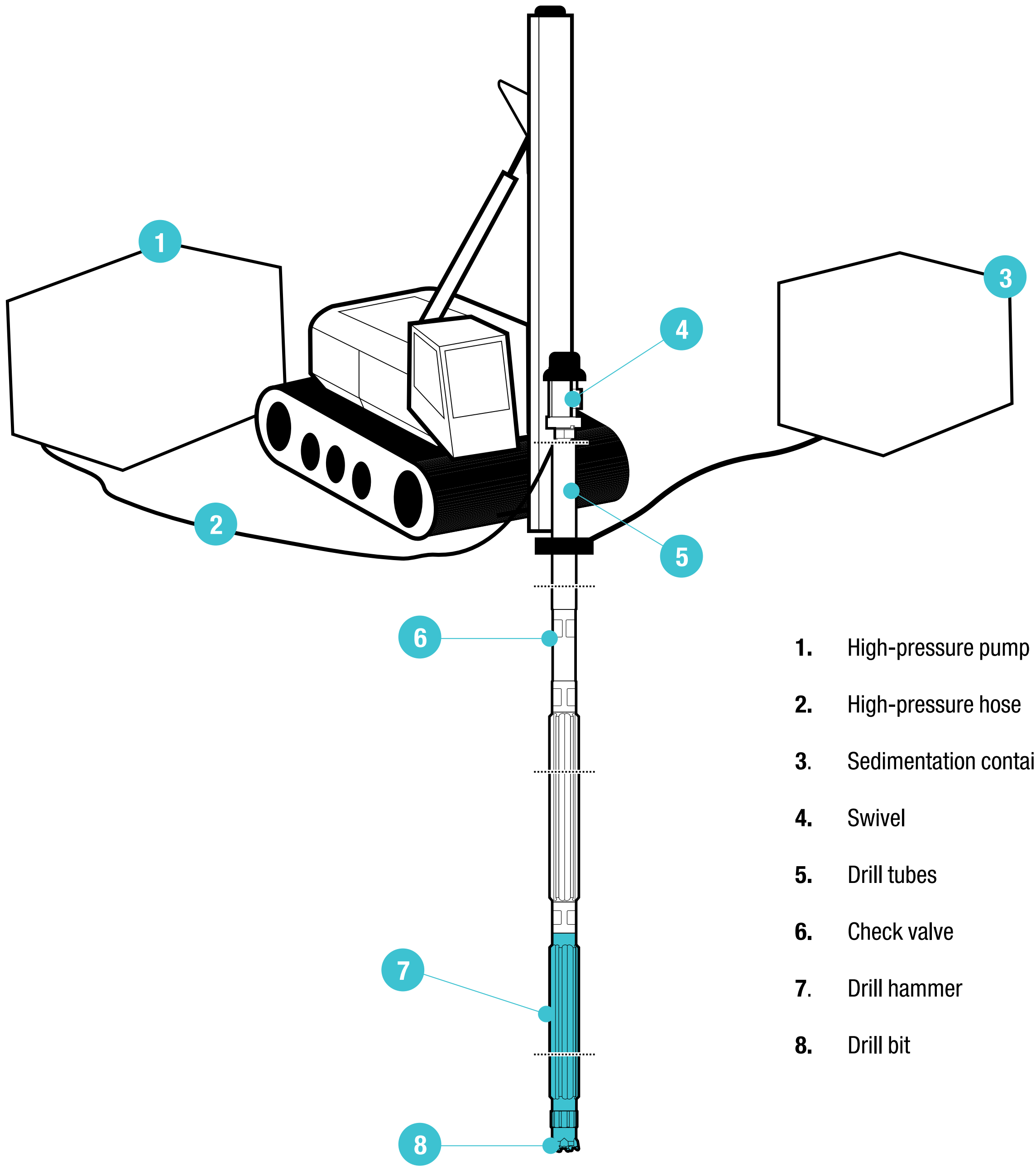
Hammer	Ø Drill bit	Water consumption	Max operating pressure
W50 (2")	60mm, 64mm (2 ⅜'', 2 ½")	80-130 l/min (20-35 USgpm)	170 bar (2500 psi)
W70 (3")	82mm, 89mm (3 ¼", 3 ½")	130-260 l/min (35-70 USgpm)	180 bar (2600 psi)
W80 (3.5")	95mm (3 ¾")	130-260 l/min (35-70 USgpm)	180 bar (2600 psi)
W100 (4")	115mm, 120mm (4 ½", 4 ¾")	225-350 l/min (60-95 USgpm)	180 bar (2600 psi)
W120 (5")	130mm, 140mm (5 ⅛", 5 ½")	300-450 l/min (80-120 USgpm)	180 bar (2600 psi)
W150 (6")	165mm (6 ½")	350-500 l/min (95-130 USgpm)	150 bar (2200 psi)
W200 (8")	216, 254mm (8 ½", 10")	470-670 l/min (125-180 USgpm)	150 bar (2200 psi)

Hammer range – Jet grouting



Hammer	Ø Drill bit	Water consumption	Recommended operating pressure	Max grout pressure
W100JG	153, 165 mm (6", 6½")	200–350 l/min (52-93 USgpm)	170 bar (2500 psi)	500 bar (7250 psi)

THE WASSARA SOLUTION



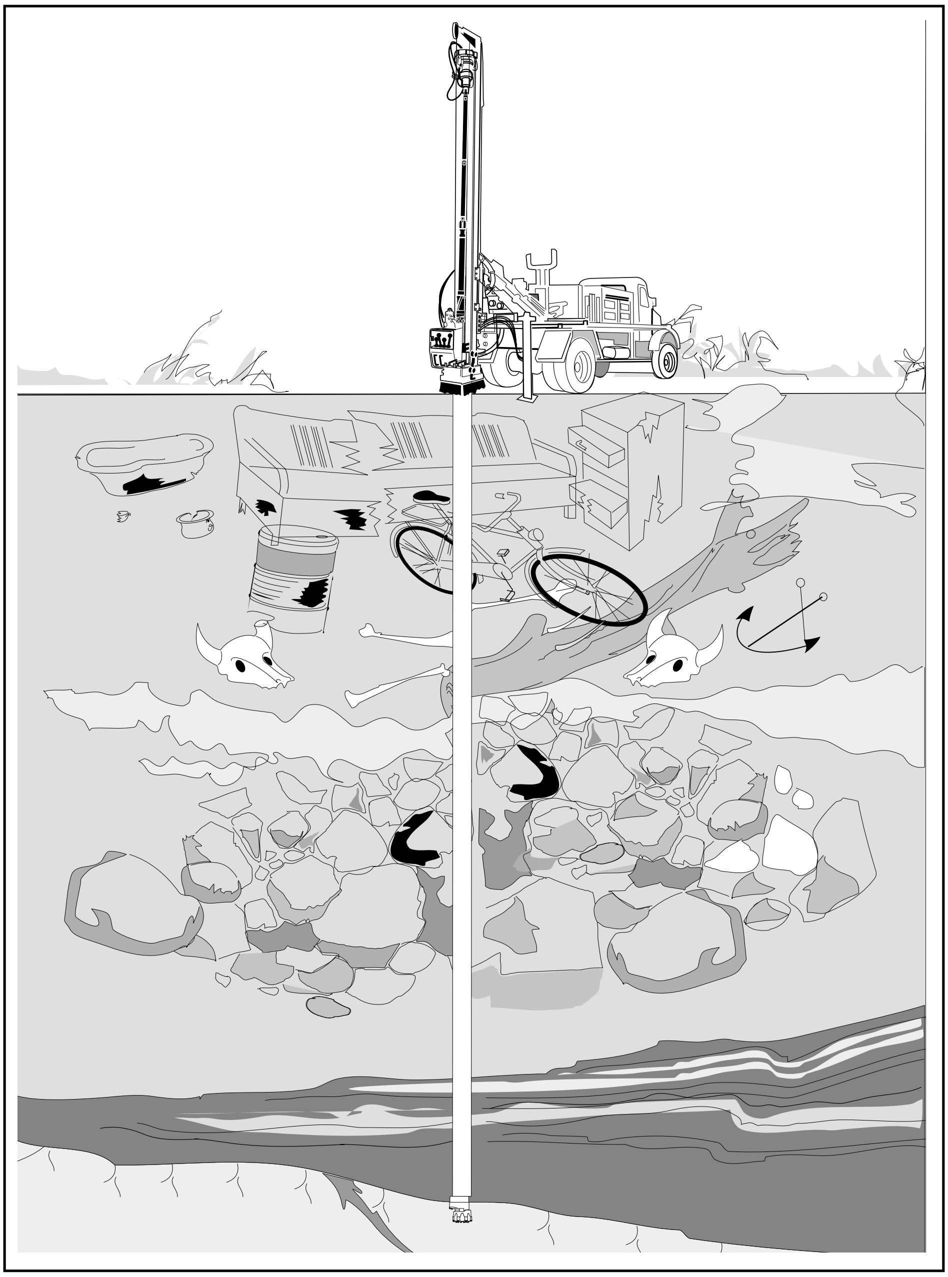
1. High-pressure pump
2. High-pressure hose
3. Sedimentation container
4. Swivel
5. Drill tubes
6. Check valve
7. Drill hammer
8. Drill bit

Vedlegg D

Utdrag fra brukerhåndbok eksenterboring

DTH DRILLING TOOLS

TUBEX XL



Mission overburden rock drilling tools

USER´S HANDBOOK

MISSION

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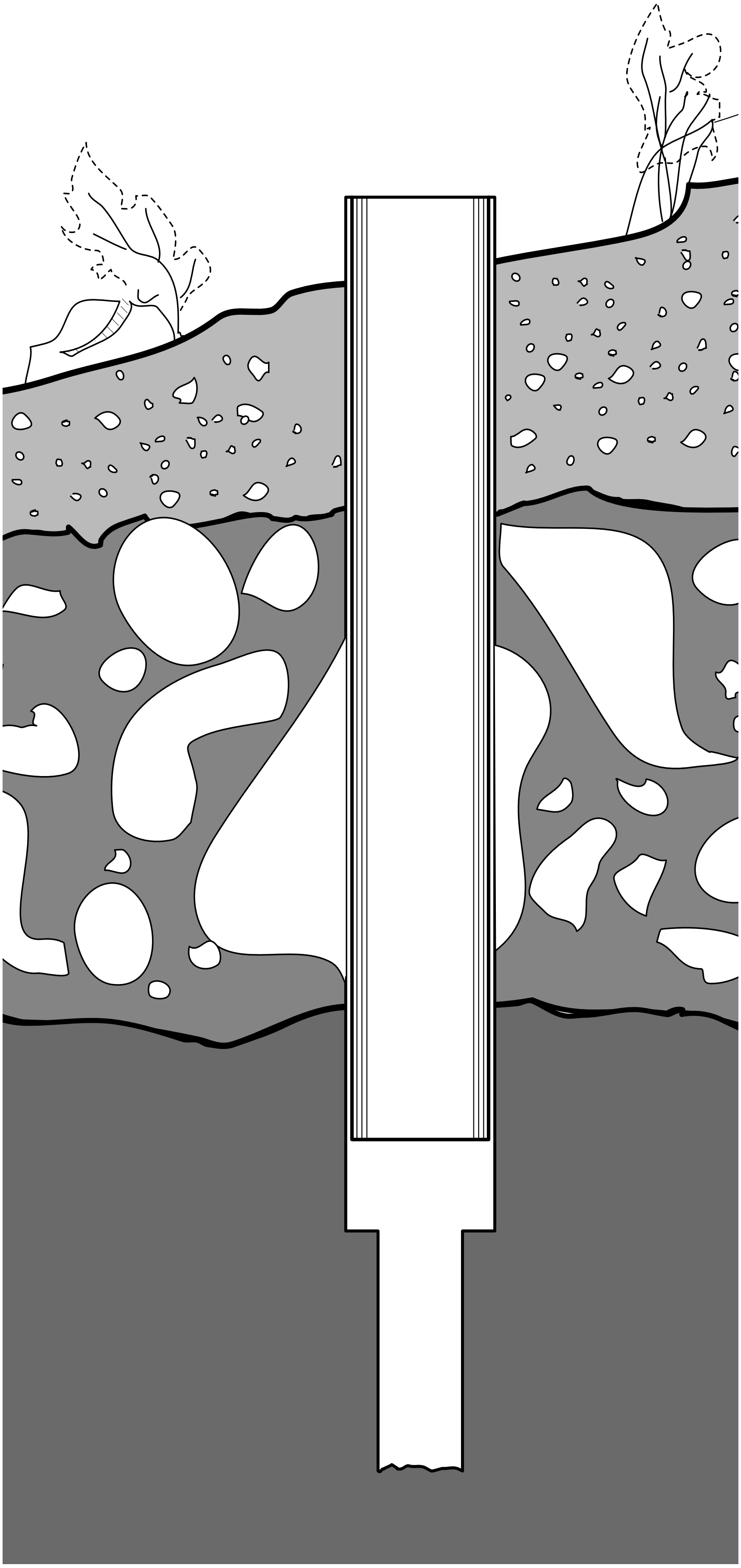
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DESCRIPTION OF THE TUBEX XL METHOD

Approximately 90 percent of the earth's surface is covered with layers of soil, clay, gravel, sand or moraine. This covering is known as overburden. The thickness of the overburden, i.e. the distance from the surface to the bedrock, varies considerably. It can be any-where between a few centimetres and several hundred metres.

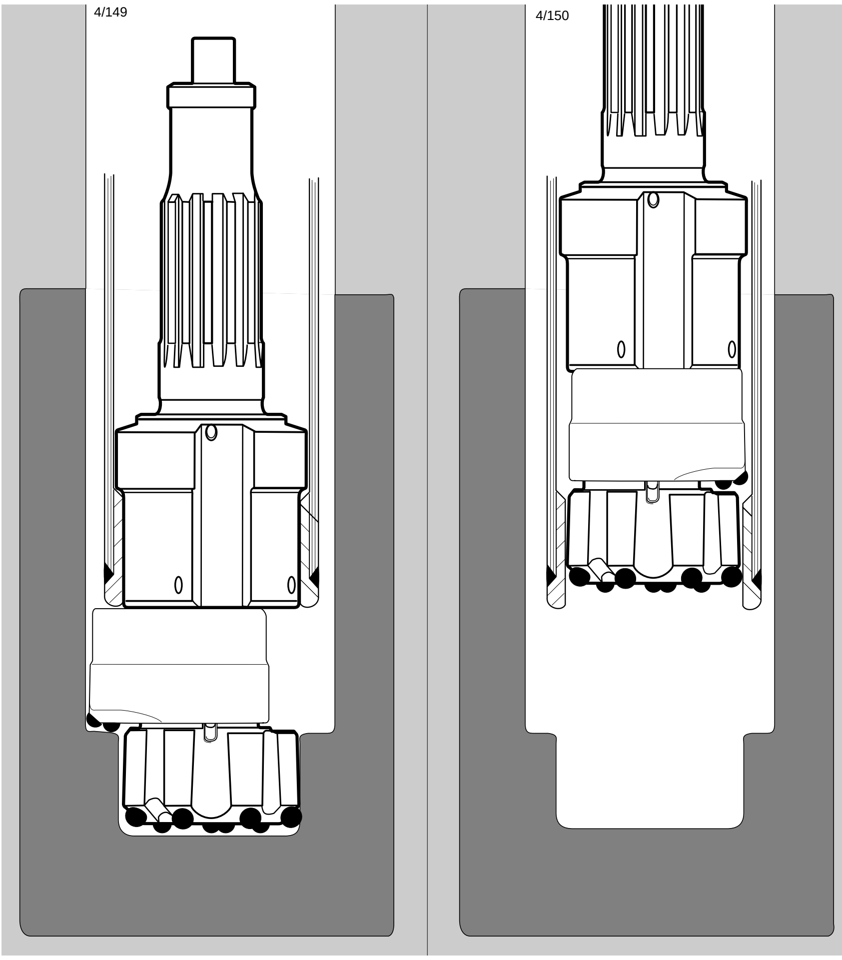
It is impossible to drill through loose overburden using conventional drilling methods. This is because the hole walls collapse continuously, which renders the drill hole useless. The TUBEX XL method was developed by Sandvik to solve this problem. TUBEX XL enables a unique form of simultaneous drilling and casing, in which the hole is lined with casing tubes as drilling proceeds. TUBEX XL equipment is available for both tophammer and down-the-hole (DTH) drilling. It enables holes to be drilled successfully through all kinds of overburden, even that in which boulders of varying sizes are suspended.

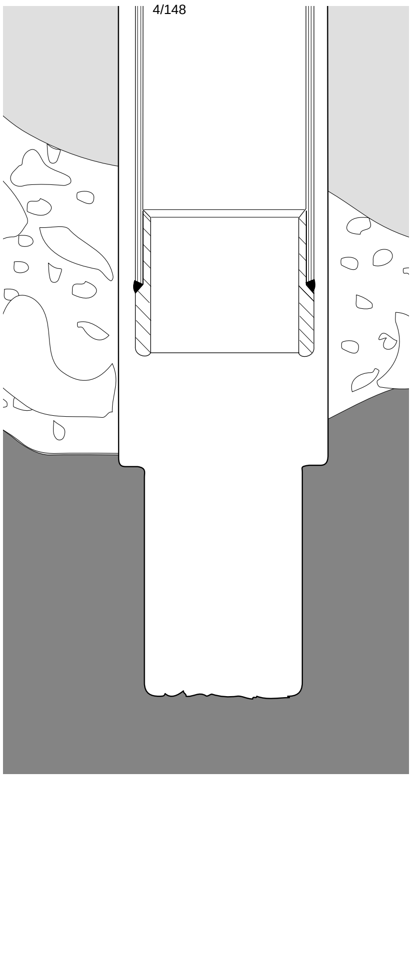
With the TUBEX XL method, the casing tubes do not need to be rotated during drilling. Instead, they are tapped down behind the TUBEX XL equipment, with the aid of a little percussion energy from the rock drill.

PRINCIPLE OF OPERATION

The TUBEX XL method is based on the principle of under-reaming, which makes it possible to install the casing tubes without the use of rotation, at the same time as the hole is drilled.

When rotation to the right (DTH) or left (tophammer) is engaged for drilling, the reamer swings out around the eccentric shaft of the TUBEX XL pilot bit. This enables it to ream a hole that is slightly larger than the outside diameter of the casing tubes. Once the desired depth has been reached, the direction of rotation is momentarily reversed, which causes the reamer to swing inwards around the eccentric shaft of the pilot bit. This enables both the pilot bit and reamer to be pulled up through the inside of the casing tubes, which remain in the hole.





With the TUBEX XL equipment removed, it is possible to continue drilling the hole through the bedrock, using conventional drilling equipment. To prevent the ingress of surface water, e.g. in water-well drilling, the casing tubes can be grouted into position where they meet the bedrock. In any event, they should be driven firmly down to the actual bottom of the reamed hole.

WHEN IS TUBEX XL USED?

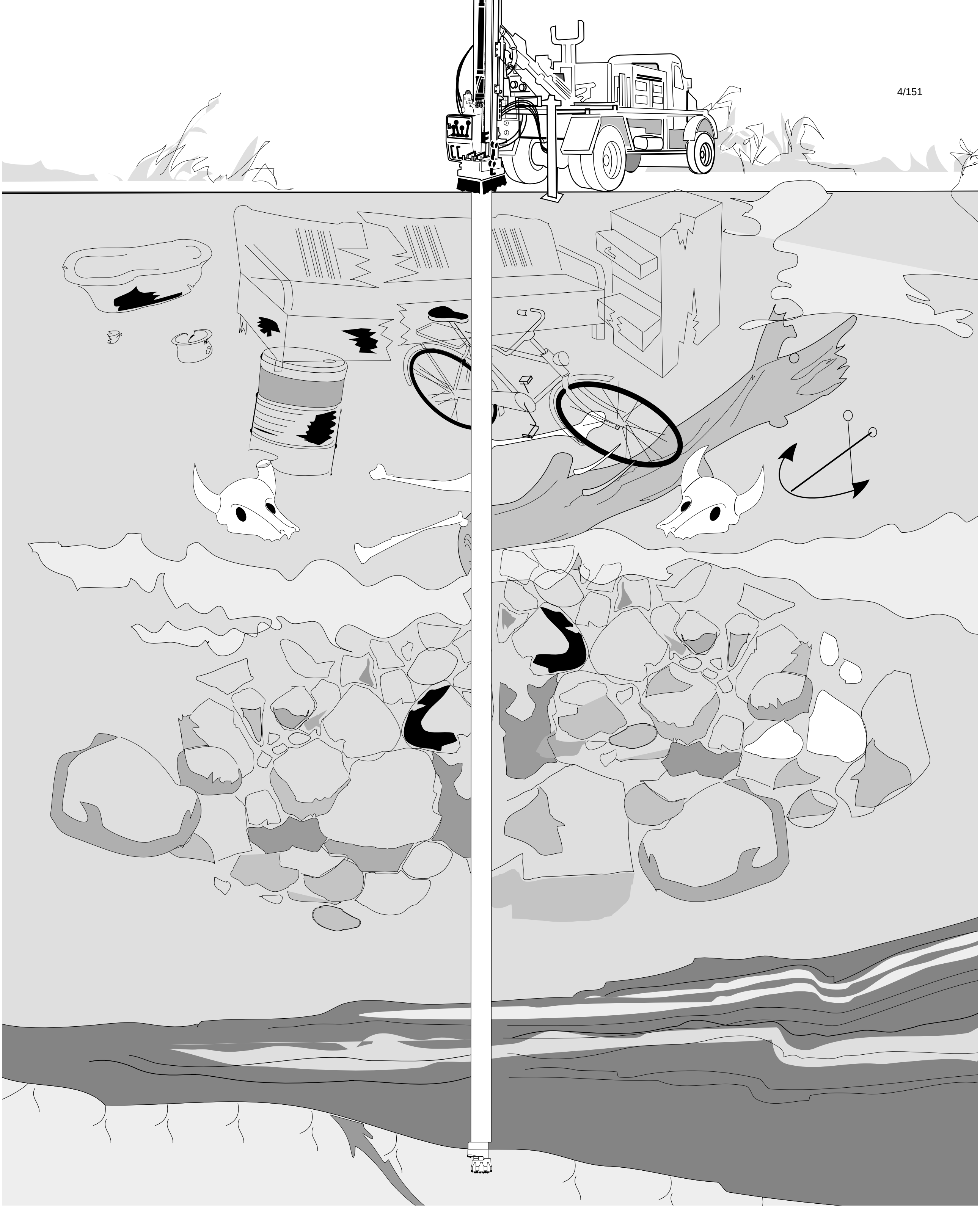
The TUBEX XL method can be used when any of the following difficulties arise:

1 Whenever there is poor hole-wall stability, which calls for the use of casing tubes.

2 When the overburden contains stones and boulders.

3 In fragmented rock formations.

4 When drilling through land fill, rubbish dumps etc. of varying composition, e.g. wood, bricks, scrap iron.



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ADVANTAGES OF THE TUBEX XL METHOD

1 The hole is cased at the same time as it is drilled.

2 The equipment is designed to drill-and-case through thick layers of overburden, which can vary greatly in composition.

3 The drilling and reaming equipment can be pulled up through the casing tubes, which means that:

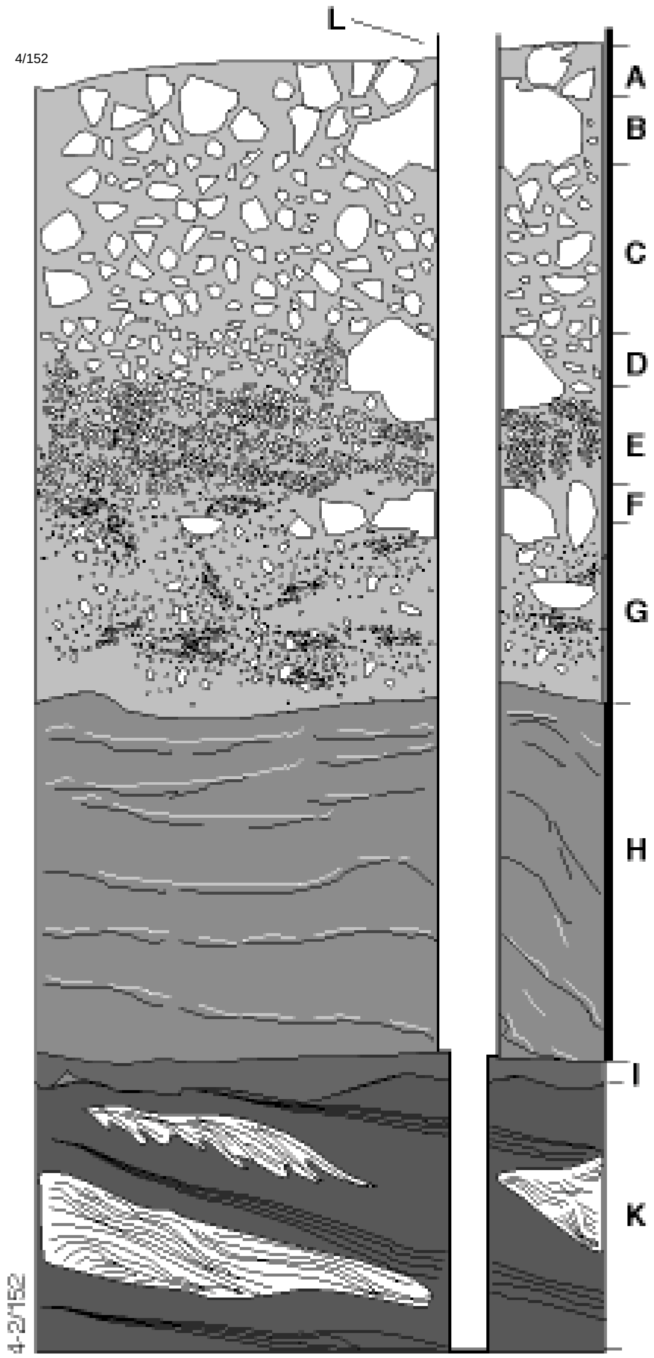
- inexpensive casing tubes can be left in the drill hole;
- drilling can be continued with conventional equipment after the casing tubes have reached the bedrock;
- it is possible to take continuous soil samples.

4 Since the casing tubes are not rotated, only moderate rotation forces are needed.

5 TUBEX XL can be used on most conventional drill rigs, even those that are small and simple. Adaptation for use with TUBEX XL is minimal and inexpensive.

6 TUBEX XL does not harm the environment.

7 TUBEX XL can be used on worksites where space is limited.



Example of typical TUBEX XL drilling:

A 1.5 m large stones
B 2.0 m boulder
C 5.0 m - moraine containing large stones
D 1.5 m - boulder
E 3.0 m - sandy moraine
F 1.0 m - boulder
G 5.0 m - coarse sand with transition to clay
H 10.0 m - very hard, stone-free clay
I 1.0 m - rock
K Bedrock
L 140 mm casing tubes

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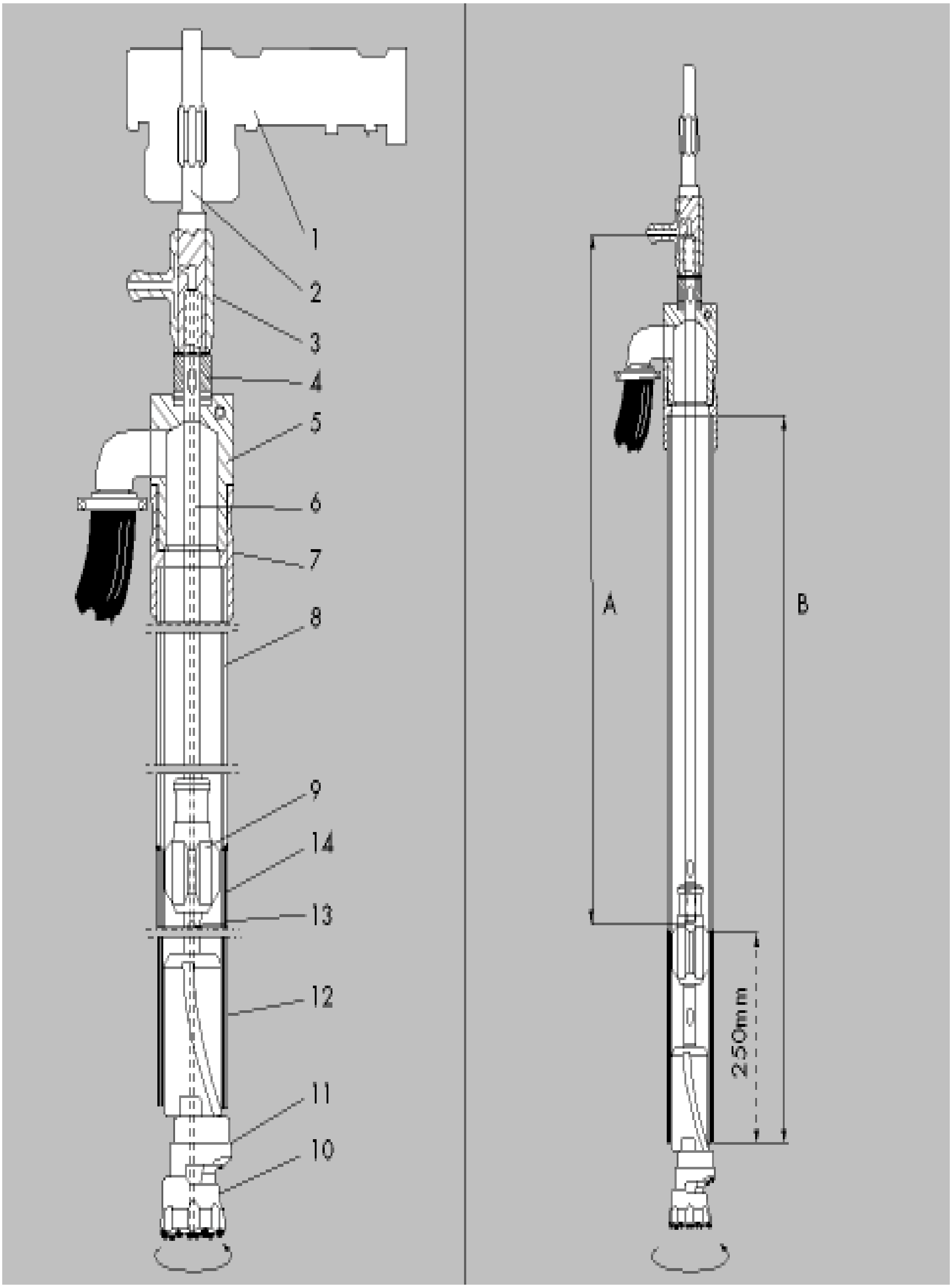

EQUIPMENT & FUNCTION

TUBEX XL equipment is available for both tophammers and DTH hammers. TUBEX XL for tophammers is used mainly in the construction industry.

The greatest area of application for TUBEX XL for DTH hammers is in the drilling of wells.

Tophammer equipment

In tophammer drilling, the drill string is rotated to the left. The casing tubes are driven down with the aid of percussion from above.

The percussion mechanism and rotation unit are built into one unit (the rock drill), which is mounted on the feed (1). Flushing is introduced separately, via the flushing device (3).

In the beginning, the casing tubes (8) sink into the drill hole by means of their own weight (in vertical drilling). However, as the depth of the hole increases, so the friction between the casing tubes and the hole wall increases. It therefore becomes necessary to apply a small amount of percussion to the casing tubes. This is achieved by means of the shank adapter (2) and driving cap (5). The casing tubes are driven down without being rotated, at the same time as the hole is drilled.

Between the shank adapter and driving cap there is a spacer (4), which enables the wrench flat of the extension rod (6) to be reached. Between the driving cap (5) and casing tube (8) there is an adapter sleeve (7) for either welded or threaded casing tubes.

The guide device (12) is joined to the extension rods (6) via a short extension rod (13) and a wing coupling (9). A wing coupling should also be connected at every third or fourth joint in the extension rods, particularly in the case of TUBEX XL 127.

The TUBEX XL ”package” consists of five components: the pilot bit (10), reamer (11), guide device (12), short extension rod (13) and wing coupling (9).

A short ”bit tube” (14), which is of better quality than the rest of the casing tubes is used if necessary. It serves to protect the front end of the casing tubes from deformation and wear.

The first casing tube (8), the starter tube, including a bit tube (14) if necessary, should be cut to a length (B) which, for TUBEX XL 76, should be equal to the total length of the first extension rod (6).

In the case of TUBEX XL 127, the corresponding starter tube should be 520 mm longer than the total length of the first extension rod.

Bear in mind that the effective length of the casing tubes that follow should always be the same as the total length of the extension rods.

Note also that the hole depth is limited because of energy losses in the joints of the drill string and the friction between the casing tubes and the hole wall.

Example:

First tube and rod Tubex 76 and 127		
TUBEX dim.	Total length Rod A	Total length Tube B ***)
76 *)	1220 1830 2435 3050	1220 1830 2435 3050
127 **)	1220 1830 2435 3050	1740 2350 2955 3570

Other tubes and rods Tubex 76 and 127 *)	
Total rod length	Effective tube length
1220 1830 2435 3050	1220 1830 2435 3050

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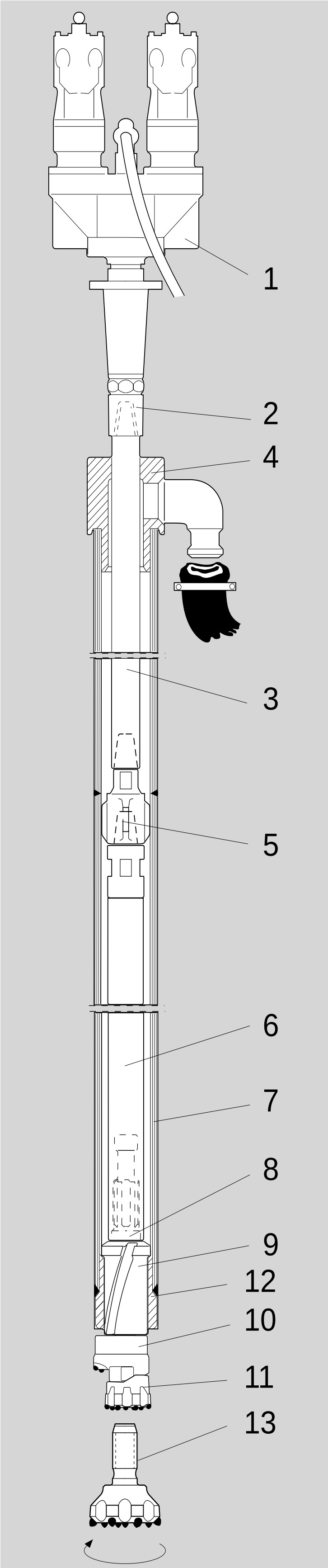


TUBEX XL FOR DTH DRILLING

In DTH drilling, the drill string is rotated to the right. The casing tubes are pulled down with the aid of percussion, which is transmitted via a specially designed casing shoe (12).

Since drill tubes are used instead of extension rods, only one guide sleeve (5) is needed, and this is placed between the first drill tube and the DTH hammer top sub.

The discharge head (4) works both as a director for drill cuttings and as a guide for the drill tubes (3).

When the drill hole is started, the casing tubes (7) sink by their own weight. However, as the depth of the hole increases, so does the friction between the casing tubes and the hole wall, which means that the casings have to be driven downwards. The percussion mechanism is down the hole in DTH drilling, where it works directly above the drill bit. For this reason, the force needed to drive down the casing tubes is transmitted via the casing shoe (12).

Considerably greater hole depths can be achieved with DTH drilling, because percussion-energy losses are very much lower than in tophammer drilling.

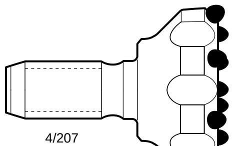
The basic TUBEX XL ”package” consists of four components: the pilot bit (11), reamer (10), guide device (9) and guide sleeve (5). The shape and function of the pilot bit and reamer are basically the same as for tophammer TUBEX XL, but the pilot bit has a right-hand thread.

The guide device (9) includes a shank for insertion into the DTH hammer, an impact shoulder for driving down the casing tubes, and a connection thread for the pilot bit. The function of the impact shoulder is to transmit percussion energy to a corresponding lip inside the the casing shoe that leads the casing tubes.

The flushing medium, which consists of exhaust air from the DTH hammer, is forced out through channels in the guide device, reamer and pilot bit. The drill cuttings are led via flushing grooves in the guide device, up through the annulus between the drill tubes and the casing tubes. They are collected at the discharge head (4), which sits on top of the casing tubes, and diverted through an elbow into a discharge hose.

In horizontal drilling, e.g. through road and rail embankments, where there is a great demand for straight holes, the road- embankment bit (13) is recommended instead of the eccentric pilot bit and reamer (11 and 10). The road-embankment bit, which is of the full-face type, can be used for ”breakthrough” drilling only, i.e. when the drill bit re-emerges at the other end of the drill hole.

Note that the road-embankment bit must be removed before the drill string can be pulled back through the casing tubes.



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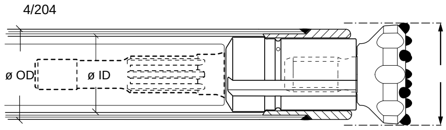

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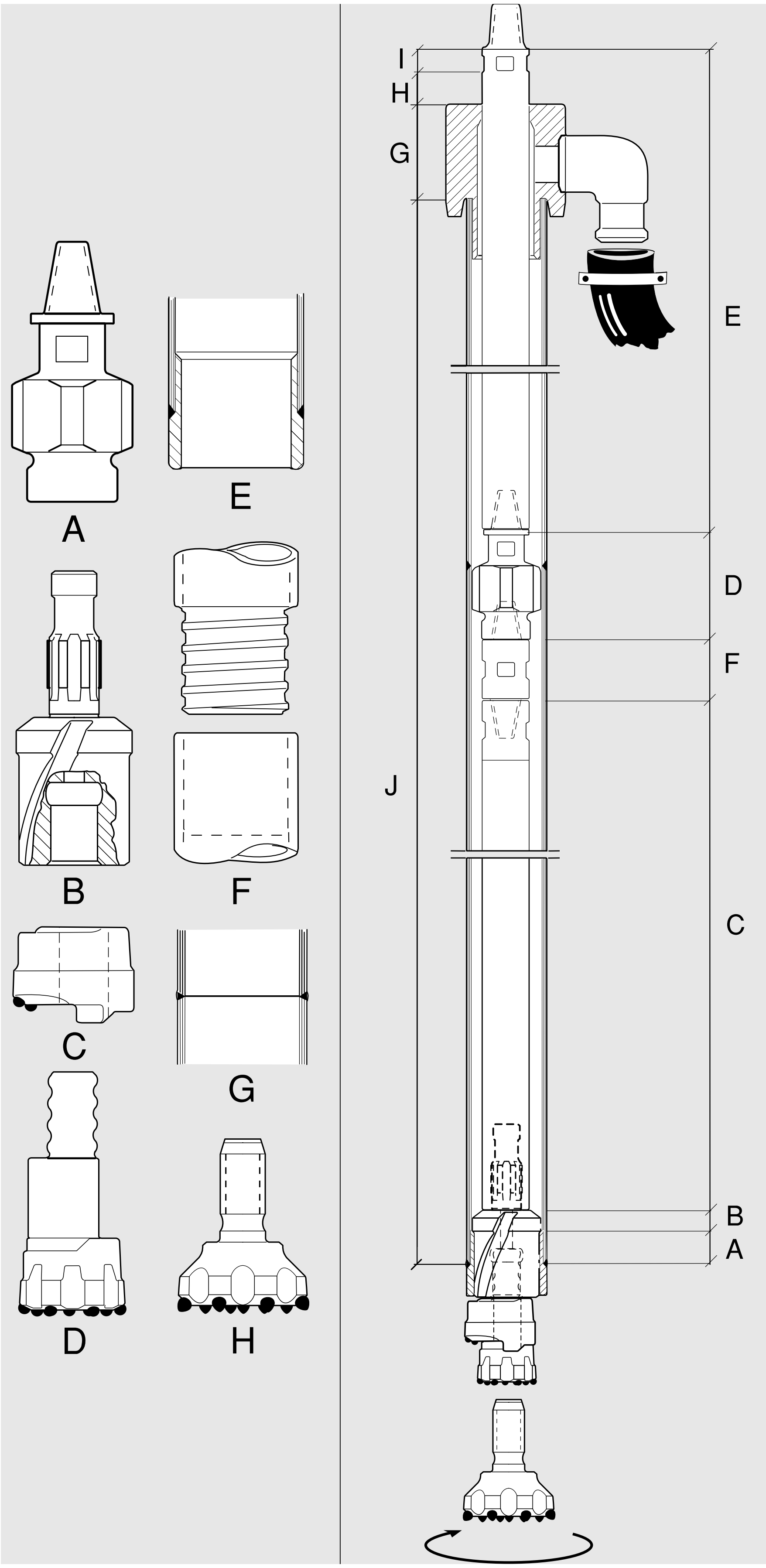


TUBEX XL FOR DRILLING WITH DTH HAMMERS

Guide sleeve A
- for centralizing the drill string inside the casing tubes
- placed between the DTH hammer and the first drill tube

Guide device B
- centralizes the pilot bit and reamer inside the casing shoe
- transmits percussion energy from the DTH hammer to the casing tubes, via the casing shoe. The percussion energy serves to drive down the casing tubes.
- has spirally milled flushing grooves to conduct the drill cuttings into the annulus between the drill tubes and the casing tubes
- the shank of the guide device connects the TUBEX XL package to the DTH hammer and transmits percussion energy from the hammer to the pilot bit and reamer

Reamer C
- is fitted with cemented carbide buttons
- turns around the axis of the eccentric shaft of the pilot bit
- has a diameter marginally smaller than the internal diameter of the casing shoe
- when swung out on the eccentric shaft, it reams a hole some-what larger in diameter than the outside diameter of the casing tubes

Pilot bit D
-is fitted with cemented carbide buttons
- has an eccentric shaft to accommodate the reamer
- has stop lugs that limit the turning movement of the reamer to 180°

- has a threaded shaft for screwing into the guide device

Casing shoe E
- is welded to the front of the leading casing tube
- transmits percussion energy from the guide device to the casing tubes
- centralizes the guide device inside the casing tubes
- protects the front edge of the casing tubes from deformation and wear
- the outside diameter of the casing shoe is the same as the outside diameter of the casing tubes

Threaded casing tubes F
- used when you wish to pull up and re-use the casing tubes
- should be seamless tubes that meet the relevant specifications regarding quality and thickness.
- should be suitable for re-use, i.e. they should have hardened threads
- male and female, right-hand threads for TUBEX XL 76 and 127 for tophammer drilling
- male and female, left-hand threads for TUBEX XL 90 and upwards, for DTH drilling
- must be flush joint

Welded casing tubes G
- should be seamless tubes that meet the relevant specifications regarding quality and thickness. Should be suitable for welding, i.e. the C content should be low (0.10 - 0.15)
- the preparation of joints for welding is done with the aid of special tools

Road-embankment bit H
- has cemented carbide buttons
- has full-face type bit head
- threaded shaft for screwing into the guide device

Casing tubes

The recommended casing tubes are listed in the table on page 32.

The first casing tube is called the starter tube. It is the tube to which the casing shoe is welded, and must therefore be cut to length (J), as follows:

A. The length of that part of the casing shoe which slides inside the starter tube __________

B. The length of the impact shoulder on the guide device __________

C. The effective length of the DTH hammer __________

D. The effective length of the guide sleeve __________

E. The effective length of the drill tube __________

F. The effective length of any additional sub(if used) __________

Sub Total 1 __________

Step 2 Add up the following measurements:

G. The length of the discharge head, measured from the inner shoulder to the upper part __________

H. Extra addition (min. 75 mm) __________

I. The length from the shoulder of the drill tube to the lower edge of the wrench flats (or, if there is a narrowing of the drill tube beneath the wrench flats, to the point where the tube regains full diameter) __________

Sub Total 2 __________

Step 3 The length (J) of the starter tube is obtained by subtracting Sub Total 2 from Sub Total 1. __________

Note that if a shorter starter tube is required, the measurements for A, B, C, D and F are added up. Sub Total 2 is then subtracted.

Note also that lengths of the casing tubes that follow should always be the same as the effective lengths of drill tubes with which they are used.

The thickness of the casing tubes should not be less than the dimensions given in the table on page 32. The smallest permissible diameter for the casing tubes is determined by the greatest diameter on the guide device.

If the tolerance between the guide device and the casing tubes is altogether too small, there is a risk that the guide device will jam inside the casing tubes when the TUBEX XL equipment is with-drawn. Dents in the casing tubes, (oval) deformation, or poorly welded joints with excessive bead penetration can prevent the TUBEX XL equipment from being pulled up through the casing tubes.

The outside diameter of the casing tubes is also of great importance. Tubes with an OD that is altogether too big will run the risk of getting stuck in the hole, since the diameter of the reamed hole will not be large enough to accommodate them. In this case, clearance around the casing tubes would perhaps disappear completely, making further penetration impossible.

Recommended tolerances:

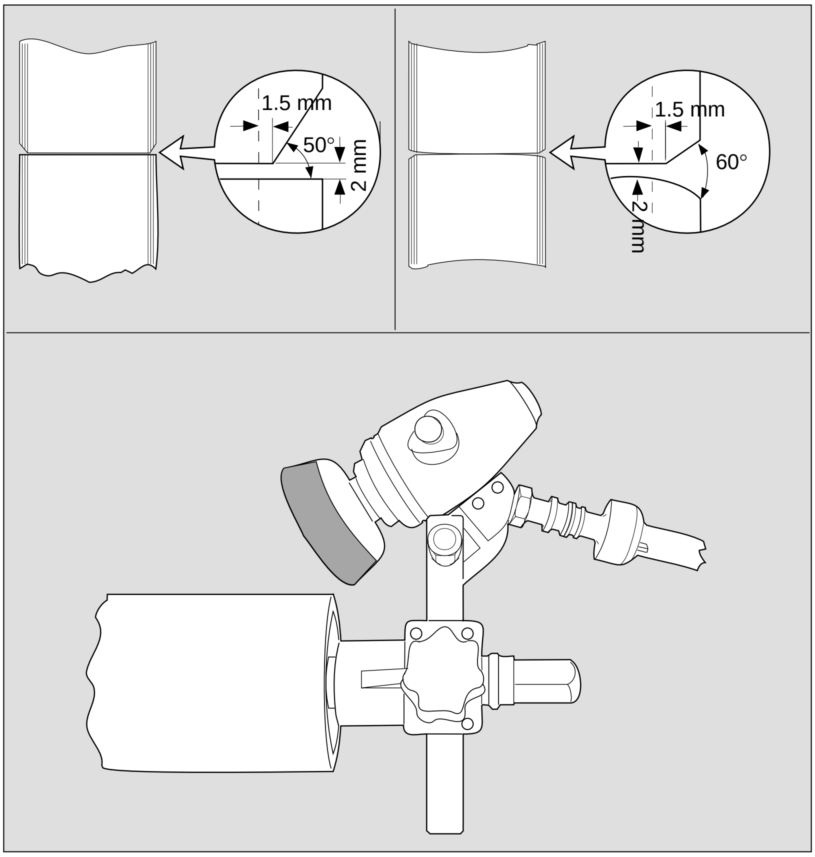
Outside diameter of casing tube: ± 1%

Thickness of casing tubes: ± 10%

Tensile strength of casing tubes: ≥ 35 kp/mm^2

The difference in diameter between the guide device and the casing tubes should not be less than that shown below.

TUBEX XL	76	127	90	115	140	165	190	215	240	280	365
Difference in diameter, mm	2	2	2	2	6	4,5	4	5	4	5.5	6



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Bevelling/chamfering

In order to produce a weld of good strength, the lower end of the casing tube should be bevel-led, as shown in the figure on the left. Alternatively, the ends of both casing tubes can be bevel-led, as shown on the right. The bevelling can be carried out using a special bevelling grinder, which rotates around a fixture that is centralized inside the casing tube. The bevelling grinder is powered by compressed air, and is very easy to operate in the field.

Welding method

Manual metal-arc welding (commonly called arc welding) is recommended for the welding of casing tubes, using coated electrodes. A welding machine powered by a combustion engine or hydraulic motor is recommended for use in the field.

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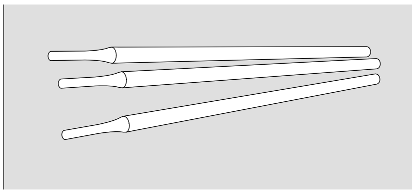


Electrodes

Basic, normal yield electrodes should be used. The electrode types listed below (or equivalent electrodes of other makes) are recommended:

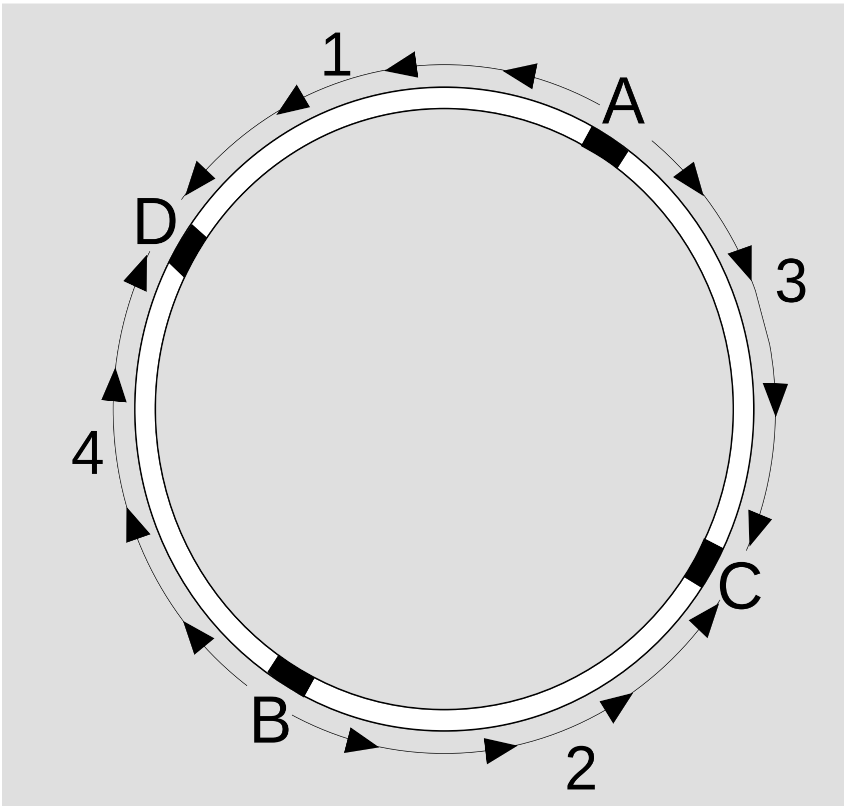
- ESAB OK 48.00
- Philips 35
- Oerlikon Supercord
- Arcos Ductilend 70

The above electrodes meet the specifications in ISO E-445 B 20. The nominal weld metal analysis is C = 0.1%, Si = 0.7%, Mn = 0.7%. The yield point of the weld deposit is greater than 400 N/mm^2 (40 kp/mm^2) and its ultimate tensile strength is greater than 500 N/mm^2 (50 kp/mm^2).

It is very important that basic electrodes are stored in such a way that the flux coating does not absorb moisture from the atmosphere. Electrodes should therefore be stored in the sealed plastic wrapping in the box in which they were supplied, or in some other way that prevents damp penetration.

Welding procedure

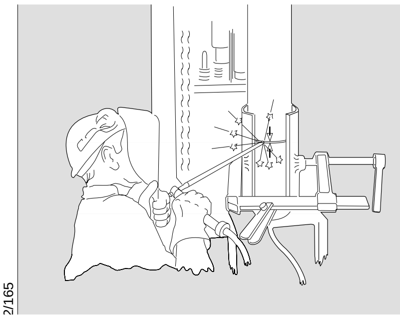
Joint preparation shall be carried out as shown in the figure on page 12. Under worksite conditions, bevelling can be carried out by means of gas cutting, manual grinding or semi-automatic grinding. The latter method, for which a special tool is available, is recommended. The casing tubes are fixed into position by means of a special fixture. It is recommended that welding be carried out using



electrodes with a diameter of 2.5 mm, at approx. 85 A. Leave a 2 mm gap between the casing tubes to facilitate welding. The welding sequence is shown below.

Demands on the weld

The weld should be of good strength, which requires full bead penetration with no significant



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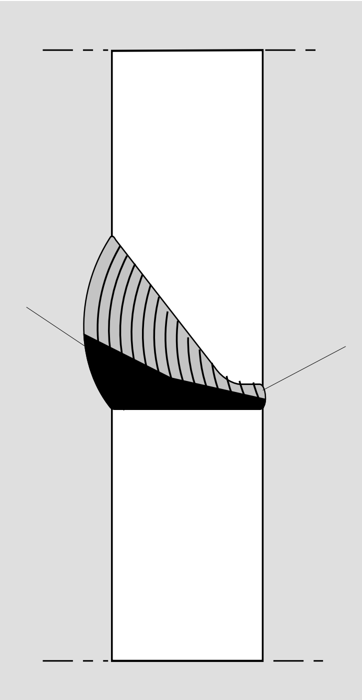
inclusions or pores, and no embrittlement either in the weld itself or in the zones affected by the heat of the weld.

The depth of bead penetration should not exceed 0.5 mm beyond the internal diameter of the casing tube. The height of the weld on the outside of the casing tube should not exceed 2 mm, and should be ground down. Grinding on the casing tubes should be carried out in the longitudinal direction only.

Scratches caused by grinding across the longitudinal axis of the casing tubes should be avoided, so as not to impair the strength of the weld.



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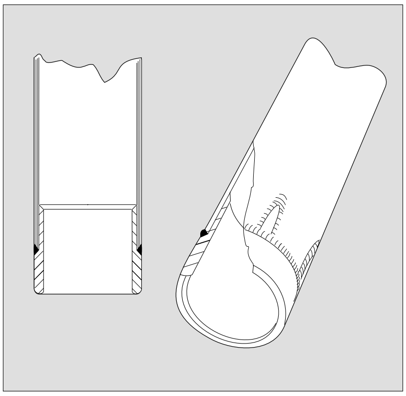
If the height of the weld is not ground down, problems could arise when drilling through boulders.

Similarly, if bead penetration is excessive, jamming could occur when TUBEX XL equipment is pulled up through casing tubes.

Welding casing shoe & bit tube

The casing shoe serves both to centralize the TUBEX XL equipment inside the casing tubes and to receive the percussion energy that drives down the casing tubes. For this reason, the quality of the weld which joins it to the leading casing tube is very important.

The casing shoe must be aligned carefully so that it is located concentrically inside the leading casing tube. The centre line of the casing shoe must be absolutely parallel to that of the casing tube. To increase the area of the weld,



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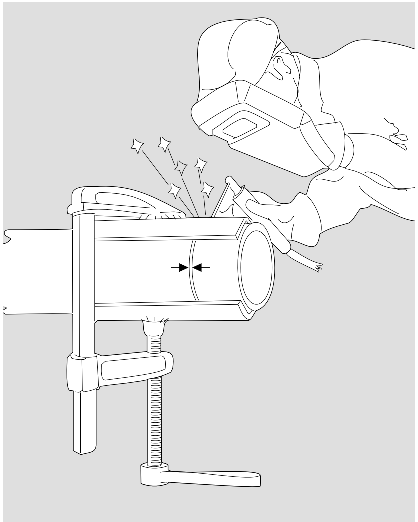
you can make slits or holes at the end of the casing tube.

When deep holes are to be drilled with TUBEX XL, it is very important to use genuine Sandvik Coromant casing shoes. Sandvik casing shoes are made of steel with high fatigue strength and are especially hardened for this purpose. Poor quality material in a casing shoe will wear out before required hole depth is reached.

The casing shoes and bit tubes have internal diameters to suit the respective guide devices for different sizes of TUBEX XL equipment. There should be as little play as possible between the guide device and the casing shoe or bit tube. Excessive play could result in the reamer not being able to ream a hole sufficiently large for the casing tubes. This could result in the casing tubes getting stuck, which would prevent them from being driven down to the desired depth.

TUBEX XL casing shoes and bit tubes are made of a material that meets SIS 2225 or DIN 17200 (25 Cr, Mo4). Steel of this quality should not be welded at low temperatures. In order to obtain a satisfactory weld, the casing shoe or bit tube should first be heated up to a temperature of 150-200° C. Ideally, welding should be carried out in a workshop.

A special electrode should be used for the welding of casing shoes and bit tubes.



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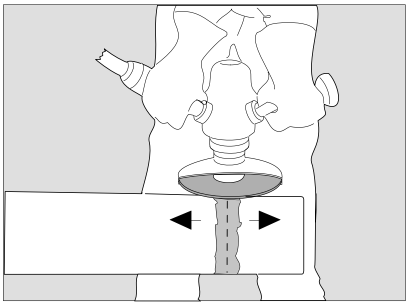
1 Heat up the casing shoe or bit tube to 150-200° C.
2 Fit the welding fixture and line up the two ends that are to be welded.
3 Use OK 78.16 welding electrodes or equivalent electrodes of another make.
Use a 2.5 mm electrode for the bead weld, and a current strength of 75-100 A.
4 Start by tack welding, as illustrated on page 14.
5 Remove the welding fixture.
6 Fill the joint with another 1-2 weld runs, using a 2.5 or 3.25 mm electrode.

Step 1 Add up the following measurements:

When welding is finished, the weld must be ground to make it even. This will reduce the friction between the casing tubes and the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hole wall as the tubes are driven down. Use the same grinding machine as for bevelling. Grind only along the longitudinal axis of the tube. Scratches caused by grinding across the longitudinal axis of the tube can cause increased tension in the joint. Grind until the surface across the welded joint is flat.

DRILLING PROCEDURE
When it comes to the actual drilling method, the following tips should be taken into consideration for all TUBEX XL equipment.

High penetration rates should not be a dominating factor. It can be all too easy to obtain rapid penetration in the soft formations in which TUBEX XL is often used. However, rapid penetration can have a negative effect on cuttings removal, which can lead to difficulties in closing the reamer when the time comes to withdraw the the TUBEX XL equipment from the hole. The objective should rather be to maintain constant cuttings removal and to avoid blockages. Rotation and penetration should therefore be as smooth and even as possible.

To close the reamer, reverse rotation of the tophammer or rotation device should be sudden, short and intensive. The operator should be aware that it is possible to unthread the pilot bit during this operation, which would result in both the pilot bit and the reamer being lost down the hole. Reverse rotation should therefore be applied for a maximum of one revolution only.

If the reamer does not close, this could be due to:

A Uncleared drill cuttings preventing the reamer from closing.

B Conditions are such that the surrounding material is not giving any resistance to the reamer.

Action:

A Switch on the flushing (without drilling) for a few minutes, increasing the air or water pressure if possible. Try closing the reamer again.

B Lift the TUBEX XL drill string so that the upper edge of the reamer comes into contact with the underside of the casing shoe or bit tube. Apply reverse rotation carefully and see if this causes the reamer to close.

C Continue drilling and casing until more favourable material is reached.

Important points when drilling with TUBEX XL for DTH hammers

1 Use low pressure when drilling through easily drilled material.
2 When drilling through conglomerate and clay, reduce the air pressure and increase the rotation speed.

3 If threaded casing tubes are to be re-used, make sure that they have hardened threads.

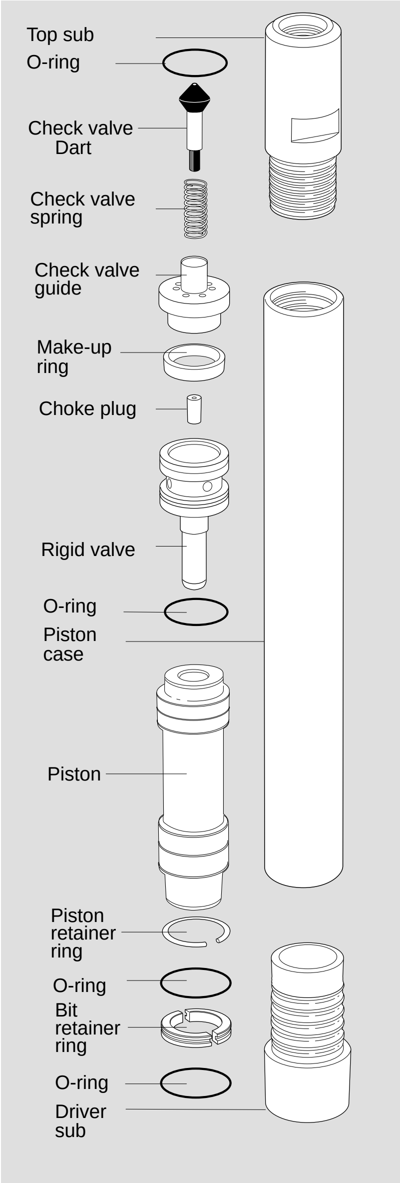
4 Correct welding of the casing tubes is very important, owing to tensile stress in the weld. Follow the instructions given.

5 The wall thickness of the casing tubes should not be less than that given in the table on page 32.

6 N.B. Before continuing to drill with conventional rock drilling equipment, the guide sleeve above the DTH hammer must be removed. This is because its diameter is greater than the diameter of the impact shoulder inside the casing shoe.

7 In the case of continued drilling, the diameter of the standard drill bit must be less than the smallest inside diameter of the casing shoe (see table on page 32).

8 Most DTH hammers have an exchangeable choke plug. A solid choke plug is used when maximum piston energy is required. For TUBEX XL drilling, it is recommended that a bored choke plug be used in order to obtain the best flushing and cuttings removal. The size of the hole in the choke plug should be matched to the compresssor's capacity.



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9 Make sure that the check valve of the DTH hammer closes and seals tightly. A leaking check valve can cause dirt and impurities to enter the rock drill when the air supply is switched off. This is of the utmost importance when drilling in heaving formations such as quicksand. For increased safety in difficult conditions such as these, it can be advisable to install an extra check valve either in the guide sleeve or in one of the drill tubes.

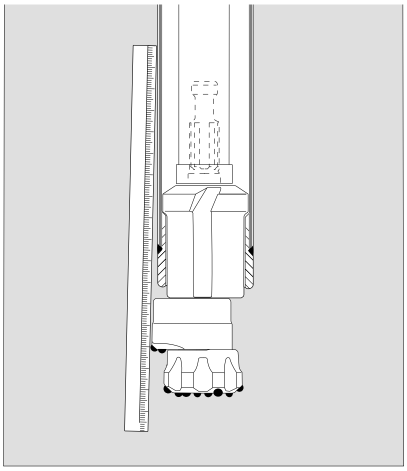
10 The drill tubes should always be handled and stored so that they remain clean on the insides.

11 If the TUBEX XL equipment is to be left in the drill hole for longer periods of time, it is recommended that the pilot bit and reamer are drawn up inside the casing tubes. This is especially important in heaving formations.

12 Before starting each new hole, it is very important to check the wear on the reamer. The easiest way to do this is with the aid of a straight rule. The reamer must always produce a hole of greater diameter than the outside diameter of the casing tubes.

13 If a pilot bit pin is used (TUBEX XL 140 and upwards), make sure that it is undamaged before starting each new hole.

Pilot pin



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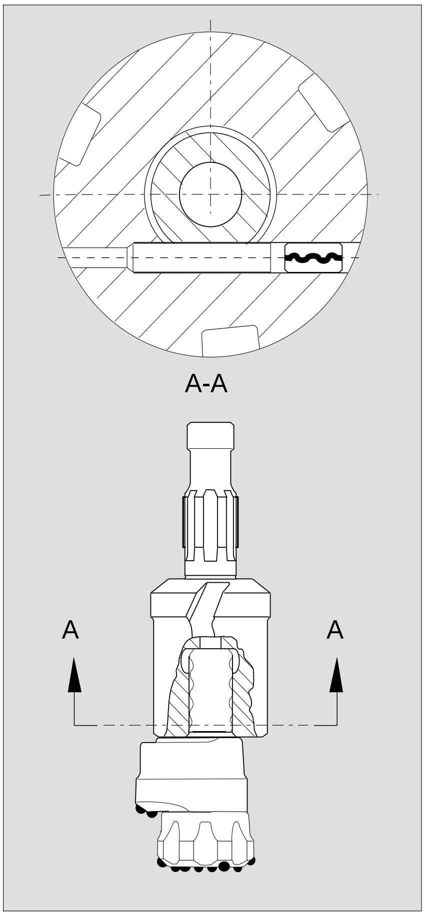
TUBEX XL 140 and larger dimensions are equipped with a through hardened pilot bit pin that is held in place by a self-locking spring pin. The main function of the pilot bit pin is to prevent the pilot bit from unscrewing when drilling in soft and cavitied formations, i.e. formations that do not give sufficient resistance to the blows from the hammer (idle blows). When closing the reamer, it is very important to reverse rotate only one revolution at a time, in order to avoid fracturing the pilot bit pin. Check that the pilot bit pin is undamaged before starting each new hole.



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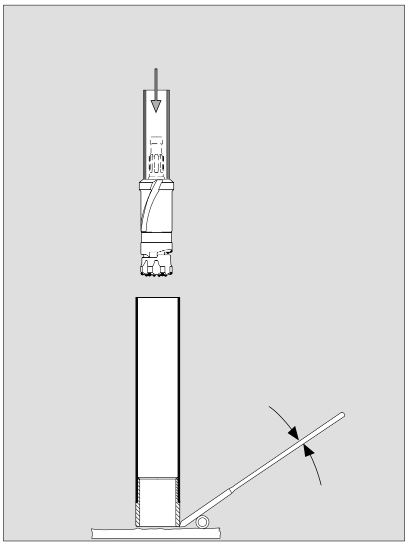
Preparations for drilling

First assemble the DTH hammer and TUBEX XL equipment. Then take the first casing tube, to which the casing shoe has been welded, and insert the TUBEX XL equipment together with the DTH hammer. The reamer must of course be closed completely. Do not rotate the drill tube, or the reamer will expand inside the casing tube.

With the larger TUBEX XL variants (140 and upwards), the DTH hammer is suspended in the rotation device. The casing tube is set on the ground, and the DTH hammer and TUBEX XL equipment is lowered carefully into the casing tube. If the TUBEX XL equipment does not pass through the casing shoe, try to centralize the casing tube with the aid of a lever or some other implement. Under no circumstances should



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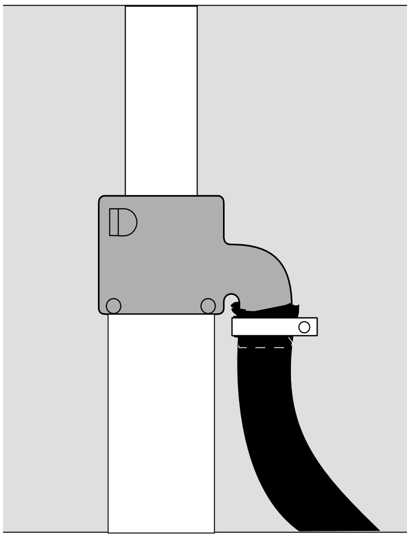
the percussion mechanism of the DTH hammer be used to get the TUBEX XL equipment through the casing shoe! At worst, this could result in the equipment jamming inside the casing shoe, which would then have to be cut open in order to remove the TUBEX XL equipment.

Alternatively, the rig's winch can be used to slide the casing tube over the TUBEX XL equipment and DTH hammer. With the casing tube and drilling equipment lying on the ground in front of the rig, the winch cable is attached to the casing tube. The casing tube is then pulled towards the rig so that the drilling equipment slides into it.

Discharge head

TUBEX XL drilling takes place with the discharge head resting on top of the casing tubes. Without the discharge head, the drill cuttings would be sprayed all over the rig, the operator, adjacent buildings and anything else in the vicinity. With the discharge head fitted into place, the drill cuttings can be led away to a container or suchlike, and it is easy to take samples of the cuttings during drilling. And by using the discharge head, you



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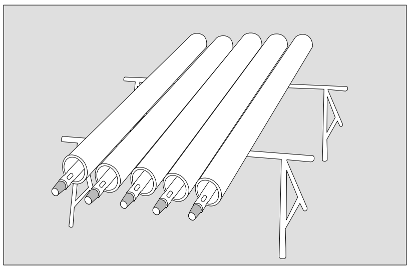
will not have to wash down any buildings etc!

Tube handling

Take care when handling the tubes, in order to avoid denting or deformation of the tube ends. A dented tube can cause the TUBEX XL equipment to jam when you try to pull it up through the casing tubes.

To make tube handling easier, it is useful to have two A-trestles, across which the casing tubes (with drill tubes inserted) can be laid. The ends of the drill tubes should be fitted with protective covers to prevent dirt and water from entering the tubes. Protective covers protect not only the threads of the drill tubes, but



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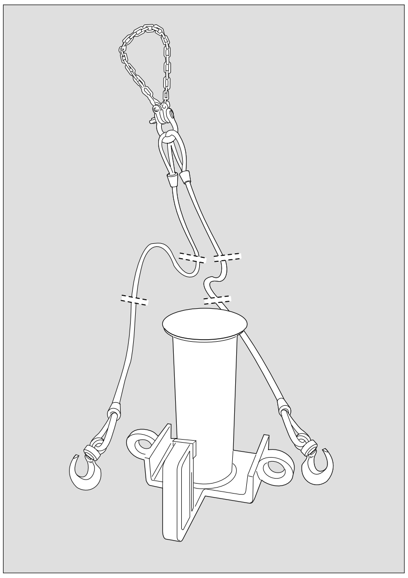
ultimately the internal components of the DTH hammer as well.

Handling of longer tubes

It is best to use the rig winch together with a special lifting sling for tube handling.

Attach the lifting sling to the casing tube, and then insert the drill tube into the casing tube.



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Fit the discharge head on to the drill tube and, with the aid of the winch, lift the entire assembly up the feed beam.

Thread the drill tube securely into the spindle of the rotation unit.

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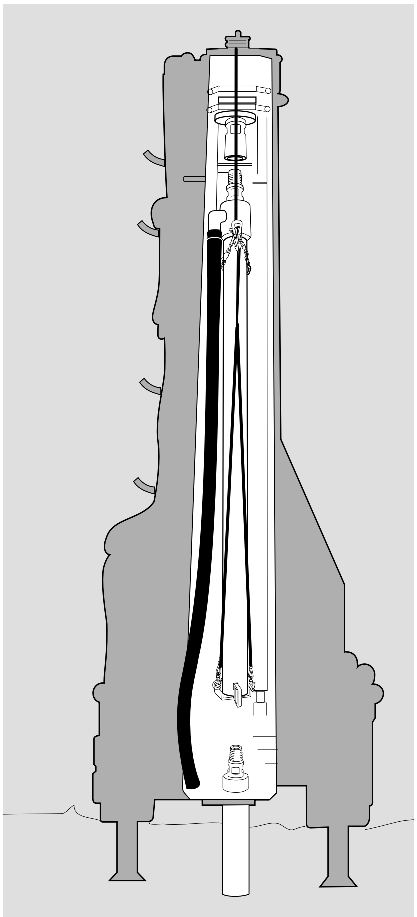
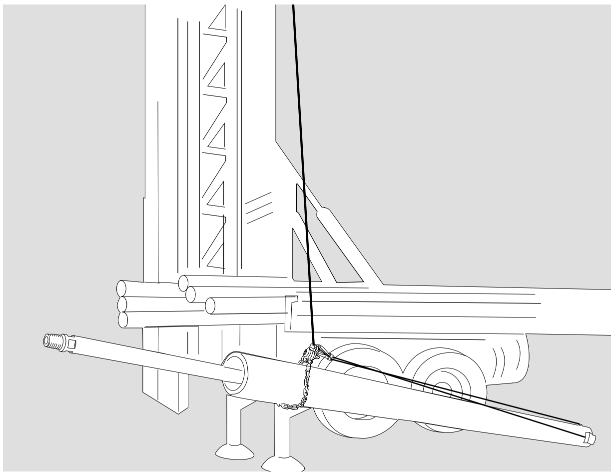


Lower the casing tube so that it rests on the edge of the drill steel support, and remove the lower



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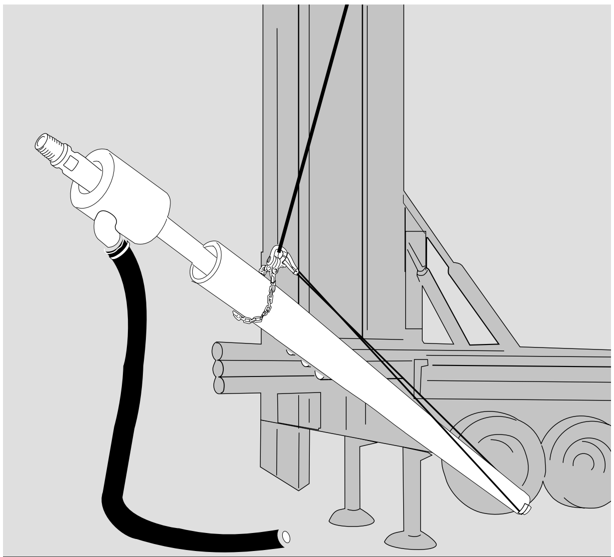
part of the lifting sling.

Lift the casing tube so that it hangs directly above the casing



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tube that is already embedded in the ground.
Apply slow rotation, to thread the drill tubes together.

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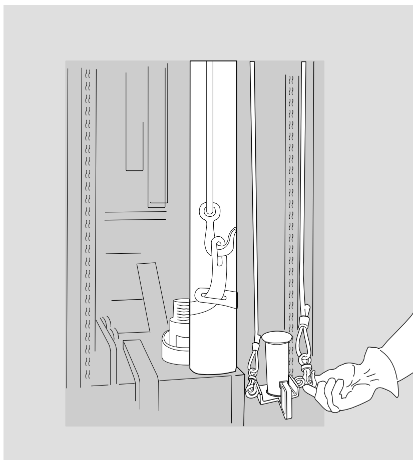

Fix the casing tubes end to end, with the aid of the welding fixture (page 14).

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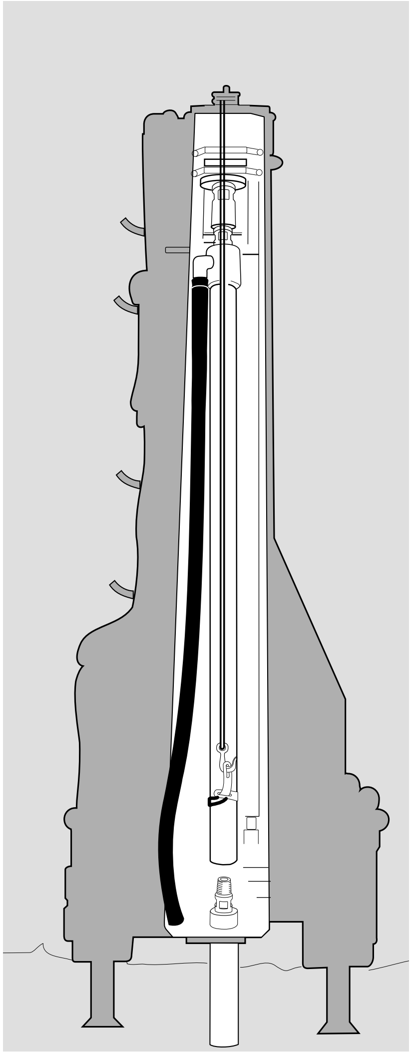

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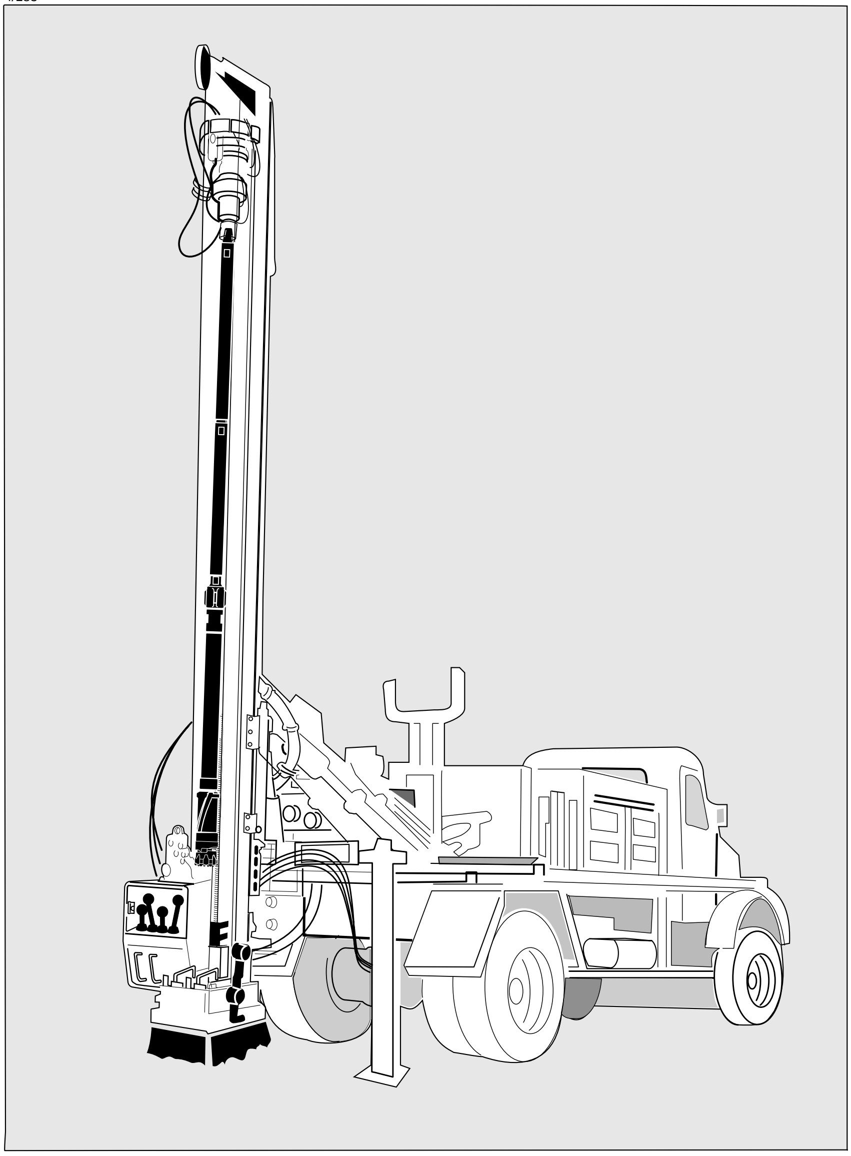

Setting up the drill rig

In order to obtain the greatest possible hole straightness, it is important that the drill rig be properly set up to ensure stability.

All unintentional movements of the feed beam or drill rig will cause deviation between the original and final angle of the drill hole. Such deviations lead to crooked holes, jammed equipment, difficulty in joining casing tubes etc.

At worst, the casing tube string could break, which would make it impossible to withdraw the drilling equipment from the hole.

Drilling

Before drilling is started, the pilot bit must be screwed securely into the guide device (with the aid of a breakout wrench). Once this has been done, the pilot bit pin should be inserted (TUBEX XL 140 and upwards). The joints between the drill tubes must also be properly tightened before drilling is started. This should ensure that the drill string does not uncouple when reverse rotation is applied for the purpose of closing the reamer and pulling up the TUBEX XL equipment.

Make sure that the casing tube is properly guided in the drill steel support. Collar the hole carefully, using reduced percussion pressure and reduced feed pressure. Lift the equipment regularly, and flush out the hole. This will prevent the flushing holes in the pilot bit and the flushing grooves in the guide device from becoming blocked.

Once the casing tube has penetrated the ground by about 1 meter or so, you can switch over to normal percussion pressure (up to 14 bar) and feed force. You should still stop drilling from time to time, just to clean out the drill hole. Frequent flushing makes a clean drill hole and prevents blockages!

In clay formations, the use of foam makes drilling easier (see the chapter on foam drilling, page 29).

Lift the casing tubes from time to time to make sure that they always slide freely inside the drill hole. If this is not done, there is a risk that the tubes will break at the first joint if you pass through a clay zone and then continue drilling in softer rock formations.

IMPORTANT: Keep the casing tubes as "free" as possible inside the hole. This can be done by lifting the tubes frequently and flushing out the hole.

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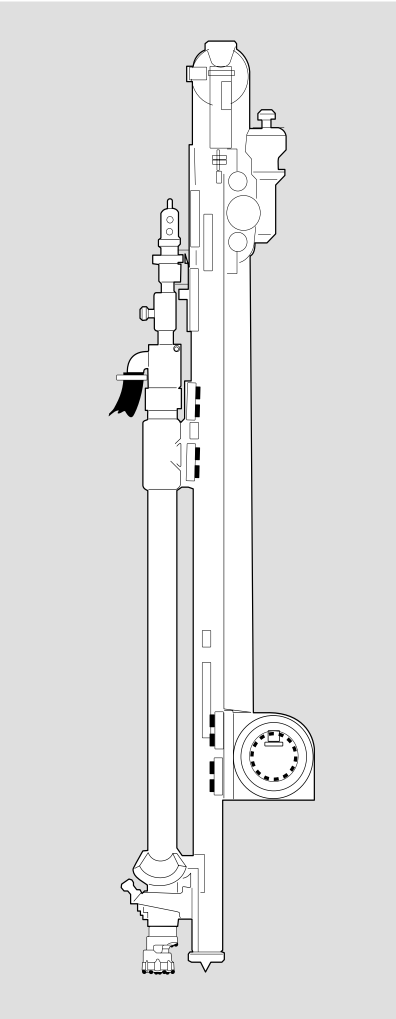

Before drilling is discontinued for any length of time, the hole should be flushed out thoroughly to remove any drill cuttings. If drilling is discontinued without flushing the hole properly, drill cuttings can drop to the bottom of the hole and jam the DTH hammer in the hole.

When drilling is to be started again after a stoppage, always begin by flushing out the hole.

Telescopic drilling

By starting TUBEX XL drilling with a large diameter and gradually changing to smaller sizes of TUBEX XL, great hole depths can be achieved.

Possible TUBEX XL combinations in **telescopic drilling:**

365-240-190-140-90

365-280-215-165-115

365-280-215-140-90

Example:	
TUBEX XL 215	50 metres
TUBEX XL 165	60 metres
TUBEX XL 115	70 metres
DTH drilling	100 metres
Total	280 metres

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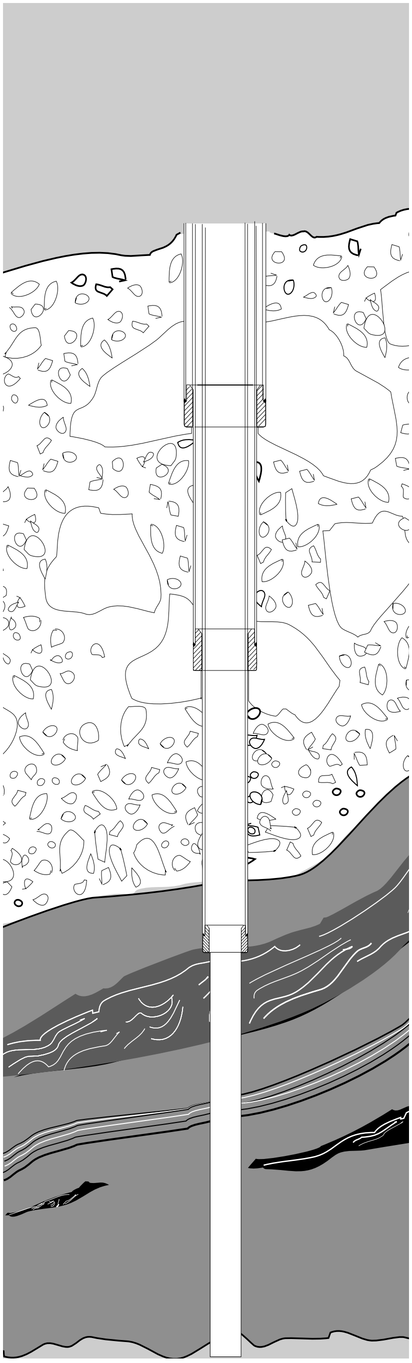
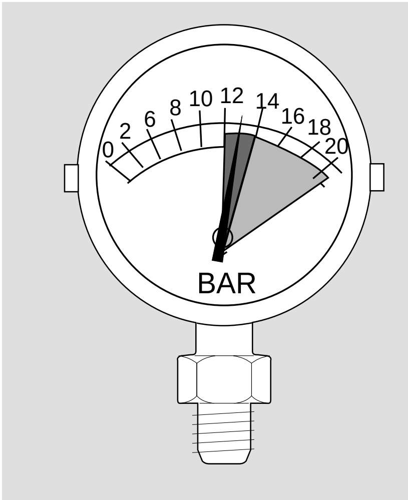


Recommended drilling data

TUBEX XL equipment is best suited for air pressures between 12 and 14 bar. In order to obtain the best service life for TUBEX XL equipment and avoid damage, the air pressure should not exceed 14 bar.

Suitable rotation speed depends on the size of TUBEX XL being used, and on the characteristics of the rock formation.

The table below gives guiding values.



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The speed of rotation should be set according to the frequency of the DTH hammer and the diameter of the reamed hole. The rotation speeds given above refer to drilling in rock. When drilling in fragmented rock, clay and soft materials, higher rotation speeds are needed.

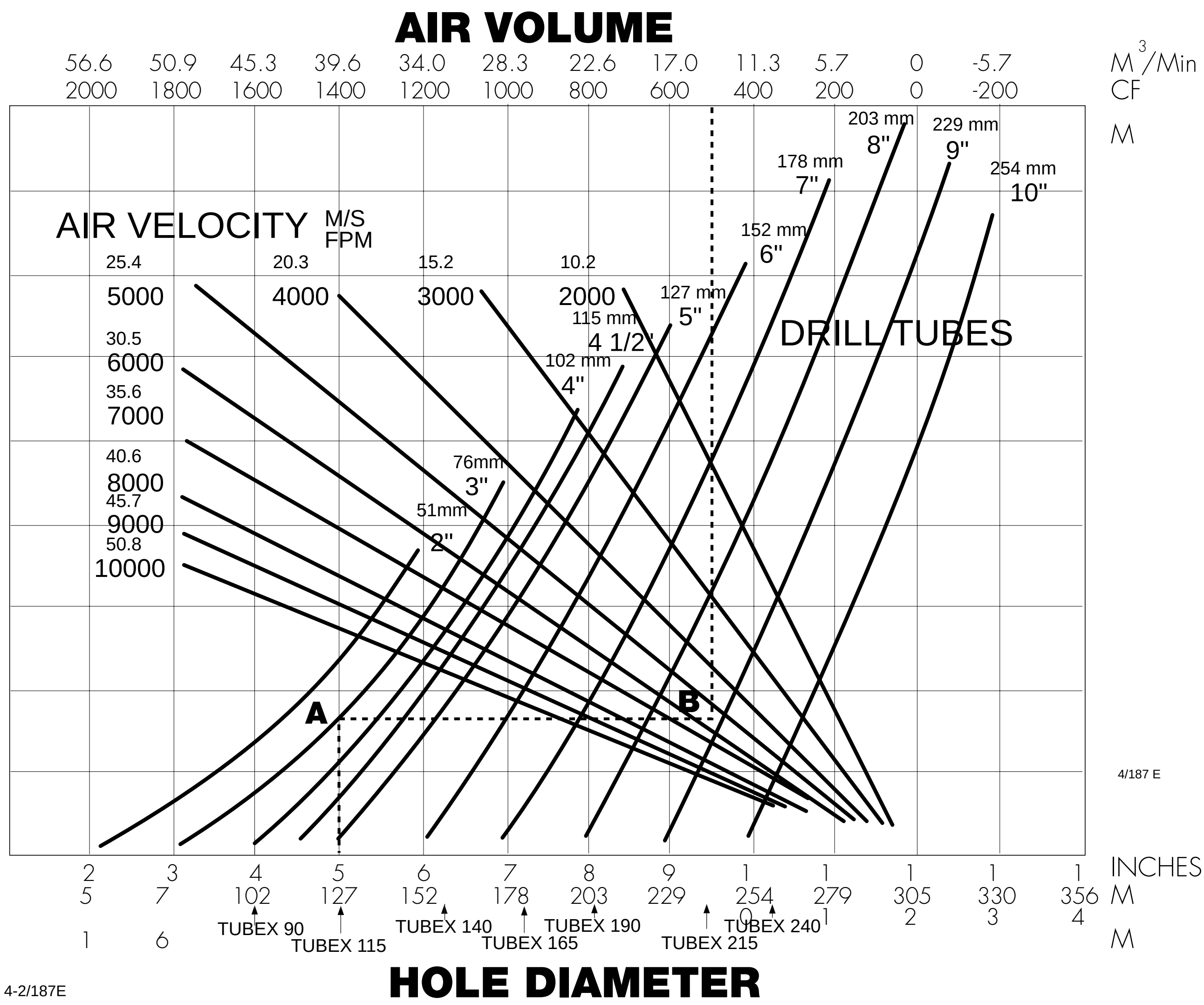
TUBEX XL	76	127	90	115	140	165	190	215	240	280	365
Rotation speed (RPM)	50-70	15-25	20-30	20-25	15-20	15-20	10-15	10-15	10-15	10-15	10-15

TUBEX XL	76	90	115	127	140	165	190	215	240	280	365
Rotational torque minimum (Nm)	800	900	2000	2000	3000	4000	>6000	>6000	>6000	>10000	>10000
Possible hole depth (m)	40	60	100	40	100	100	100	100	100	100	100

Rotational torque

It is important that the drill rig be equipped with a rotation motor of sufficient torque, especially when deep holes are to be drilled with the TUBEX XL method.

The hole depths given should be regarded as nominal hole depths for the respective sizes of TUBEX XL equipment. In practice, it is the characteristics of the overburden that will determine the maximum hole depth. Obviously, greater hole depths can be achieved if powerful drill rigs are used for easily drilled formations. Bear in mind that the feed motor of the drill rig should have sufficient capacity to lift up all the drilling equipment.



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Flushing velocity

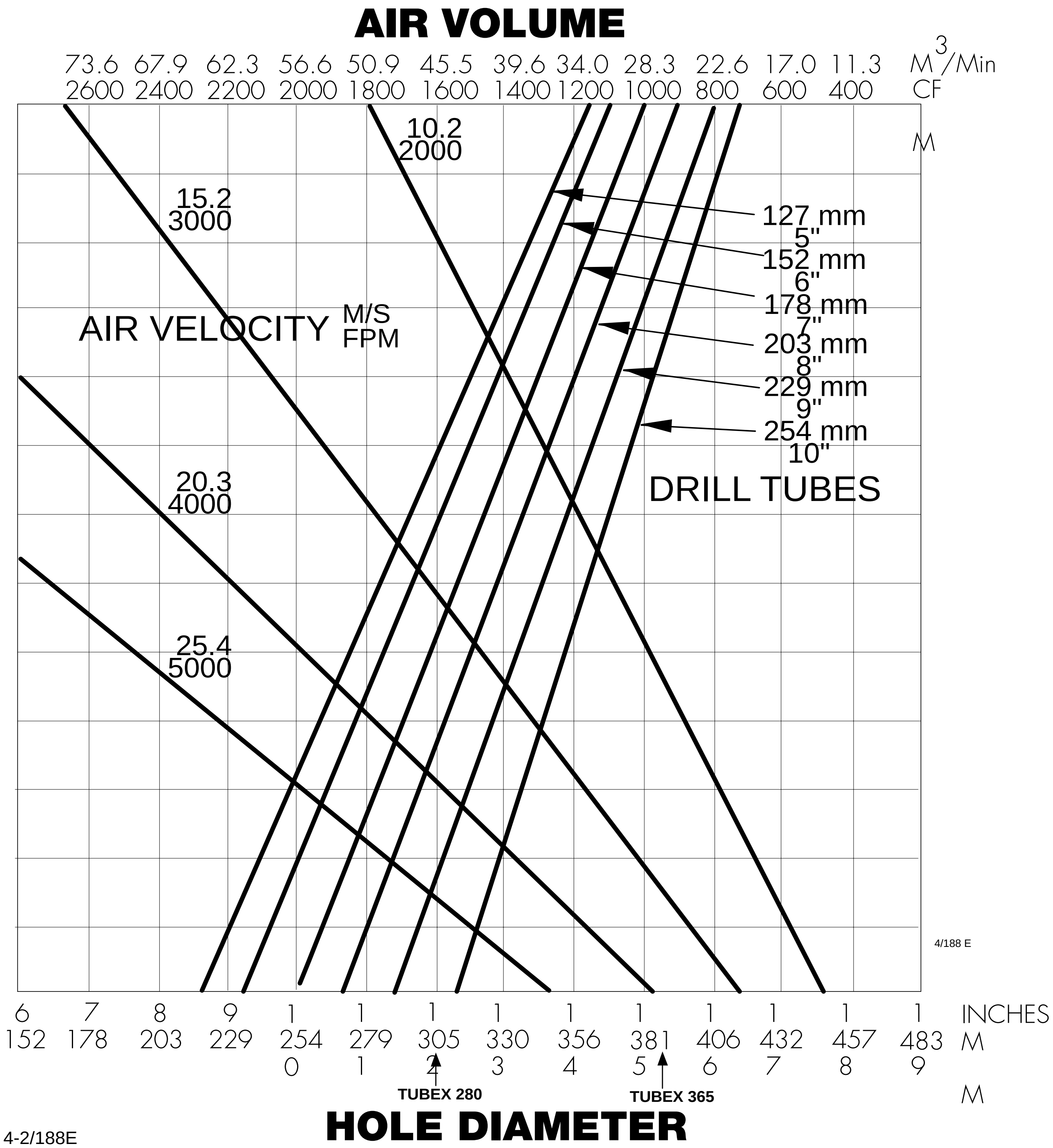
In order to lift the drill cuttings efficiently to the surface, the velocity of the flushing medium in the annulus between the drill tubes and casing tubes should be at least 20 m/s (about 4000 FPM). Velocity depends on the capacity of the compressor and on the size of the annulus between the drill tubes and casing tubes. The drill tubes should not be thicker than the outside diameter of the hammer. The formulae on page 25 are used to calculate the flushing velocity in m/s.

Example:

If you are drilling a 5" hole (TUBEX XL 115) with 3" drill tubes and a compressor capacity of 14 m^3/min: follow the hole-diameter line up to "3-inch drill tubes" (A); move horizontally to the line for "14 m^3/min" air volume (B). The flushing velocity can be read according to the diagonal line at the meeting point (B) - about 28 m/s. When converting to FPM, 1.0 m/s is equivalent to about 197 FPM.

m^3/min - m/s - FPM

Use the diagram to determine the flushing velocity when the hole diameter, drill tube diameter and air volume are known. Follow the vertical line from the hole diameter
(TUBEX XL size) until you meet the line for the size of drill tube that you are using. Then go horizontally to the vertical line for existing compressor capacity. The meeting point gives the flushing velocity with the aid of the diagonal lines, which show different flushing velocities.


AIR VOLUME
73.6 67.9 62.3 56.6 50.9 45.5 39.6 34.0 28.3 22.6 17.0 11.3 M3/Min
2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400 CFM
10.2
2000
15.2
3000
20.3
4000
25.4
5000
AIR VELOCITY M/S FPM
127 mm 5"
152 mm 6"
178 mm 7"
203 mm 8"
229 mm 9"
254 mm 10"
DRILL TUBES
4/188 E
6 7 8 9 10 11 12 13 14 15 16 17 18 19 INCHES
152 178 203 229 254 279 305 330 356 381 406 432 457 483 MM
TUBEX 280
TUBEX 365
HOLE DIAMETER
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$$\text{Flushing velocity (m/s)} = \frac{F \times 21220}{D_H^2 - D_P^2}$$

F	=	Free air consumption (m^3/min)
D_H	=	Inside dia of casing tube (mm)
D_P	=	Outside dia of casing tube (mm)

$$\text{Flushing velocity (m/s)} = \frac{F \times 1273}{D_H^2 - D_P^2}$$

F	=	Free air consumption (l/s)
D_H	=	Inside dia of casing tube (mm)
D_P	=	Outside dia of casing tube (mm)

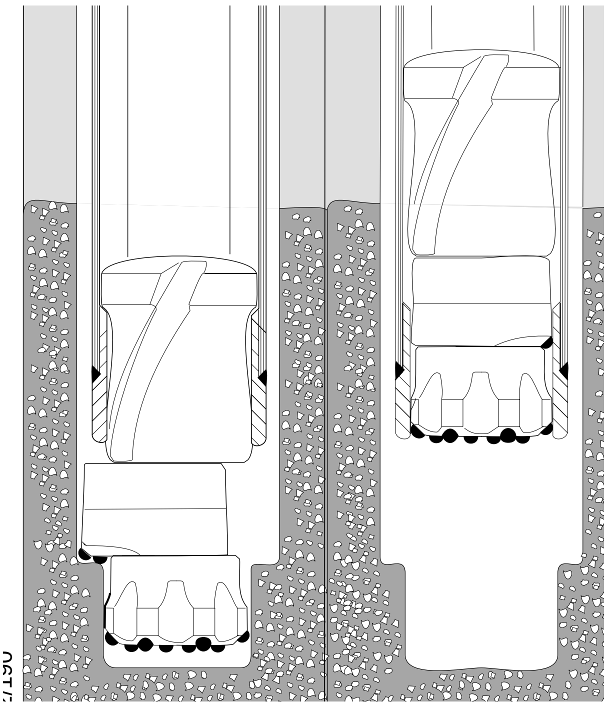
Formulae for calculation of flushing velocity

Withdrawal of TUBEX XL equipment

Once the casing tubes have been taken down to the desired depth, TUBEX XL drilling is stopped and the equipment is pulled up through the inside of the casing tubes.

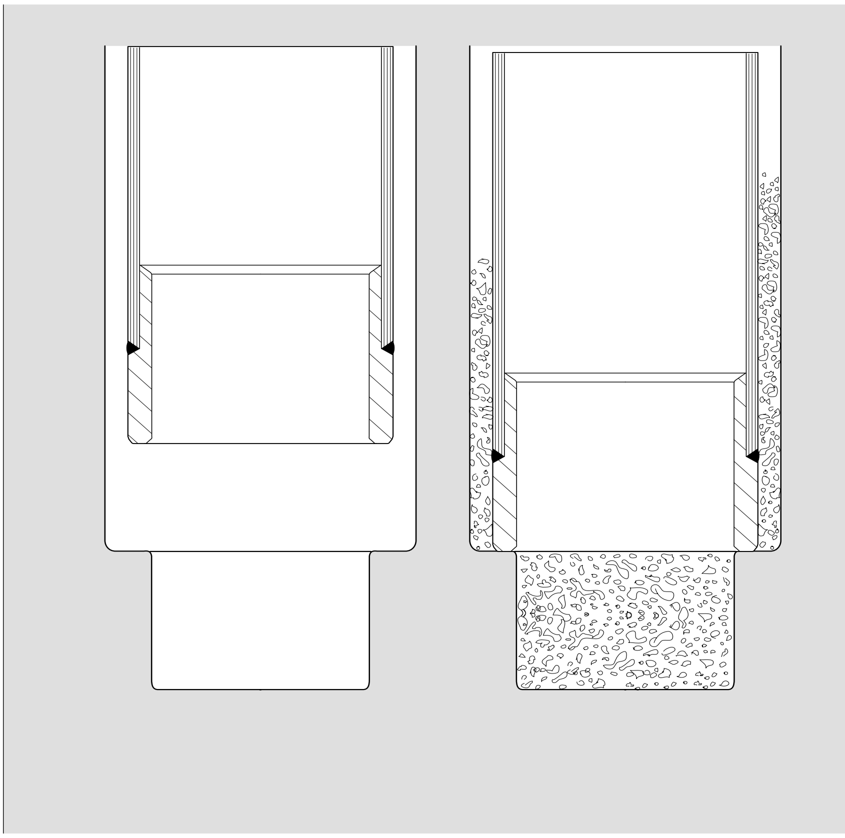
Start by flushing out the drill hole thoroughly, at the same time rotating the drill string as for drilling. Lift the drill string slightly, until the reamer meets the underside of the casing shoe. Then lower the drill string by about 10 mm and apply reverse rotation for a maximum of one revolution. Now try to lift the drill string. If the TUBEX XL equipment does not enter the casing shoe, apply rotation (as for drilling) for a few revolutions, and repeat the procedure, i.e. generous flushing followed by reverse rotation (max. 1 rev.).

N.B. The shaft of the pilot bit is threaded into the guide device by about 2.5 turns. If for some reason the pilot bit loosens in the guide device, then too many turns in reverse rotation will risk losing both the pilot bit and the reamer down the hole.



Termination of TUBEX XL drilling

When the casings are driven down to the desired depth and the TUBEX XL equipment is pulled out of the hole, the bottom end of the casing string should be fixed into position. In water-well drilling, the bottom end of the casing string is usually grouted into position.



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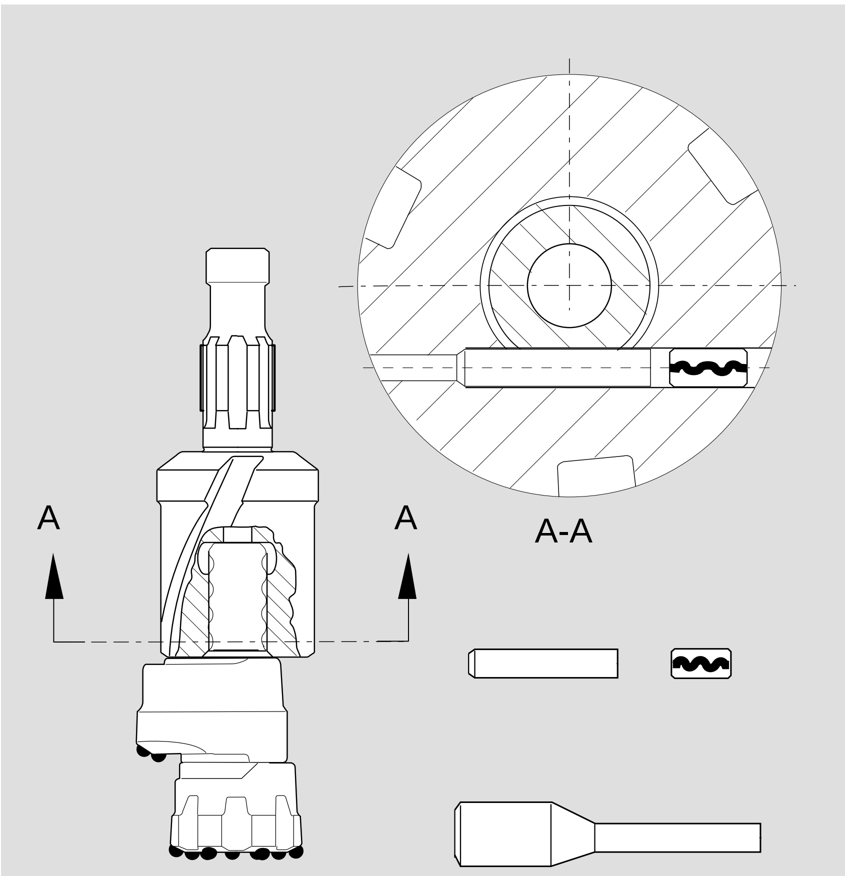

Start by pulling up the casing string by about 10 cm. Then (for TUBEX XL 115) pour about 10 litres of cement grout into the hole. To obtain an effective seal, the cement can be pressed up around the outside of the casing tubes, with the aid of a special tool.

Finally, knock the casing tubes down to the bottom of the reamed hole.

In certain cases it is not necessary to grout the casing tubes into position upon termination of TUBEX XL drilling. The casing tubes are simply driven down as far as possible by striking the upper edge of the tubes with the hammer.

Breaking the joints in the TUBEX XL equipment

The drill rig should be equipped with a breakout cylinder to facilitate uncoupling of the joints in the TUBEX XL equipment. The breakout procedure can be divided into three steps:

1 If a pilot bit pin has been used (TUBEX XL 140 and upwards), it must be tapped out together with the self-locking spring pin. This is done using a punch, and it must be done before any attempt is made to break the joint between the pilot bit and the guide device.

2 Loosening of the pilot bit
- place the bit wrench in the drill-steel support and locate the flushing grooves of the pilot bit so that they fit into the lugs in the bit wrench.
- put the guide-device wrench in

place, at the top of the guide device
- engage the feed to press the DTH hammer downwards, so that the tools are located into position
- attach the breakout cylinder to the guide-device wrench
- break the joint between the pilot bit and the guide device.

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3 Loosening the guide device
- place the guide device support in the drill-steel support and centralize the guide device over the shaft on the support
- place the guide device wrench at the top of the guide device
- engage the feed and press the DTH hammer downwards so that the tools are fixed into position
- fit a breakout wrench around the casing of the DTH hammer
- break the joint in the bottom sub of the DTH hammer with the aid of the breakout cylinder.

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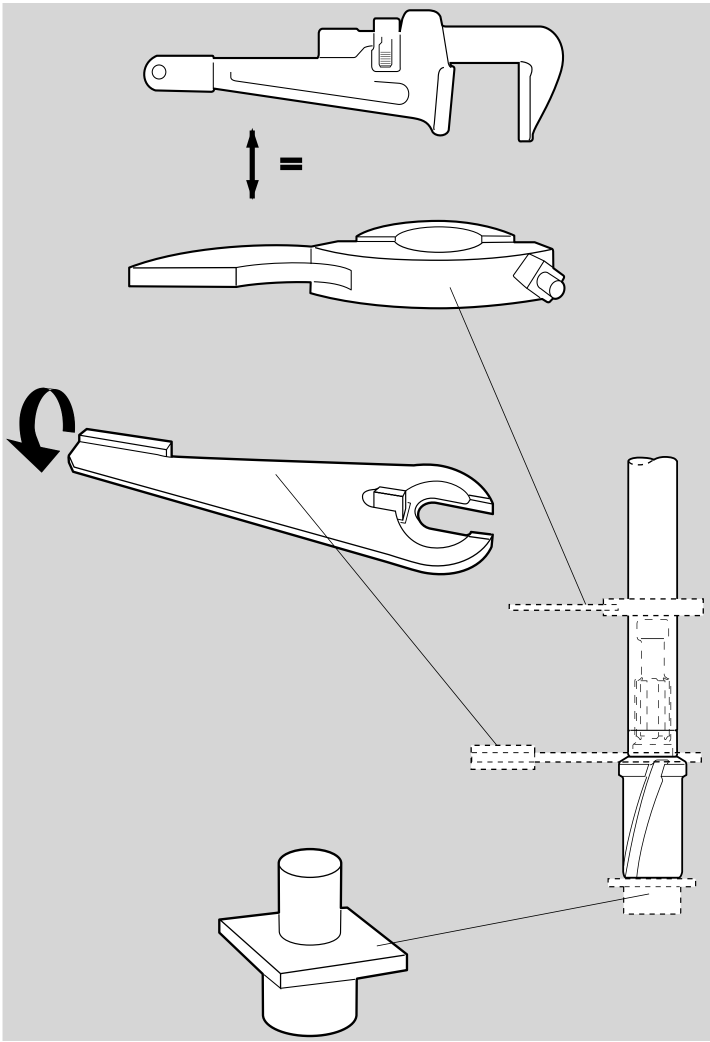

If the drill rig is intended for larger TUBEX XL equipment, it will probably be equipped with a hydraulic breakout table and an adjustable chain tongue. The equipment will make all breakout operations easier.

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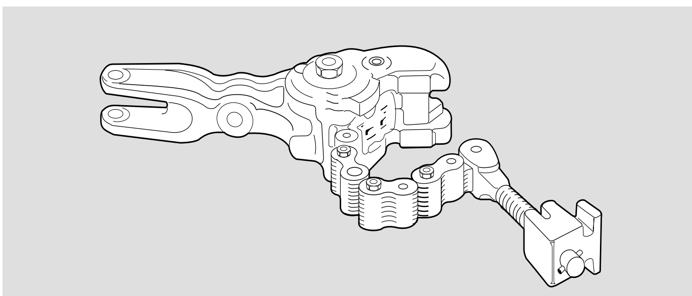


Continued drilling with TUBEX XL

If, for some reason, you need to withdraw the TUBEX XL equipment from the hole before reaching the desired depth, you should observe the following before putting it back down the hole:

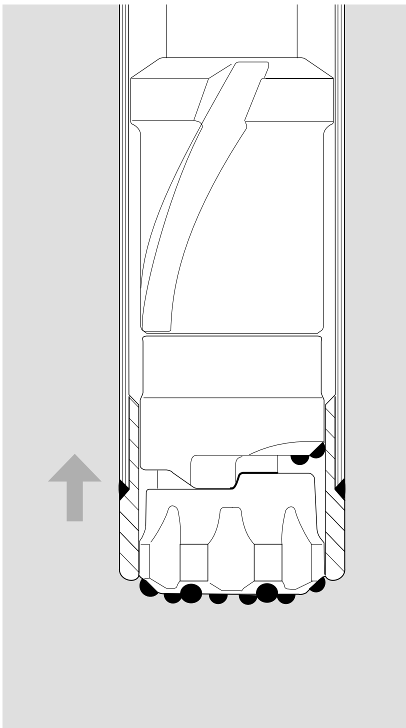
- make sure that the reamer can be opened (swung out) without jamming
- check that the flushing holes in the pilot bit are not blocked
- check the wear on the cemented carbide buttons, and regrind if necessary
- check the wear on the reamer (see page 17)
- replace defective components, e.g. the pilot bit pin (TUBEX XL 140 and upwards).

When putting the TUBEX XL equipment back down the hole:

- do not rotate the drill string until the reamer has passed through the casing shoe! If the reamer gets stuck in the casing shoe, you might have to withdraw the entire string of casing tubes.
- do not use percussion to help the reamer through the casing shoe!
- if the casing tubes have been knocked down so that they are resting on the bottom of the reamed hole, they must be pulled up by about 20 cm before the TUBEX XL equipment is put back down the hole.

Continued drilling with regular DTH

Once the casing tubes are in place, and possibly grouted into position, drilling continues using an ordinary DTH drill bit. Great



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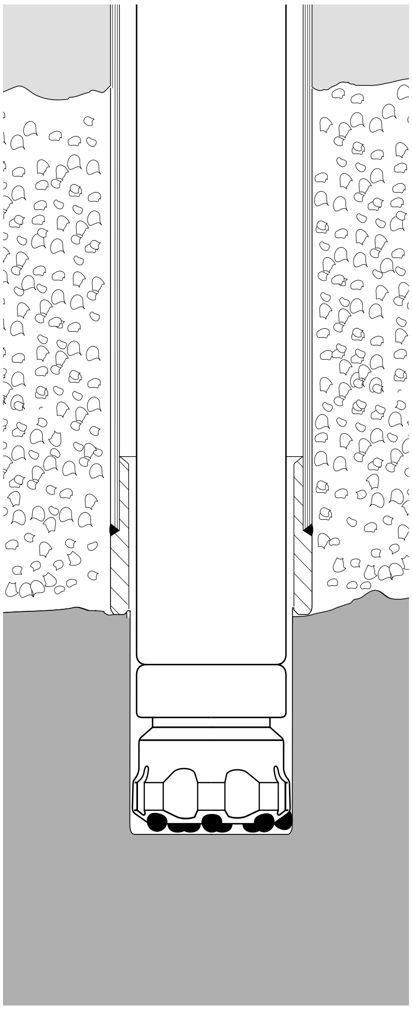

care must be taken when passing the DTH drill bit through the casing shoe, since the cemented carbide buttons can be easily damaged by the impact shoulder in the casing shoe. Damaged buttons and fragments of cemen-ted carbide in the drill hole can cause even the next drill bit to be rendered unserviceable after only a few metres of drilling. The TUBEX XL ”size” gives the maximum diameter of the DTH drill bit that can pass through the casing shoe, e.g. TUBEX XL 140 = ordinary DTH drill bit, max. 140 mm in diameter.

The diameter of the DTH drill bit should be greater (by approxima-tely 10 mm) than that of the pilot bit. Otherwise there is a great risk that the DTH drill bit will jam in the pilot hole, which could result in damage to the peripheral buttons. The first 20 cm should be drilled with very slow rotation and reduced percussion pressure. When the pilot hole has been drilled out, the feed, rotation and percussion pressures can be increased to the normal values.

To minimize the risk of jamming in the pilot hole, you could throw some small stones into the drill hole, to fill up the pilot hole before drilling.

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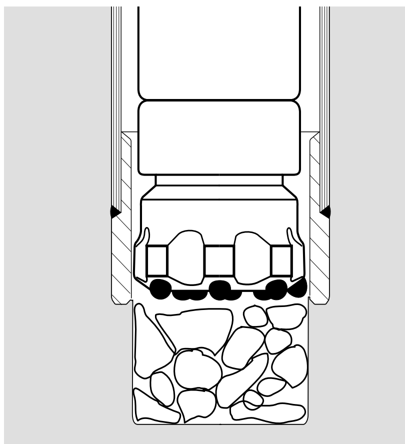

N.B. The guide sleeve used in TUBEX XL drilling must be removed from the top sub of the DTH hammer before normal drilling can continue. This is because its outside diameter is greater than the inside diameter of the casing shoe.

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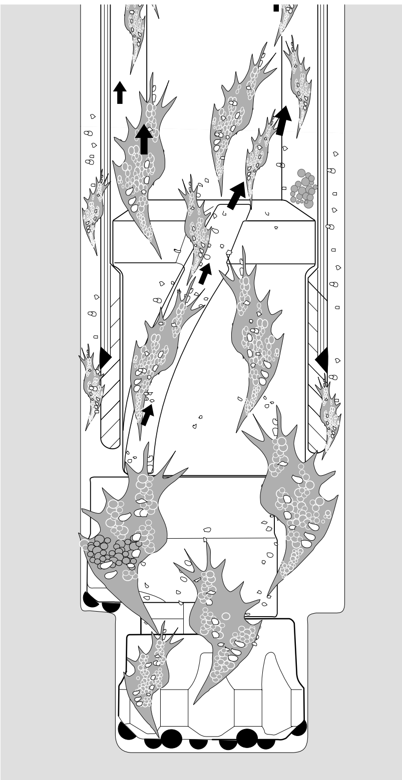


Foam flushing

It is not essential to use foam flushing with the TUBEX XL method. Depending on the ground conditions, either conventional air flushing or air/water flushing can give satisfactory results.

However, foam flushing has many significant advantages, especially when problems occur with the removal of drill cuttings, e.g. in clay formations and in water-bearing strata. The advantages of foam flushing could be summarized as follows:

- Reduced flushing air requirements when using air flushing.
- More efficient flushing in front of the pilot bit and reamer reduces wear to the TUBEX XL equipment and gives more uniform penetration.
- Foam ”lubricates” the drill string and casing tubes, which results in less wear and a lower rotational torque requirement.
- Foam lubricates and stabilizes the hole wall, which helps the casing tubes to slide more easily. This enables the casing tubes to be driven even deeper.
- Foam seals cracks and smaller cavities, which helps to maintain flushing efficiency.
- Foam breaks up clay and drill cuttings.
- Foam moistens and binds even the smallest of particles, e.g. drilling dust when drilling through rock.

Check that the foam rises evenly and steadily out of the hole during drilling.

If the foam spurts out of the hole erratically, it is an indication that the ”column of foam” in the hole is not filling the hole. This can be remedied by increasing the volume of foaming concentrate. If the foam is thin and watery, and does not succeed in carrying the drill cuttings, simply increase the volume of foam concentrate in the foam/water mixture.

Tophammer drilling

The use of foam flushing in combination with a tophammer and shank adapter for separate flushing does not call for additional comment. The best foam consistency is obtained at a flushing air pressure of 3-4 bar, although the operator should not hesitate to increase the pressure if he considers it necessary to maintain efficient drilling.

DTH drilling

When foam flushing is used in DTH drilling, the foaming concentrate is mixed with the compressed air supply to the rock drill. This means that it passes through the hammer itself. Experience has shown that this can be done without damaging the hammer. The foaming concentrate has built-in lubricating properties, which prevent siezing in the rock drill. N.B. The lubricating device for the rock drill should be disconnected, or oil in the air will break down the foam. When you are finished drilling with foam, pour a little lubricating oil into the drill string and let the hammer run for a few minutes, before pulling up the drill string.

N.B. you should remember to reconnect the lubricating device when returning to ordinary air flushing.

The simplest way of all to obtain foam flushing is to pour a little ordinary dish-washing liquid into the water tank. Alternatively, you could simply mix water and dish-washing liquid in a bucket and pour it directly into the drill string.

This very simple method will solve problems when drilling in sticky conditions.

OTHER COMMENTS

Equipment lost down the hole

It is necessary to make fishing tools to retrieve components that have been lost down the hole. The design and shape of a tool will depend on what kind of component has been lost down the hole, what kind of formation you are drilling in etc.

The fishing tool should be shaped so that it can attach itself to the inside of the component that has been lost down the hole.

For small steel components, a magnet attached to the end of a length of wire can be a useful tool.

When drilling through soft overburden, it is sometimes possible to force the lost component aside and continue drilling without further stoppage.

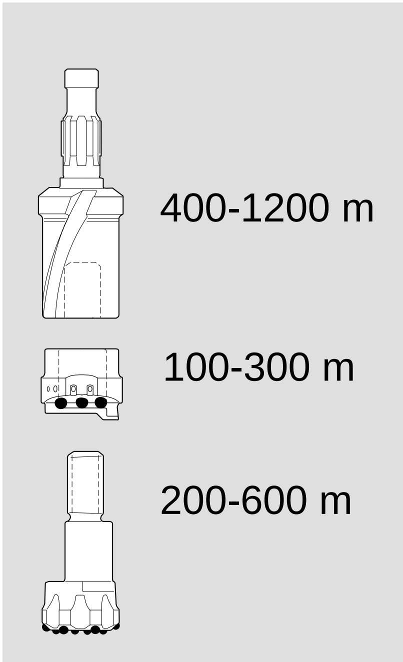
Tophammer drilling exceptions

Most information for TUBEX XL drilling with DTH hammers also applies to tophammer drilling. However, there are some differences, the most important of which are as follows:

- the casing tubes are driven down by blows from the top of the string
- there is no casing shoe
- hole depth is more limited

Wear and service life

Wear patterns on TUBEX XL bits show that body steel wears faster than cemented carbide, especially on the reamer. This is quite natural when drilling in soft overburden. The greatest wear occurs when drilling through sand and gravel.



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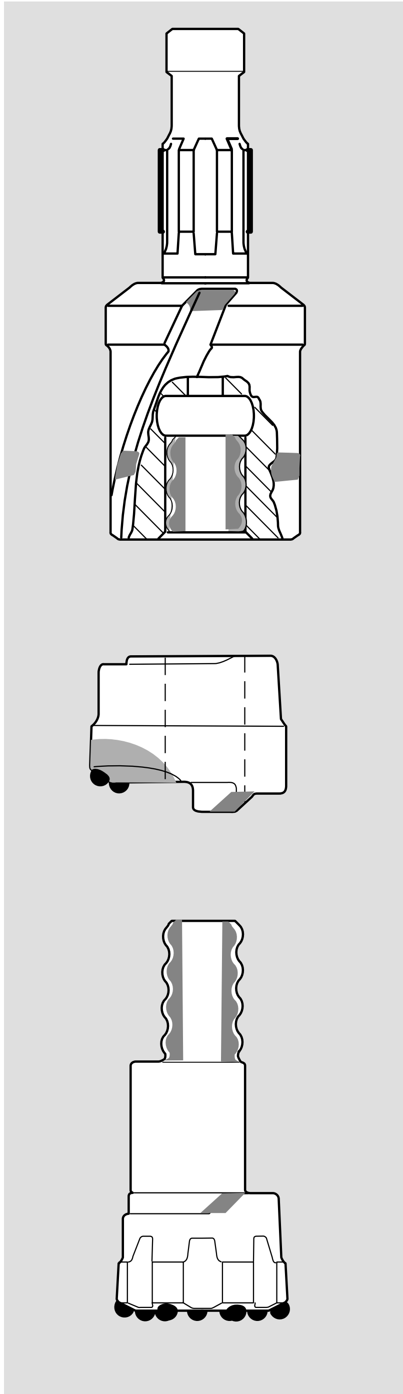
Different components in the TUBEX XL package have different service lives. A rough rule of thumb is that two reamers are used to one pilot bit, and two pilot bits are used to one guide device.

Certain parts of the pilot bit, reamer and guide device are subjected to more wear than others. It is important to keep a close watch on the development of wear.

The pilot bit: Stop-lug for reamer - the reaming diameter diminishes if wear to the stop-lug becomes too great.

The reamer: Stop-lug - the reaming diameter diminishes if wear to the stop-lug becomes too great.



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The guide device: Outside diameter of the lower part - excessive wear causes poor guiding in the casing shoe. This can result in breakage of the pilot bit thread or of the guide device shaft.

Build-up welding (hardfacing)

The service life of TUBEX XL components can be extended by hardfacing the zones that have been most badly affected by wear, e.g.

Pilot bit: Stop-lug for reamer, hardface when wear exceeds 3-4 mm.

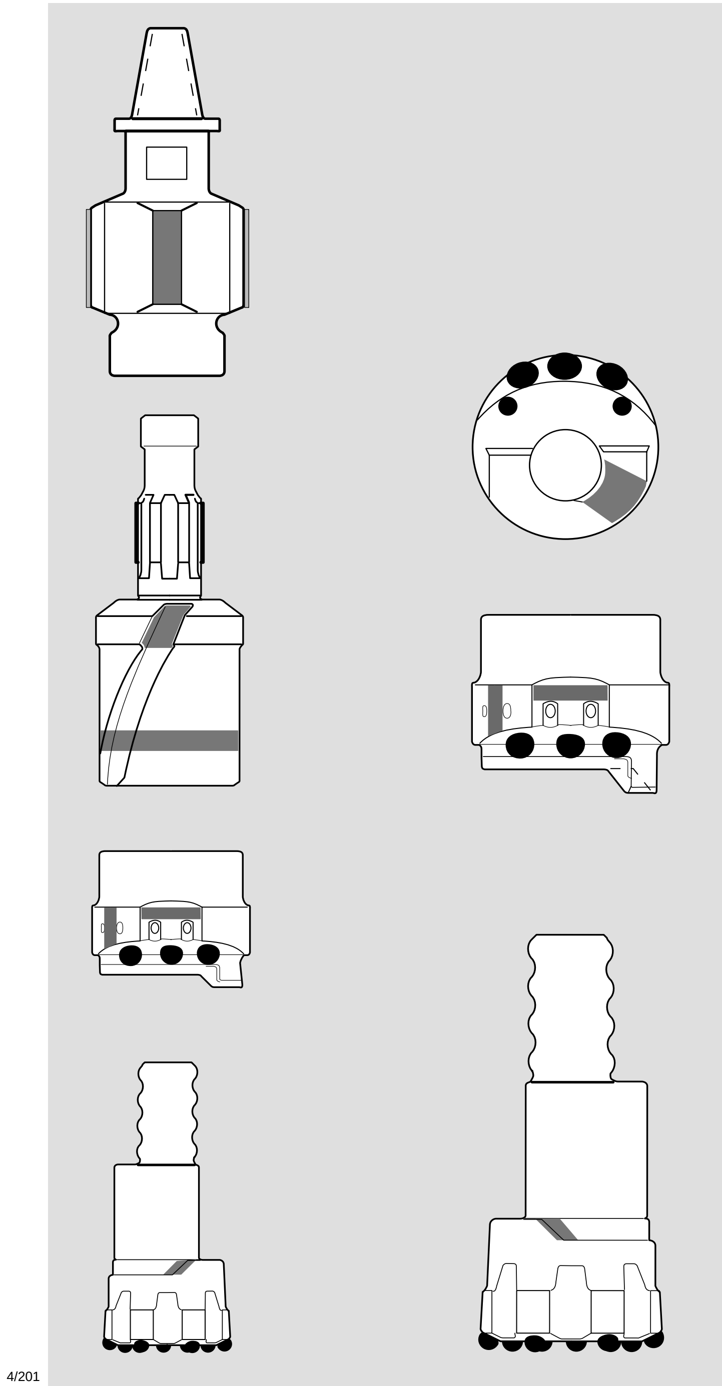
Reamer: Stop-lug, hardface when wear exceeds 3-4 mm.

In order to protect the buttons, hardfacing can also be applied to the periphery of the reamer, if necessary.

Guide device: Restore the diameter of the lower part of the guide device when wear exceeds 3-4 mm. Restore the appearance of the upper part of the flushing grooves. This will prevent unnecessary wear to the front end of the DTH hammer.

Guide sleeve: Restore the diameter of the guide sleeve when wear exceeds 3-4 mm.

Hardfacing can be carried out in two ways:



Method 1: Pre-heat to max. 200° C. Apply one weld layer using Castolin 2222, Castolin 6200 or an equivalent electrode of another make. Finish off with a layer of Castolin 6080, or equivalent.

Method 2: Pre-heat to max. 200° C. Build up surface using Castolin 6080, or an equivalent electrode of another make.

N.B. Method 1 gives a better result, with less risk of crack formation in the original material.

The above instructions also apply to TUBEX XL equipment for tophammers.

N.B. Normal product guarantees are not valid after hardfacing.

TUBEX XL PRODUCT RANGE

For DTH hammer with casing shoe

TUBEX XL TYPE	Rock drill	Casing, recom. size, mm		Min. wall thickness mm	Max. drill bit diameter mm A	Reaming diameter mm B	Road - bank bit diameter mm C
		Max. OD	Min. ID				
90*	A 30-15 COP 32	115	102	5	90	123	125
115*	A 34-15 SD-4 XL 4 COP 42 DHD 340A DH-4	142	128	5	115	152	155
140	A 43-15 SD-5 XL 5 XL 5,5 COP 42 COP 52 DHD 350R DH-5	171	157	5	140	187	190
165	B 53-15 SD-6 XL 6 COP 62 DHD 360 DH-6 SF-6 SF-6L	196	183	5,5	165	212	215
190	B 53-15 SD-6 A 63-15 SD-8 COP 62 DHD 360	222	205	6,3	190	237	240
215	A 63-15 SD-8 COP 62 DHD 380	257	241	6,3	215	278	275
240	A 63-15 SD-8 DHD 380	273	260	6,3	240	306	295
280‡	SD-10	327	305	7,1	280	370	345
365	A 100-15 SD-12	406	387	7,1	365	450	430

* Threaded casing tube also available

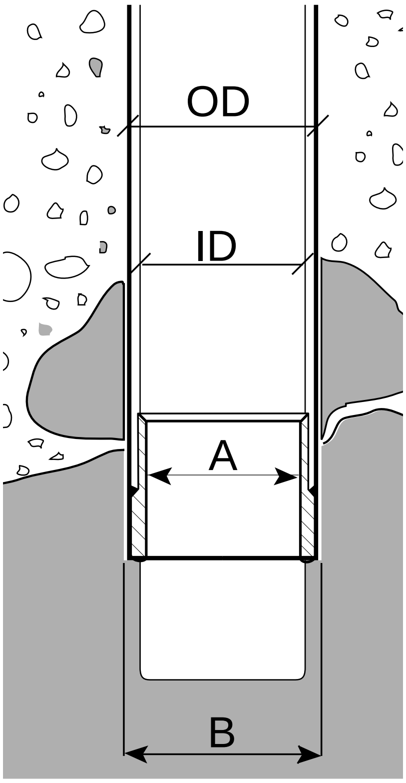
‡ Not standard

TUBEX XL PRODUCT RANGE

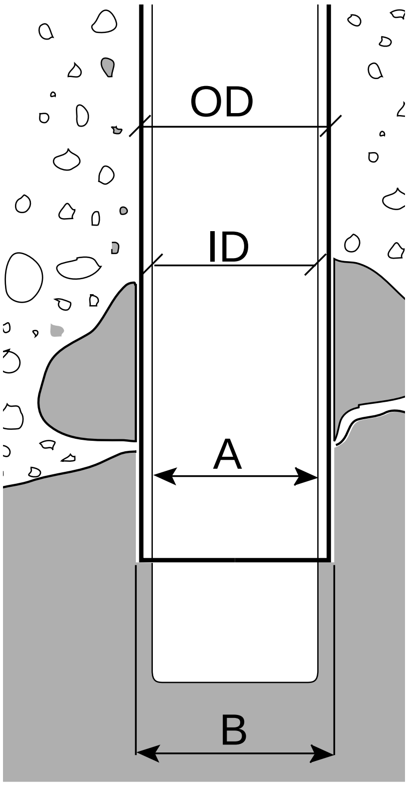
For Tophammers (no casing shoe)

TUBEX XL TYPE	Rock drill	Casing, recom. size, mm		Min. wall thickness, mm	Max. drill bit diameter, mm A	Reaming diameter, mm B
		Max. OD	Min. ID			
76*	TRP 600 BBE 57 COP 1238	89	78	4,5	76	96
127*	TRP 600 BBE 57 COP 1238	142	128	5	127	162

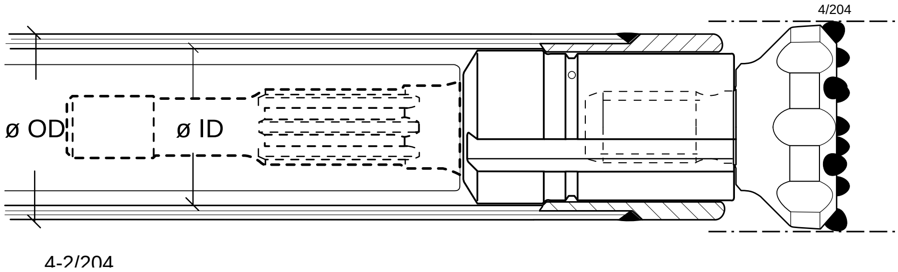
Casing tubes for DTH drilling



Casing tubes for tophammer drilling



TUBEX XL for horizontal drilling, with breakthrough



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SOME IMPORTANT POINTS ABOUT TUBEX XL DRILLING

The TUBEX XL method offers many advantages over other methods and is often the only practical way of drilling through troublesome overburden. It should be remembered, however, that success with TUBEX XL requires attention to certain details. Some of the more important details are as follows:

1 Correct choice of casing tubes (regarding inside/outside diameter and length).
2 Hardened threads - casing tubes intended for re-use should have hardened threads.
3 Correct welding (when unthreaded casing tubes are used).
4 Flushing: selection of suitable flushing medium for the type of drilling in question.
5 Correct drilling procedure.

The illustration above shows basic drilling procedure.

A TUBEX XL is used to drill through the overburden, down to the bedrock. The casing tubes are driven a short way into the bedrock. The TUBEX XL equipment is then pulled up through the inside of the casing tubes, and removed.
B Conventional drill steel equipment is fitted, and drilling continues in the bedrock (can be tophammer, DTH hammer or diamond-drilling equipment).
C Hole is completed. Drill string is withdrawn, leaving casing tubes supporting the hole through the overburden.

Depending on the purpose of the hole, the casing tubes can either be left in the hole or pulled up and re-used, in which case they should have hardened threads.

Applications - TUBEX XL for tophammers

- overburden drilling followed by blasthole drilling in the underlying bedrock
- drilling for anchor installation
- drilling for grout injection
- embankment drilling, for installing pipes and cables under roads and railways
- overburden drilling followed by diamond drilling in the bedrock
- cuttings sampling
- earth sampling
- investigation of thickness of overburden
- ground water level investigation
- underwater drilling

Applications - TUBEX XL for DTH hammers

- well drilling (for water, drainage, investigation, heat-pump installation, observation wells in refuse dumps, monitoring wells)
- grout injection drilling
- anchor installation drilling
- pile installation (steel cores)
- ground reinforcement (underpinning)
- sheet piling (pile walls)
- underwater drilling
- road/rail embankment drilling
- blasthole drilling
- drilling for sampling purposes

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Eksempel sentrisk-, ringbor- og vingesystem

Atlas Copco Ground Engineering Products

Product catalogue

Symmetrix overburden drilling systems

Product catalogue

Atlas Copco Overburden Drilling Systems

As much as 90% of the land surface of the earth is covered with loose, unconsolidated material such as soil, clay, silt, sand, gravel and boulders, which varies in depth from a few centimeters to hundreds of meters.

Drilling through this so-called overburden is often problematic, due to the tendency of the earth to cave in behind the drill bit. This makes it difficult to retrieve the drill string after the hole has been drilled. In practice, the bore hole is often lost before a casing tube can be inserted to support it. The Symmetrix™ range of overburden drilling systems represent the latest technology in simultaneous casing advancement.

Drilled piles were first used in Italy, when repairing and reinforcing foundations of buildings that had been damaged during World War II. Drilling was originally done with rotary drill rigs and drilling tools were pipes with cutting teeth at the lower end. Pipes were rotated and pushed into the ground while circulating bentonite-water slurry as a drilling mud.

Over the years the engineering has improved and new equipment and technologies developed. With the introduction of percussive drilling methods, it became possible to penetrate all kinds of soil and rock.

In the early ’90s, the DTH method was used above all for well drilling. Well drillers had continuous problems with drill bits making work slow. When the drill bit hit a boulder it might cause deviation from drilling direction. In addition the holes in overburden tend to collapse before reaching bedrock. Then a new casing drilling system, namely Symmetrix, was invented in Finland. Until the time the drilling was done with asymmetric drill bits, but the new invention was a symmetrical drill bit system, which advance a casing pipe simultaneously when drilling the hole.

The Symmetrix system

Symmetrix is a patented system comprised of an ingeniously simple concentric method of drilling through overburden with casing. Symmetrix drills straight holes, in any type of ground conditions, at any angle and to depths beyond 100 meters.

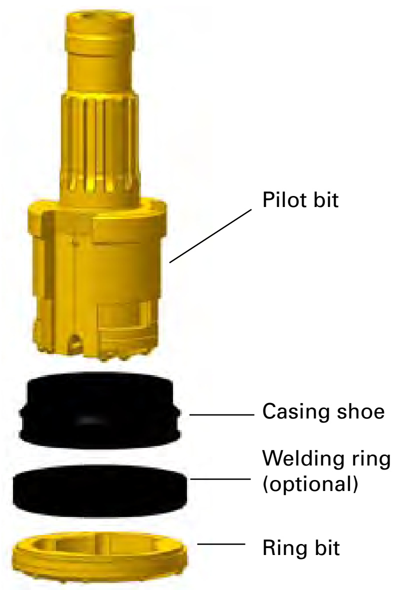
The three main components of the system are made up of:

A pilot bit that drills away the center part of the hole and guides the drill string. The pilot bit is attached to any common DTH hammer shank or top hammer rod thread.

A casing shoe welded to the casing pipe which is pulled down by the impact of the hammer and pilot bit.

A symmetrical ring bit that is locked onto the pilot bit drills the void for the casing to advance down the hole. There are three different types of ring bit and casing shoe assemblies;

- A solitary ring bit with no connection to the casing shoe.
- A welding ring that holds the ring bit and casing shoe together.
- A factory assembled ring bit set with integrated ring bit and casing shoe.



a) Symmetrix system with a solitary ring bit and an optional welding ring.

Drilling in overburden

Casings are installed into the overburden basically for two different reasons:

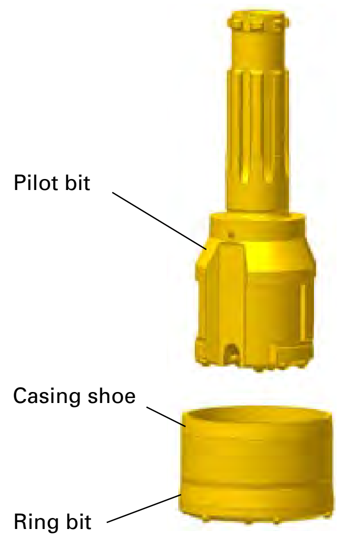
1. To create a conduit through the overburden for example;

- gas, oil, water and geothermal wells
- utility lines
- starter casings for exploration
- grouting casings

2. To create foundation and support structures such as;

- piles
- forepoling, pipe roofs
- ground stabilization
- anchors

Depending on the use of the casing it is either left in the hole permanently or retrieved by pulling out. Symmetrix range includes systems for drilling both permanent and retrievable casings. In case of the permanent casing the ring bit is sacrificed and left in the bottom of the hole, while drilling retrievable casings all system components are retrieved for re-use.

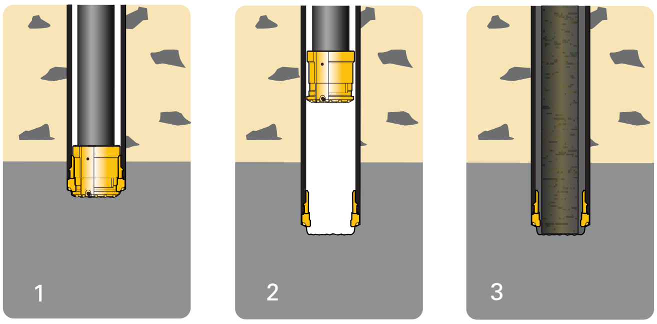


b) Symmetrix system with a ring bit set; an integrated ring bit and casing shoe.

Permanent or retrievable casings

Pile types in foundation drilling

Foundation piles are generally divided in two different types, end bearing piles and skin friction piles.



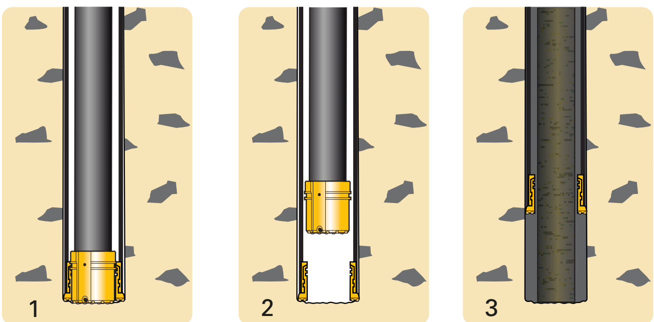
Installing end bearing piles
1. Casing is installed until bedrock.
2. Drill string is pulled out from the hole.
3. Reinforcement element is installed and concrete poured into the hole.

End bearing piles

A very important factor which determines the choice of foundation and its design is formed by the geotechnical properties of the ground.

In many cases piles can be footed in a firm stratum, such as dense till or bedrock, in which case they will get most of their bearing capacity from the base and consequently be classified as end bearing piles. Solitary ring bits can be used in this type of drilling. In case there is a special need to tie the casing shoe and ring bit together (like cavities or soft clay in ground or where drilling starts over water surface) the connection can be made economically by using a separate welding ring. Ring bit and casing shoe can be integrated in the factory. These factory assembled ring bit sets are easy to use.

The systems are available through the whole product range the smallest being for 114 mm (4 1/2") casing and largest size available at the moment is for 1220 mm (48") casing.



Installing skin friction piles
1. Casing is installed.
2. Drill string is pulled out from the hole.
3. Reinforcement element is installed and concrete poured in. Finally the casing is pulled out with ring bit set.

Skin friction piles

Where there is no particular dense underlying stratum, the bearing capacity will depend on the friction forces that are mobilized along the length of the pile. These piles are called skin friction piles. Casings are often retrieved after reinforcement structure has been installed.Skin friction piles can be drilled with the solitary ring bit as above, pulling out the casing after the concrete is poured in, but more common is to use a system where also the ring bit is retrieved. Such systems always have large ring bit inner diameters to allow maximal inside diameter usage for reinforcement structure.

The same method can also be applied to well drilling for applications where casings are retrieved. Retrievable systems are available for casing sizes from 89 mm to 1220 mm (3 1/2" to 48").

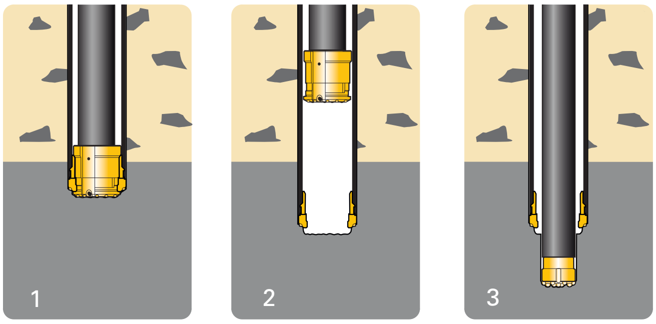
Common system requirements

Large pass through inner diameter

There are casing drilling applications where the passage through the ring bit is essential. Such requirement is typical in both piling as well as in well drilling. Symmetrix product range includes models taking this requirement into consideration.

In piling a large pass through ring bit inner diameter is normally required to drill a hole for a rock socket without the casing with a DTH bit. On the other hand the structure of pile reinforcement placed into the casing requires a certain space and when casings are retrieved ring bit inner diameter needs to be large enough.

In well drilling the casing is drilled through overburden into the bedrock and then the drilling of rock well is continued with a DTH bit. For that reason the ring bit inner diameter needs to be large enough.



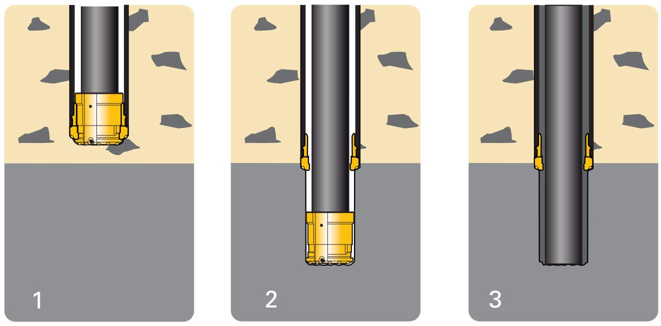
System with large pass through inner diameter
1. Casing is installed until bedrock.
2. Drill string is pulled out from the hole.
3. Drilling of the well continues with a DTH bit, which passes through the ring bit.

Systems with drill-through pilot bit

Sometimes it is economically reasonable to drill the hole for the rock socket with the actual Symmetrix pilot bit. This applies to all cases where the rock socket length is short compared to the casing length. By utilizing the Symmetrix pilot bit for drilling the rock socket, time is saved, since there is no need to replace the Symmetrix pilot bit with a DTH bit between work phases.

Symmetrix product family has such drill through systems for both permanent and retrievable casings.

Drill through systems are available for most casing sizes. In the product designation code, not only the ring bit inner diameter, but also the outer diameter of the pilot bit is given since the pilot bit makes a larger hole than the ring bit's inner diameter.



System with drill-through pilot bit
1. Casing is installed until surface of bedrock.
2. Drill through pilot bit is unlocked from ring bit and after that pilot bit drills a rock socket. Drill string is pulled out from the hole.
3. Reinforcement element is installed and concrete poured into the hole.

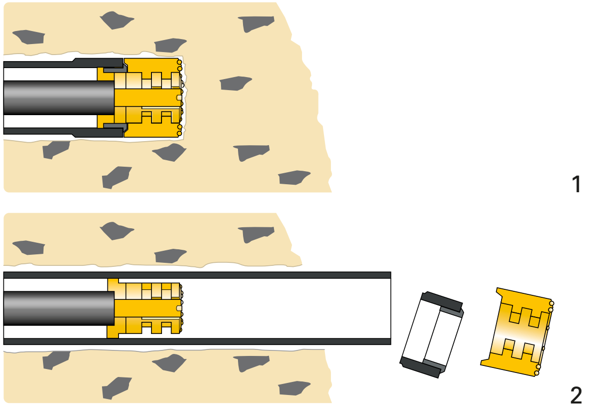
Common system requirements

Heavy-duty systems

Symmetrix product family includes the heavy-duty system, which has very strong striking and pulling surfaces. In horizontal drilling the friction between soil and casing can grow very high and Symmetrix heavy-duty drill bits are designed to stand the abrasion in such conditions.

These systems are intended for break through drilling where the ring bit is recovered for re-use. System can be also used for drilling deep vertical holes, if there is no requirement on a large ring bit inner diameter.

Heavy duty systems are available for casings from 140 mm up to 1 220 mm (5 1/2" to 48").

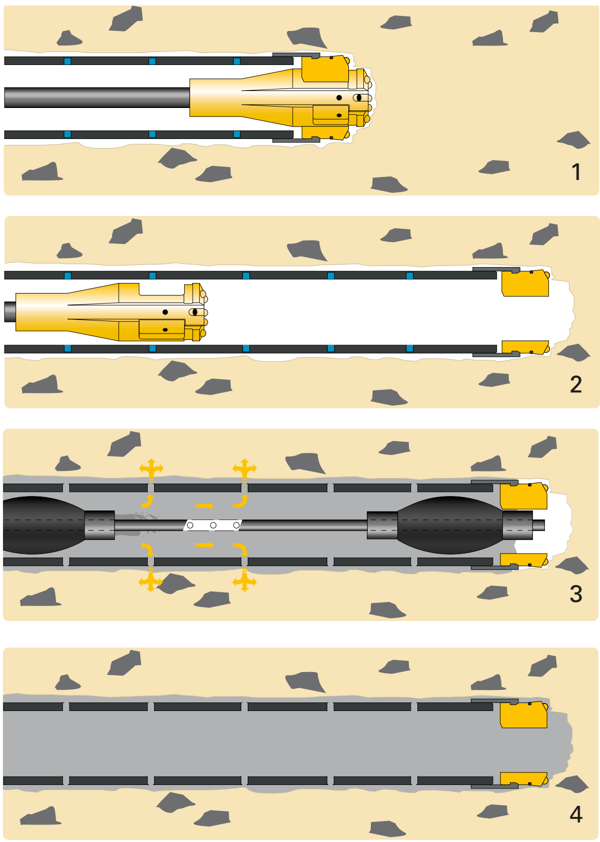


Heavy duty system - horizontal drilling
1. Casing is installed through overburden layer.
2. Ring bit (and casing shoe with starter casing) are recovered from receiving pit. Drill string is withdrawn to starter pit.

Symmetrix heavy-duty system with a solitary ring bit, which can be connected to a casing shoe by optional welding ring.

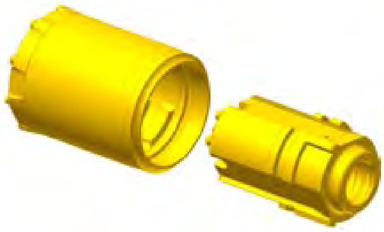
Top hammer systems

While most of casing drilling is done with DTH hammers there are also requirements to drill casings with top hammers. Symmetrix product range naturally consists models for drilling both permanent and retrievable casings with top hammer.



Forepoling with top hammer
1. Casing is installed.
2. Drill string is pulled out from the hole.
3. Double packers are used for grouting.
4. After grouting installation is finished.

Top hammer system for permanent casings, e.g. for forepoling

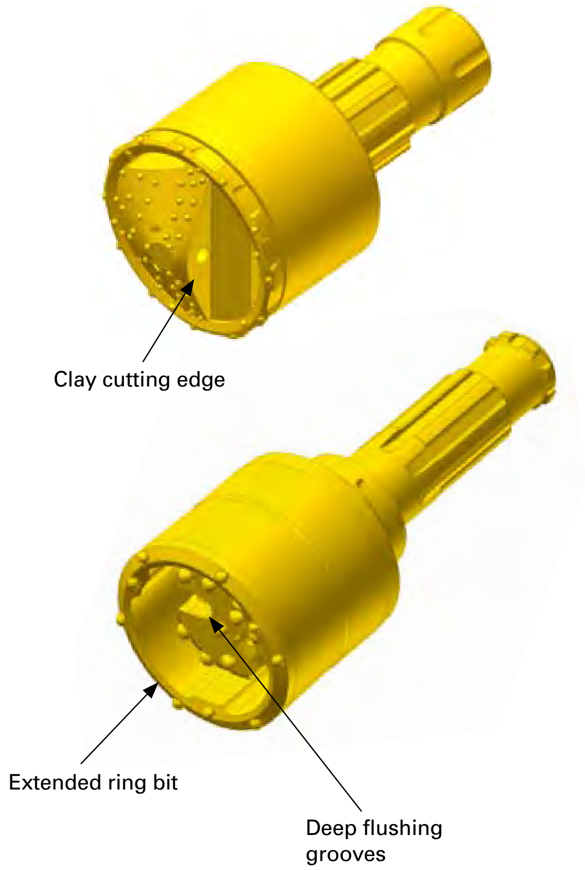


Top hammer system for retrievable casings, e.g. for anchoring

Special system designs

Clay face design

Sometimes clay makes casing advancement very problematic. Clay cannot be drilled with impact as its elastic structure does not break nor produce any cuttings to be flushed out, making penetration very slow. Hard, rubber type clays can be drilled with cutting only. For that reason Symmetrix clay face has been designed. Symmetrix clay version, which is optional for all models, has despite its large clay cutting face area enough surface with tungsten carbide inserts to allow also drilling into solid rock.



Sensitive conditions

When facing sensitive drilling conditions, such as underpinning and construction close to existing structures, pilot bits with extra deep face flushing grooves can be of great use. These Symmetrix pilot bits are used with long ring bit assembly to keep flushing within the face area and collect the cuttings back into the casing. This means less disturbances for surrounding structures. The method can also be utilized in marine constructions, where this assembly ensures controlled drilling and cuttings removal in sea bottom conditions. This system does not only keep the flushing under control but also allows accurate and straight penetration in steeply sloped bedrock face.

These two models are not included in product listing and are available on request. Please contact your local Atlas Copco customer center or distributor.

Symmetrix features

Each Symmetrix system is made from high quality alloy steel, and has been precision machined to produce a perfect bit body, heat treated to the required hardness, and fitted with durable tungsten carbide buttons.

Pilot bit with hemispherical buttons

Ballistic buttons for specific conditions

Symmetrix drill bits are manufactured with hemispherical buttons, but can be dressed also with ballistic buttons for use in soft and medium hard formations to achieve higher penetration rate. Ballistic buttons are efficient in cutting clay and also able to penetrate into wood when drilled within old wooden foundation.

Drill bits with ballistic buttons are available on request. Please contact your local Atlas Copco customer center or distributor.

How to select a Symmetrix system

When selecting the right Symmetrix casing drilling system, the first question to ask is whether the casing should be permanent or retrievable. This will influence the further choices.

The second issue to investigate is what casing size is used by determining outer diameter of the casing pipe and wall thickness. For permanent casing, both thick and thin wall casing can be used, while a thick wall casing is needed for retrievable casing.

The final step is to get a good insight of the application and requirements for the system. For example what kind of hammer is used? Is drilling continued through the ring bit after the casing has been installed? Is the drilling horizontal or vertical?

Product designation code

The Symmetrix systems will be named and numbered according to the casing type, casing size and ring bit inner diameter in both, permanent and retrievable forms.

Casing type, P=Permanent, R=Retrievable

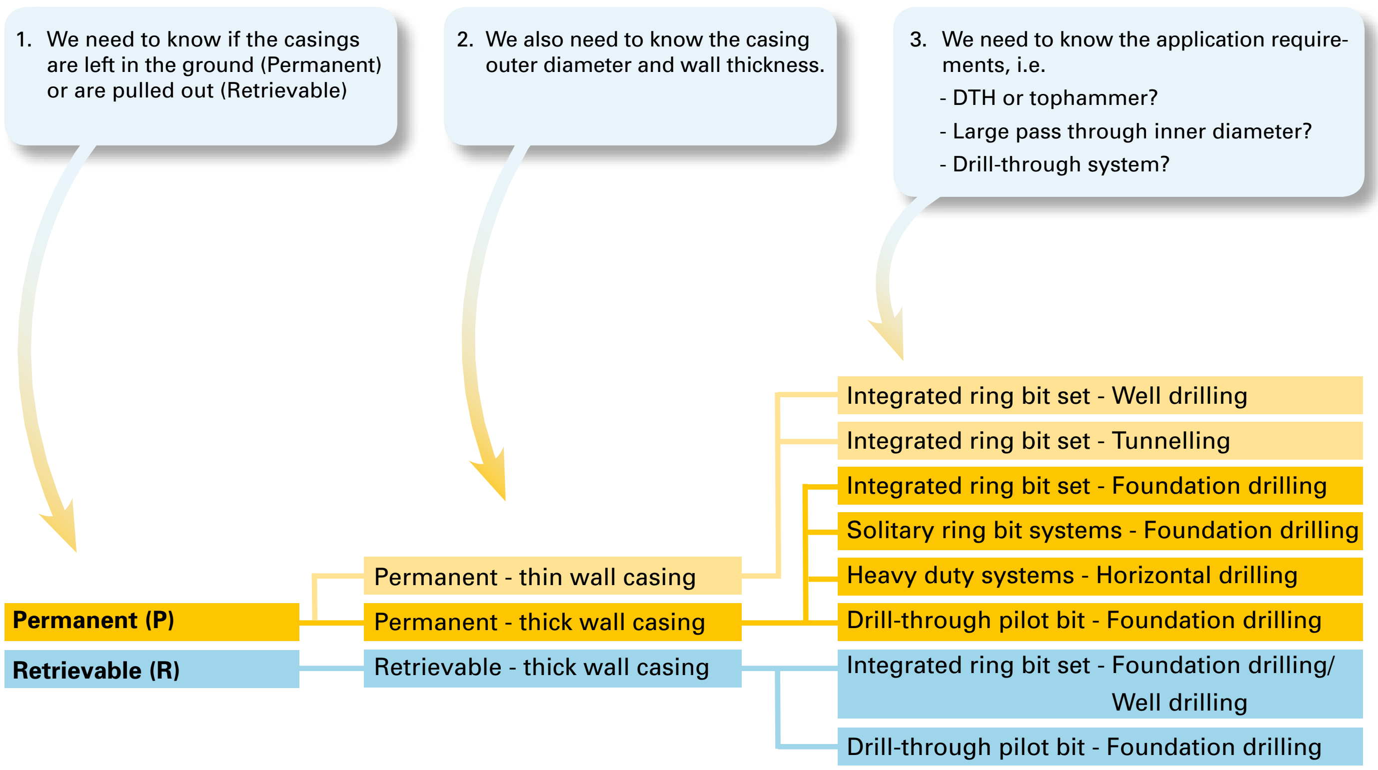
Casing outer Ø (mm)

Maximum casing wall thickness (mm)

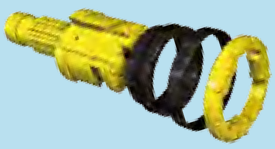
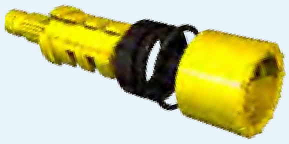
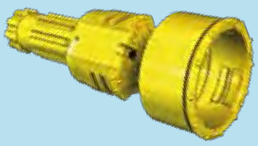
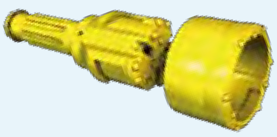
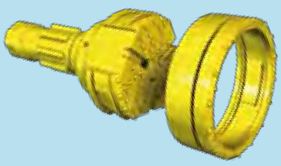
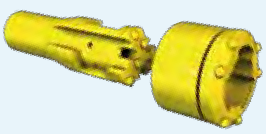
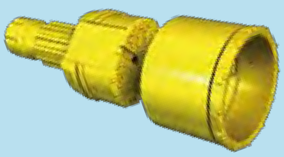
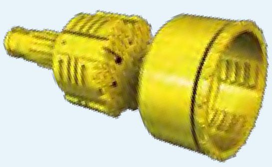
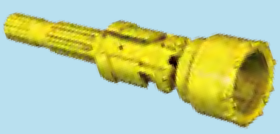
Ring bit inner Ø or ring bit inner Ø / drill-through pilot bit outer Ø (mm)

Shank or thread or product description

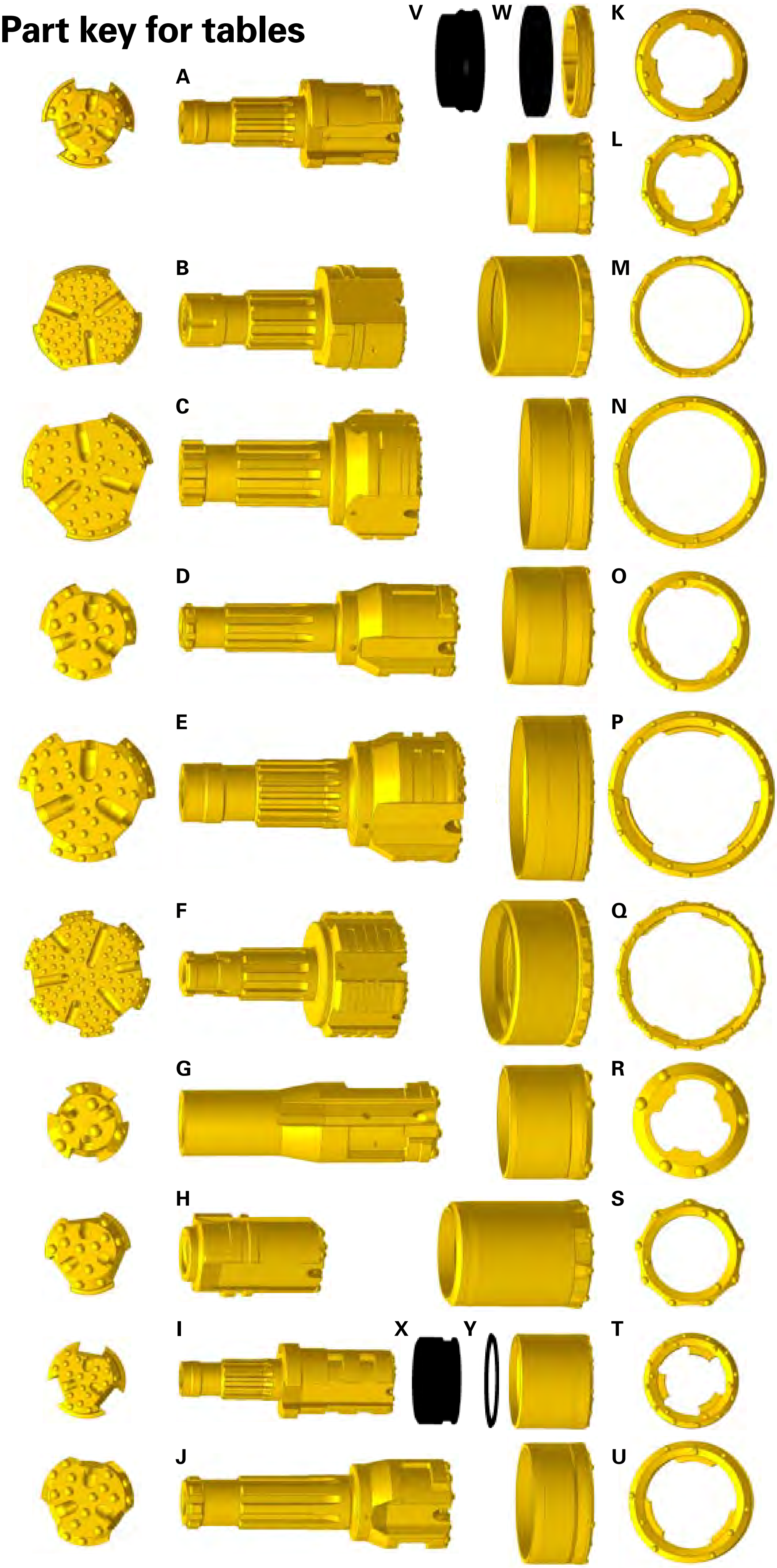
P168/12.7-103-QL50



Overview map of Symmetrix systems

	Casing type	**Hammer type**	**System feature**	**Main applications**	**Ring bit system**	**Remark**	**Casing outer Ø** mm (inch)	**Large pass through inner Ø**
	**Permanent or retrievable**	**DTH / Top hammer**		Foundation drilling, especially end bearing piles	Either solitary ring bit with optional welding ring or integrated ring bit set	When drilling with solitary ring bit casing can be retrieved and ring bit is left in the bottom of the hole	114-1220 (4 1/2 - 48)	No
	**Permanent**	**DTH**	**Heavy duty**	Horizontal drilling, vertical break-through drilling, deep vertical holes	Solitary ring bit with optional welding ring		140-1220 (5 1/2 - 48)	No
	**Permanent**	**DTH**	**Drill-through pilot bit**	Foundation drilling, especially end bearing piles, anchoring	Integrated ring bit set	The pilot bit can continue drilling hole for rock socket	168-711 (6 5/8 - 28)	Yes
	**Permanent**	**DTH**		Well drilling	Integrated ring bit set		140-194 (5 1/2-7 5/8)	Yes
	**Permanent**	**DTH**		Deep well drilling, foundation drilling	Integrated ring bit set		168-914 (6 5/8 - 36)	Yes
	**Permanent**	**Top hammer / DTH**		Forepoling in tunnels	Integrated ring bit set		76-114 (3 - 4 1/2)	No
	**Retrievable**	**DTH / Top hammer**		Foundation drilling, especially skin friction piles, anchoring. Screen wells.	Integrated ring bit set		89-1220 (3 1/2 - 48)	Yes
	**Retrievable**	**DTH**	**Drill-through pilot bit**	Foundation drilling anchoring	Integrated ring bit set	The pilot bit can continue drilling hole for rock socket.	114-1220 (4 1/2 - 48)	Yes
	**Retrievable**	**DTH**		Piling, anchoring. Pre-drilling of holes for driven piles	Integrated ring bit set		219-1016 (8 5/8 - 40)	No

Part key for tables



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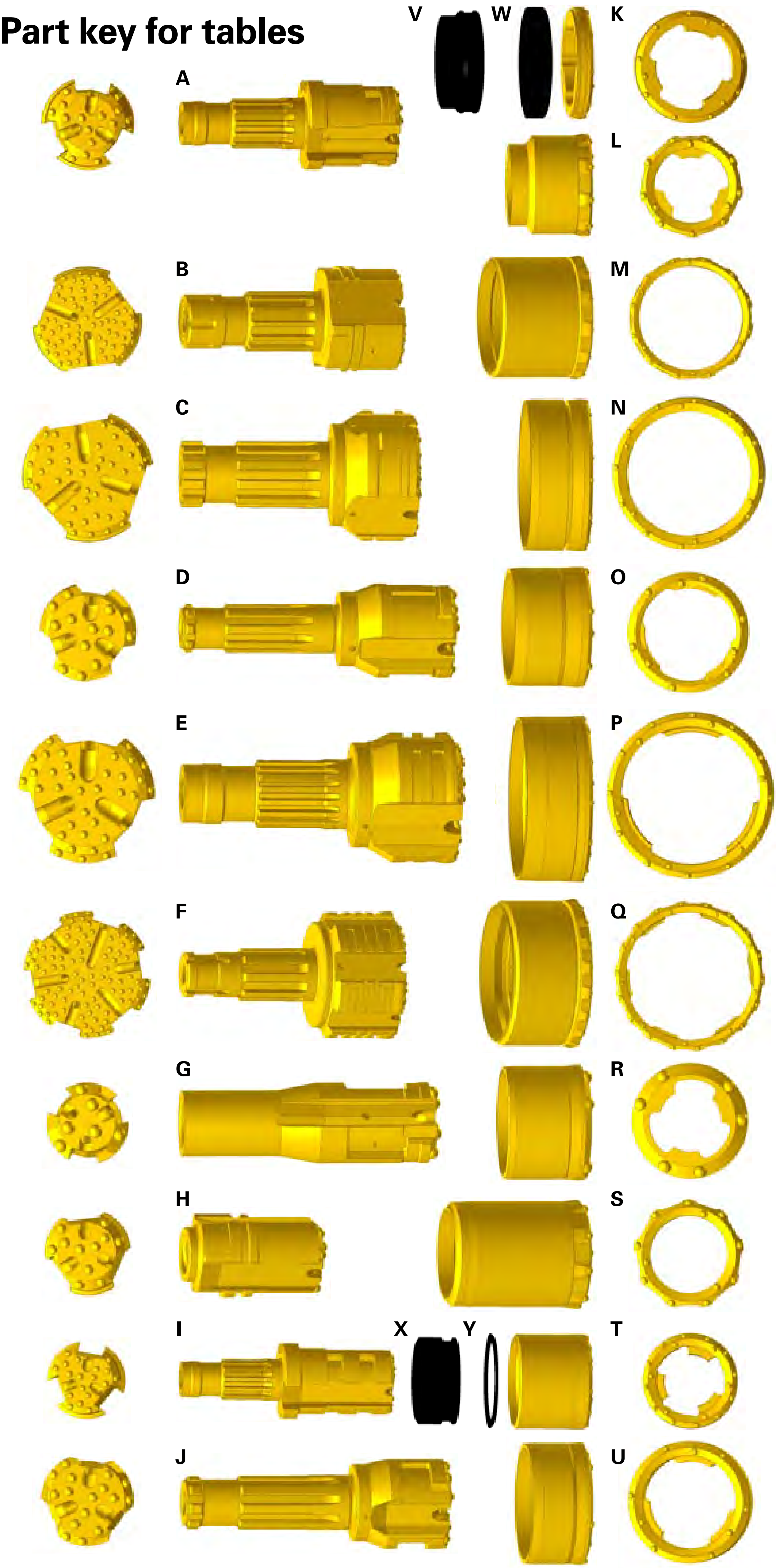
Part key for tables



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ROBIT® CASING SYSTEMS PRODUCT CATALOGUE

Catalogue de Produits · Catálogo de Productos · Каталог

Forepoling

Piling and Underpinning

Water and Thermal Well Drilling

Anchoring

Horizontal Drilling

Site Investigation

Robit® ROCKTOOLS

ROBIT® CASING SYSTEMS PRODUCT CATALOGUE

PRODUCT LINES

Lignes de produits · Línea de productos · Номенклатура продукции

Ground drilling tools – Casing Systems
Robit® Casing Systems are the key components of the Ground Drilling Tools product line. Its patented locking system enables easy and reliable drilling cost effectively. Robit® Casing Systems have several references worldwide in all major ground drilling applications: forepoling, anchoring, piling and underpinning, horizontal drilling, water and thermal well drilling, soil investigation/ monitoring and underwater drilling.

Rocktools - Button bits
Rocktools product line covers all construction, quarrying, and mining drill&blast applications from soft to hardest rock conditions. Tunnelling is one of the most important customer segments for Robit® bits, and applications like drifting, cuthole and bolthole are well covered. Also major mining and quarrying customers have approved Robit® quality worldwide.

Ground drilling tools – Système de tubage à l'avancement
Le Système de Tubage Robit® est un composant clé de la ligne de produits Ground Drilling Tools (outils pour terrains de recouvrement). Son système breveté d'enclenchement du pilote et de la bague assure un forage simple et fiable avec des coûts de forage efficaces. Le système de tubage Robit® est utilisé dans le monde entier avec des références dans toutes les applications pour terrains de recouvrement: voûtes parapluies, ancrage, pieux et underpinning, forage horizontal, puits pour l'eau et la geothermie, reconnaissance des sols, forages sous-marin.

Rocktools – Taillants à boutons
La ligne de produits Rocktools couvre toutes les applications de la construction, carrières, mines, tunnels, etc... depuis les terrains les plus tendres aux conditions de roches les plus extrêmes. Le monde du tunnel est l'un des segments les plus importants pour les taillants Robit® avec par exemple le creusement de galeries, le boulonage, les trous de décompression …Les clients des mines et des carrières les plus exigeantes au monde ont depuis longtemps approuvé la qualité des taillants Robit®.

Herramientas para perforación de terrenos – Sistemas de tuberías
Los sistemas de tuberías de Robit® son los componentes claves de la línea de productos de herramientas para la perforación de terrenos. Su sistema patentado para acoplar el piloto con la corona permite una perforación fácil y fiable con costo efectivo. Los sistemas de tuberías de Robit® tienen varias referencias en todo el mundo en todas las principales aplicaciones de perforaciones en tierra como: enfilajes, anclaje, pilotaje y recalzado de cimientos, perforación horizontal, perforación de pozos de agua y pozos térmicos, investigación y monitoreo del suelo y perforación subacuática.

Herramientas para perforación en roca – Brocas de botones
La línea de productos de Rocktools cubre todas las aplicaciones en construcciones, canteras y minería en la perforación y explosión de roca blanda y rocas de extrema dureza. Los túneles son uno de los más importantes segmentos de clientes para las brocas Robit® además de las aplicaciones para perforación de galerías, perforación para formar piedras o piezas de concreto y perforación para el anclaje. También los principales clientes de minería y canteras han aprobado la calidad de Robit® en todo el mundo.

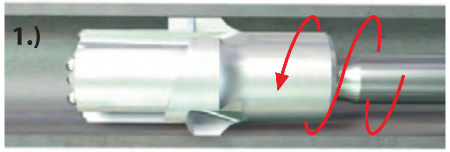
Буровой инструмент специального назначения
Robit® Casing Systems (система бурения с обсадными трубами) - основная составляющая буровых инструментов для специального бурения в ассортименте продукции Робит. Эта надежная запатентованная система обеспечивает эффективность проведения буровых работ. Robit® Casing Systems применяется по всему миру для следующих работ: Укрепление грунтов, Анкерное бурение, Бурение под установку свай, Горизонтальное бурение, Бурение водяных и термических скважин, Исследования и мониторинг почвы, Бурение под водойБуровой инструмент специального назначения.

Буровой инструмент для горных работ - штыревые коронки
Номенклатура продукции компании Robit® включает в себя горные инструменты для строительства, карьеров и рудников при буровзрывных работах в условиях от слабых до самых крепких горных пород. Проходка горных выработок большого сечения один из самых важных секторов для коронок Робит, также они применяются при бурении врубовых шпуров и бурении шпуров для установки штанг. Качество продукции Робит одобряют заказчики по всему миру.

ROBIT® PATENTED SPIRAL LOCKING SYSTEM

Verrouillage spirale automatique · Sistema de enganche en espiral patentado · Автоматический спиральный замок

1.)



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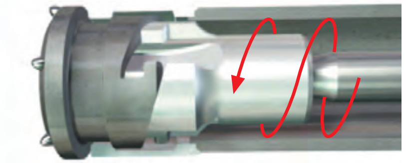
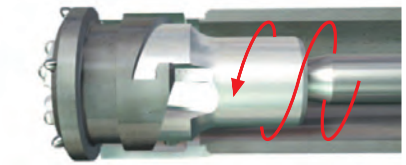
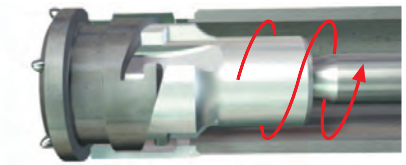


3.)



4.)



Automatic spiral locking (Patented):

1. Drive the pilot bit through the casing tube
2. Rotate to locked position in the ring bit
3. Robit® Casing System is READY TO DRILL
4. Finish drilling by rotating the pilot bit in opposite direction and pulling it out

Verrouillage spirale automatique (Breveté):

1. Conduire le pilote dans le tube jusqu'à la bague
2. La rotation du pilote engendre le verrouillage de ce dernier avec la bague
3. Le système Robit® est PRÊT À FORER
4. À la fin du forage, la rotation du pilote en sens inverse permet le déverrouillage de ce dernier avec la bague

Sistema de enganche en espiral (Patentado):

1. Insertar broca piloto a través de la tubería de revestimiento hasta llegar a la zapata
2. Girar broca piloto en dirección del enganche
3. El sistema de enganche de Robit está LISTO PARA PERFORAR.
4. Al terminar la perforación, girar levemente en sentido contrario del enganche y retirar broca piloto.

Автоматический спиральный замок (запатентованный):

1. Направьте пилотную коронку внутрь обсадной трубы
2. Поверните вращательным движением до присоединения к кольцевой коронке
3. Система бурения с обсадными трубами Robit® Casing System ГОТОВА К БУРЕНИЮ
4. Когда бурение закончено, вращайте направляющую пилотную коронку в противоположном направлении извлекая ее.

ROBIT® CODES

Codes Robit® · Códigos Robit® · Коды Robit®

Casing System codes · Codes du système de tubage · Códigos de sistemas de tuberías · Коды системы бурения с обсадными трубами

e.g DTH - RoX MU 114,3 / 10

Maximum casing wall thickness · Epaisseur maximale du tube · Grosor máximo de la pared del tubo
Максимальная толщина стенки обсадной трубы = **10 mm (0.394")**

Casing outer diameter · Diamètre extérieur du tube · Diámetro exterior de tubo
Обсадная труба, внешний диаметр = **114,3 mm (4 ½")**

Model · Modèle · Modelo · Модель = **MU (Multi-Use** · Multi-Use · Multi-Uso · Multi-Use)

Series type · Type de série · Tipo de serie · Тип серии = **RoX**

Type of use · Type d'utilisation · Tipo de uso · Цель применения = **DTH (Down the Hole** · Fond de trou · Martillo de fondo · Погружное бурение)

Buttons · Boutons · Botones · Штыри

All the products are available with ballistic or SuperDome buttons. · Tous les produits sont disponibles avec des boutons balistiques ou SuperDômes.
· Todos los productos estan disponibles con botones balísticos o SuperDomos. · Вся продукция поставляется или с баллистическими или с штырями SuperDome.

Ballistic button

Bouton balistique · Botón balístico · Баллистические штыри

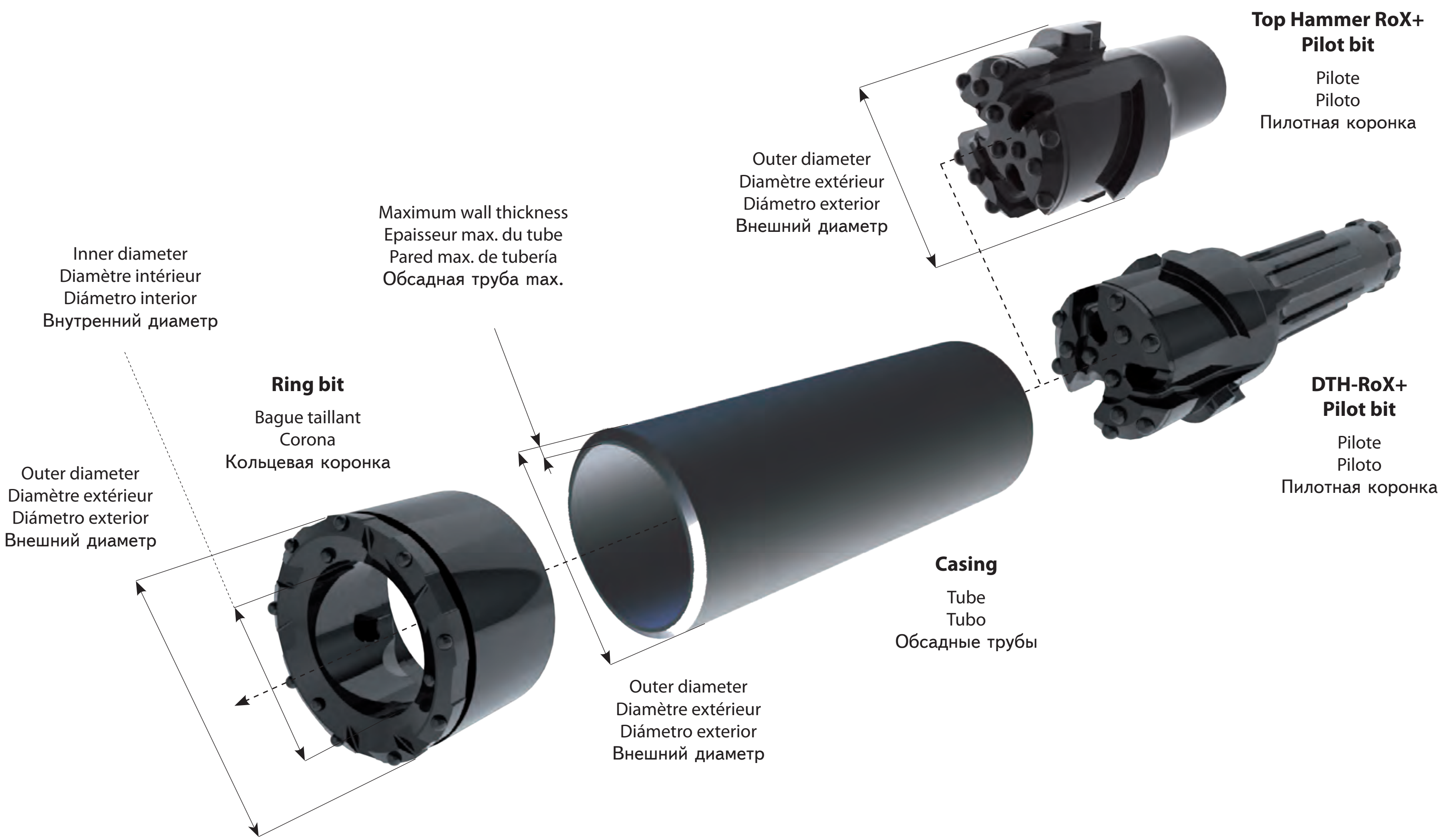
SuperDome button

Bouton SuperDôme · Botón SuperDomo · Штыри SuperDome

ROBIT® DIMENSIONS EXPLANATION

Explanation des dimensions · Explicación de dimensiones · Системы для бурения с обсадной трубой

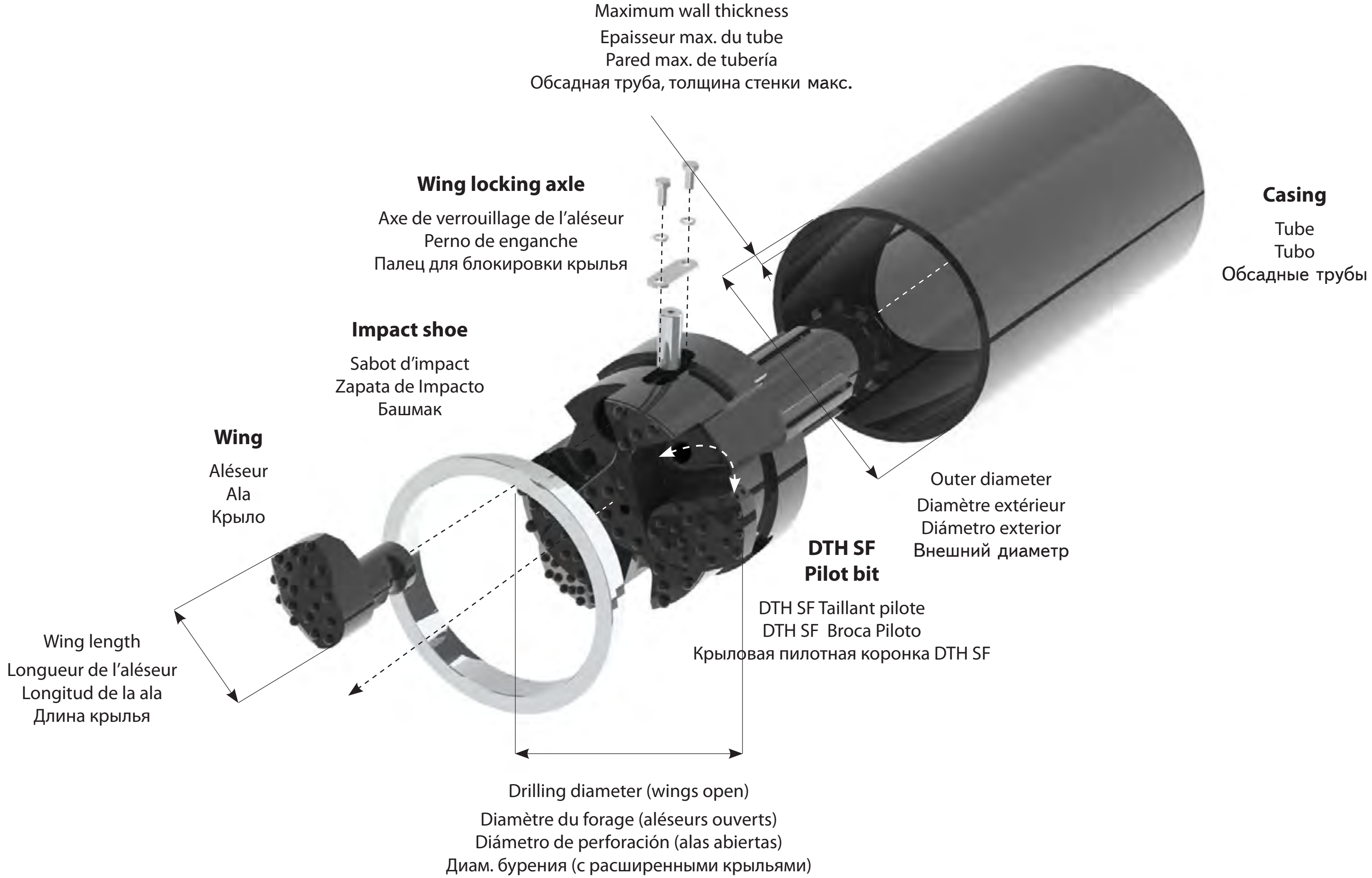
Casing System dimensions · Dimensions du système de tubage · Dimensiones del Sistema · Описание размеров



ROBIT® STEEL FIST DIMENSIONS EXPLANATION

Robit® Steel Fist détails des dimensions · Robit® Steel Fist explicación del sistema · Robit® Steel Fist

Casing System dimensions · Dimensions du système de tubage · Dimensiones del Sistema · Размеры системы для бурения с обсадной трубой



ROBIT® SYSTEM CHART

Charte des systèmes Robit® · Tabla de los sistemas Robit® · Robit® Описание технологий бурения

Casing installation · Installation du tube · Instalación de la tubería de revestimiento · Технология бурения

Model Modèle Modelo Модель		**Top Hammer** Taillant pilote Martillo de cabeza Перфоратор	**DTH Hammer** Marteu fond de trou Martillo de fondo Молоток для погружного бурения	**Permanent Casing** Tubage permanent Tubería permanente Неизвлекаемая обсадная труба	**Temporary Casing** Tubage temporaire Tubería temporal Временная обсадная труба
RoX+		x		x	
RoX GFRP		x		x	
DTH-RoX+			x	x	
DTH-RoX++			x	x	
DTH-RoX DS			x	x	
DTH-RoX SR			x	x	x

ROBIT® SYSTEM CHART & SHANK TYPES

Charte des systèmes Robit® & emmanchements · Tabla de los sistemas Robit® & tipos de shank · Robit® Описание технологий бурения и типоразмеры хвостовиков

Casing installation · Installation du tube · Instalación de la tubería de revestimiento · Технология бурения

Model Modèle Modelo Модель		**Top Hammer** Taillant pilote Martillo en cabeza Перфоратор	**DTH Hammer** Marteu fond de trou Martillo de fondo Молоток для погружного бурения	**Permanent Casing** Tubage permanent Tubería permanente Неизвлекаемая обсадная труба	**Temporary Casing** Tubage temporaire Tubería temporal Временная обсадная труба
DTH SF			x	x	x
DTH-RoX MU			x		x
DTH-RoX HZ			x	x	
DTH-RoX NS			x		x

Standard shank designs · Emmanchements standards · Diseños estándares de shanks · Стандартные типоразмеры хвостовиков

DTH-hammer size · Taille du marteau FDT · DTH-tamaño del martillo · Диам. погружного пневмоударника

Standard shank design · Modèle standard d'emmanchement · Diseño estándar del shank · Стандартный типоразмер хвостовика

3 ½"	IR 3,5"	5"	IR 350	8"	IR 380	12"	SD-12
4"	IR 340	6"	IR 360	10"	SD-10	18"	N180
						24"	N240

All inquiries for other shank designs please contact Robit sales.

Pour tout les autres modèles d'emmanchements, contactez l'équipe de ventes Robit. · Para otros diseños de shanks, por favor contactar a su agente de ventas Robit. · По остальным типоразмерам просим обратиться к отделу продаж компании Robit.

ROBIT® GENERAL DRILLING PARAMETERS

Robit® paramètres de forages généraux · Parametros generales de perforación Robit® · Общие буровые параметры

Drilling with DTH casing system

· Forer avec un systeme de tubage fond de trou (DTH) · Perforación con sistema de tubería de revestimiento con martillo DTH · Погружное бурение с обсадной трубой

1. **Pulldown force**
The moderate pulldown force on pilot is 9 kg/mm (500 lbs/inch)
2. **Rotation speed**
Normal operating RPM ranges are from 10 to 60 RPM (see chart 1.)
3. **Compressor pressure**
Normal operating pressure is from 10 to 15 bar or 150 to 225 psi. Note: in loose formation (i.e. sand) compressor can be set to 7 bar or 100 psi
4. **Flushing**
Drill exhaust air passes through the bit to clean the bit face and carry cuttings to the surface up the annular space between the drill pipe and the casing tube.

The air consumption can be calculated as below:

$$Q = V (D^2 - d^2) / 1273500$$

Q – Air consumption in m^3/min.
V – Velocity of cuttings (between 1100 to 1500 m/min.)
D – Inside diameter of casing tube in mm
d – Outside diameter of the drill tubes in mm

1. **Force d’appui**
La force d’appui moyenne sur le pilote est de 9kg/mm (500 lbs/inch)
2. **Vitesse de rotation**
Les vitesses de rotation en opérations normales, s’étendent de 10 à 60 RPM (voir graph. ci-dessous)
3. **Pression du compresseur**
Les pressions en opérations normales sont comprises entre 10 et 15 bar ou 150 et 225 psi.- Note : Dans des formations très tendres (ex : sables) le compresseur peut être ajusté à 7 bar ou 100 psi.
4. **Souffalge**
L’échappement de l’air utilisé pour le forage arrive a travers le pilote et remonte par l’espace annulaire entre la tige de forage et le tubage pour évacuer les cuttings.

La consommation d’air peut être calculée de la manière suivante:

$$Q = V (D^2 - d^2) / 1273500$$

Q – Consommation d’air en m^3/min.
V – Vélocité des cuttings (entre 1100 et 1500 m/min.)
D – Diamètre intérieur du tubage en mm
d – Diamètre extérieur des tiges de forage en mm

ROBIT® GENERAL DRILLING PARAMETERS

Robit® paramètres de forages généraux · Parametros generales de perforación Robit® · Общие буровые параметры

Drilling with DTH casing system

· Forer avec un systeme de tubage fond de trou (DTH) · Perforación con sistema de tubería de revestimiento con martillo DTH · Погружное бурение с обсадной трубой

1. **Fuerza pulldown**
La fuerza pulldown en el piloto es de 9 kg/mm (500 lbs/pulg)
2. **Velocidad de rotación**
Los rangos normales de RPM de operación son de 10 a 60 RPM (ver gráfica 1.)
3. **Presión del compresor**
La presión normal de operación es desde 10 a 15 bar o 150 a 225 psi.
Nota: En gravas y arenas puede ser 7 bar o 100 psi.
4. **Barrido**
El barrido es para limpiar los detritos de la cara de la broca piloto y sacarlos entre la sarta de perforación y tubería de revestimiento.

1. **Усилие подачи**
Среднее усилие подачи на пилотную коронку 9 кг/мм (500 фунт/дюйм)
2. **Скорость вращения**
Стандартная эксплуатационная скорость от 10 до 60 оборотов в минуту (см.таблицу 1)
3. **Давление компрессора**
Нормальное рабочее давление от 10 до 15 Бар или от 150 до 225 psi (фунтов на квадратный дюйм). Примечание: в рыхлый породах (например песок) давление компрессора может быть от 7 Бар до 100 psi (фунтов на квадратный дюйм).
4. **Продувка/промывка**
Отработанный при бурении воздух подается на коронку, для того чтобы очистить ее поверхность и вынести буровой шлам на поверхность в кольцевой зазор между бурильной штангой и обсадной трубой .

El consumo de aire puede ser calculado de la siguiente forma:

$$Q = V (D^2 - d^2) / 1273500$$

Q – Consumo de aire en m^3/min.
V – Velocidad de los detritos (entre 1100 a 1500 m/min.)
D – Diámetro interno de la tubería de revestimiento en mm
d – Diámetro externo de la sarta de perforación en mm

Расчет потребления воздуха:

$$Q = V (D^2 - d^2) / 1273500$$

Q – Потребление воздуха $м^3$/мин.
V – Скорость выноса шлама (от 1100 до 1500 м/мин.)
D – Внутренний диаметр обсадной трубы в мм
d – Внешний диаметр бурильной штанги в мм

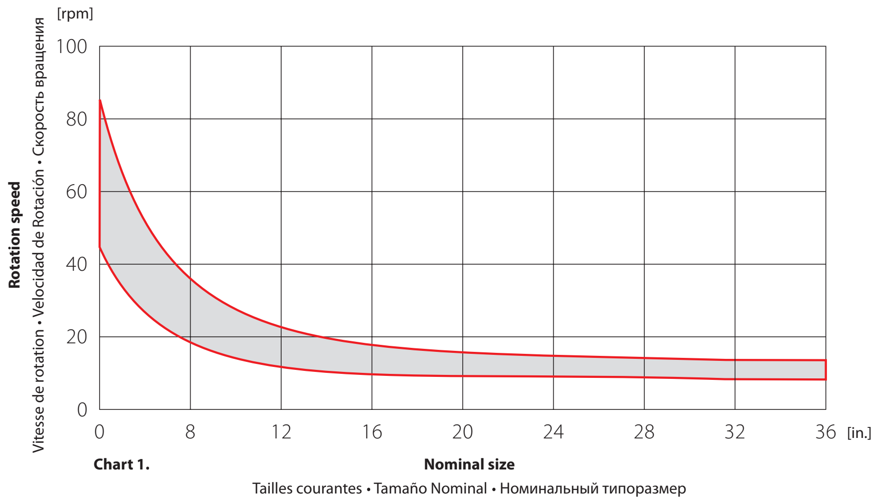


Chart 1.

ROBIT® RoX IN BRIEF

Robit® RoX en bref · Robit® RoX en breve · Robit® система однократного использования для гидроперфораторов

RoX+

Single-use system for top hammer

Robit® Single Casing Systems are available for traditional top hammer machinery.

Typically Robit® Single-Use system for Top Hammer is used in applications with relatively short hole requirement and where the casing is left in the ground, such as:

- forepoling or tube umbrella
- anchoring
- micropiling

Sistema permanente para martillo en cabeza

El sistema Robit® de tubería de revestimiento permanente está disponible para la maquinaria tradicional que utiliza martillo en cabeza.

Típicamente el sistema permanente de Robit® para martillo en cabeza es usado en aplicaciones que requieren perforaciones cortas y la tubería de forma permanente. Por ejemplo:

- enfilajes o paraguas
- anclajes
- micropilotes permanentes

Système pour marteaux hors trou à usage unique

Les systèmes de tubage Robit® sont disponibles pour les machines à marteaux hors trous conventionnelles.

Typiquement les systèmes Robit® à usage unique pour marteaux hors trou sont utilisés pour des applications dont le forage est relativement court et où les tubes sont laissés dans le sol, tels que:

- voûtes parapluies
- ancrage
- micropieux

ROBIT® RoX Система однократного использования для гидроперфораторов

Система бурения с обсадными трубами однократного использования Robit® Single Casing Systems применяется для традиционного бурения гидроперфораторами.

Обычно такая система для бурения гидроперфораторами используется для бурения относительно коротких шпуров и там , где обсадные трубы остаются в грунте, например:

- зонтичная крепь
- анкерование
- устройство микросвай

ROBIT® RoX IN BRIEF

Robit® RoX en bref · Robit® RoX en breve · Robit® система однократного использования для гидроперфораторов

RoX+

Drilling parameters example · Exemple des paramètres de forage · Ejemplo de parámetros de perforación · Буровые параметры (пример)

Product Produit · Producto · Продукция	RoX+ 139,7/10
Rock / Ground conditions Conditions roche / terrain · Condiciones de Roca / Terreno · Горно-геологические условия	All rock and ground formations Tout types de formation de roche · Todo tipo de formación de roca · Все типы пород
Application Application · Aplicación · Цель применения	Tube Umbrella, Forepoling Voûtes parapluie · Enfilajes · Укрепление грунта
Top hammer thread Filetage · Rosca martillo en cabeza · Тип резьбы гидроперфоратора	C45
Rotation speed Vitesse de rotation · Velocidad de rotación · Скорость вращения	30 - 40 RPM
Torque Couple · Torque · Крутящий момент	1000 - 1200 Nm
Percussion Percussion · Percusión · Усилие удара	75 - 100 bars

NOTE · Note · Nota · Вним:

Parameters may vary depending on ground / rock conditions, application and machinery

Les paramètres peuvent varier selon les conditions du terrain / de la roche, l'application elle-même et les équipements de forage. · Los parámetros pueden variar dependiendo de las condiciones de roca y de terreno, de la aplicación y maquinaría usada. · Параметры могут варьироваться в зависимости от горно-геологических условий, цели применения и типа бурового оборудования

ROBIT® RoX GFRP IN BRIEF

Robit® RoX GFRP en bref · Robit® RoX GFRP en breve · Robit® RoX GFRP

RoX GFRP

Single-use system for top hammer for fiberglass casing

Robit® has developed a system for fiberglass casings. A unique casing shoe works as a shock-absorber protecting the casing from the drilling forces. Fiberglass casing brings several benefits:

- Lighter casings – easier to handle
- Lower material cost – more economic drilling
- Easy to excavate – drill and blast in overburden conditions

Robit® Fiberglass system is available for top hammer applications.

Sistema permanente para tubería de fibra de vidrio para martillo en cabeza

Robit® ha desarrollado un sistema de tubería de fibra de vidrio. Para ello, una zapata especialmente diseñada trabaja para absorber el impacto y proteger la tubería de las fuerzas ejercidas durante la perforación. Las ventajas del sistema son:

- Tubería más ligera – más fácil de maniobrar
- Menor costo de material– más rentabilidad
- Fácil de excavar – perforación y voladura en terreno inestable.

El sistema Robit® de fibra de vidrio está disponible para aplicaciones con martillo en cabeza.

Système a usage unique pour marteau hors trou pour tube en fibre de verre

Robit® a développé un système de tubage pour tube en fibre de verrre.
Un sabot spécial joue le rôle d'amortisseur pour protéger le tube en fibre de verre des forces de de frappe due au forage. Le tube en fibre de verre offre les avantages suivants:

- Tubes beaucoup plus légers – plus facile à manipuler
- Prix du tube moins élevé – forage plus économique
- Facile à excaver – possibilités de forage destructifs

Le système Robit® pour tube en Fibre de verre est disponible pour les applications utilisant le forage au marteau hors trou.

Система однократного использования для бурения гидроперфораторами с применением стеклопластиковых труб

Компания Robit® разработала систему для стеклопластиковых труб. Особый башмак обсадной трубы работает как виброгаситель и защищает обсадную трубу от ударов при бурении.
Стеклопластиковые обсадные трубы имеют следующие преимущества:

- Легкие по весу обсадные трубы - удобство в эксплуатации
- Экономия на стоимости материала- экономия в процессе бурения
- Более легкое и удобное проведение буровзрывных работ в условиях нарушенных покрывающих пород.

Система стеклопластиковых труб Robit® Fiberglass подходит также для бурении гидроперфораторами.

ROBIT® RoX GFRP IN BRIEF

Robit® RoX GFRP en bref · Robit® RoX GFRP en breve · Robit® RoX GFRP

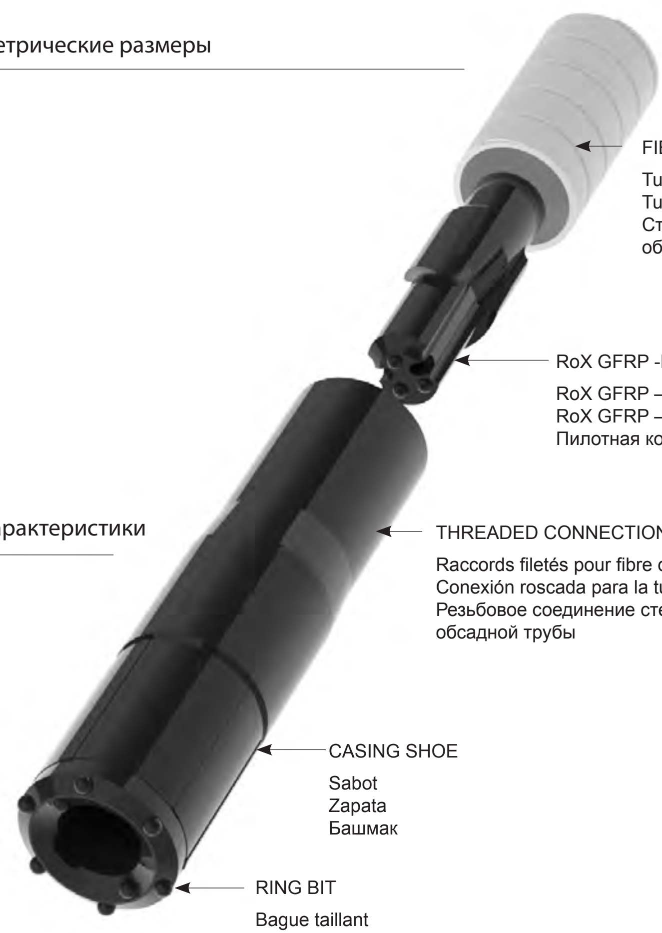
RoX GFRP

Geometrical charactersitics · Caractéristiques géométriques · Características geométricas · Геометрические размеры

Section Section · Sección · Сечение	1700 mmq.
External diameter Diamètre extérieur · Diámetro Externo · Наружный диаметр	ø 76 mm
Internal diameter Diamètre intérieur · Diámetro Interno · Внутренний диаметр	ø 60 mm
Thickness Épaisseur · Espesor · Толщина	8 mm
Weight/m Poids/m · Peso/m · Вес/м	3,2 kg

Technical charactersitics · Caractéristiques techniques · Características técnicas · Технические характеристики

Glass content in weight Teneur en verre (poids) · Contenido de vidrio en peso · Содержание стекла по весу	50%
Specific weight Poids · Peso específico · Удельный вес	1.8 g/cc
Tensile strength Limite d'élasticité · Resistencia a la tensión · Прочность на растяжение	600 MPa
Flexural strength Résistance à la flexion · Resistencia a la flexión · Прочность на изгиб	600 MPa
Elastic modulus Module d'élasticité · Módulo Elástico · Модуль упругости	20 000 MPa



ROBIT® DTH-RoX+ and ++ IN BRIEF

Robit® DTH-RoX+(+) en bref · Robit® DTH-RoX+(+) en breve · Robit® DTH-RoX+(+)

DTH-RoX+

Single-use system for down the hole hammer

Sometimes overburden is thick and full of boulders. Robit® Single-Use Casing System for DTH Hammer enables easy, fast, and reliable drilling process in all conditions. Robit® Single-Use Casing Systems are available for all the common Down The Hole hammers and are designed for all the applications where the casing is left in the ground:

- Water well drilling
- Thermal well drilling
- Piling

Sistema permanente para martillo de fondo

Algunas veces el terreno es grueso y con bolones. El sistema Robit® para aplicaciones permanentes para Martillo DTH permite simplicidad, rapidez y confianza en el proceso de perforación en todo tipo de condiciones de terreno. El sistema Robit® para aplicaciones permanentes está disponible para los martillos DTH comunes del mercado y diseñado para las aplicaciones en donde la tubería de revestimiento es permanente:

- Pozos de agua
- Perforación de pozo termal
- Pilotes

Système a usage unique pour marteau fond de trou

Certains terrains de recouvrements sont épais et pleins rochers plus ou moins gros. Le système de tubage Robit® à Usage Unique pour marteau DTH (Fond de Trou) permet un forage simple, rapide et fiable dans toutes les conditions. Le système DTH-RoX+ est disponible pour les types de marteau DTH les plus courants et a été développé pour toutes les applications ou le tubage est installé de façon permanente dans le sol:

- Forage de puits pour l'eau
- Forage de puits pour la géothermie
- Pieux et micro-pieux

Система однократного использования для погружного пневмоударника

Иногда покрывающие породы имеют большую мощность и содержат много валунов. Система для однократного использования Robit® Single-Use Casing System обеспечивает легкое, быстрое и надежное бурение при любых условиях. Эта система работает со всеми стандартными погружными пневмоударниками и предназначена для областей применения, где обсадные трубы остаются в грунте:

- Бурение водяных скважин
- Бурение геотермических скважин
- Бурение под установку свай

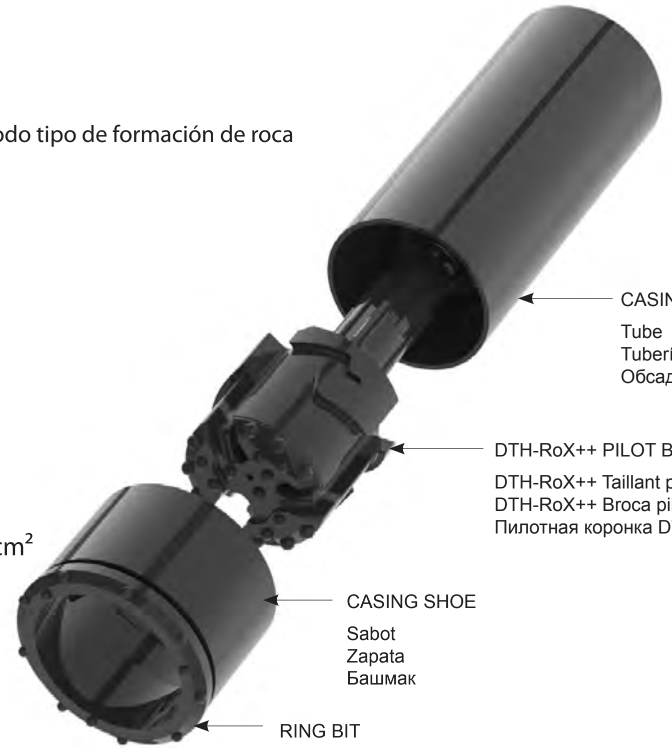
ROBIT® DTH-RoX+ and ++ IN BRIEF

Robit® DTH-RoX+(+) en bref · Robit® DTH-RoX+(+) en breve · Robit® DTH-RoX+(+)

DTH-RoX+

Drilling parameters example · Exemple de paramètres de forage · Ejemplo de parámetros de perforación · Буровые параметры (пример)

Product Produit · Producto · Продукция	DTH-RoX+ 168,3/10
Rock / Ground conditions Conditions roche / terrain · Condiciones de Roca / Terreno · Горно-геологические условия	All rock and ground formations Tout types de formation de roche · Todo tipo de formación de roca · Все типы пород
Application Application · Aplicación · Цель применения	Piling Pieux · Pilotaje · Бурение под сваи
DTH hammer size Taille du Marteau DTH (fond de trou) · Tamaño del martillo DTH · Тип погружного пневмоударника	5”
Rotation speed Vitesse de rotation · Velocidad de rotación · Скорость вращения	30 - 40 RPM
Torque Couple · Torque · Крутящий момент	1500 - 2000 Nm
Compressor output Débit compresseur · Caudal de aire · Производительность компрессора	15 - 24 m^3/min Max: 17 kg/cm^2 530 - 848 CFM 250 psi
Compressor pressure Pression compresseur · Presión del compresor · Давление компрессора	10 - 16 bar



NOTE · Note · Nota · Вним:

Parameters may vary depending on ground / rock conditions, application and machinery

Les paramètres peuvent varier selon les conditions du terrain / de la roche, l’application elle-même et les équipements de forage. · Los parámetros pueden variar dependiendo de las condiciones de roca y de terreno, de la aplicación y maquinaría usada. · Параметры могут варьироваться в зависимости от горно-геологических условий, цели применения и типа бурового оборудования

ROBIT® DTH-RoX DS IN BRIEF

Robit® DTH-RoX DS en bref · Robit® DTH-RoX DS en breve · Robit® DTH-RoX DS

DTH-RoX DS

Double strike system for down the hole hammer

In demanding soil conditions DTH-RoX DS is the suitable product to use because of its robustness and reliability. Casing shoe is integrated to the ring bit and is simple to weld straight inside the casing. You can easily lock and unlock the pilot and the ring bit as many time as required with no jamming or possibility to loosen the ring bit. Robit® Double Strike Casing Systems are available for all the common Down The Hole hammers and are designed for all the applications where the casing is left in the ground:

- Piling
- Underpinning
- Micropiling

Sistema de doble impacto para martillo de fondo

En condiciones de terreno muy demandantes, DTH-RoX DS es el producto adecuado para usar por su robustez y confianza. La zapata está integrada a la corona y es fácil de soldar dentro de la tubería. Es posible enganchar y desenganchar el piloto y la corona cuantas veces sea necesaria sin que se atasque o se afloje la corona. El sistema de doble impacto de Robit® está disponible para los martillos DTH comunes y está diseñado para las aplicaciones en donde la tubería de revestimiento es permanente. Por ejemplo:

- Pilotaje
- Recalzado de Cimientos
- Micropilotaje

Système à double strike (double frappe) pour marteau fond de trou

En cas de sol difficile, le DTH-RoX DS est le modèle à utiliser en raison de sa robustesse et de sa fiabilité. Le sabot, intégré à la couronne, est soudé directement à l'intérieur de tube. Le pilote s'enclenche et se dés-enclenche facilement à la couronne, et ce, à volonté sans blocage ou possibilité de perdre la couronne. Les systèmes Robit® Double Strike (Double Frappe) sont disponibles pour tous les types de marteaux fond de trou et sont conçus pour des applications où les tubes sont laissées dans le sol, et surtout pour:

- Pieux
- Underpinning
- Micro-pieux

Система для бурения погружным пневмоударником с двойным ударом

Система DTH-RoX DS идеальна для бурения в сложных горно-геологических условиях благодаря своей прочности и надежности. Башмак строен в кольцевой коронке и легко приваривается к обсадной трубе. Пилотную и кольцевую коронки очень легко блокировать и разблокировать без риска заклинивания или ослабления крепления кольцевой коронки. Система Robit® Double Strike Casing применяется со всеми стандартными погружными пневмоударниками для всех целей применения, когда обсадную трубу оставляют в скважине:

- Бурение под сваи
- Укрепление фундаментов
- Установка миросвай

ROBIT® DTH-RoX DS IN BRIEF

Robit® DTH-RoX DS en bref · Robit® DTH-RoX DS en breve · Robit® DTH-RoX DS

DTH-RoX DS

Drilling parameters example · Exemple de paramètres de forage · Ejemplo de parámetros de perforación · Буровые параметры (пример)

Product Produit · Producto · Продукция	DTH-RoX DS 168,3/10		
Rock / Ground conditions Conditions roche / terrain · Condiciones de Roca / Terreno · Горно-геологические условия	All rock and ground formations Tout types de formation de roche · Todo tipo de formación de roca · Все типы пород		
Application Application · Aplicación · Цель применения	Piling Pieux · Pilotaje · Бурение под сваи		
DTH hammer size Taille du Marteau DTH (fond de trou) · Tamaño del martillo DTH · Тип погружного пневмоударника	5”		
Rotation speed Vitesse de rotation · Velocidad de rotación · Скорость вращения	30 - 40 RPM		
Torque Couple · Torque · Крутящий момент	1500 - 2000 Nm		
Compressor output Débit compresseur · Caudal de aire · Производительность компрессора	15 - 24 m^3/min 530 - 848 CFM	Max:	17 kg/cm^2 250 psi
Compressor pressure Pression compresseur · Presión del compresor · Давление компрессора	10 - 16 bar		

NOTE · Note · Nota · Вним:

Parameters may vary depending on ground / rock conditions, application and machinery

Les paramètres peuvent varier selon les conditions du terrain / de la roche, l’application elle-même et les équipements de forage. · Los parámetros pueden variar dependiendo de las condiciones de roca y de terreno, de la aplicación y maquinaría usada. · Параметры могут варьироваться в зависимости от горно-геологических условий, цели применения и типа бурового оборудования

ROBIT® DTH-RoX SR IN BRIEF

Robit® DTH-RoX SR en bref · Robit® DTH-RoX SR en breve · Robit® DTH-RoX SR

DTH-RoX SR

Solitary ring system for down the hole hammer

DTH-RoX SR products are economical and cost-effective to use when the ground is homogenous with few small boulders. With the same pilot you can install piles and interlocked Pipe-Pile-Wall piles just by using ring bits with different outside diameters. Robit® Solitary Ring Casing Systems are available for all the common Down The Hole hammers and can be used for all applications where the casing is left in the ground, but have been especially designed for:

- Piling
- Underpinning
- Micropiling

Sistema de corona solitaria para martillo de fondo

El sistema DTH-RoX SR es económico y rentable para usar cuando las condiciones de terreno son homogéneas y hay una leve presencia de bolones. Con la misma broca piloto se puede instalar pilotes y paredes de tubos intercaladas al usar coronas con diferentes diámetros externos. El sistema de Robit® Corona Solitaria está disponible para todos los martillos de fondo comunes en el mercado y puede ser usado para todas las aplicaciones en donde la tubería de revestimiento es permanente. El sistema ha sido especialmente diseñado para:

- Pilotaje
- Recalzado de Cimientos
- Micropilotaje

Système solitary ring pour marteau fond de trou

Lorsque le sol est homogène, avec quelques petits rochers, Le système DTH-RoX SR est la solution économique à utiliser. Avec le même pilote, vous pouvez installer des pieux et des "interlocked pipe-pile-wall" en utilisant des bagues à diamètres extérieurs différents.
Les systèmes Robit® Solitary Ring sont disponibles pour tous les types de marteaux fond de trou et sont conçus pour des applications où les tubes sont laissées dans le sol, et surtout pour:

- Pieux
- Underpinning
- Micro-pieux

Система «эконом класса» для бурения погружным пневмоударником

Система DTH-RoX SR (Solitary Ring) предлагает экономичный вариант для бурения в однородных породах с небольшими валунами. Одна и та же пилотная коронка позволяет бурить скважины для буронабивных свай и свай для конструкций «стена в грунте» с применением кольцевых коронок разного наружного диаметра. Система DTH-RoX SR применяется со всеми стандартными погружными пневмоударниками для всех целей применения, когда обсадную трубу оставляют в скважине:

- Бурение под сваи
- Укрепление фундаментов
- Установка миросвай

ROBIT® DTH-RoX SR IN BRIEF

Robit® DTH-RoX SR en bref · Robit® DTH-RoX SR en breve · Robit® DTH-RoX SR

DTH-RoX SR

Drilling parameters example · Exemple de paramètres de forage · Ejemplo de parámetros de perforación · Буровые параметры (пример)

Product Produit · Producto · Продукция	DTH-RoX SR 219,1/12,7
Rock / Ground conditions Conditions roche / terrain · Condiciones de Roca / Terreno · Горно-геологические условия	Homogenous soil with small boulders Terrain homogène avec petits rochers · Terreno homogéneo con bolones leves · Однородные породы с небольшими валунами
Application Application · Aplicación · Цель применения	Piling and Pipe-Pile-Wall Pieux · Pilotaje (Paredes de tubos) · Установки конструкций «стена в грунте»
DTH hammer size Taille du Marteau DTH (fond de trou) · Tamaño del martillo DTH · Тип погружного пневмоударника	6"
Rotation speed Vitesse de rotation · Velocidad de rotación · Скорость вращения	20 - 30 RPM
Torque Couple · Torque · Крутящий момент	2200 - 3200 Nm
Compressor output Débit compresseur · Caudal de aire · Производительность компрессора	20 - 24 m^3/min Max: 17 kg/cm^2 707 - 848 CFM 250 psi
Compressor pressure Pression compresseur · Presión del compresor · Давление компрессора	10 - 16 bar

NOTE · Note · Nota · Вним:

Parameters may vary depending on ground / rock conditions, application and machinery
Les paramètres peuvent varier selon les conditions du terrain / de la roche, l'application elle-même et les équipements de forage. · Los parámetros pueden variar dependiendo de las condiciones de roca y de terreno, de la aplicación y maquinaría usada. · Параметры могут варьироваться в зависимости от горно-геологических условий, цели применения и типа бурового оборудования

ROBIT® DTH SF IN BRIEF

Robit® DTH SF en bref · Robit® DTH SF en breve · Robit® DTH SF

DTH SF

Steel Fist system for down the hole hammer

Robit® Steel Fist product family is designed for specific piling operations, sizes from 273 mm up to 1016 mm. New economic way for traditional piling work, but also capable for installing water-proof Pipe-Pile-Walls. No ring bit is needed when piling with DTH SF. Usage in homogenous soil conditions with small boulders. Robit® Steel Fist Casing Systems are available for all the common Down The Hole hammers and can be used for all applications where the casing is left in the ground, but have been especially designed for:

- Piling
- Piling (Pipe-Pile-Walls)

Système Steel Fist pour marteau fond de trou

La famille des systèmes Robit® Steel Fist est conçue pour des opérations de pieux spécifiques, pour des diamètres de 273mm à 1016mm. Méthode économe utilisée pour l'installation de pieux traditionnels, et aussi capable d'installer des « Pipe-Pile-Wall » étanches. Aucune bague n'est requise lorsque le pieu est installé par le DTH SF. Sont utilisation est conseillée dans des conditions de terrains homogènes avec petits rochers. Les systèmes de tubage de Robit® Steelfist sont disponibles pour tous les types de marteaux fond de trou et sont conçus pour des applications où les tubes sont laissées dans le sol, et sont spécialement conçus pour:

- Pieux
- Pieux (Pipe-Pile-Walls)

Sistema Steel Fist para martillo de fondo

La familia de productos Robit® Steel Fist está diseñado para operaciones específicas de pilotaje, que varían desde los 273mm hasta 1016mm. Es un método nuevo y económico para pilotaje tradicional, pero también es posible instalar paredes de tubo resistentes al agua. El sistema no necesita ninguna corona cuando se ejecutan los pilotes con DTH SF. Se recomienda con condiciones de terreno homogéneas y bolones leves. El Sistema Steel Fist está disponible para todos los martillos de fondo comunes del mercado y puede ser usado para todas las aplicaciones en donde la tubería de revestimiento es permanente. Esta diseñado especialmente para:

- Pilotaje
- Pilotaje (Paredes de tubos)

Система Robit® Steel Fist для бурения погружным пневмоударником

Крыловые пилотные коронки Robit® Steel Fist предназначены для специальных операций по бурению под сваи с диам. 273 – 1016 мм. Эта новая, экономичная технология подходит как для традиционных свайных работ, так и для установки водонеприницаемых конструкций «стена в грунте». Эта система не требует применения кольцевой коронки и прекрасно подходит для бурения через слои однородных пород с небольшими валунами. Системы Robit® Steelfist могут применяться со всеми стандартным погружными пневмоударниками для всех целей применения, когда обсадную трубу оставляют в скважине, но они специально предназначены для:

- бурения под сваи
- установки конструкций «стена в грунте»

ROBIT® DTH SF IN BRIEF

Robit® DTH SF en bref · Robit® DTH SF en breve · Robit® DTH SF

DTH SF

Drilling parameters example · Exemple de paramètres de forage · Ejemplo de parámetros de perforación · Буровые параметры (пример)

Product Produit · Producto · Продукция	DTH SF 323,9/12,7		
Rock / Ground conditions Conditions roche / terrain · Condiciones de Roca / Terreno · Горно-геологические условия	Homogenous soil with small boulders Terrain homogène avec petits rochers · Terreno homogéneo con bolones leves · Однородные породы с небольшими валунами		
Application Application · Aplicación · Цель применения	Piling and Pipe-Pile-Wall Pieux · Pilotaje (Paredes de tubos) · Установки конструкций «стена в грунте»		
DTH hammer size Taille du Marteau DTH (fond de trou) · Tamaño del martillo DTH · Тип погружного пневмоударника	8" - 10"		
Rotation speed Vitesse de rotation · Velocidad de rotación · Скорость вращения	15 - 25 RPM		
Torque Couple · Torque · Крутящий момент	7000 - 10000 Nm		
Compressor output Débit compresseur · Caudal de aire · Производительность компрессора	24 - 33 m^3/min 848 - 1165 CFM	Max:	17 kg/cm^2 250 psi
Compressor pressure Pression compresseur · Presión del compresor · Давление компрессора	10 - 14 bar		

NOTE · Note · Nota · Вним:

Parameters may vary depending on ground / rock conditions, application and machinery

Les paramètres peuvent varier selon les conditions du terrain / de la roche, l'application elle-même et les équipements de forage. · Los parámetros pueden variar dependiendo de las condiciones de roca y de terreno, de la aplicación y maquinaría usada. · Параметры могут варьироваться в зависимости от горно-геологических условий, цели применения и типа бурового оборудования

ROBIT® DTH-RoX HZ IN BRIEF

Robit® DTH-RoX HZ en bref · Robit® DTH-RoX HZ en breve · Robit® DTH-RoX HZ

DTH-RoX HZ

Horizontal system for down the hole hammer

The loads in Horizontal Drilling that the casing system must endure are severely higher than in typical vertical drilling. Robit Rocktools® has developed a system which is capable of handling even the toughest conditions.
The Robit® HZ -system consists three parts; pilot bit, ring bit assembly with the ring bit and protective layer and impact shoe. The pilot bits hits directly the casing via the welded casing shoe. This causes that all the efforts of pulling the tube is diverted to the impact shoe and not on the ring. The ring bit is rotated with the pilot bit. This system leads to a longer life time of the ring bit, better penetration during drilling and increased reliability to finish the hole on time and according to plans.

Système forage horizontal pour marteau fond de trou

La charge supportée par un système de tubage lors d'un forage horizontal est beaucoup plus important que lors d'un forage vertical. C'est pourquoi Robit Rocktools® a développé un système capable de supporter cette charge dans les conditions les plus difficiles.
Le système Robit® HZ est composé de 3 pièces ; le taillant pilote, la bague taillant avec un sabot protecteur et le sabot d'impact. Le taillant pilote frappe directement sur le tube via le sabot d'impact qui y est soudé. Ainsi, les efforts pour tirer le tube est dirigé sur le sabot d'impact et non sur la bauge. La bague est elle entrainée en rotation par le taillant pilote. Ce système accroit la durée de vie du taillant pilote et de la bague, tout en offrant une meilleure pénétration de tous les types de terrains.

Sistema horizontal para martillo de fondo

Las cargas en la Perforación Horizontal que el sistema debe de soportar son mucho más severas que en las perforaciones verticales. Robit Rocktools® ha desarrollado un sistema el cual es capaz de soportar las condiciones más complicadas.
El sistema Robit® HZ consiste en tres partes; broca piloto, la zapata y corona y adicional una zapata de impacto. La broca piloto golpea directamenet la zapata de impacto, la cual esta soldada por el interior. Esto hace que la mayoría de la fuerza del impacto sea canalizada con mayo eficaz hacia la zapata y sin desgastarla tanto. La corona gira con la broca piloto. Este sistema permite una vida útil más larga a la zapata, mayor penetración durante la perforación y incrementa la certeza de terminar la perforación a tiempo y de acuerdo a lo planeado.

Горизонтальное бурение погружным пневмоударником

При горизонтальном бурении весь комплекс погружного бурения подвергается высоким нагрузкам, которые значительно выше, чем при традиционном вертикальном бурении. Для этой цели Robit Rocktools® разработала специальную систему, способную работать даже в самых тяжелых условиях.
Система Robit® HZ состоит из трех частей: пилотной коронки, кольцевой коронки с защитным слоем и ударного башмака. Пилотная коронка ударяет непосредственно об обсадную трубу через приваренный башмак. При этом большинство ударных нагрузек направляется на обсадную трубу. Кольцевая коронка вращается внутри пилотной коронки. Эта система обеспечивает более длительный срок службы кольцевой коронки, более высокую скорость проходки, а также гарантирует надежное бурение скважины в согласованные сроки.

ROBIT® DTH-RoX HZ IN BRIEF

Robit® DTH-RoX HZ en bref · Robit® DTH-RoX HZ en breve · Robit® DTH-RoX HZ

DTH-RoX HZ

Drilling parameters example · Exemple de paramètres de forage · Ejemplo de parámetros de perforación · Буровые параметры (пример)

Product Produit · Producto · Продукция	DTH-RoX HZ 323,9/12,7
Rock / Ground conditions Conditions roche / terrain · Condiciones de Roca / Terreno · Горно-геологические условия	All rock and ground formations Tout types de formation de roche · Todo tipo de formación de roca · Все типы пород
Application Application · Aplicación · Цель применения	Horizontal drilling Forage horizontal · Perforación horizontal · Горизонтальное бурение
DTH hammer size Taille du Marteau DTH (fond de trou) · Tamaño del martillo DTH · Тип погружного пневмоударника	8" - 10"
Rotation speed Vitesse de rotation · Velocidad de rotación · Скорость вращения	15 - 25 RPM
Torque Couple · Torque · Крутящий момент	7000 - 10000 Nm
Compressor output Débit compresseur · Caudal de aire · Производительность компрессора	24 - 33 m^3/min Max: 17 kg/cm^2 848 - 1165 CFM 250 psi
Compressor pressure Pression compresseur · Presión del compresor · Давление компрессора	10 - 14 bar

NOTE · Note · Nota · Вним:

Parameters may vary depending on ground / rock conditions, application and machinery

Les paramètres peuvent varier selon les conditions du terrain / de la roche, l'application elle-même et les équipements de forage. · Los parámetros pueden variar dependiendo de las condiciones de roca y de terreno, de la aplicación y maquinaría usada. · Параметры могут варьироваться в зависимости от горно-геологических условий, цели применения и типа бурового оборудования

PILING, MICROPILING AND UNDERPINNING

Pieux · Pilotaje, Mircopilotaje y Sostenimiento · Бурение под установку свай, микросвай и укрепление фундамента

PILING, MICROPILING AND UNDERPINNING

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Please note: Face designs might vary depending on bit diameter.

Note: Le design des têtes peut varier selon le diamètre des taillants.
Nota: Los diseños de cara pueden variar dependiendo del diámetro de la broca.
Дизайн рабочей поверхности коронки также зависит от диаметра коронки.

PILING, MICROPILING AND UNDERPINNING

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Piling, Micropiling and Underpinning

Softer ground conditions require that the foundations of any type of construction must be stabilized. Drilling system consists of casing tubes drilled through the overburden to the solid bedrock and filled with concrete. Drilled piles made with Robit® Casing Systems have significant advantage compared with other piling methods and systems: Fast drilling with maximum hole straightness, reliability to reach the targeted depth, and extreme simplicity to use. Robit® Casing Systems mostly used in piling are DTH-RoX+ for permanent casing and DTH-RoX MU for temporary casing.

Pieux et micro-pieux

Certains sols instables impliques la stabilisation des fondations de n'importe quel type de construction. Des tubes en aciers sont installés au travers du terrain de recouvrement jusqu'au socle rocheux. Les pieux forées réalisés avec le Système de tubage de Robit® offrent des avantages significatifs comparés à d'autres systèmes et méthodes : forage rapide avec rectitude maximum du trou, fiabilité pour atteindre la profondeur désirée, et la simplicité extrême d'utilisation.

Les systèmes de tubage Robit® les plus utilisés pour les pieux et micro-pieux sont le DTH-RoX+ pour le tubage permanent du forage et le DTH-RoX MU pour le tubage temporaire du forage.

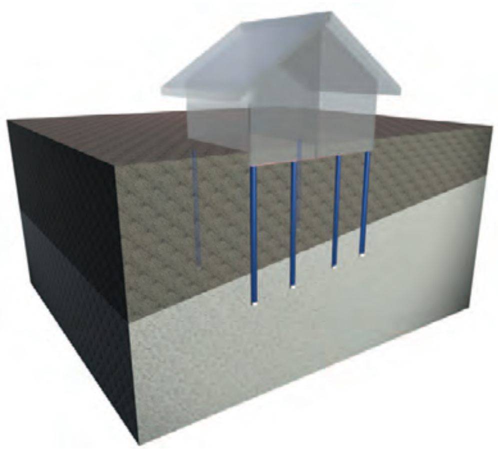
Бурение под установку свай, микросвай и укрепление фундамента

Рыхлые грунты требуют повышения устойчивости и укрепления фундамента любого строения или конструкции. Обсадные трубы пробуриваются сквозь верхний мягкий слой покрывающей породы до коренной породы и затем заполняются цементным раствором. Бурение под установку свай с использованием Robit® Casing Systems обладает большим преимуществом по сравнению с другими системами: быстрое бурение с максимальной точностью скважины по направлению, надежность в достижении заданной глубины, простота использования.

При системе бурения с обсадными трубами Robit® Casing System, которая применяется при бурении под установку свай, в основном используются DTH-RoX+ для постоянной обсадки и DTH-RoX MU для временной обсадки.

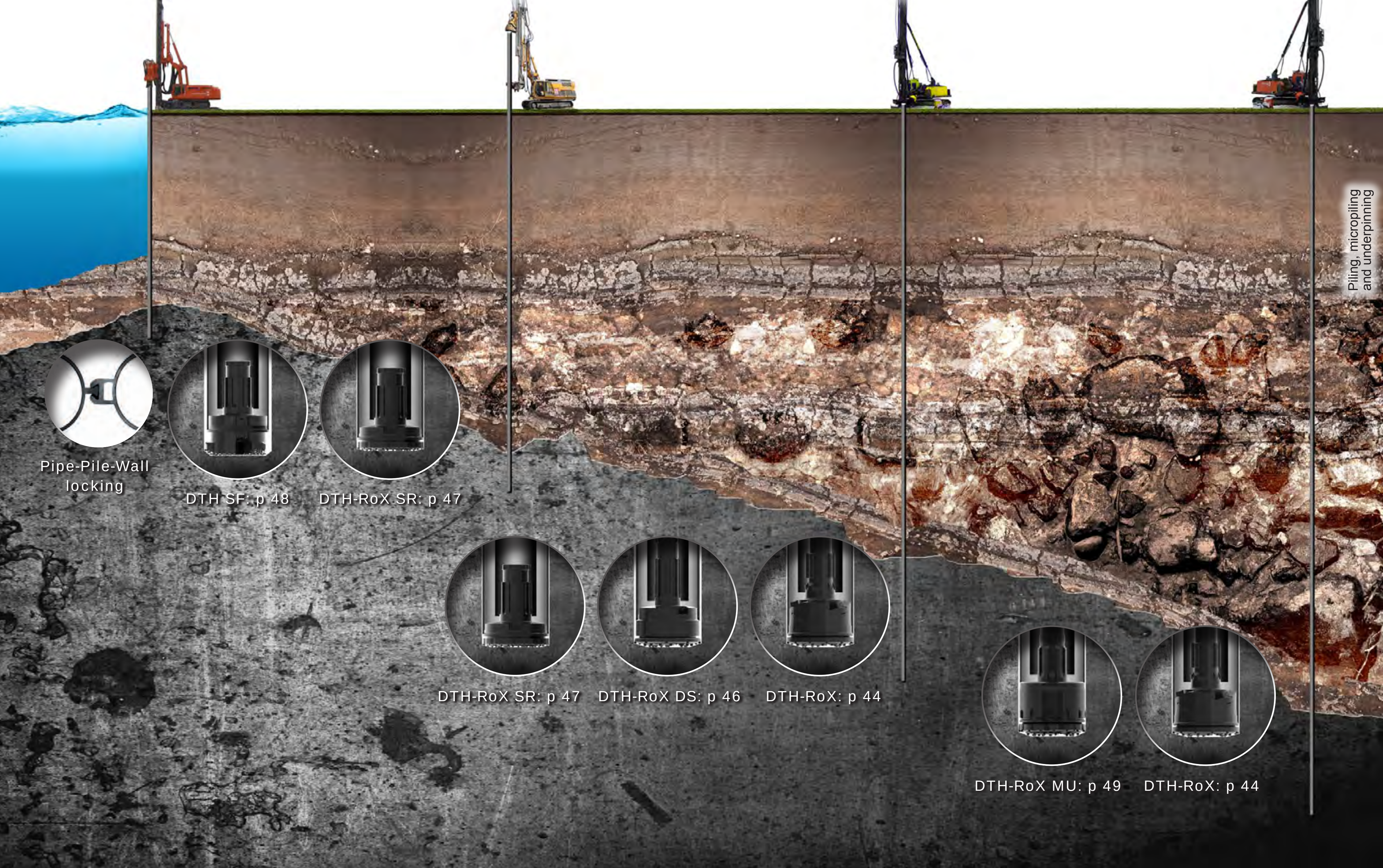
Pilotaje

Las condiciones de terrenos inestables requieren que los cimientos de cualquier tipo de construcción sean estabilizados. El sistema de perforación consiste en que la tubería de revestimiento sea introducida a través del terreno hasta la base sólida de roca y sea llenada de concreto. El sistema Robit tiene varias ventajas significativas en comparación de otros métodos y sistemas: Perforación rápida con máxima rectitud, confianza de llegar a la profundidad deseada, y extremada simpleza de operación. Los sistemas de Robit® más usados para pilotaje son DTH-RoX+ para pilotes permanentes y DTH-RoX MU para pilotes temporales.



PILING, MICROPILING AND UNDERPINNING

Pieux · Pilotaje, Mircopilotaje y Sostenimiento · Бурение под установку свай, микросвай и укрепление фундамента



WATER AND THERMAL WELL DRILLING

Forage de puits pour l’eau et la géothermie · Perforación de pozos de agua y pozos térmicos · Бурение водяных и термических скважин

WATER AND THERMAL WELL DRILLING

Forage de puits pour l’eau et la géothermie · Perforación de pozos de agua y pozos térmicos · Бурение водяных и термических скважин

Please note: Face designs might vary depending on bit diameter.

Note: Le design des têtes peut varier selon le diamètre des taillants.
Nota: Los diseños de cara pueden variar dependiendo del diámetro de la broca.
Дизайн рабочей поверхности коронки также зависит от диаметра коронки.

WATER AND THERMAL WELL DRILLING

Forage de puits pour l'eau et la géothermie · Perforación de pozos de agua y pozos térmicos · Бурение водяных и термических скважин

Water and thermal well drilling

Casing drilling is used in making water and thermal wells in broken overburden conditions. Robit® Casing Systems allow easy driving of the casing tubes into the ground with relatively low torgue demand. The casing is left in the ground as a protection pipe of the water or thermal well.
Robit® Casing System mostly used in water and thermal well drilling is DTH-RoX+.

Forage de puits pour l'eau et la géothermie

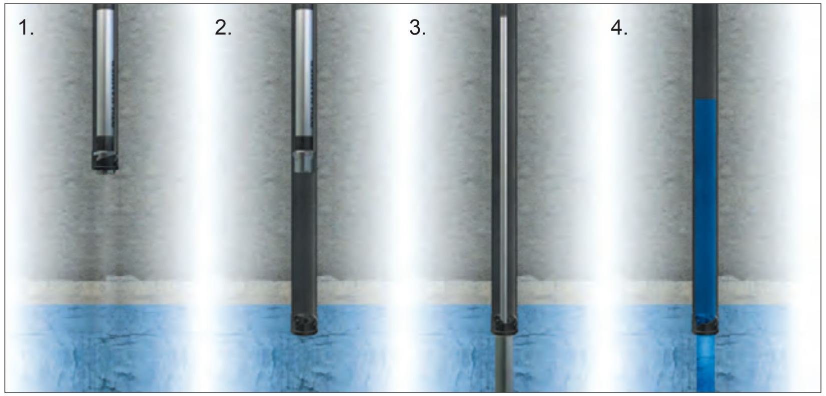
Le tubage à l'avancement est une méthode couramment utilisée pour la réalisation de puits pour l'eau ou la géothermie dans des conditions de terrains difficiles. Le système de tubage Robit® permet une installation simple et efficace des tubes dans le sol avec un couple de rotation limité. Le tube peut être laissé dans le terrain de façon permanente comme protection du puit.
Le système de tubage Robit® le plus utilisé pour les puits à eau et géothermie sont le DTH-RoX+.

Pozos de agua y de energía termal

Normalmente se utiliza tubería de revestimiento para hacer pozos de agua y energía termal cuando el terreno son formaciones de roca fragmentada. El sistema Robit® permite una perforación sin necesidad de un torque alto. La tubería es permanente porque necesita proteger el agua o la energía termal extraída. El sistema Robit® normalmente utilizado para estas aplicaciones es DTH-RoX+.

Бурение водяных и термических скважин

Бурение с обсадными трубами необходимо, когда стенки скважины осыпаются и могут обвалиться или бурение производится в мягких покрывающих породах. При системе бурения с обсадными трубами Robit® Casing Systems обсадные трубы легко продвигаются в грунте с относительно небольшой потребностью в крутящем моменте. Обсадные трубы остаются в грунте и служат защитой геотермальной или водяной скважины.
При системе бурения с обсадными трубами Robit® Casing System, которая применяется для бурения водяных и геотермических скважин в основном используются DTH-RoX+ .



ANCHORING

Ancrage · Anclaje · Анкерное бурение

ANCHORING

Ancrage · Anclaje · Анкерное бурение

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Дизайн рабочей поверхности коронки также зависит от диаметра коронки.

ANCHORING

Ancrage · Anclaje · Анкерное бурение

Anchoring

Anchoring is a method where walls with masses of overburden are anchored to the solid rock. Casing tubes are driven through the overburden. After that drilling is continued with normal drill bit. Steel cable is inserted to the bottom of the hole and next the hole is filled with grouting.
New Robit® Non-Stop Casing System is perfect for anchoring.

Ancrage

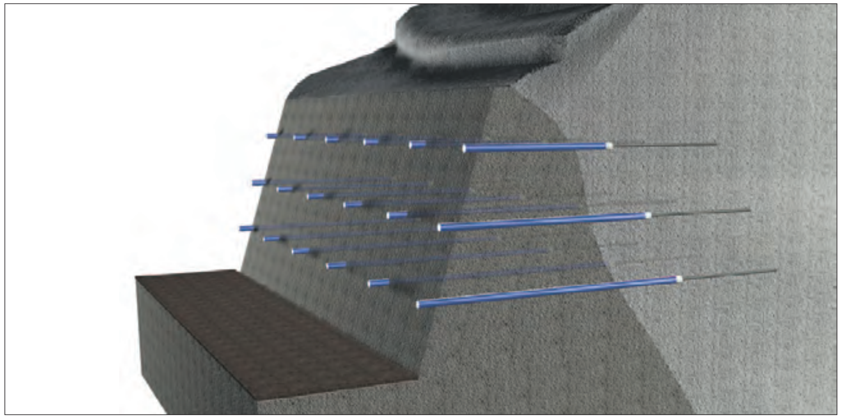
L'ancrage est technique qui permet de retenir une paroi, soumise au poids du terrain de recouvrement, à une couche de terrain plus résistante. Des tubes en aciers sont installés au travers de la paroi. Une fois dans la partie plus résistante du terrain, le forage continue sans les tubes. Des câbles en acier ou autres types d'ancrages sont mis en place dans le forage qui sera ensuite injecté avec du mortier de ciment.
Le Nouveau système Robit® Non-Stop est la solution parfaite pour l'ancrage.

Anclaje

El anclaje es un método que se emplea para sujetar terreno inestable a una base de roca sólida. La tubería de revestimiento atraviesa el terreno. Después al llegar a la roca se continua con una broca normal. Se insertan cables de acero al fondo de la perforación y después se inyecta lechada o concreto. El sistema de Robit® Non-Stop es perfecto para los anclajes.

Анкерное бурение

Анкерование – это метод, при котором борты с неустойчивой породой крепятся к массиву. Обсадные трубы прокладываются в покрывающих породах , а затем бурение может быть продолжено обычной буровой коронкой. Стальной трос закладывается в шпур, и затем шпуры заполняются цементным раствором.
Новая система безостановочного бурения Robit® Non-Stop Casing System идеально подходит для анкерования.



Vedlegg F

Eksempel kjerneboring

1.1.1 RØRPRODUKTER

Wireline borrør

Wireline borrør produseres av høykvalitets karbonstålrør som gir god ytelse og styrke. Disse kommer med ulike typer gjenger.

Konvensjonelle borrør

Konvensjonelle borrør finnes i "mellomvektsstål" og/eller aluminium som gir ergonomisk fleksibilitet, og er enklere å håndtere under vanskelige forhold.

Tilleggsutstyr

For å øke effektiviteten og kvaliteten av kjerneboringen finnes ulikt utstyr, deriblant vannsvivel, løfte og senkeutstyr og "fiske"utstyr.

1.1.2 Generelle tekniske spesifikasjoner

Tabellene nedenfor er hentet fra Atlas Copco og er ment som en rask referanseguide for valg av utstyr.

Doble rør – overflate og/eller undergrunn				
Størrelse (overflate-undergrunn)	**mm**		**in**	
	Hulldiameter	**Kjernediameter**	**Hulldiameter**	**Kjernediameter**
BO/BO-U	60.0	36.4	2.36	1.43
NO/NO-U	75.7	47.6	2.98	1.88
HO/HO-U	96.1	63.5	3.78	2.50
PO	122.7	85.0	4.83	3.34

Tredoble rør – overflate				
Størrelse (overflate-undergrunn)	**mm**		**in**	
	Hulldiameter	**Kjernediameter**	**Hulldiameter**	**Kjernediameter**
NO3	75.7	45.0	2.98	1.78
HO3	96.1	61.1	3.78	2.41
PO3	122.7	83.0	4.83	3.27

Doble rør – tynnveggede – overflate og/eller undergrunn				
Størrelse (overflate-undergrunn)	**mm**		**in**	
	Hulldiameter	**Kjernediameter**	**Hulldiameter**	**Kjernediameter**
AOTW/-U	48.0	30.3	1.89	1.19
BOTW/-U	60.0	42.0	2.36	1.65
NO2	75.7	50.7	2.98	2.0

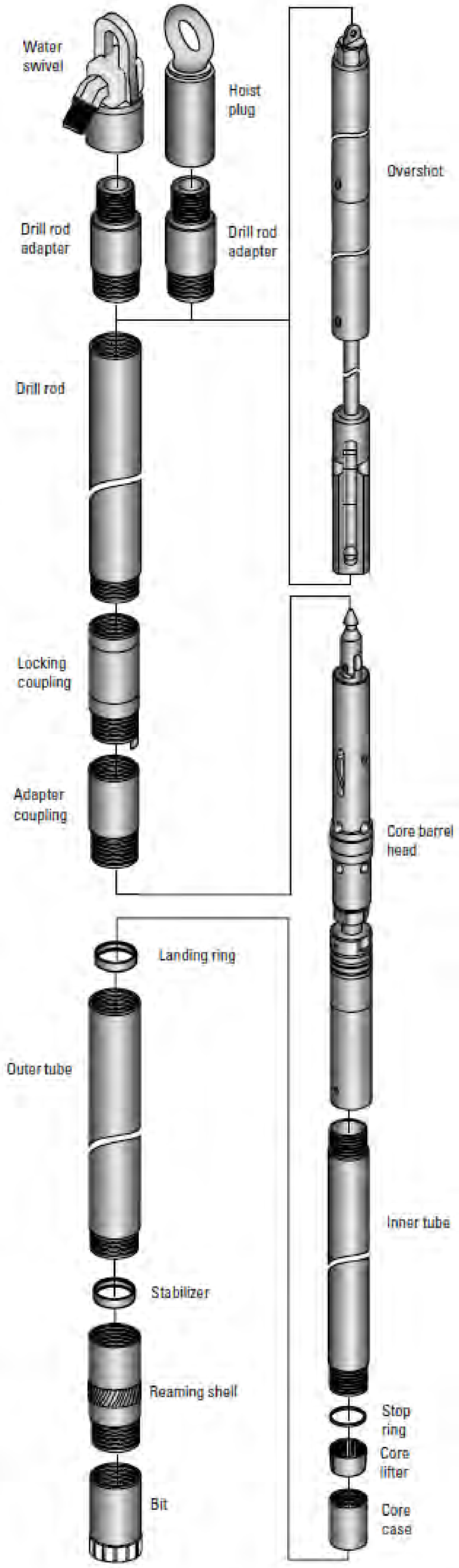
Lengder og dimensjoner								
Størrelse	**Metrisk målesystem**				**Engelsk målesystem**			
	Diameter		**Lengde**		**Diameter**		**Lengde**	
			1.5 m	**3.0 m**			**5 ft**	**10 ft**
Rør	**OD**	**ID**	**kg**		**OD**	**ID**	**lbs**	
AO/AT	44.5	34.9	6.8	13.9	1.75	1.38	15.7	31.4
AGM/ATT	44.5	36.8	5.9	11.8	1.75	1.45	13.0	26.0
BO/BT	55.6	46.0	8.9	17.9	2.19	1.81	20.1	40.2
BGM/BTT	56.5	48.8	7.6	15.3	2.23	1.92	16.8	33.8
NO/NMO/NT	69.9	60.3	11.4	22.9	2.75	2.38	25.7	51.4
HO/HMO/HT	88.9	77.8	17.1	34.2	3.50	3.06	38.0	76.7
PT	114.3	101.6	25.4	56.0	4.50	4.00	56.9	123.5
Foringsrør								
AW	57.1	48.4	8.3	16.9	2.25	1.91	18.40	37.40
BW	73.0	60.3	15.3	31.2	2.88	2.38	33.80	68.80
NW	88.9	76.2	19.1	38.8	3.50	3.00	42.10	85.60
HW/HWT	114.3	101.6	25.0	50.8	4.50	4.00	55.10	112.10
PW/PWT	139.7	125.5	34.9	69.7	5.50	5.50	76.70	153.30

1.1.3 Wireline doble kjernerør

Doble kjernerør for wireline boring er den dominerende kjernerørkonfigurasjonen. Som en generell regel kan doble kjernerør brukes i alle grunnforhold, bortsett fra der man har spesielt dårlige og løse grunnforhold.

Ved et overflatesystem senkes det indre røret ned av egen vekt, og brukes normalt i borehull med fall mellom 45 og 90 grader.

Ved bruk av denne typen kjernerør og tilhørende borrør, er det også vanlig å bruke en vannsvisel og en løfteplugg brukes for å løfte og senke borestrengen.



Doble rør – overflate og/eller undergrunn				
Størrelse (overflate - undergrunn)	**mm**		**in**	
	Hull dia.	**Kjernedia.**	**Hull dia.**	**Kjerne dia.**
BO/BO-U	60.0	36.4	2.36	1.43
NO/NO-U	75.7	47.6	2.98	1.88
HO/HO-U	96.1	63.5	3.78	2.50
PO	122.7	85.0	4.83	3.34

Ref : Atlas Copco Exploration products – Product Catalogue

Vedlegg G

Eksempel selvborende stag

Minova MAI SDA Selbstbohranker

Minova MAI SDA self-drilling anchor

ORICA
A member of the Orica Group

MINOVA
The Ground Support Company

MAI Selbstbohranker und seine Anwendungen

Der Minova MAI Selbstbohranker (SDA)™ ist eine Ankerlösung für instabile Böden wie Sand, Kies, Schlick, Lehm und wenig bis mittelstark zerklüftete Gebirge.

Für Projekte in solchen Bedingungen sollte der Minova MAI SDA als beste Lösung berücksichtigt werden. Der Minova MAI SDA wurde für optimierte Installation entwickelt und kann an jeweiligen Projekt-Bedürfnisse angepasst werden.

Man erreicht ein erstklassiges Arbeitsergebnis, indem der Hohlstabanker mit verlorener Bohrkrone in den Boden oder das Lockergestein gebohrt wird und nach dem Bohren mit Injektionsgut durch den Hohlstab vom Bohrlochtiefsten aus den umgebenden Boden verfestigt.

Der Minova MAI SDA besteht aus:

- Einer Sechskant-Mutter
- Einer Ankerplatte
- Verlängerungsmuffen, wenn der Anker aus mehreren Teilen besteht
- Hohlstab Anker(n)
- Einer verlorenen Bohrkrone

Der Minova MAI SDA ist für 3 Anwendungsbereiche geeignet:

Böschungssicherung
Der Minova MAI SDA wird genutzt, um instabile Gebirgs-/Bodenformationen zu stabilisieren. Bei Lockergestein/verwitterten Böden ist der Einsatz der SDA im Vergleich zur konventionellen Ankertechnik als schnelle und einfache Installationsmethode zu bevorzugen.

Fundamente mit Mikropfählen
Minova MAI SDA Mikropfähle sind gebohrte Pfähle bestehend aus Minova MAI SDA mit verfestigtem Zementmörtel. Der SDA stellt die Bewehrung des Pfahles dar. Sie können auf Baustellen mit wenig Raum mit kleinem Bohrgerät eingesetzt werden, in die meisten Böden oder Gesteine gebohrt werden und sind für Zug- und Druckbelastungen geeignet. Der große Vorteil ist die Kombination aus Bohren und Injizieren, die eine hohe Arbeitsleistung gewährleisten.

Tunnelbau
Minova MAI SDA sind die ökonomische Lösung bei der Systemankerung und vorauseilenden Sicherung im Tunnel oder nicht standfestem Gebirge.

MAI SDA self-drilling anchor and its applications

The Minova MAI self-drilling anchor (SDA)™ is a bolting solution for unstable ground conditions such as sand, gravel, silt, clays and in soft to medium fractured rock formations.

For projects facing such ground conditions, Minova MAI SDA self-drilling anchors should be considered as the main productivity solution.

The Minova MAI SDA solution is designed for optimized installation, tailored to the project's needs. By drilling a hole in collapsing soil or loose rock with a sacrificial drill bit and a hollow rod, and after the drilling operation injecting cementitious grout or resin into the hollow rod and surrounding cavity, makes it a top productivity solution.

A Minova MAI SDA self-drilling anchor consists of:

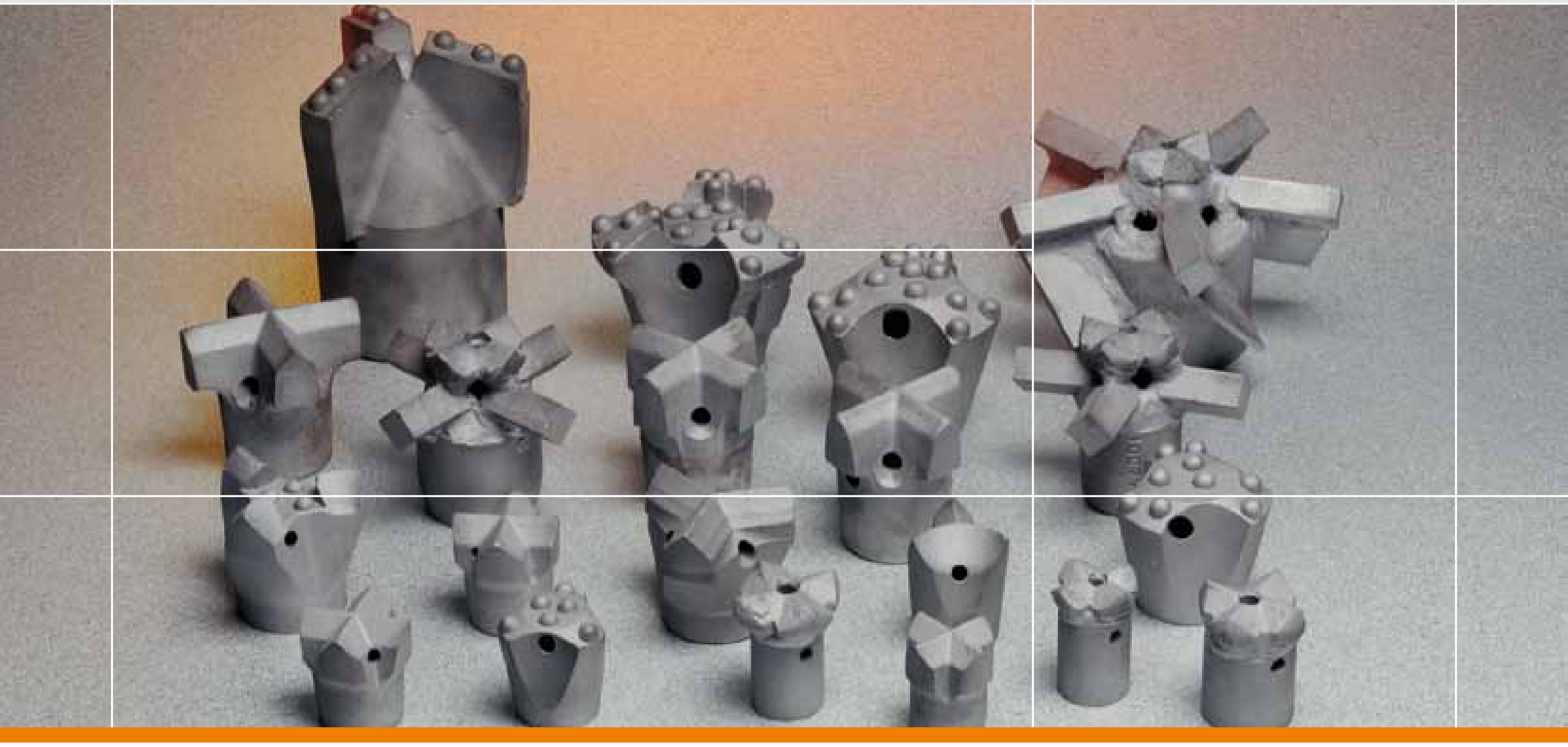
- a hexagonal nut
- a bearing plate
- extension couplings, if the anchor consists of several anchor rod sections
- hollow anchor rod(s)
- a sacrificial drill bit

The Minova MAI SDA is suited for 3 application areas:

Slope stabilization
It is used to stabilise unstable rock/soil formations. The unconsolidated or weathered ground conditions favour the SDA technique for fast and simple method of installation compared to traditional methods.

Foundations with micropiles
Minova MAI SDA micropiles can be defined as drilled piles, composed of injected grout with the Minova MAI SDA anchor rod as steel reinforcement. They can be installed in sites with limited space using light drilling equipment, into most ground conditions including rock and are suitable for tension and compression loads. The big advantage is the combined drilling and grouting making high piling outputs possible.

Tunnelling
Minova MAI SDA self-drilling anchors are the most economical solution for the reinforcement of the tunnel circumference and advance roof support for tunnel excavation in overburden and soft fractured rock conditions.



Minova MAI SDA Zubehör

Minova MAI SDA components

Verlorene Bohrkronen
Die verlorene Bohrkrone ist der entscheidende Teil des Ankersystems und verantwortlich für die Effizienz des Einbaus. Minova bietet eine breite Palette an Bohrkronen, die der wechselnden Geologie eines Projekts gerecht werden. Um die Performance und Kosteneffizienz zu verbessern, werden weltweit die Projektdaten gesammelt und mit der Zielsetzung der Produktverbesserung und Kostenreduzierung in die Weiterentwicklung der Anker einbezogen.

Auswahl der Bohrkronen
Der erfolgreiche Einbau des SDA Systems ist von der Auswahl der passenden Bohrkrone abhängig. Im Gegensatz zu konventionellen Bohrkronen für maximale Leistung in Gebirge und Boden, werden die Kriterien für SDA Bohrkronen durch folgende Faktoren bestimmt:

- Hohe Qualität für begrenzte Lebensdauer
- Installierte Ankerlänge
- Geologie
- Geometrie

Sacrificial drill bits
The sacrificial drill bit is the most crucial part of the anchoring system, and is responsible for the productivity of the installation. Minova offers a large range of drill bits to suit the changing of geology encountered during a project. In order to improve on performance and cost efficiency, data is collected from projects around the world and incorporated into the design with the aim to improve penetration rate and bit quality and to reduce manufacturing and application costs.

The selection of drill bits
A successful installation of the SDA system depends on the selection of the most suitable drill bit. Compared to conventional drill bit types offered globally for maximum standing performance for rock or soil, the criteria for SDA drill bits are defined by consideration of the following factors:

- High quality for a limited service life
- Installed MAI SDA length
- Geology
- Geometry

MAI SDA - Weiteres Zubehör

Hohlstab-Anker
Um Spülen oder gleichzeitiges Bohren und Injizieren zu ermöglichen, ist der Anker hohl und hat ein Linksgewinde für den Anschluss an Standard Bohrgeräte. Er wird aus API Standard dickwandigem Stahl hergestellt, ist kaltgewalzt zum Standard ISO Gewindeprofil. Der Walzprozess verfeinert die Struktur des Stahls, vergrössert die Streckgrenze und liefert einen Anker mit langer Lebensdauer für verschiedenste Anwendungen. Das Standardgewinde des Ankers ermöglicht sowohl eine gute Haftung zwischen Ankerstange und Injektionsgut, als auch die einfache Verbindung mit allen Atlas Copco Bohrgeräten und die Nutzung des umfangreichen Bohrzubehörs.

Verlängerungskupplungen
Die Kupplung verfügt über ein patentiertes Design, das die Kraftübertragung zwischen dem Ankerstangen ermöglicht, Verlust reduziert und eine maximale Stoßkraft an der Bohrkrone sicherstellt. Um den genauen Sitz der Ankerstange in der Kupplung zu ermögliche, sind alle Ankerstangen abgeschrägt, sodass ein Kontakt der Ankerenden möglich wird.

Ankerplatten
Ankerplatten sind geschmiedete Stahlplatten mit einem mittigen Loch, das die Drehung um 7° in alle Richtungen ermöglicht. Alle Funktionsteile werden von der Minova MAI Qualitätskontrolle laufend geprüft.

Sechskant-Muttern
Die Sechskant-Muttern aus Stahl haben abgerundete Kanten an beiden Enden und sind vergütet, um allen Anforderungen des Ankersystems und der täglichen Arbeit gerecht zu werden. Alle Mutter weisen eine höhere Bruchlast als die Ankerstange auf.

MAI SDA - Additional components

Hollow anchor rods
The anchor rod features a hollow bore for flushing or simultaneous drilling and grouting and has a left-hand thread for connection to standard drill tooling. It is manufactured from API standard thick wall steel tubing, cold rolled to a standard ISO rope thread profile. The rolling process refines the crystaline structure of the steel, increasing the yield strength and producing a durable drill rod suitable for a wide range of applications. The standard rope thread of the anchor rod produces an excellent bond between the rod and grout, as well as enabling connection to various drill rigs and use with a wide range of drill steel accessories.

Extension couplings
The coupling features a patented design that enables direct end-to-end energy transmission between each bar, reducing losses and ensuring maximum percussive energy at the drill bit. To enable the correct seating of each bar within the coupler, all bars are chamfered with precision to enable the bar ends to have face-to-face contact.

Bearing plates
The bearing plates are forged steel plates with a centre hole, allowing articulation of seven degrees in all directions. All functional parts are constantly tested, in line with Minova MAI rigorous quality assurance policy.

Hexagonal nuts
Hexagonal nuts are manufactured from high precision steel with chamfered edges on both ends from high precision steel, and tempered to meet the stringents demands on anchor specifications and the daily operations of underground works. All nuts exceed the ultimate strength of the bar.

Minova MAI SDA - Weiteres Zubehör

Verzinkte Anker
Korrosion ist ein komplexer Prozess und kann nur schwer vorhergesagt werden. Trotzdem können Vorhersagenmethoden bei der Festlegung des Korrosionsschutzes hilfreich sein. Daher hat Minova MAI einen Feuerverzinkten Anker entwickelt. Alle SDA Anker und Zubehör sind mit diesem Korrosionsschutz erhältlich.

Abstandshalter
Für spezielle Anwendungen ist ein Abstandshalter verfügbar. Für normale Anwendungen ist er nicht erforderlich, da er die Drehung und die Verteilung des Injektionsgutes im Bohrloch behindert. Die Nutzung des Abstandhalters kann die vollständige Benetzung des Ankers mit Injektionsgut nicht garantieren, denn es ist unmöglich, die Verteilung des Injektionsgutes im Bohrloch zu überprüfen.

Übergangsmuffen
Übergangsmuffen aus dickwandigem Stahl (abgeschrägt und gehärtet) werden an stark beanspruchten Stellen, normalerweise direkt am Bohrgerät, genutzt. Ein Drehmoment wird normalerweise verwendet, um ein Lösen zusätzlicher Ankerstangen zu verhindern. Alle Übergangsmuffen sind mit einem Steg versehen, der als Mittelstop dient.

Minova MAI SDA - Additional components

Galvanized anchors
Corrosion is a very complex process, and corrosion rates are very hard to predict accurately. However, analytical evaluations can be helpful to recommend the need for corrosion protected rock bolts. For this reason Minova MAI has developed a hot dip galvanizing corrosion protection. The full range of SDA bars and accessories are available with this corrosion protection.

Spacer
A gap spacer is available for specialist applications. For general use the centralizer is not required as it snags during rotation and interferes with grout circulation in the borehole. However the use of a centralizer does not guarantee comprehensive grout cover along the length of the bar as it's is impossible to control the grout within the borehole.

Coupling boxes
Manufactured from thick-wall steel which is machined and case hardened. Coupling boxes are used at high wear locations, typically just below the hammer drive. A locking torque is normally applied to the coupling box at the permanent joint, to

Wenn ein Reduzierungselement genutzt wird, um z.B. mit einem R38 Bohradapter einen R32 Anker zu installieren, sollte ein Drehmoment am R38er Ende verwendet werden, um ein Wandern des kleineren Ankers in die größere R38er Öffnung zu verhindern. Erhöhungs-Elemente sind nicht erforderlich, da das zusätzliche Drehmoment den kleineren Antrieb überlasten würde.

Shank Adapter/Einsteckende

Die bevorzugte Installationsmethode ist die Drehschlagende, bei der sowohl hydraulische als auch pneumatische Bohrgeräte genutzt werden können. Um die Rotation und den Schlag vom Bohrgerät auf den Anker zu übertragen wird ein Shank Adapter benötigt. Minova kann verschiedenste Adapter für alle Bohrgeräte liefern.

Injektionsadapter

Nach dem Spülen des Bohrloches mit Wasser oder Luft wird injiziert. Als Verbindung des Injektionsschlauches der Pumpe mit dem Anker wird ein Injektionsadapter genutzt, der nach der Injektion abgenommen und bei der nächsten Injektion wieder verwendet wird.

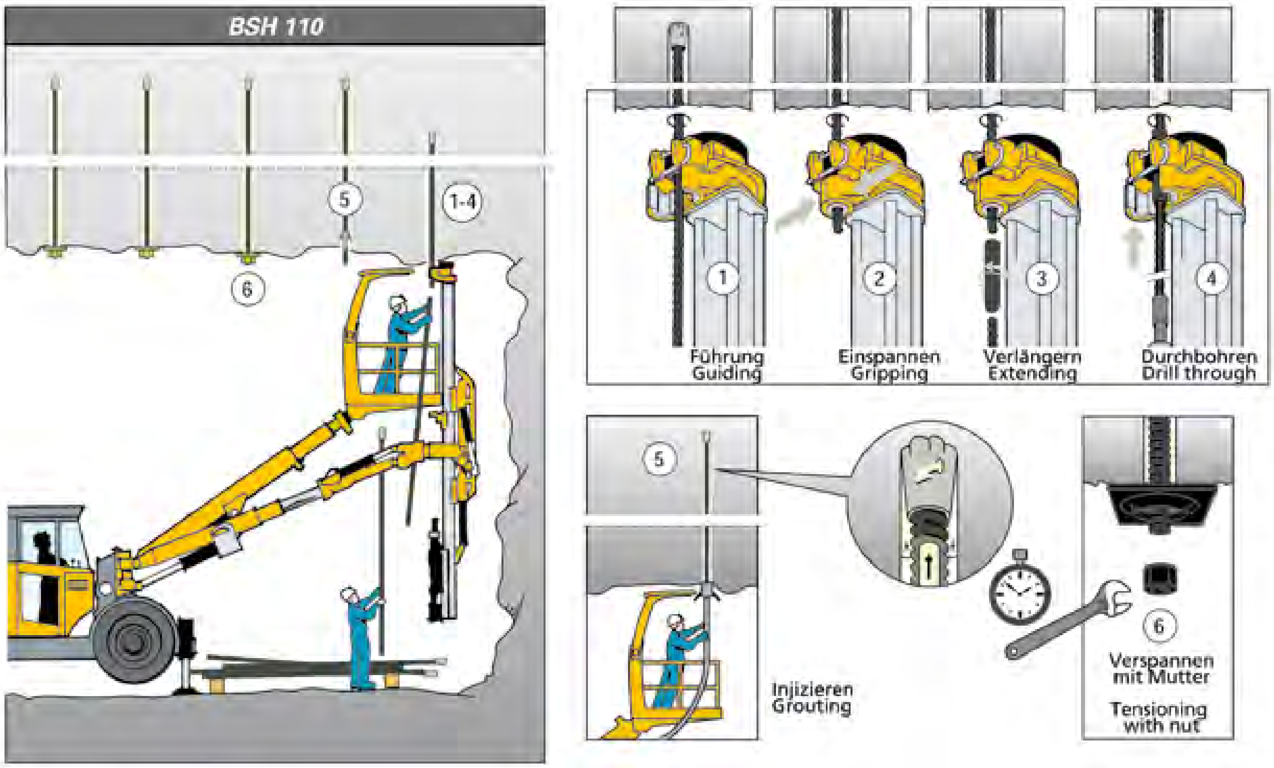
avoid release when additional anchor bars are added. All the coupling boxes are supplied with a bridge to act as a centre stop. When a step down (reducer) drive arrangement is used i.e. R38 shank to drive to install R32 anchor bar, a locking torque should be applied at the R38 end to prevent the R32 bar climbing into the R38 chamber. Step up drive arrangements are not recommended as the additional torque overloads the smaller drive.

Shanks

Rotary percussion is the preferred method of installation. Either hydraulic or air hammer is suitable. To transfer the rotation and percussion from the hammer to the bar's system there is a need for a special tool named shank adapter. Minova is providing a full range of different shank adapters for different hammers.

Grout coupling

After using standard flushing media - water or air, grouting has to be done. For connecting the grouting hose from the pump with the anchor bar, the grout coupling is used. The grout coupling will be removed and reused after the grouting process is done.



Minova MAI SDA Installation

Manuelle Installation
Das obige Schema erläutert die Arbeitsschritte bei der manuellen Installation des Minova MAI SDA.

Halbautomatische Installation
Die Kunden aus Bau und Bergbau haben konstanten Bedarf, die Effizienz und Qualität des Ankersetzens zu verbessern. Für die Auftraggeber wird außerdem die Steigerung der Sicherheit durch Verringerung der Arbeitszeit in ungesicherten Bereichen immer wichtiger, vor allem, wenn unter schwierigen Bedingungen geankert wird.

Ein Wechsel von der konventionellen (nachträglichen) Injektion zur halb-automatischen (sofortigen) Injektion mit Hilfe eines IRIA (Integrierter Bohr-Injektions-Adapter) bietet einen Arbeitsablauf, der Verbesserungen bietet, die für den Kunden wertvoll sind:

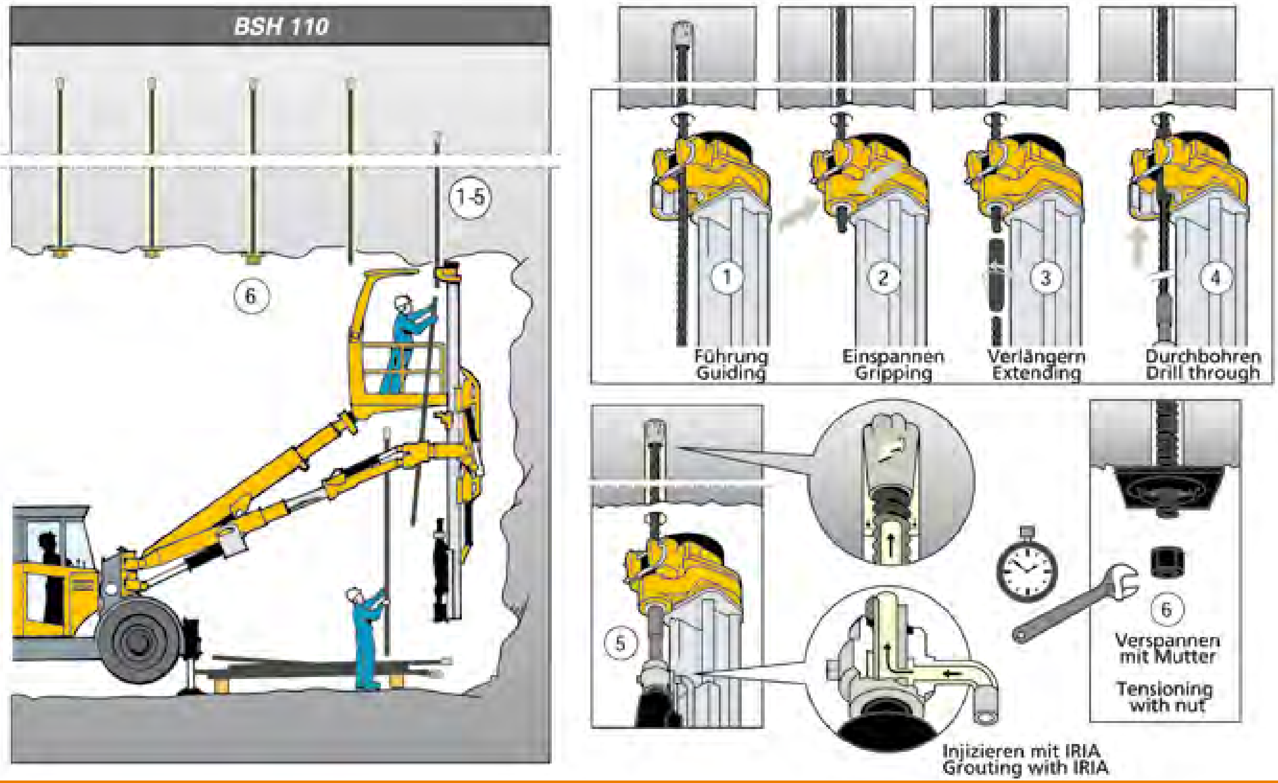
- Installation wird in einem Arbeitsgang ausgeführt, die Geschwindigkeit wird durch den Bohrvorschub bestimmt
- Kein zusätzlicher Arbeitsschritt für Nach-Injektion
- Reduzierte Kosten für zusätzliche Geräte (Arbeitsplattformen etc.)
- Bessere Abstimmung des Installationsprozesses auf eine sich ändernde Geologie
- Flexible Auswahl und Anpassung der Spülmittel (Wasser, Luft, Injektionsgut)

Manual installation
The above scheme explains the working steps for the manual installation of Minova MAI SDA anchors.

Semi-mechanized installation
The anchoring or bolting industry has a demand for increased efficiency and quality of the installation of bolts. In addition increased safety by minimizing work in unprotected areas is becoming more important to contractors when installing bolts in difficult rock/soil conditions.

A change from the conventional post grouting method to a semi-mechanized installation method using an IRIA (Integrated Rotary Injection Adapter) method provides an adaptable installation process, which offers an improved solution and as such added value to the customer:

- SDA installation becomes one work cycle performed only by the drill feed
- No additional work cycle for post grouting
- Reduced operation cost for additional equipment (working platforms etc.)
- Better adjustment of the installation process in respect with the changing geology
- Flexible selection and adjustment of flush media as needed (water, air or grout)



Minova MAI SDA Installation

Verbesserte Injektionsqualität

- Bessere Verfüllung des Ringspalts durch sofortigen Mischprozess
- Gleichmäßige Lastverlagerung über die gesamte Ankerlänge zwischen Anker und Boden/Gebirge
- Verbesserter Korrosionsschutz verlängert die Lebensdauer

Die Möglichkeit einer schnellen Gebirgsverfestigung mit SDA im Vergleich zu Lösungen mit verrohrten Bohrlöchern

- Kein separates Bohrgerät, gleiches Personal
- Keine Subunternehmer und keine Investition in Betriebsmittel

Ermöglicht Technologien zur Einführung schnell reagierener Injektionen

- Gegendruck während der Injektion kann durch Bohrvorschub und Bohrgerät ausgeglichen werden, somit wird ein höherer Injektionsdruck möglich, was durch niedrigeren W/C Faktor die Reaktionszeit reduziert und durch einen schneller tragenden Anker die Ausbauzeit verringert.

Improved quality of grouting

- Better filling of borehole annulus due to immediate mixing process
- Consistent load transfer over the whole bolt length between soil/rock and bolt
- Improvement of corrosion protection extending the service life

The option to introduce high speed ground stabilization with SDA versus cased borehole drilling solutions

- No separate drilling equipment needed, same crew
- No subcontractors and no investments in capital equipment

Providing technology to introduce high speed curing grout formulas

- Back pressures during grouting can be absorbed by drill feed and boomer, thus enabling higher grout pressures, thus allowing lower W/C factors reducing the curing time, providing earlier and higher load bearing of SDA resulting in a reduced excavation cycle time.

Technische Daten • Technical Data

MAI SDA Ankerstangen/anchor rods

Beschreibung/Description	R32 L	R32 N	R32 S	R38 N	R51 L	R51 N	T76 N	T76 S	T111 L	T 111 N	Einheit/ Unit
Außendurchmesser/Outer diameter	32.0	32.0	32.0	38.0	51.0	51.0	76.0	76.0	111.0	111.0	mm
Innendurchmesser/Inner diameter	20.6	18.5	15.0	19.0	33.3	30.2	51.0	44.0	85.0	75.5	mm
Querschnittsfläche/Cross-sectional area	350	430	520	750	900	1070	1870	2400	3185	4395	mm²
Bruchlast/Ultimate tensile load (UL)	210	280	360	500	550	800	1600	1900	2640	3650	kN
Zuglast/Yield load (YL)	160	230	280	400	450	630	1200	1500	2000	2750	kN
Streckgrenze/Yield strength	460	530	530	530	500	590	640	630	630	630	N/mm²
Zugfestigkeit/Tensile strength	600	650	690	660	610	750	860	790	830	830	N/mm²
Gewicht/Weight	2.8	3.4	4.1	5.9	7.0	8.4	14.7	18.9	25.0	34.5	kg/m

MAI SDA Verlängerungsmuffen/extension couplings

Beschreibtung/Description	R32 L	R32 N	R32 S	R38 N	R51 L	R51 N	T76 N	T76 S	T111 L	T 111 N	Einheit/ Unit
Durchmesser/Diameter	42.4	42.4	51.0	51.0	63.5	63.5	95.0	95.0	140.0	140.0	mm
Länge/Length	145.0	145.0	190.0	220.0	170.0	220.0	220.0	220.0	250.0	250.0	mm
Gewicht/Weight	0.8	0.8	1.0	1.7	1.7	2.2	4.7	4.7	11.5	11.5	kg

MAI SDA Muttern/nuts

Beschreibung/Description	R32 L	R32 N	R32 S	R38 N	R51 L	R51 N	T76 N	T76 S	T111 L	T 111 N	Einheit/ Unit
Schlüsselmaß/Key size	46.0	46.0	46.0	50.0	75.0	75.0	100.0	100.0	150.0	150.0	mm
Länge/Length	45.0	45.0	45.0	60.0	70.0	70.0	80.0	80.	120.0	120.0	mm
Gewicht/Weight	0.4	0.4	0.4	0.5	1.6	1.6	2.7	2.7	9.0	9.0	kg

MAI SDA Ankerplatten/anchor plates

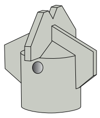
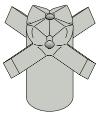
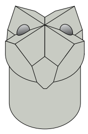
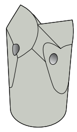
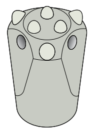
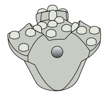
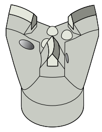
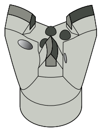
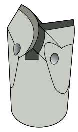
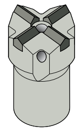
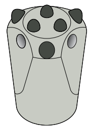
Beschreibung/Description	R32 L	R32 N	R32 S	R38 N	R51 L	R51 N	T76 N	T76 S	T111 L	T 111 N	Einheit/ Unit
Gewölbte Ankerplatten/Domed anchor plates											
Dimension/Dimension	150x150	200x200	200x200	200x200	-	-	-	-	-	-	mm
Dicke/Thickness	8.0	8.0	10.0	12.0	-	-	-	-	-	-	mm
Lochdurchmesser/Hole diameter	35.0	35.0	35.0	41.0	-	-	-	-	-	-	mm
Gewicht/Weight	1.4	2.6	3.2	3.8	-	-	-	-	-	-	kg
Flache Ankerplatten/Solid anchor plates											
Dimension/Dimension	-	95x95	120x120	140x140	150x150	180x180	250x250	250x250	300x300	350x350	mm
Dicke/Thickness	-	25.0	30.0	35.0	40.0	45.0	60.0	60.0	80.0	90.0	mm
Lochdurchmesser/Hole diameter	-	35.0	35.0	41.0	56.0	56.0	90.0	90.0	130.0	130.0	mm
Gewicht/Weight	-	1.6	3.2	5.0	6.2	10.5	26.4	26.4	47.8	76.8	kg

MAI SDA Abstandhalter/spacers

Beschreibung/Description	R32 L	R32 N	R32 S	R38 N	R51 L	R51 N	T76 N	T76 S	T111 L	T 111 N	Einheit/ Unit
Außendurchmesser/Outside diameter	72.0	72.0	72.0	78.0	91.0	91.0	130.0	130.0	170.0	170.0	mm
Länge/Length	30.0	30.0	30.0	30.0	30.0	30.0	40.0	40.0	50.0	50.0	mm
Gewicht/Weight	0.3	0.3	0.3	0.3	0.3	0.3	0.9	0.9	1.6	1.6	kg

Technische Daten • Technical Data

MAI SDA Bohrkronen/drill bits

Bohrkronen Form/Bit shape											
Typ Bohrkrone/Bit Type	**Clay Bit**	**XX**	**EX**	**EC**	**ES-F**	**ES-D**	**EY**	**EYY**	**ECC**	**EXX**	**ESS-F**
Art des Bodens	**Weicher Ton und Boden**	**Lockerer bis mitteldichter Boden, Sand und Kies**	**Lockerer bis dichter Boden/Sand, einschließlich Schichten aus weichem Gestein**	**Lockerer bis dichter Boden/Sand, einschließlich Schichten aus weichem Gestein**	**Schwache zementierte Böden/Sand und schwach gebrochener Fels & reiner Beton**	**Schwache zementierte Böden/Sand und schwach gebrochener Fels & reiner Beton**	**Schwache zementierte Böden/Sand und schwach gebrochener Fels & reiner Beton**	**Mittelstark gebrochene Felsformationen**	**Mittelstark gebrochene Felsformationen**	**Mittelstark gebrochene Felsformationen**	**Stark gebrochene Felsformationen**
Type of soil/ ground	**Soft clay and soil**	**Loose to medium dense soil, sand and gravel**	**Loose to dense soil/sand, including bands of soft rock**	**Loose to dense soil/sand, including bands of soft rock**	**Weak cemented soil/sands and weak fractured rock & plain concrete**	**Weak cemented soil/sands and weak fractured rock & plain concrete**	**Weak cemented soil/sands and weak fractured rock & plain concrete**	**Medium fractured rock formations**	**Medium fractured rock formations**	**Medium to strong fractured rock formations**	**Strong fractured rock formations**
SPT-N Wert/SPT-N Value UCT (N/mm^2)	< 40 -	< 40 -	< 50	< 50 -	> 50 < 10 Mpa	> 50 < 10 Mpa	> 50 < 10 Mpa	- < 50 Mpa	- < 50 Mpa	- < 70 Mpa	- < 100 Mpa
R32 (L&N&S)	76		51	51	51		76	76	51	51	51
	90		76								
	110		90								
mit R38 Adapter/ with R38 adaptor	130									90	
R38 (N)	90	110	76		76		76	76		90	76
	110	130	90								
	130	150									
mit R51 Adapter/ with R51 adaptor	150										
	175										
R51 (L&N)	76	100	100		100	115					76
	90	130	130								100
	150	150									
	175	170									
		200									
T76 (N&S)	130	130	130								120
	150	145	150								
	175	175									
	200	200									
T111 (L&N)	220		220								170

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MINOVA
The Ground Support Company

ORICA
A member of the Orica Group

DYWIDAG-SYSTEMS INTERNATIONAL

DYWI® Drill Hollow Bar System

Content

DYWI® Drill Hollow Bar System

The DYWI® Drill Hollow Bar is a fully threaded self-drilling anchorage system which can be simultaneously drilled and grouted into loose or collapsing soils and brittle rock without the need for a casing. Furthermore, the bar features a left-hand thread for standard rotary percussive drilling.

Manufactured from high grade steel tubing to EN 10083-1, DYWI® Drill Hollow Bar is cold rolled to form standard rope thread or "T" thread profiles. The DYWI® Drill rolling process refines the grain structure of the steel, increasing the yield strength and producing a robust drill steel suitable for a range of drilling and grouting applications.

The DYWI® Drill Hollow Bar System includes a full range of drill bits, adaptor sleeves, couplers, nuts and bearing plates. In addition, thanks to a wide range of DYWI® Drill injection adaptors and drill tooling, the hollow bar can be used with many types of drilling equipment.

Key features of the DYWI® Drill Hollow Bar System are:

No Casing Required

Bars can be drilled into loose or collapsing soils without the need for a casing to support the borehole.

Simultaneous Drill and Grout Installation

Grout is injected at all points of the borehole as drilling is advanced, permeating the local strata for increased bond performance and producing bulbing between the strata and the hollow bar in the softer sections of the soil.

Rotary Percussive Drilling

This drilling technique is highly efficient, ensures fast progress of drilling as well as good directional stability of the drill string and helps to consolidate the grout within the borehole.

Fully Threaded Rod Sections

Continuous thread ensures that rods can be cut and coupled or extended at any point.

High Strength Threads

Both the rope threads and "T" threads provide a strong and robust thread, ideal for rotary percussive (drifter) drilling as well as ensuring a high level of bond with the borehole grout.

Self-Drilling System

Thanks to their self-drilling function, bars can be drilled into most ground conditions for tension, compression or alternating load applications and can also be used as an injection conduit.

Bar/Grout bond

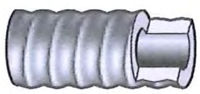
Restricted access soil nailing

DYWI® Drill Hollow Bar soil nails, top bar galvanized, for slope stabilization

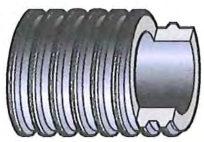
DYWI® Drill Technical Data

	R32-210	R32-250	R32-280	R32-320	R32-360	R38-420	R38-500	R38-550
Nominal Thread Diameter (mm)	32	32	32	32	32	38	38	38
Effective External Diameter (mm)	29.5	29.5	29.5	29.5	29.5	36.4	36.4	36.4
Internal Diameter [a] (mm)	21.5	19.7	18	16.5	15	21	19	18.2
Cross Section Area A_{eff} [b] (mm^2)	321	380	429	470	507	695	757	781
Ultimate Strength F_u (kN)	210	250	280	320	360	420	500	550
Load at 0.2 % Yield $F_{0,2,k}$ (kN)	170	190	220	280	300	350	400	430
Steel Grade [c] Yld/Ult (N/mm^2)	530/660	510/670	520/670	590/680	590/710	510/610	530/660	550/710
Average Section Modulus (cm^3)	1.83	2.04	2.21	2.32	2.43	4.18	4.59	4.84
Moment of Inertia (cm^4)	2.72	3.06	3.30	3.46	3.62	8.02	8.46	8.78
Thread (Left-Hand)	ISO 10208							
Weight (kg/m)	2.8	3.0	3.4	3.9	4.1	5.3	6.0	6.2

DYWI® Drill Rope Thread (R)



DYWI® Drill "T" Thread



- Bar Lengths: 3 m or 4 m
- Bar Finishes: Plain or Galvanized to EN 1461

E Value:

- Strain at Ultimate Load
- Fractile Value of Strain

	R51-550	R51-660	R51-800	T76-1200	T76-1600	T76-1900
Nominal Thread Diameter (mm)	51	51	51	76	76	76
Effective External Diameter (mm)	48.4	48.4	48.4	73.5	73.5	73.5
Internal Diameter [a] (mm)	35	33	30.5	52	46.5	40
Cross Section Area A_{eff} [b] (mm^2)	878	985	1109	2119	2545	2986
Ultimate Strength F_u (kN)	550	660	800	1200	1600	1900
Load at 0.2 % Yield $F_{0,2,k}$ (kN)	450	530	630	1000	1200	1500
Steel Grade [c] Yld/Ult (N/mm^2)	510/630	540/670	570/720	470/570	470/630	500/640
Average Section Modulus (cm^3)	8.42	8.86	9.40	26.8	29.9	33.5
Moment of Inertia (cm^4)	20.8	21.9	23.2	98.3	110.0	123.1
Thread (Left-Hand)	ISO 1720			Int. Standard		
Weight (kg/m)	7.1	7.8	9.0	16.5	20.0	24.0

- a) Internal Øs based on nominal values
- b) Cross section area based on average values
- c) Steel Grades from Characteristic Strengths, in accordance with EN 10083-1

Drilling with long reach excavator

DYWI® Drill Hollow Bar soil nails with reinforced geogrid facing

Crawler mounted drill boom for simultaneous drill & grout soil nails

Rotary percussive top hammer (hydraulic)

Excavator mounted drill boom, installing top bar galvanized soil nails

The DYWI® Drill Hollow Bar offers high rates of installation, as drilling and grouting can be combined as a single cycle. To achieve these benefits, it is important that the correct equipment is selected to ensure efficient drilling.

Drilling Technique

The three main drilling functions are:

- Rotation: 120-150 RPM. This is the key drilling function to ensure the full diameter of the borehole is cut as drilling advances
- Percussion: 300-600 BPM, for directional stability and drilling efficiency
- Fine Feed: Feed pressures should be regulated to match the achievable drilling rate

Rotary percussive top hammer (drifter)

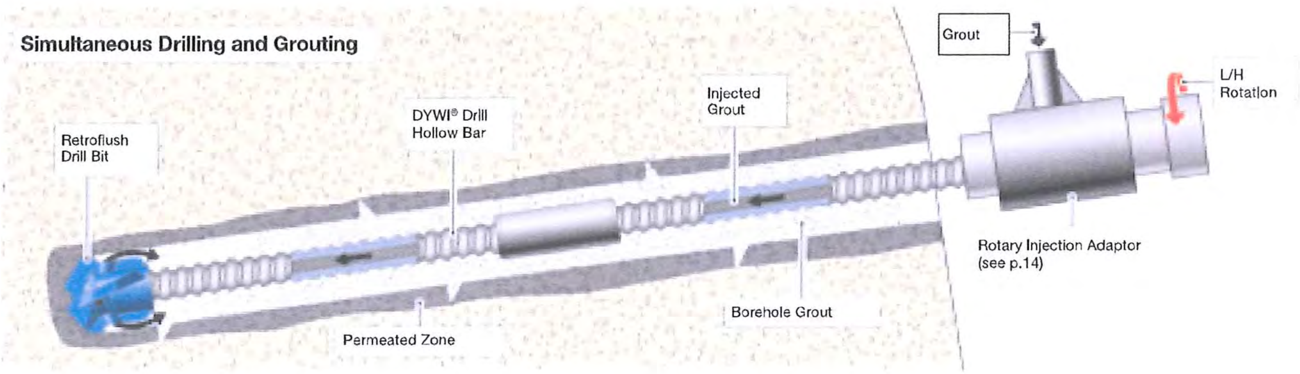
This is the essential piece of equipment for hollow bar drilling. Rotary percussive drilling ensures efficient drilling in most ground conditions, provides good directional stability for the drilled bar and helps consolidate the placed grout. The hammer should have sufficient torque and rotation speed.

Simultaneous Drilling and Grouting

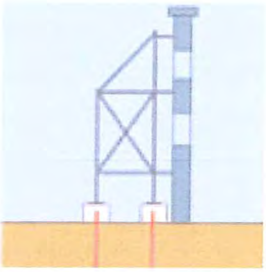
This technique ensures grout is placed at all points of the borehole as drilling is advanced, permeating the local soil strata and producing bulbing in the softer sections of the borehole.

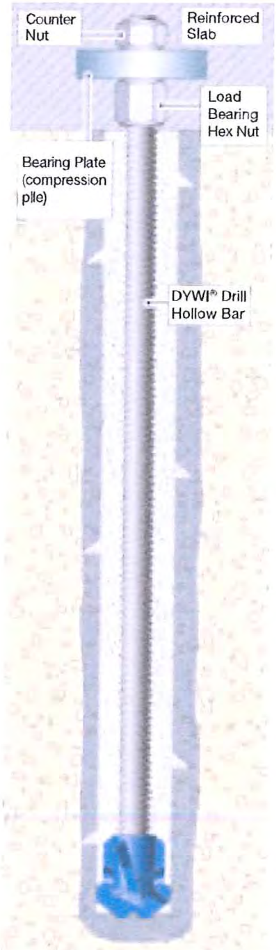
Reaming of the bottom rod section at full depth will further enhance bond performance, as the ground strength is typically highest at this point, due to overburden pressure.

Long reach excavator for restricted access drilling



Micropiles





DYWI® Drill Hollow Bar Micropiles can be installed into areas of restricted access or within the close proximity of buildings. Thanks to the fully threaded system, the micropile can be extended and grouted in areas where the founding level is deeper than expected.

The percussive drilling method ensures minimal disturbance compared to driven piling systems, enabling the foundations of old structures or buildings to be upgraded without damage. Pile stiffness can be increased by placing a steel tube over the top 2m of bar and grouting the annulus.

Applications for DYWI® Drill injection piles, in accordance with EN 14199, include: retained facade bases, foundation upgrades, pylon bases, wind turbines, refurbishment of old structures and gantry bases for rail electrification.

DYWI® Drill T76 micropiles with in-situ steel tube over top 2m

Raking micropiles for bridge pier upgrades

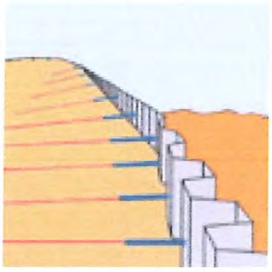
Long stroke drill boom for deep micropiles

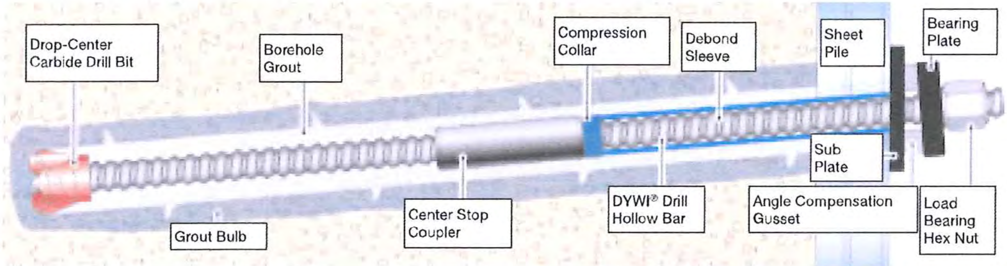
Base slab reinforcement using micropiles

Grout injection behind sheet piles

Micropiles for retained facade frame bases

Ground Anchors





DYWI® Drill Injection Anchors are used extensively in temporary works, as the anchor can be readily drilled into a range of difficult ground conditions or collapsing soils without the need for a casing. The bond stress of both Rope thread and "T" thread bars is high and compares favourably with reinforcing bars of similar diameter (this has been proved by tests carried out by the Technical University of Munich).

The DYWI® Drill free length system incorporates a special debond sleeve and compression collar so that the self-drilled anchors remain debonded in the free length for stressing.

The stressing operation and acceptance tests ensure that each anchor is fully tested and that additional extension will not occur during its service life.

Irrespective of threadform, hollow bar systems are only suitable as temporary anchors. The high impact energy during rotary percussive drilling prevents the use of an adequate corrosion protection system approved by the building authorities. However, corrosion protection is mandatory for stressed (active) permanent anchors, in accordance with the design standards for permanent anchors (EN 1537).

DYWI® Drill free length system for temporary anchors

Drilling through a secant piled wall

4m long T76 bars for 32 m deep anchors, sheet pile tie-back

Hollow bar drilling from a floating barge for sheet pile tie back

Sheet pile tiebacks using large diameter hollow bars

Grouting

The grout injection technique used for the installation of DYWI® Drill Hollow Bar is dependent on the type of drilling and the respective application. The most popular method is simultaneous drill and grout. This method ensures that all points of the borehole are homogeneously grouted as drilling is advanced.

Grout Pumps

These units typically comprise of a mixer and a pump. The choice of grout pump is dependent upon the application; Colcrete Colloidal mixing pumps, Hani, Putzmeister or Turbosol are all suitable. The key requirement is full mixing of the grout and a steady pumping pressure.

For simultaneous drilling and grouting, pressure requirements are not high (up to 7 bar), but constant supply is necessary to ensure that grout circulates within the borehole during drilling. For granular soils, a small return of grout at the mouth of the borehole is all that is required; for cohesive soils, greater flush is necessary.

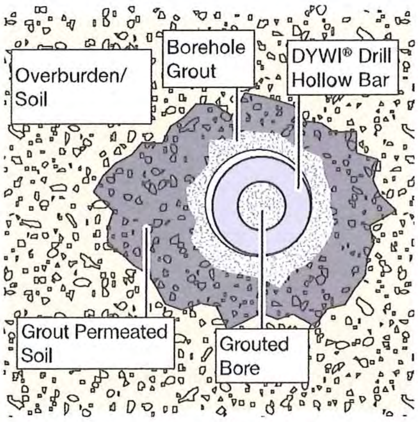
Grout pump with colloidal mixing unit

Typical Grouting Volumes

DYWI® Drill Hollow Bar	Drill Bit Ø (mm)	Grout (kg/m)	Drill Bit Ø (mm)	Grout (kg/m)
R32	75	30-40	100	32-42
R38	110	32-42	130	35-45
R51	115	35-45	150	38-48
T76	130	38-48	200	40-50

Grout consumption is dependent on:

- a) Amount of flush used - simultaneous drill and grout is a part flush/part injection technique
- b) Ground being drilled - granular soils or fractured ground with voids will result in increased grout take
- c) Rate of drilling advance



Typical section of grouted DYWI® Drill Hollow Bar

Grout Mixes

- a) 0.40 w/c ratio (water: cement ratio) = 40 liters water: 100kg cement
- b) 0.45 w/c ratio (water: cement ratio) = 45 liters water: 100kg cement

Grout Yields

- a) One 25kg bag of cement, mixed at 0.40 w/c cement ratio, will give 17.5 liters of grout
- b) Four 25kg bags of cement, mixed at 0.40 w/c cement ratio, will give 70 liters of grout

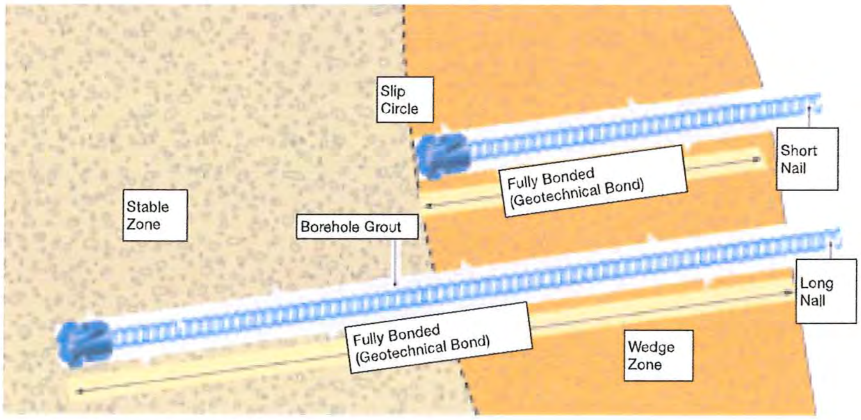
Grouted soil nails on shotcrete face

Stressing and Testing

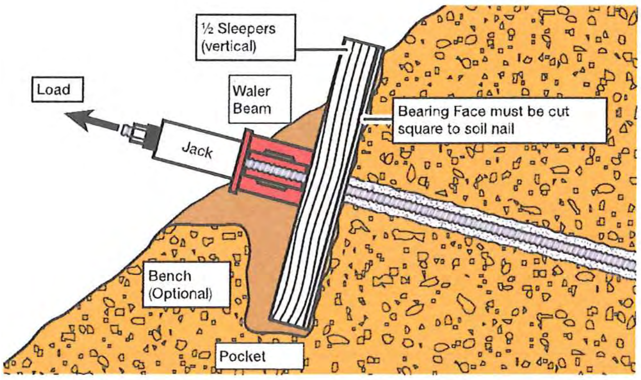
Soil Nail Testing - Long Nail/Short Nail System

Simultaneous drill and grout installation produces a fully grouted (therefore fully bonded) soil nail. Grout is placed in the wedge as well as the stable zone during drilling, therefore, any test must incorporate a mechanism for discounting load generated in the wedge zone from the overall test load. The long nail/short nail testing method is the most effective solution.

Note: The use of debonded free lengths will debond the bar, but will not debond the borehole grout from the soil in the critical wedge zone.



Long Nail/Short Nail testing



Typical excavated pocket for soil nail testing

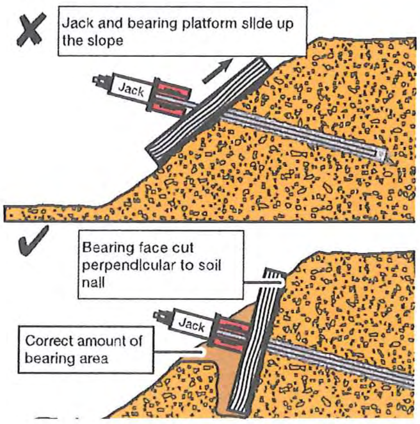

Long Nail/Short Nail testing system for fully grouted hollow bar soil nails

Ground Anchor Testing

The free length system employed for self-drilled hollow bars (see CHB 133) features debonded bars with partially bonded couplers (smooth wall). It is important to appreciate the influence of friction generated at the coupler locations, as this will affect extension readings. Therefore, acceptance criteria based on theoretical free length extensions will be erroneous for self-drilled hollow bar systems. The most effective test method is a maintained load displacement test in accordance with EN1537, Test Method 1 (Section E2).

Micropile Testing

The test set up varies according to the load characteristic of the pile. Tension Micropiles are relatively straightforward to test using bearing plates and a testing beam. Compression Micropiles are much more difficult to test as the pile stiffness at the head needs to be ensured, in order to avoid axial misalignment as the load is applied. Failure to provide lateral restraint or stiffening at the pile head will result in poor load testing.




1,500kN jack for T76 temporary anchors

Heavy duty spreader beam for micropile tension test

ISCHEBECK TITAN®

Foundations / underpinning

Anchorages

Slope stabilisation

TITAN Injection Pile

An innovation prevails.

Design and construction

National Technical Approval
Z-34.14-209

Foundations / underpinning
Resisting uplift with TITAN 40/20 injection piles
Arts Centre, Westerhaar, Netherlands

Anchorages
Excavation shoring anchored with TITAN injection piles
Dresden, Germany

Slope stabilisation
Stabilising a slope with TITAN 30/11 injection piles
Teltow Canal, Lot 2, Berlin, Germany

12 m long soil nails in-stalled from a floating pontoon, with drilling rig mounted on telescopic boom.

About this brochure...

This brochure provides basic information about our TITAN injection piles and includes detailed explanations regarding applications. Injection piles are used for many applications in geotechnical engineering:

- As compression piles for foundations
- As tension piles for retaining structures anchored in the ground
- For stabilising slopes
- For cyclic and repeated loadings

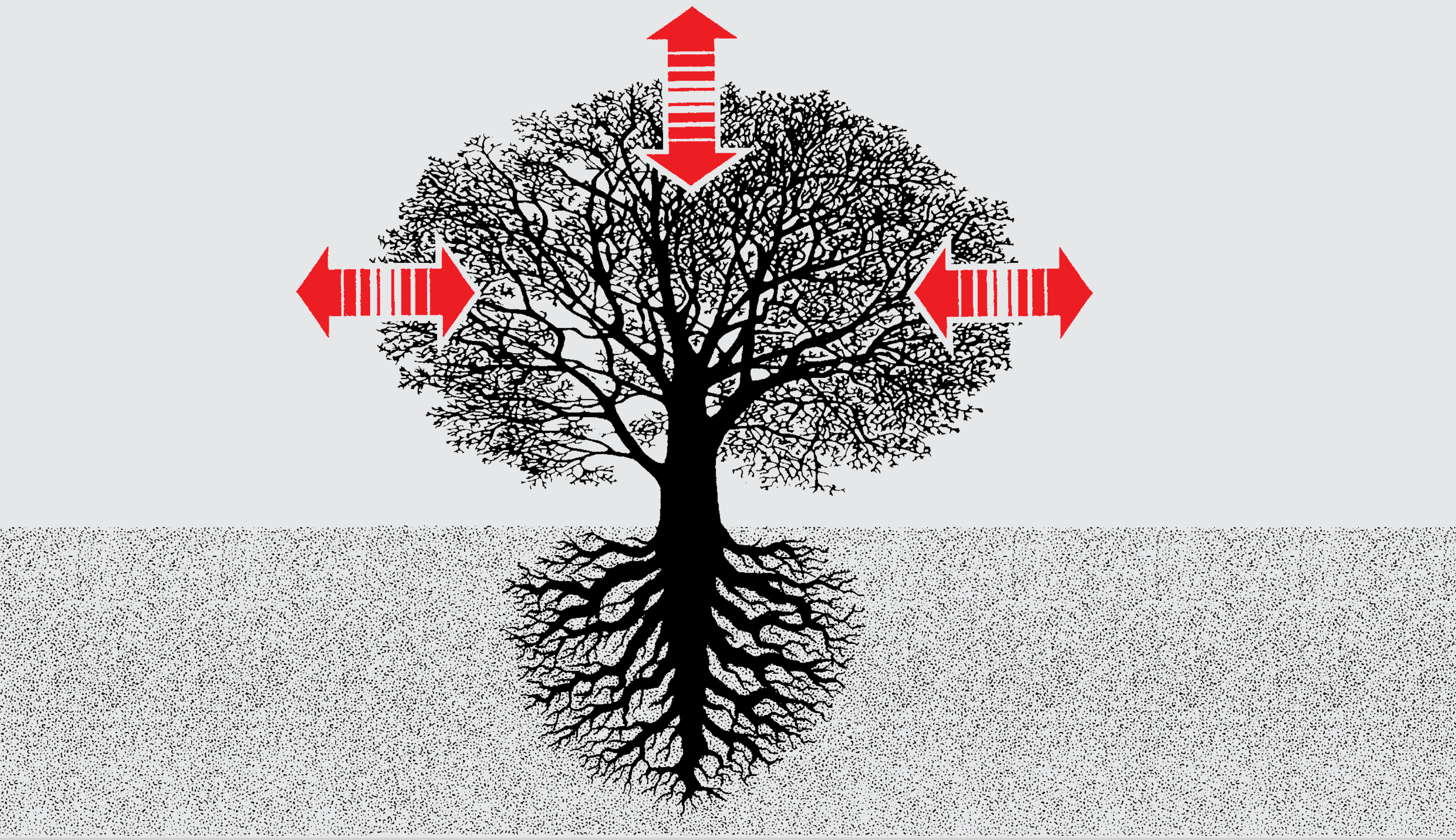
The “Design advice” chapter with design examples also provides an overview of the standards to be complied with and the analyses required.
The appendix summarises a number of basic tests and provides an overall view of all the system components available in tabular form.

Detailed information on the various potential applications for TITAN injection piles can be found in the ISCHEBECK application brochures and in the Internet (go to www.ischebeck.com), or can be obtained from your ISCHEBECK representative.

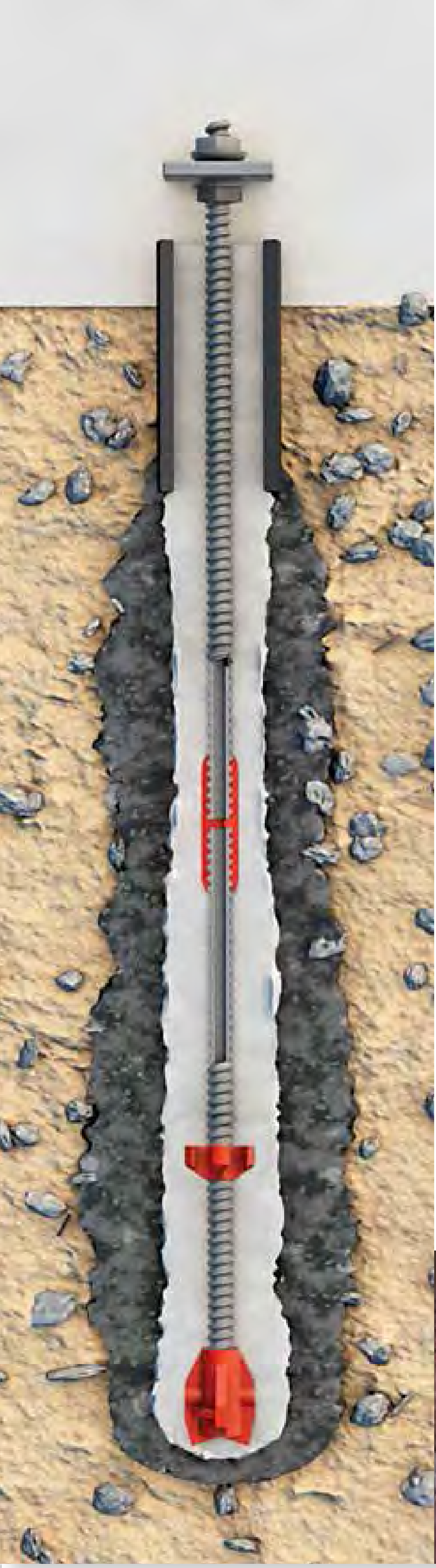
1. Our model

The roots of a tree – a model for us.

It was the image of a mighty tree that guided us. The tree has a network of large and small roots that support it and anchor it in the soil, without the need for a concrete foundation. The roots resist the vertical and horizontal static and dynamic forces, also bending moments and impacts, acting on the tree and transfer them to the ground. So the tree can withstand wind, snow and earthquakes.
The roots interlock with the soil, bond with it to create a monolithic root ball composed of roots and soil, and thus a composite material. How the tree "calculates" the size of the root system it needs for its stability remains largely a mystery to us. But the tree teaches us how to build with the soil, how to use it sparingly, how to improve it and reinforce it.
This new way of thinking about foundations was recognised by Dr. F. Lizzi as long ago as 1952. He called his micropiles "root piles" (pali radice).



ISCHEBECK TITAN



TITAN injection piles – our system.

TITAN injection piles comply with DIN EN 14199 "Execution of special geotechnical works – injection piles" and in Germany their use is regulated by National Technical Approval Z-34.14-209 issued by the German Institute of Building Technology (DIBt).

In the TITAN injection pile, the loadbearing member is a ribbed hollow steel bar that serves as a sacrificial drilling rod, an injection tube and a reinforcing bar (the 3-in-1 principle). In contrast to the method known from DIN 4128, which specifies a casing to prevent the drilled hole from collapsing in, for instance, loose soil or boulders, in the ISCHEBECK system, the drilled hole is prevented from collapsing by a drilling fluid, which renders an additional casing unnecessary. That saves operations in the drilled hole, which in many cases leads to higher productivity during installation than for systems employing a separate casing.
Another advantage is that the drilling operation with the drilling fluid is followed immediately by the dynamic pressure grouting with a cement suspension.

In the absence of a casing, the grout body forms a mechanical interlock with the surrounding soil. This enhanced shear bond means that displacements of the head of the pile are generally only a few millimetres in the case of non-prestressed injection piles, i.e. in a similar order of magnitude to the displacements of prestressed anchors to DIN EN 1537.
Therefore, taking into account their loadbearing behaviour, TITAN injection piles represent an equivalent but economic alternative to prestressed permanent anchors.

Depending on the type of application, injection piles are also known as micropiles, anchor piles or soil nails.

Mechanical interlock between grout body and soil

2. Range of applications

Micropile
for foundations, underpinning

TITAN injection pile as micropile to DIN EN 14199 for foundations, underpinning. For transferring tension and compression loads to loadbearing soil strata deeper in the ground.

- New structures
- Change of use in older buildings
- Following damage (e.g. undermining etc.)
- Securing against uplift

Micropile
for anchorages

TITAN injection pile as micropile to DIN EN 14199 for tying back structures. For transferring tension loads to loadbearing soil strata deeper in the ground.

- Excavations
- Anchorages for sheet pile walls
- Anchorages for retaining walls
- Temporary and permanent
- An alternative to prestressed anchors

Soil nail

TITAN injection pile as soil nail to DIN EN 14490 for enhancing tensile and shear strength.

- Stabilising slopes
- Stabilising embankments
- Reinforced soil
- Fixing protective netting

> Further information about applications for TITAN injection piles can be found in the ISCHEBECK application brochures or in the Internet (go to www.ischebeck.com).

Tunnelling

TITAN injection pile for tunnels.

- Portal stabilisation
- Soil nails around tunnel portal
- Pipe umbrellas
- Driving with spiles
- IQ Quickset Roofbolts, secured with special resin

Special applications

- Drill Drain
  TITAN injection pile as horizontal drain with a special, permeable grout body for reliable, specific drainage of slope seepage water

- Monojet
  TITAN injection pile used according to the jet-grouting principle with up to 200 bar.

- Geothermal projects
  TITAN Geothermal Energy Pile as a combined loadbearing and geothermal element

Advantages for design
- Approved system
- Quick, dependable planning
- Diverse applications – even with difficult boundary conditions
- Suitable for use in all soil types

Advantages for construction
- Standard method irrespective of type of application
- Suitable for use on cramped sites
- Fast progress on site
- Unaffected by changing soil conditions
- No additional plant necessary

Advantages for clients
- No ongoing costs for monitoring tests
- Permanent corrosion protection
- Highly reliable installation method
- No major intervention in existing works
- Economic system

3. The TITAN injection pile in detail

3.1 Loadbearing element with three functions

- Direct drilling without casing
- Fewer operations on site = more efficient working
- Highly reliable installation method

Hollow steel tendon as
- Reinforcing bar
- Injection tube
- Drilling rod

3.1.1 The reinforcing bar function

Hollow steel tendon made from fine-grained structural steel

Standards

The hollow steel tendon is a steel bar for reinforced concrete injection piles in the meaning of DIN EN 14199 section 6.2.1 and must comply with DIN EN 10080*. Eurocode 2 (DIN EN 1992) and DIN 488 divide steel reinforcing bars into three or two classes respectively. Class B bars must have the following properties:

- Yield stress $f_{y,k}$: 400-600 N/mm²
- Yield stress ratio $(f_t/f_y)_k$, i.e. $R_m/R_e \geq 1.08$
- Elongation at maximum load ε_{uk}, i.e. $A_{gt} \geq 5.0$ %

Fine-grained structural steel S 460 NH to DIN EN 10210

An element made from fine-grained structural steel can carry a higher load than one made from a normal structural steel with the same dimensions. Therefore, a tougher, more ductile steel with a high notched impact strength is used for the reinforcing bar. The notched impact strength of this steel is approx. 100 Joule/cm² (at -20 °C) and therefore much higher than the values of typical structural and prestressing steels, which are 27 and 15 Joule/cm² respectively (at -20 °C). That minimises the risk of damage during rotary percussive drilling. Once installed by means of rotary percussive drilling, all the demands placed on reinforcing steel are fulfilled. Furthermore, the fine-grain structural steel is not sensitive to stress corrosion cracking.

Ductility – no sudden failure of the material

The high ductility of the steel means that it reacts with a highly uniform strain in the event of an overload. The load remains constant. In practice, a potential overload therefore initially causes deformations before the component fails. Sudden failure is therefore ruled out.

Permanent protection against corrosion

The grout cover, i.e. the grout body, around the hollow steel tendon provides permanent protection against corrosion (see p. 32).
The following additional measures can be employed to improve the corrosion protection for special applications:

- Hot-dip galvanising
- Duplex coating
- Stainless steel
  (see 6.3, "Verification of durability")

*Note: DIN EN 10080 has been withdrawn in Germany and replaced by DIN 488.

3.1.2 The injection tube function

Hollow instead of solid steel tendon

No additional casing = less work

The hollow steel tendon is driven to the required depth by means of rotary percussive drilling. The drilling fluid injected via the drill bit automatically stabilises the drilled hole. An additional casing is unnecessary, there is no need to insert a separate steel tendon or extract a casing.

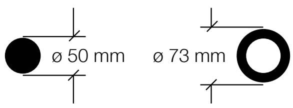
Reliable filling = no multi-stage grouting

The hollow steel tendon is used to fill the drilled hole starting at its deepest point, i.e. from the bottom up. That guarantees that the drilled hole is inevitably completely filled, including all fissures and crevices. No additional injection hoses are needed. Multi-stage grouting is unnecessary.

Additional advantage: better structural cross-section

A hollow tendon is better than a solid tendon with the same cross-sectional area because of its better structural behaviour in terms of buckling, circumference (bond area) and bending stiffness. The result is a higher buckling and flexural stability for the same amount of steel (cost of material) and the same tensile and compressive forces.

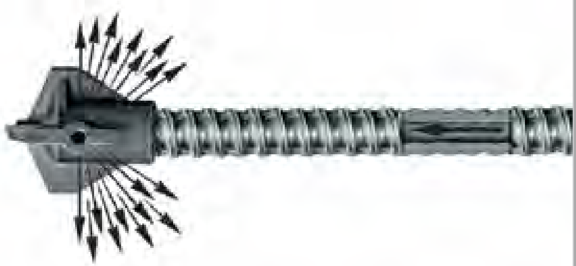
Example: comparison of 50 mm dia. solid bar and TITAN 73/53



$A_{solid} \approx 19.60$ cm² — $A_{hollow} = A_{eff} \approx 16.15$ cm² (see p. 43)

$W_{solid} \approx 12.3$ cm³ — $W_{hollow} \approx 22.2$ cm³

$I_{solid} \approx 30.7$ cm⁴ — $I_{hollow} \approx 77.5$ cm⁴



3.1.3 The drilling rod function

Hollow steel tendon with TITAN thread*

Continuous thread for flexible usage

The hollow steel tendons can be readily cut to any length to suit cramped site conditions or a limited overhead clearance. The continuous thread guarantees that a thread is available at every point for coupling, prestressing, etc.

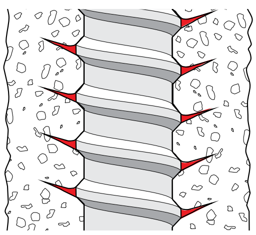
Self-locking thread

The self-locking pitch saves two counternuts per coupling nut.

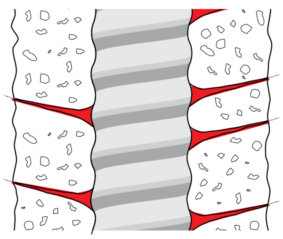
Optimum shear bond with minimum crack widths in grout body

The shear bond, the most effective, most reliable type of bond, is essentially dependent on the geometry of the ribs. Here, the relative rib area f_R serves as a parameter for the quality of the bond. The relative rib area of the TITAN thread is very high; it lies close to the optimum value of $f_R = 0.21$ - $f_R = 0.33$ and is therefore many times higher than the relative rib area of ribbed reinforcing bars ($f_R = 0.056$). In addition to the good bond, the rib surfaces at an angle of 45° reduce the splitting forces. The crack widths at maximum load lie below the 0.1 mm stipulated for verification of permanent corrosion protection. Such a crack width cannot be achieved by drilling rods with rope threads, e.g. R32 or R38 (to ISO 10208 and ISO 1720).

TITAN thread*
Damaging microcracks do not penetrate the grout body



rope thread
A few cracks penetrating the grout body



The special TITAN thread guarantees an excellent shear bond and minimises the risk of longitudinal cracks in the grout body.

*The form and structure of the thread complies with Eurocode 2, DIN 488, DIN EN 10080 and ASTM-A 615.

3. The TITAN injection pile in detail

3.2 Sacrificial drill bits

Clay bit
Clay and loam, sandy-cohesive mixed soils without obstructions < 50 S.P.T.[1]

Cross-cut bit
Dense sand and gravel with obstructions > 50 S.P.T.[1]

Button bit
Weathered rock[2], phyllite, slate, mudstone; strength < 70 MPa

Carbide cross-cut bit
Dolomite, granite, sandstone; strength 70–150 MPa

Carbide button bit
Reinforced concrete or rock[2], predrilling; strength > 70 MPa

Carbide shouldered bit:
For drilled holes with a stable direction in the case of faults in the ground

- All drill bits include venturi flushing outlets.
- Illustrations of drill bits are typical only; forms and colours may differ from those shown here.

[1] S.P.T. = standard penetration test
[2] The compressive strength of rock lies well below that of the rock material itself because of the faults that are present in almost every situation. The rule of thumb is: the compressive strength of rock can be assumed to be 10–20% of that of the rock material itself. (source: Prof. Dr. Kurosch Thuro, Chair of Engineering Geology, Munich TU).

3.3 Coupling nut
Connection without counternuts

The coupling nut can accommodate both repeated loadings and dynamic load changes – made possible by the central stop (steel ring with seals). Tightening against the central stop also achieves an optimum transfer of the blow energy during drilling.

3.4 Centraliser
Guaranteeing the grout cover

The centraliser fitted ahead of each coupling nut (every 3 m at least, according to approval) is carried into the hole as it is drilled. The dimensions of the centraliser are such that it guarantees a consistent grout cover of min. c = 20 mm around the tendon and that the tendon remains in the centre of the drilled hole. The drill bit increases the diameter of the drilled hole (see p. 14) and this helps to guarantee the grout cover specified in the approval. The shape of the centraliser is optimised for transporting drilling debris out of the drilled hole. Furthermore, the centraliser helps to maintain the direction during drilling. Centralisers are fitted with the tapered side pointing towards the bottom of the hole.

3.5 End plate details
Compensating for angles between 0° and 45°



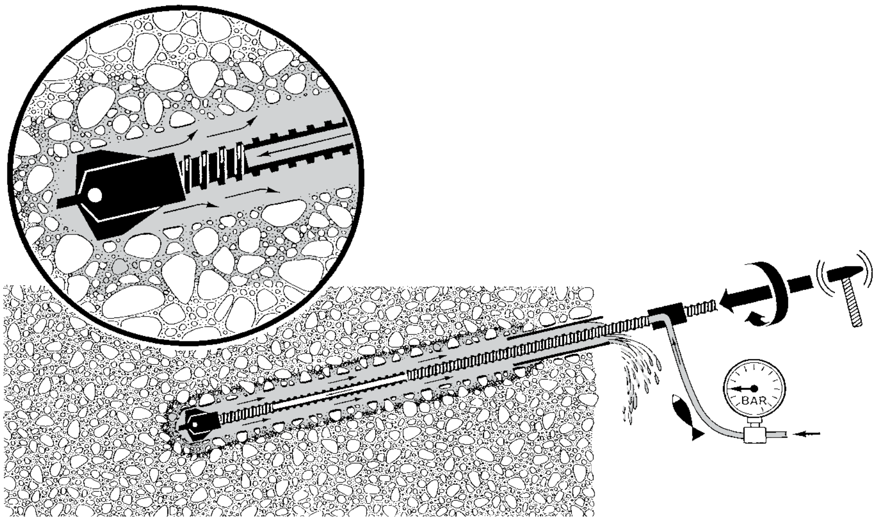

Various end plate details are available to suit different applications. The heads of piles are generally embedded in reinforced concrete (capping beam, foundation, ground slab) or sprayed concrete (soil nailing) or connected to a steel structure (sheet pile wall, waling).
In reinforced concrete, the head of the pile is frequently in the form of an end plate fitted to the projecting end of the tendon with two spherical collar nuts. This type of detail must be checked for bearing pressure, punching shear and bending of the plate.
In sprayed concrete, an end plate with a spherical recess is used in conjunction with one spherical collar nut. Angles of up to 5° can be compensated for with this type of detail.
A tapered plate can be mounted on the end plate with spherical recess in order to compensate for angles of up to 36°. When anchoring sheet pile walls, angles of up to 45° to the vertical are achieved by using an end plate with spherical recess in conjunction with a steel ball. It is also possible to achieve movement in the horizontal direction depending on the angle in the vertical plane.

Design advice for connections in reinforced concrete and for anchoring sheet pile walls can be found in our brochure detailing the standard end plate variations.

4. Method of installation

4.1 An anchorage in two steps

One method for all applications
Irrespective of the ground conditions and the particular application, TITAN injection piles are always installed using the same method.



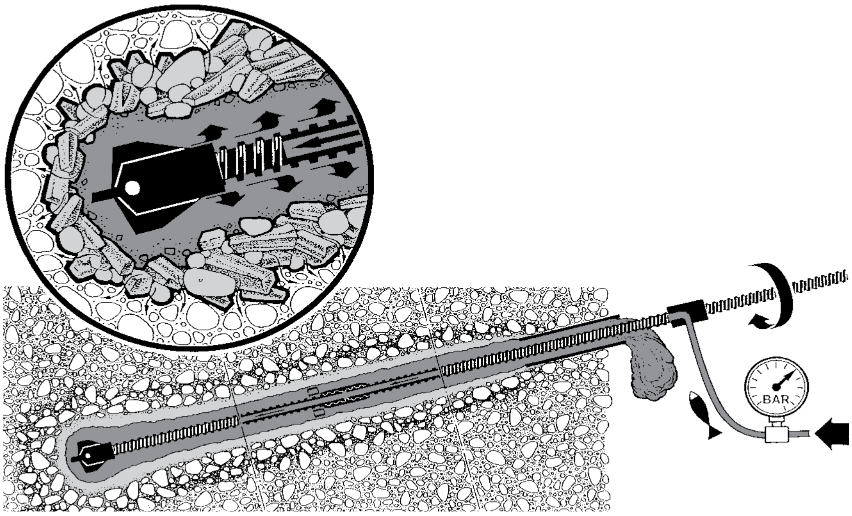
- Standard method for all types of soil
- Standard method for all types of application, e.g. for pile foundations, anchor piles or soil nails
- No multi-stage grouting

Step 1: Direct drilling
Rotary percussive drilling with a flushing medium

Rotary percussive drilling in conjunction with a cement suspension displaces and improves the soil in the same way as a displacement pile. During the drilling procedure, the water is filtered off from the cement suspension to leave behind a filter cake that stabilises the drilled hole. This filter cake can also be called the initial injection that improves the shear bond between the grout body and the soil. The cement forms a mechanical interlock with the microstructure of the soil. In contrast to the down-the-hole (DTH) hammer technique with air flushing or a cased hole, the side of the hole is not loosened or relieved.
The method represents the state of the art and is used for diaphragm walls to DIN 4126 and bored piles to DIN 4014 (but in this case with cement suspension instead of bentonite!). There are also similarities with stabilising with sprayed concrete: the side of the drilled hole is immediately closed with cement.

The flushing medium
A cement suspension with a water-cement (w/c) ratio of 0.4–0.7 (e.g. 70 l water per four 25 kg bags of cement, w/c = 0.7) and a strength of $f_{c,k} \geq 35$ N/mm² is used as a flushing and drilling fluid. The use of thinner cement suspensions, water or air can be considered as the flushing medium depending on the particular application.

Drilling rate and cleaning out the hole
The quality of the grout body and the bond are improved by lowering the drilling rate (approx. 1 m/min) and cleaning out the hole more often.
Cleaning out means repeatedly extracting and reinserting the drilling rod while continuing to rotate it and also continuing to flush out the hole. This method of working rinses the drilled hole clean and forces drilling debris out of the top of the hole. As a check, the flushing medium flowing out of the top of the hole can be passed through a sieve. There should be no interruption to this flow out of the hole. If there is an interruption, or the medium disappears down the drilled hole, flushing should continue without drilling, possibly with a thicker cement mix, until the cement suspension starts to flow out of the top of the hole again.



Step 2: Dynamic pressure grouting
with grout suspension

Dynamic pressure grouting is the name given to injecting grout and rotating the tendon simultaneously. The cement suspension used for pressure grouting has a w/c ratio of 0.4–0.5. This stiff mix displaces the flushing medium that supports the side of the drill hole, forcing it out of the top of the hole. Dynamic pressure grouting can be likened to a poker vibrator in concrete and results in a dense grout body around the tendon.
If the first step (drilling) is carried out using a grout suspen-sion with a w/c ratio of 0.4–0.5, then according to the approval, dynamic grouting (step 2) is not required.

Injection pressure
A rising injection pressure towards the end of the pressure-grouting phase indicates a well-installed pile. The increase in the injection pressure, despite the fact that the top of the drilled hole is open, is explained by the fact that the plugs of rapid-hardening cement ratio that are pushing up the drilled hole become wedged between the rotating hollow steel tendon and the surrounding soil, either creating a natural blockage (packer) or according to Darcy's law describing fluid flow through porous media. With the right injection pressure, sufficient skin friction develops. Therefore, the final injection pressure must be recorded in every installation log.
Multi-stage grouting is unnecessary because the injection pressure of 5 bar specified in section 7.2 of DIN 4128 is always reached.

Controlled underreaming and dowelling effect of injected material due to radial jets

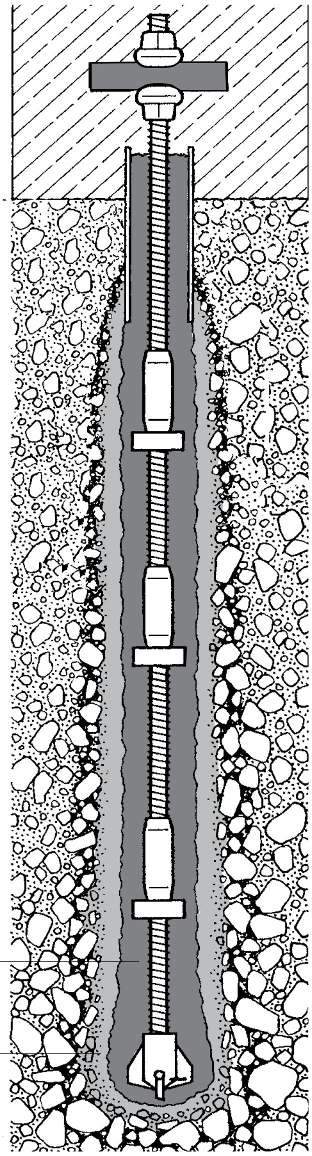
All drill bits have lateral venturi openings which leads to a sort of dowelling effect between the injected material and the surrounding soil, and which can be exploited to create a controlled under-reaming effect. Injection piles excavated for inspection purposes have revealed that the radial jets cut into the soil even at low pressures in a similar way to "jet grouting" and "compaction grouting" (profiled surface to grout body with a diameter up to twice that of the drill bit).

4. Method of installation

4.2 Result

Grout body
Interlock with the soil over full length

During drilling with the flushing and drilling medium, the cement suspension forms a mechanical interlock with the microstructure of the soil. The ensuing filter cake not only prevents the side of the hole from collapsing, but also improves the shear bond between the grout body and the soil, and protects the hollow steel tendon permanently against corrosion.



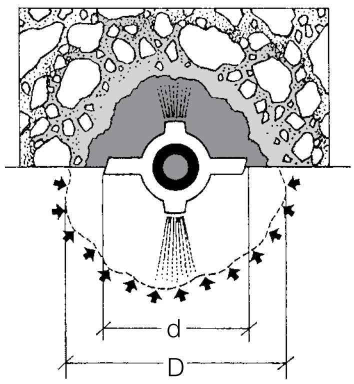
Cement grout cover

Filter cake

Widening of drilled hole

The drilling process with the radial jets creates an annulus for the grout body which has a larger diameter than that of the drill bit.

- According to DIN SPEC 18539, it may be assumed that the pile diameter when installed with external jetting is at least equal to the maximum diameter of the drill bit or the installation plant (drill bit diameter in this case) plus 20 mm.



D = d + a
Widening value a ≥ 20 mm
Empirical values supplied by Ischebeck (measured on excavated grout bodies)
a = 75 mm (medium and coarse gravel)
a = 50 mm (sand and sandy gravel)

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The mechanical interlock between the hollow steel tendon, cement grout cover, filter cake and the soil. The grout body broken away for inspection purposes shows the hollow steel tendon and coupling nut within – permanently protected against corrosion.

5. Plant

A typical site setup consisting of a grouting unit and a drilling rig mounted on construction plant.

TITAN injection piles with a nominal outside diameter (D_{Steel}) of up to 40 mm can be installed with hand-held, pneumatic hammer drills. Any construction plant with a hydraulic rotary percussive drive and drilling attachment can be employed for nominal outside diameters up to D_{Steel} = 52 mm.

TITAN injection piles have a continuous thread and can therefore be cut and joined at any point. The use of small, lightweight drilling equipment makes it possible to install TITAN injection piles even on sites with cramped conditions (e.g. basements, enclosed yards, factories between machinery) or sites with difficult access (e.g. beneath bridges, riverbanks, steep slopes, mountainous areas). The space required for a mini excavator with drilling attachment is less than that required for a drilling rig mounted on crawler tracks (6 m of levelled ground in front of installation area).

In some circumstances, lightweight drilling equipment can be delivered to inaccessible sites, e.g. mountainous districts, by helicopter.

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5. Plant

Hand-held pneumatic hammer drill
- Suitable for installing the smaller TITAN 30 and TITAN 40 anchors.

- **Drilling attachment for mounting on any construction plant with hydraulic drive**
- Suitable for installing the small to medium-sized TITAN 30, TITAN 40 and TITAN 52 anchors
- Manufacturers: Morath, TEI Rock-drills, etc.

Anchor drilling rigs
- Universal crawler track-mounted units for installing all TITAN anchors
- Manufacturers: Klemm, Hütte-Casa-grande, Morath etc.

Suitable drills		Pressure-grouting plant	
TITAN 30/...	Atlas Copco COP 1036, 1038, 1238; SIG PLB 291 A; TAMROCK HL 438; Krupp HB 5, HB 11, HB 15, HB 20; Eurodrill HD 1001, HD 1002; Klemm KD 204, KD 511; Morath HB 23; TEI TE 300 HT	35 l/min	Grouting unit with water regulation, turbo mixer for colloidal mixing, 1 mixing receptacle + 1 reservoir, duplex plunger pump, up to 100 bar Manufacturers: Scheltzke, Obermann, Häny, Morath
TITAN 40/...	Atlas Copco COP 1036, 1038, 1238; SIG PLB 291 A; TAMROCK HL 438; Morath HB 70; Klemm KD 204, KD 511, KD 1011; Krupp HB 11, HB 15, HB 20; Eurodrill HD 1001, HD 1002; TEI TE 300 HT	50 l/min	
TITAN 52/...	Morath HB 100; Klemm KD 511, KD 1011, KD 1215; Krupp HB 25, HB 35; Eurodrill HD 2004; TEI TE 500 HT	70 l/min	
TITAN 73/...	Krupp HB 35, HB 45, HB 50; Morath HB 100; Klemm KD 1011, KD 1215; Eurodrill HD 2004, HD 4010	90 l/min	
TITAN 103/... TITAN 127/...	Krupp HB 50, HB 60; Klemm KD 1215, KD 1624, KD 1828; Eurodrill HD 4010, HD 5012	120 l/min	

Drilling rate: 0.31–1.0 m/min, approx. 50 r.p.m., flushing pressure 10–15 bar
Note: Compared with drilling holes for explosive charges in rock, reducing the drilling rate and the percussive action to approx. 1/3 is recommended.
We recommend using rotary percussive plant for installing TITAN injection piles.

Typical grouting unit

Flushing heads are available for the most popular drifters which connect the hollow steel tendon and the grouting unit to the drifter.

6. Design advice

6.1 Designing a TITAN injection pile as a micropile

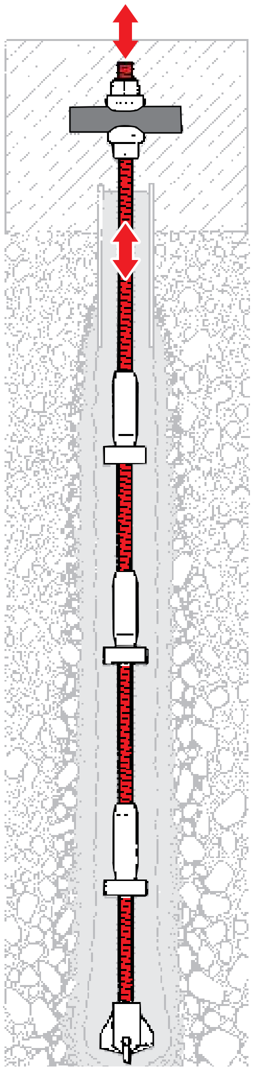
The design of a TITAN injection pile is carried out to different DIN standards depending on the particular application. Verification of the following is always necessary irrespective of the type of application:

> 1. Load-carrying capacity
> 2. Grout/soil friction
> 3. Buckling (compression piles)
> 4. Serviceability

6.1.1 Verification of load-carrying capacity

The analysis requires that the design value of the actions E_d is less than the design value of the resistance of the hollow steel tendon $R_{M,d}$.
The partial safety factor for calculating $R_{M,d}$ according to EC7 and National Technical Approval Z-34.14-209 is □$_M$ = 1.15 ($R_{M,d} = R_{M,k} / \gamma_M$).

Verification: $E_d < R_{M,d}$



Relevant standards:
- National Technical Approval Z-34.14-209 (resistance)
- EC7 (actions)

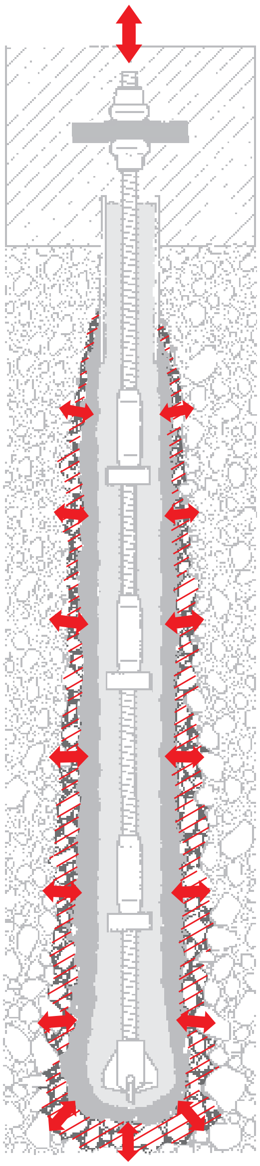
Designation	Unit	TITAN 30/16	TITAN 30/11	TITAN 40/20	TITAN 40/16	TITAN 52/26	TITAN 73/56	TITAN 73/53	TITAN 73/45	TITAN 73/35	TITAN 103/78	TITAN 103/51	TITAN 127/103
Nominal outside diameter Ø	mm	30	30	40	40	52	73	73	73	73	103	103	127
Nominal inside diameter Ø	mm	16	11	20	16	26	56	53	45	35	78	51	103
Characteristic load-carrying capacity $R_{M,k}$ according to German approval document[1)]	kN	155[2)]	225	372	465	620	695[2)]	860	1218	1386	1550	2325	1800[2)]
Yield Point $F_{0.2,k}$ (mean value)	kN	190	260	425	525	730	830	970	1270	1430	1800	2670	2030

[1)] In the case of permanent tension loads and a cement grout cover c < 40 mm, the load-carrying capacities may need to be reduced according to approval Z-34.14-209.

[2)] An approval is not available for these sizes: for TITAN 30/16, 73/56 and 127/103, the values were interpolated in a similar way to the approval.

6.1.2 Verification of grout/soil friction
(at interface between grout body and soil)

- DIN EN 14199
- EC7



Micropiles transfer their loads to the loadbearing soil strata mainly by the means of skin friction. End bearing is normally neglected (with the exception of rock). The pile resistance in the ground (grout/soil friction) is primarily dependent on the surface area $A_{s,i}$ of the grout body and the characteristic skin friction $q_{s,i,k}$ of the insitu soil.

The bonded length lb of the pile required to transfer the loads into the soil is calculated from the diameter of the grout body and the skin friction value $q_{s,i,k,}$ which is reduced by the appropriate partial safety factor for the pile resistance according to Tab. A 2.3 of DIN 1054:2010-12.

Unless the true project-specific skin friction values have been determined by way of load tests on preliminary test piles, the skin friction values used in the calculations should be those given in Tabs. 5.29 and 5.30 of "EA-Pfähle" (recommendations of the "micropiles" working group of the German geotechnical association) for tensile and compressive loads according to DIN 1054:2010-12.

It is important to select the correct drill bit first (see "Technical data" brochure) when determining the grout body diameter D required.
The choice of drill bit depends on:

- the prevailing soil type
- the minimum cement grout cover to the hollow steel tendon stipulated in the standard/approval

Depending on the subsoil and the method of installation, the grout body diameter D will be larger than the drill bit diameter by an amount equal to the widening value a:

$$D = d + a$$

Widening of drilled hole a:
- to DIN SPEC 18539: a_{min} = 20 mm
  (for installation with external jetting)

- Average empirical value supplied by Ischebeck for preliminary design purposes:
  Sandy soils: a ≈ 50 mm
  Gravelly soils: a ≈ 75 mm
  (values measured on excavated grout bodies)

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Verification: $E_d \leq R_d$

Compression:
$R_{c,d} = R_{c,k} / (\square_s \cdot \square_1) = \square \cdot D \cdot l_b \cdot q_{s,k} / (\square_s \times \square_1)$ [kN]

Tension:
$R_{t,d} = R_{t,k} / (\square_{s,t} \cdot \square_1 \cdot \square_M) = \square \cdot D \cdot l_b \cdot q_{s,k} / (\square_{s,t} \cdot \square_1 \cdot \square_M)$ [kN]

where:

- Correlation factor ξ_1
  (depends on the number of load tests planned/performed)

n	1	2	3	4	5
ξ_1	1.35	1.25	1.15	1.05	1.00

- Model factor $\square_M$
  (for tension loads, irrespective of rake of pile according to amendment DIN 1054/A1:2012-08)
  $\square_M = 1.25$

Partial safety factors γ_R for resistances
(extract from DIN 1054:2010-12, Tab. A 2.3)

Resistance	Symbol	Design situation		
		BS-P	BS-T	BS-A
Pile resistances obtained from static and dynamic pile loading tests				
Base resistance	$\square_b$	1.10	1.10	1.10
Shaft resistance (compression)	$\square_s$	1.10	1.10	1.10
Total/combined resistance (compression)	$\square_t$	1.10	1.10	1.10
Shaft resistance (tension)	$\square_{s,t}$	1.15	1.15	1.15
Pile resistances based on empirical values				
Compression piles	$\gamma_b, \gamma_s, \gamma_t$	1.40	1.40	1.40
Tension piles (in exceptional circumstances only)	$\gamma_{s,t}$	1.50	1.50	1.50
Pull-out resistance				
Soil nails or rock bolts	γ_a	1.40	1.30	1.20
Grout bodies of injection piles	γ_a	1.10	1.10	1.10
Flexible reinforcing elements	γ_a	1.40	1.30	1.20

Ranges of empirical skin friction values for pressure-grouted injection piles are specified in “EA-Pfähle”(recommendations of the "micropiles" working group of the German geotechnical association). These can be read off in relation to the results of cone penetration tests (C.P.T.) according to DIN 4094-1. They specify ranges of empirical values for the characteristic skin friction q_{sk} for pressure-grouted injection piles ($D_s < 0.30$ m).

EA-Pfähle Tab. 5.29 in non-cohesive soils

Average end bearing q_c in C.P.T. in MN/m²	Ultimate skin friction $q_{s,k}$ in kN/m² *
7.5	135-175
15	215-280
$\geq$ 25	255-315

EA-Pfähle Tab. 5.30 in cohesive soils

Shear strength $c_{u,k}$ of undrained soil in kN/m²	Ultimate skin friction $q_{s,k}$ in kN/m² *
60	55-65
150	95-105
$\geq$ 250	115-125

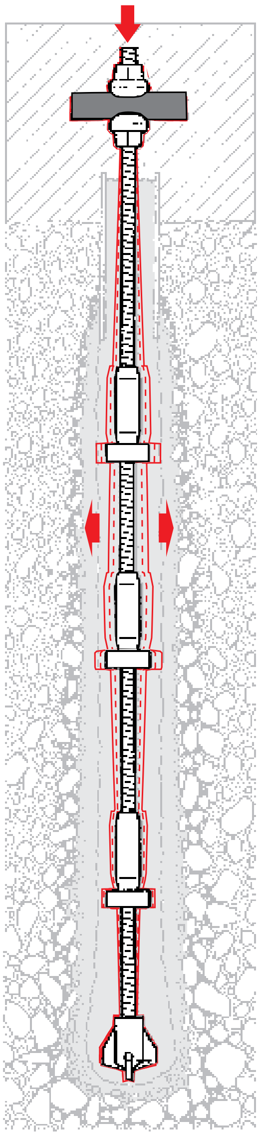
* Intermediate values may be obtained by linear interpolation.

6. Design advice

6.1 Designing a TITAN injection pile as a micropile

6.1.3 Verification of buckling (compression piles)

Relevant standards
- EC7
- DIN EN 14199



According to EC7 and DIN EN 14199, injection piles loaded in compression must be checked for buckling when the undrained shear strength $c_{u,k}$ is < 15 kN/m² in soft cohesive soils.
According to the approvals issued by the DIBt, buckling has to be checked for $c_{u,k}$ < 10 kN/m² without assuming lateral support from the ground (to DIN 18800, see approval) and for 10 kN/m² ≤ $c_{u,k}$ < 30 kN/m² with lateral support. Design methods (in German) can be found in...
- Ofner, R./Wimmer, H.: Bautechnik 84 (2007), No. 12
- Vogt, N./Vogt, S.: “Knicken von Pfählen mit kleinem Durchmesser in breiigen Böden, Fraunhofer IRB Verlag, 2005"

Recommendation R9 of “EAU 2004” (Recommendations of the Committee for Waterfront Structures, Harbours and Waterways) contains the following undrained shear strength values $c_{u,k}$ for cohesive soils that are to be considered as critical:

Silt/clay, soft	$c_{u,k}$ = 5 - 60 kN/m²
Silt/clay, stiff	$c_{u,k}$ = 20-150 kN/m²
Silt/clay, semi-stiff	$c_{u,k}$ = 50-300 kN/m²
Organic silt/clay, very soft	$c_{u,k}$ = 2 < 15 kN/m²
Mud/digestive sludge, very soft	$c_{u,k}$ = < 6 kN/m²

Guidance values for relationships between the consistency and the shear strength of the undrained soil for cohesive soils (“EA-Pfähle” Tab. 3.3):

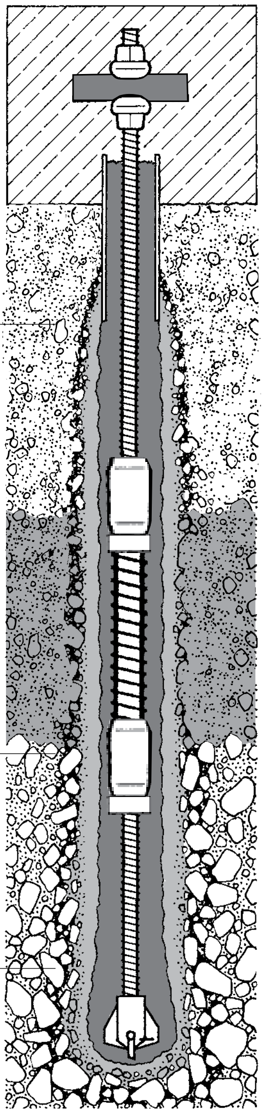
Consistency I_c	Consistency	Shear strength of undrained soil $c_{u,k}$
0.5 ... 0.75	soft	15 ... 50 kN/m²
0.75 ... 1.00	firm	50 ... 100 kN/m²
> 1.00	firm to stiff, stiff	> 100 kN/m²

The undrained shear strength can be calculated from CPT 10 and CPT 15 tests (DIN 4094-1:2002, annex D, D.4).

$$c_u = (q_c - \sigma_{vo}) / \square_k$$

where :
- c_u undrained shear strength
- q_c cone resistance
- σ_{vo} total overburden pressure
- $\square_k$ cone factor

Further details can be found in “EAU” and “EA-Pfähle”.



Combination pile - the solution for subsoils with a risk of buckling

Combination of different sizes

The TITAN system includes the option of creating a combination pile. What this means is that in subsoils with a risk of buckling ($c_{u,k}$ < 30 kN/m²), the hollow steel tendon can be overdesigned. Strengthening the hollow steel tendon in this area increases the bending strength of the pile without the need for additional, expensive constructional measures, e.g. installing a steel casing. The design of the hollow steel tendon is carried out using the design load of the compression pile and the in situ $c_{u,k}$ value according to the acknowledged buckling analyses of Ofner/Wimmer or Vogt or DIN 18800.

The drawing shows an 18 m long TITAN 73/53 compression pile (max. E_d = 748 kN) that is in the form of a 6 m long TITAN 103/78 in the area of the soft clay strata with $c_{u,k}$ = 20 kN/m². The TITAN 103/78 is designed according to the buckling analysis of Ofner/Wimmer.

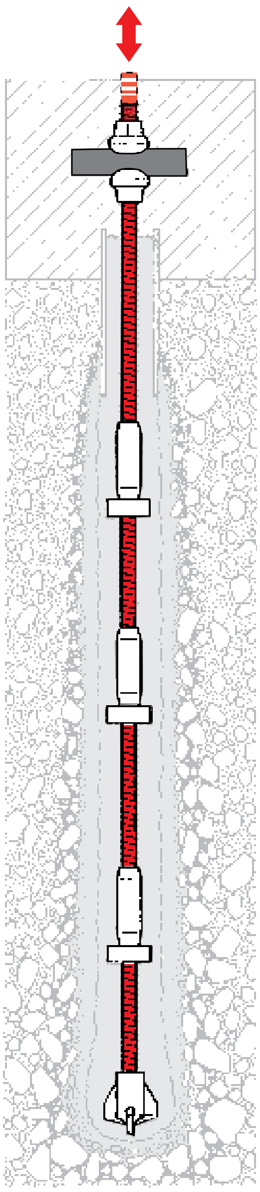
Designation	Unit	TITAN 30/16	TITAN 30/11	TITAN 40/20	TITAN 40/16	TITAN 52/26	TITAN 73/56	TITAN 73/53	TITAN 73/45	TITAN 73/35	TITAN 103/78	TITAN 103/51	TITAN 127/103
Bending stiffness E · I*	10^6 kNmm²	3,7	4,6	15	17	42	125	143	178	195	564	794	1163

*These values were determined in tests. It is not possible to calculate the modulus of elasticity, cross-sectional area or moment of inertia from these figures.

6.1.4 Verification of serviceability

Estimating the total deformation

Relevant standards
- DIN 18800
- EC7



Deformation calculations are complex and are carried out with the help of elaborate computational methods (e.g. DC-Software) or pile test loads. Extensive soil surveys, which could be used as a basis, are often unavailable. Load–deformation diagrams (based on extensive loading tests) make it easier to estimate quickly the displacement at the head of the pile. A simplified design approach enables the remaining displacement of the head of the pile to be estimated.

- The strain stiffnesses of the steel tendon and the grout body are used to determine the remaining deformation because the TITAN injection pile is a composite component.
- Strain stiffness of steel tendon (see technical data)
- Strain stiffness of grout body can be calculated with a modulus of elasticity E_{cement} = 17000 N/mm².

This results in a simplified way of obtaining a total strain stiffness for the injection pile, which is:

$$(EA)_{sum} = (EA)_{steel} + (EA)_{cement}$$

and a deformation/displacement at the head of the pile:

$$\square_{l,sum} = \frac{E_k}{(EA)_{sum}}$$

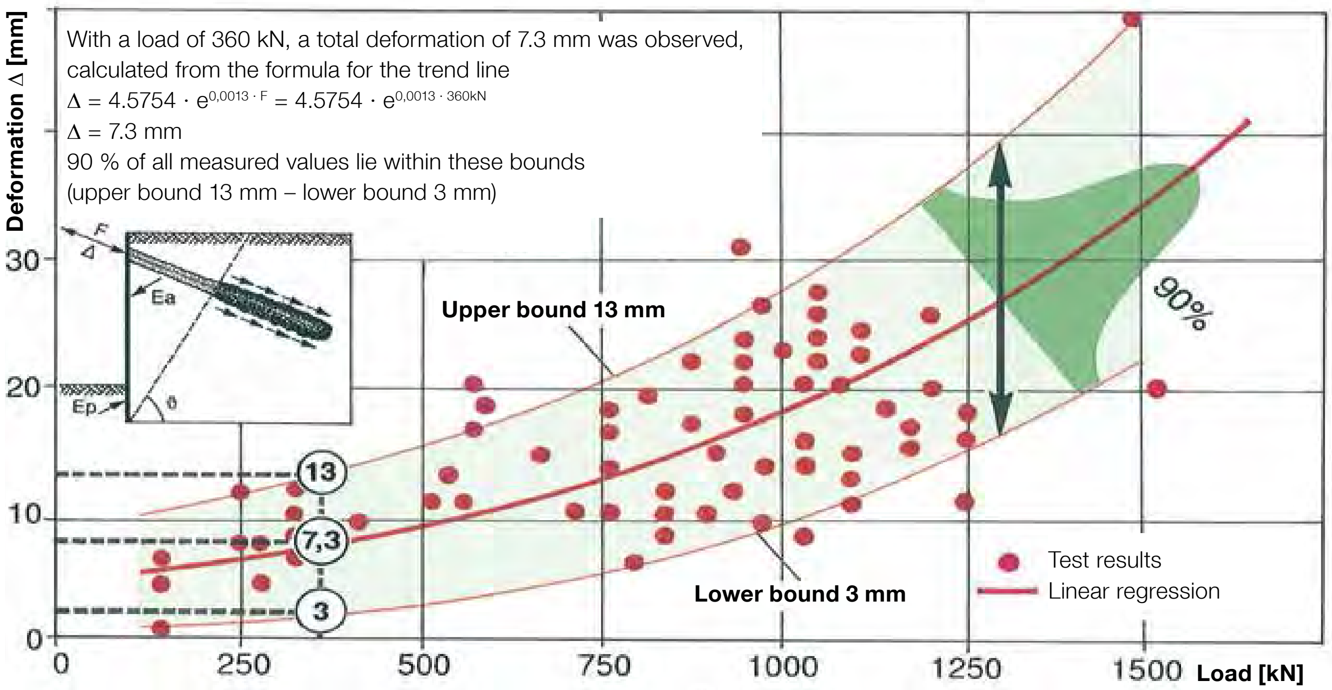
Designation	Unit	TITAN 30/16	TITAN 30/11	TITAN 40/20	TITAN 40/16	TITAN 52/26	TITAN 73/56	TITAN 73/53	TITAN 73/45	TITAN 73/35	TITAN 103/78	TITAN 103/51	TITAN 127/103
Outside diameter D_a *	mm	29	29	40,5	40,5	50,3	72,4	72,4	72,4	72,4	101	101	126,8
Effective cross-sectional area A_{eff}	mm	340	415	730	900	1250	1360	1615	2239	2714	3140	5680	3475
Strain stiffness E · A*	10³ kN	63	83	135	167	231	251	299	414	502	580	1022	640

*See annex 2 of the approval

**These values were determined in tests. It is not possible to calculate the modulus of elasticity, cross-sectional area or moment of inertia from these figures.

Load–deformation diagram

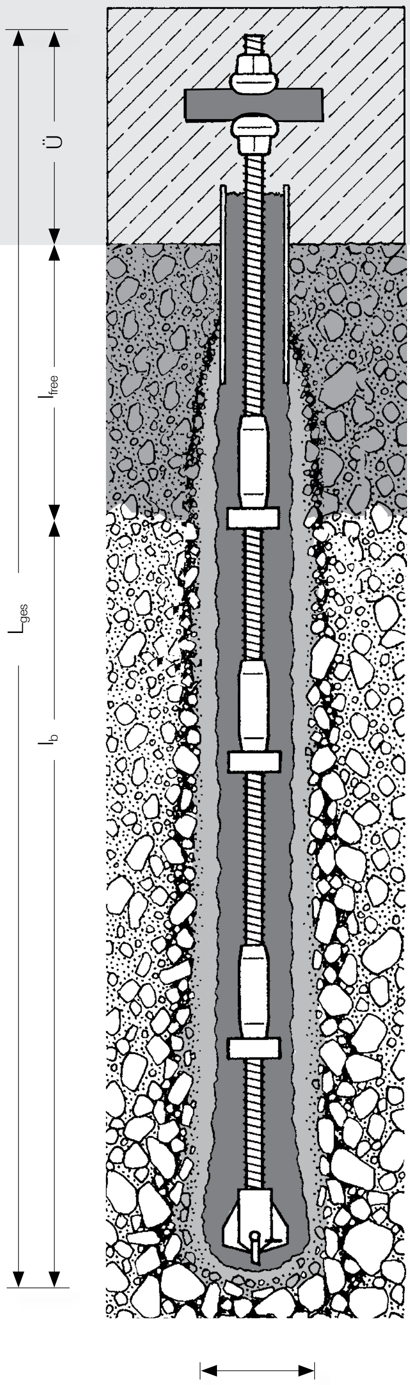
Statistical evaluation of 136 tensile tests carried out for suitability and acceptance purposes. The displacement at the head of the pile was measured (total deformation, measured at head of pile). Bonded length in sandy and gravelly soils, loadbearing subsoil at different depths. Deformation Δ depending on load.



Diploma thesis by A. Scholl: "Entwicklung eines Modells zur Verformungsberechnung von Verpresspfählen (schlaffen Ankern) TITAN nach DIN EN 14199, auf der Grundlage von durchgeführten Eignungs- und Abnahmeversuchen" (development of a model for calculating deformations of TITAN injection piles – non-prestressed anchors – to DIN EN 14199 based on tests carried out for suitability and acceptance purposes), 2008, Siegen University, Prof. Dr.-Ing. R. Herrmann

6. Design advice

6.2 Design examples



6.2.1 Example of pile foundation: compression pile

Design load (compression): $E_d = 712$ kN
Selected: TITAN 73/53 hollow steel tendon

Verification of load-carrying capacity:

$E_d \leq R_{M,d}$
$R_{M,d} = R_{M,k} / \square_M$
$R_{M,d} = 860$ kN / 1.15 = <u>748</u> kN (where $\square_M = 1.15$)
-> Satisfactory

Verification of grout/soil friction:
Calculation of bonded length l_b required using:

Shaft resistance (compression): (to DIN 1054:2010-12 Tab. A.2.3)	γ_s	=	1.10
Given: Loading tests carried out on two piles:	ξ_1	=	1.25
Subsoil: down to 4 m: fill (inadequate loadbearing capacity)	l_{free}	=	4 m
below 4 m depth: gravel/sand (end-bearing pressure)	q_c	=	15 MN/m²
Drill bit: Cross-cut drill bit	d	=	175 mm
Widening value: DIN SPEC 18539: (alternative Ischebeck empirical value:	a a	= =	20 mm 50 mm)
Projection	Ü	=	0.50 m
Skin friction: "EA-Pfähle" (Tab. 5.29)	$q_{s1,k}$	=	215 kN/m²

Must be confirmed by loading tests:
selected: 2 (correlation factor ξ_1, see p. 23)

$$P_P = 712 \text{ kN} \cdot 1.10 \cdot 1.25 = \underline{979} \text{ kN*}$$

*(Larger steel cross-sections may need to be selected for loading tests.)

Bonded length l_b

$$l_b = \frac{E_d}{\pi \cdot (d + a) \cdot \frac{q_{s1,k}}{\gamma_s \cdot \xi_1}} = \frac{712 \text{ kN}}{\pi \cdot (0.175 \text{ m} + 0.02 \text{ m}) \cdot \frac{215 \text{ kN/m}^2}{1.10 \cdot 1.25}} = \underline{7.43} \text{ m}$$

Total length of pile L_{sum}

$L_{sum} = l_b + Ü + l_{free}$

$L_{sum} = 7.43 \text{ m} + 0.50 \text{ m} + 4.0 \text{ m} = \underline{11.93}$ m

Selected: $L_{sum} = 12.00$ m

6.2.2 Example of pile foundation (estimate of pile head displacement)

Steel/grout body displacement only

Pile length:	L_{sum}	= 12.00 m
Action:	E_k	= 500 kN

TITAN 73/53 (S)

Nominal outside diameter:	D_{steel}	= 73 mm
Effective cross-section:	A_{eff}	= 1615 mm²
Strain stiffness:	$(EA)_{steel}$	= 299000 kN

Grout body (Z)

Pile diameter: $D = 180$ mm

Cross-section, grout body

$$A_{cement} = (\pi \cdot (D^2 - D_{steel}{}^2)) / 4$$

$$A_{cement} = (\pi \cdot (180^2\ mm^2 - 73^2\ mm^2)) / 4 = \underline{21262}\ mm^2$$

(The cement within the hollow steel tendon is neglected.)

Modulus of elasticity, grout body

$$E_{cement} = 17000\ N/mm^2 = \underline{17}\ kN/mm^2$$

Strain stiffness, grout body

$$(EA)_{cement} = E_{cement} \cdot A_{cement}$$

$$(EA)_{cement} = 17\ kN/mm^2 \cdot 21262\ mm^2 = \underline{361454}\ kN$$

Total strain stiffness

$$(EA)_{sum} = (EA)_{steel} + (EA)_{cement}$$

$$(EA)_{sum} = 361454\ kN + 299000\ kN = \underline{660454}\ kN$$

Calculation of deformation/displacement at head of pile

$$\varepsilon_{l,sum} = \frac{E_k}{(EA)_{sum}}$$

$$\varepsilon_{l,sum} = \frac{500\ kN}{660454\ kN} = \underline{0.08}\ \%$$

$$f = \varepsilon_{l,sum} \cdot L_{sum}$$

$$f = 0.08\% \cdot 12.00\ m = \underline{9}\ mm$$

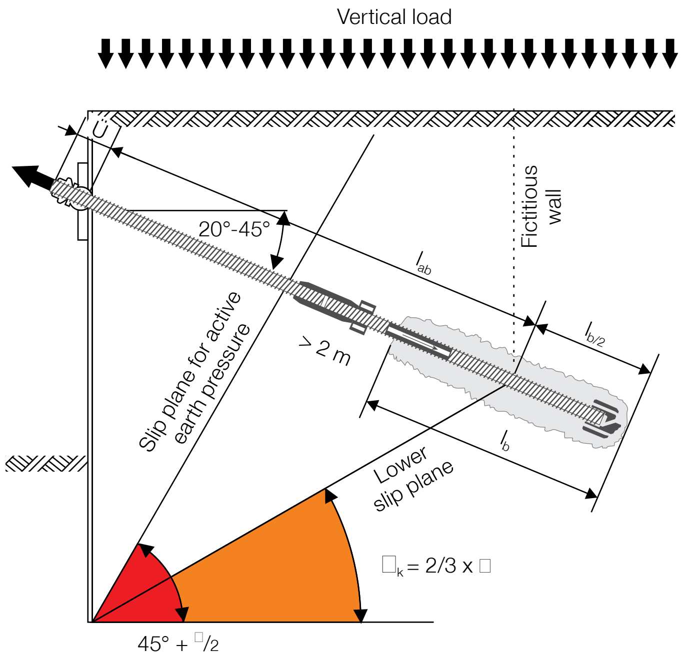
Foundation to noise barrier adjacent to Karlsruhe–Freiburg railway line, south-west Germany

Erection of noise barrier directly adjacent to railway tracks, on separate pad foundations with TITAN 40/16

6.2.3 Example of piled foundation: tension pile

Verification according to “EAU” based on the design model of Kranz, 1940

Design load (tension) $E_d = 400$ kN
Selected: TITAN 40/16 hollow steel tendon



Verification of load-carrying capacity:

$E_d \leq R_{M,d}$
$R_{M,d} = R_{M,k} / \square_M$
$R_{M,d} = 465$ kN / 1,15 = <u>404</u> kN (where $\square_M$ =1,15)
-> Satisfactory

Verification of grout/soil friction:

Calculation of bonded length l_b required using:

Shaft resistance (tension): $\gamma_s = 1.15$
(to DIN 1054:2010-12 Tab. A.2.3)

Model factor $\eta_M = 1.25$

Given:
Load tests carried out on three piles: $\xi_1 = 1.15$

Subsoil: cohesive soil (undrained shear strength) $c_u = 250$ kN/m²

Drill bit: clay bit $d = 150$ mm

Widening value: DIN SPEC 18539: $a = 20$ mm

Skin friction: $q_{s1,k} = 115$ kN/m²
(assumption from “EA-Pfähle”: Tab. 5.30)

Must be confirmed by load tests:
selected: 3 (correlation factor ξ_1, see p. 23)

$$P_P = 400 \text{ kN} \cdot 1.15 \cdot 1.25 \cdot 1.15 = \underline{661} \text{ kN*}$$

* (Larger steel cross-sections may need to be selected for load tests.)

Bonded length l_b

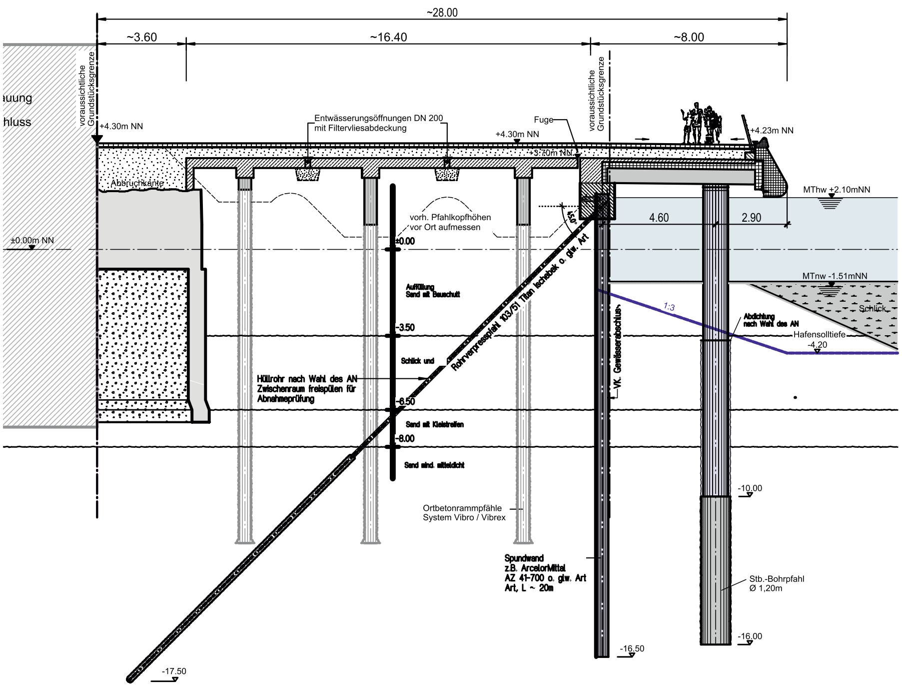
$$l_b = \frac{E_d}{\pi \cdot (d + a) \cdot \frac{q_{s1,k}}{\gamma_s \cdot \xi_1 \cdot \eta_\square}} = \frac{400 \text{ kN}}{\pi \cdot (0.15 \text{ m} + 0.02 \text{ m}) \cdot \frac{115 \text{ kN/m}^2}{1.15 \cdot 1.25 \cdot 1.15}} = \underline{10.77} \text{ m}$$

Total length of pile L_{sum}

Wall-lower slip plane distance: $l_{ab} = 8{,}10$ m

$$L_{sum} = \frac{l_b}{2} + l_{ab} + \ddot{U} = \frac{10.77}{2} + 8.10 \text{ m} + 0.30 \text{ m} = \underline{13.80} \text{ m (selected 14 m)}$$

Rückverankerung der Pieranlage Elbtor
Magdeburger Hafen, Hamburg



6. Design advice

6.3 Verification of durability

Relevant standards:
- According to approval
- DIN EN 14490 – “Soil nailing”, appendix B 3.4.5.1
- DIN 4128
- DIN 1045:1978, section 17.6.2
- DIN 50976
- EN 1537 appendix A

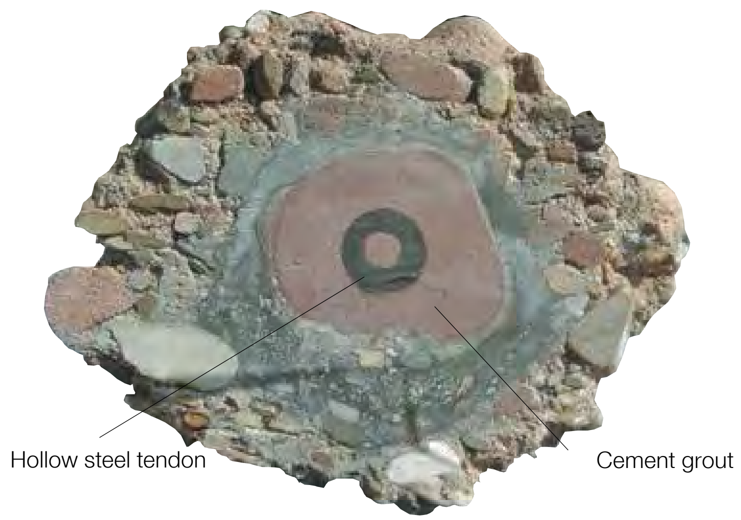
Permanent corrosion protection for TITAN injection piles is guaranteed by:

Cement grout cover
Permanent corrosion protection for TITAN injection piles is achieved with a covering of cement grout. Research findings have shown that the grout body ensures corrosion protection for permanent works, provided the cracks under loading are < 0.1 mm wide (see also DIN EN 14490 “Soil nailing”, appendix B 3.4.5.1). The 1983 edition of DIN 4128 also refers to limiting crack widths: “...DIN 1045:1978 section 17.6.2 must be applied to verify that the expected crack width is limited to ‘very small’” (section 9.2). It was this that led to the cement grout cover called for in the approval, which is in some cases somewhat larger than the minimum cover required by relevant standards:

- min. 20 mm in soils (to DIN 4128 Tab. 1)
- min. 10 mm in rock (to DIN 4128 Tab. 1)
- min. 20 mm for compression piles (to EN 14199)
- min. 30 mm for tension piles (to EN 14199)

Such values can be regarded as standard corrosion protection. A thicker covering of cement grout increases the corrosion protection substantially.

Limiting the width of cracks in the grout body to < 0.1 mm was therefore also a stipulation of the DIBt for issuing the National Technical Approval for TITAN injection piles for temporary and permanent applications **without** additional measures to protect against corrosion. Proof of this has been provided by extensive bond tests with measurement of the crack widths.



The following additional measures can be taken in the case special requirements or more aggressive soils:

Hot-dip galvanising
According to DIN EN 14199 section 7.6 "Corrosion protection of steel elements" and the DIN SPEC 18539 supplements, protecting pressure-grouted injection piles against corrosion is dealt with in the approval. Galvanising is a special precaution that can be provided to protect the hollow steel tendon against corrosion. The coating of zinc applied to the steel withstands severe corrosion and represents a durable, economic form of corrosion protection.

Duplex coating
Hot-dip galvanising to DIN EN ISO 1461 with an additional powder coating (duplex) complying with DIN 55633 (Apr 2009).
This comprises a powder coating for corrosivity category C5-M Medium to DIN EN ISO 12944 part 1 plus corrosion protection according to DIN EN ISO 12944 parts 2 and 5.

Advice for installation: If hollow steel tendons with a duplex coating are used, the clamping and braking device should be fitted with "soft" jaws so that the coating is not damaged.

Stainless steel
TITAN 30/11-INOX and TITAN 40/16-INOX are hollow steel tendons made from stainless steel in accordance with National Technical Approval Z-30.3-6. They comply with the highest class of resistance IV/severe (chlorides, sulphur dioxide, mine water). Even without a covering of cement grout, this grade of steel does not corrode. It is recommended where a consistent cover of cement grout cannot be guaranteed, e.g. when refurbishing old tunnels. A detailed corrosion report prepared by the Federal Institute for Materials Research & Testing (BAM) can be sent on request (ref. No. 1.3/12279).

According to the additional technical contractual conditions (ZTV-W) for sheet pile walls, piles and anchorages, a figure of 1.7 times the calculated theoretical volume of the drilled hole should be used in quotations for work: "Volumes of grout of up to 1.7 times the theoretical void size created upon installing injection piles and pressure-grouted displacement piles will not be remunerated separately. Larger quantities of grout will only be remunerated after prior agreement with the client."

Sample calculation for volume of drilled hole

TITAN 52/26

Clay drill bit	d = 175 mm
Cohesive soil	a = 25 mm (hole widening)
Diameter of drilled hole	D = 17.5 cm + 2 cm = 19.5 cm

Theoretical cross-section of grout body:
$A = \pi \cdot (D/2)^2 = \pi \cdot (9.75\ \text{cm})^2 = \underline{299}\ \text{cm}^2$

Volume of drilled hole per 1 m length of injection pile:
$V = A \cdot 1\ \text{m}$
$V = 299\ \text{cm}^2 \cdot 100\ \text{cm} = 29900\ \text{cm}^3$
V = 29.9 litres

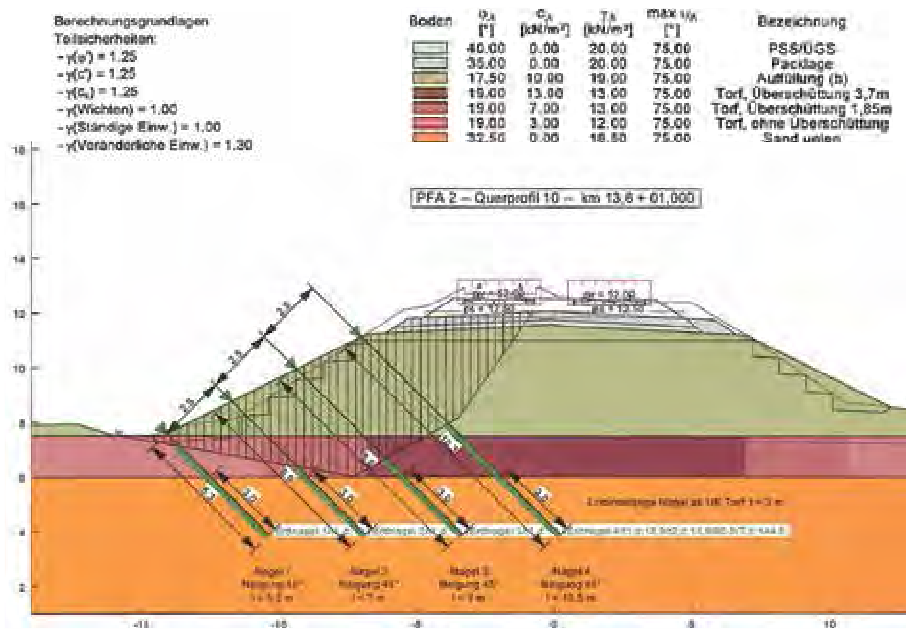
Volume of drilled hole per 1 m length of injection pile:
The table below shows how many litres of cement suspension can be obtained for a certain water/cement (w/c) ratio with a certain number of bags of cement.
Example: w/c = 0.5
= 25 l water / 50 kg cement (corresponds to 41.7 l cement suspension)

ISCHEBECK recommendation for special applications
The use of a ready mixed expanding cement, e.g. CIMEX 15 based on ettringite, is recommended for cohesive soils, e.g. loess, clayey-silty mixed soils. The boundary layer consolidates faster under the expansive pressure.
The use of a ready mixed thixotropic anchor mortar, e.g. WILMIX LAWINA 98, with FLOWCABLE additive, etc. is recommended for drilling overhead.

Volume of drilled hole and volume of cement depending on w/c ratio

Pile dia. D	Volume of drilled hole	w/c ratio 0,4	0,5	0,6	0,7	0,8	0,9	1,0
[mm]	[l/m]	Quantity of cement [kg] per lin. m of grout body						
60	2,8	3,9	3,4	3,0	2,7	2,5	2,3	2,1
90	6,4	8,7	7,6	6,8	6,2	5,6	5,2	4,8
120	11,3	15,4	13,6	12,1	10,9	10,0	9,2	8,5
150	17,7	24,1	21,2	18,9	17,1	15,6	14,3	13,3
180	25,4	34,7	30,5	27,3	24,6	22,5	20,6	19,1
200	31,4	42,8	37,7	33,7	30,4	27,7	25,5	23,6
220	38,0	51,8	45,6	40,7	36,8	33,5	30,8	28,5
250	49,1	66,9	58,9	52,6	47,5	43,3	39,8	36,8
300	70,7	96,4	84,8	75,7	68,4	62,4	57,3	53,0

Böschungsvernagelung Ausbaustrecke JadeWeserPort Wilhelmshaven



7. Appendix

7.1 Proofs and basic tests

Extensive basic tests have been carried out since the system was first developed. The values obtained from the tests are given on the following pages as verification.

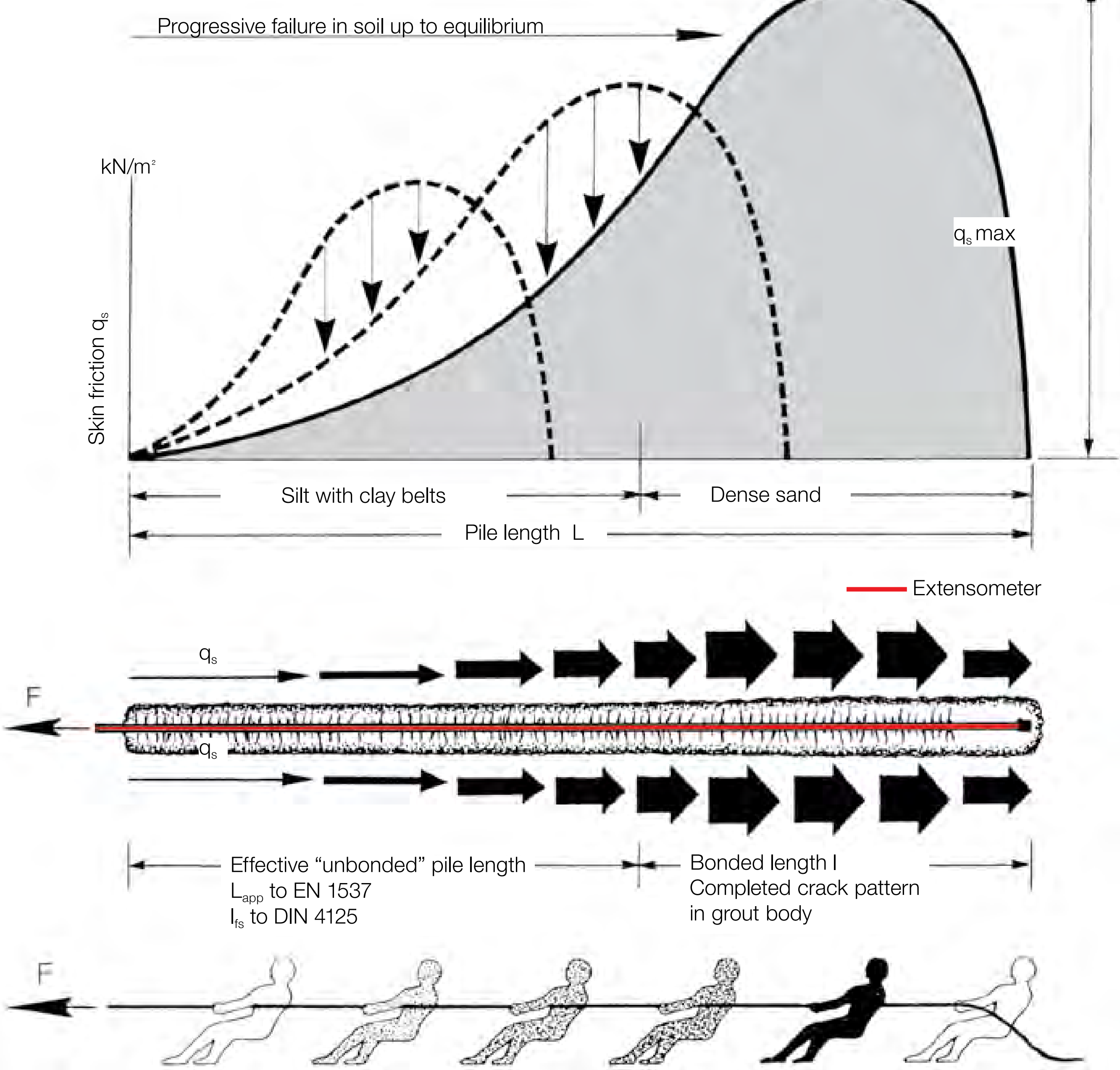
7.1.1 Directional stability

TITAN 103/78 injection pile
Installation at an angle of 20° to the horizontal.
Deviation from intended direction: 66 cm for micropile length of 27 m = 2.4%
According to DIN SPEC 18539:2012-02, an installation tolerance of ±7.5 cm at the point of application of the drill and a deviation of 3° in the angle is permissible (which would correspond to 1.41 m here).

7.1.2 Loadbearing function

The elongation of the steel over the total grouted length has been measured in tests. To do this, an extensometer was embedded within the hollow steel tendon.
The test results prove that subsoil with little or no loadbearing capacity is relieved and therefore an effective "unbonded" pile length is formed. This length, like the unbonded steel length of injection piles to DIN 4125, can be measured and checked in a similar way by means of test loads.

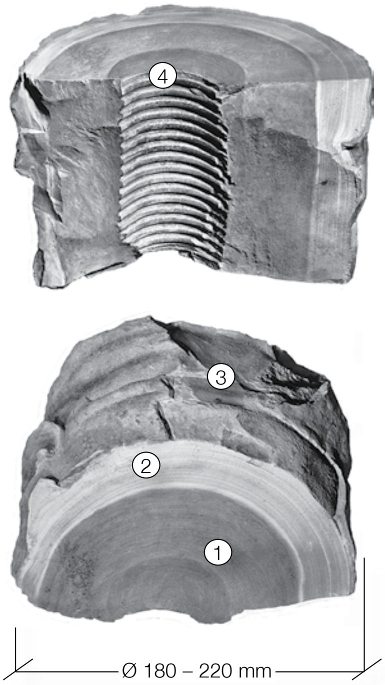
Loadbearing function for injection pile
measured with extensometer



7.1.3 Diameter of grout body

The grout bodies around TITAN injection piles excavated for inspection purposes show quite clearly the good mechanical interlock with the soil, the enlarged diameter compared with that of the drill bit and the consistent covering of cement grout.

Diameter of grout body using the example of the Ericusspitze project, Hamburg: the head of the TITAN 103/78 injection pile was exposed to reveal the widening of the drilled hole in the sandy subsoil when using a Ø175 mm cross-cut drill bit.

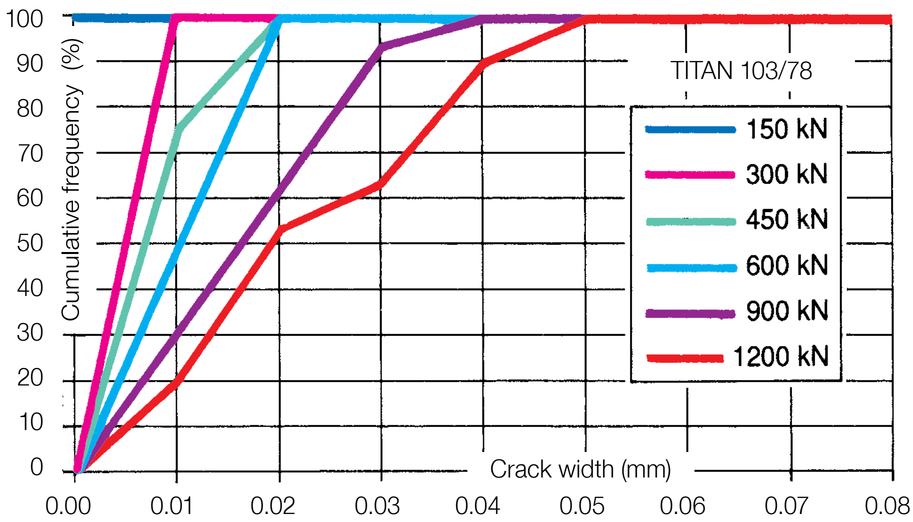


Excavated grout body for TITAN 103/78 pressure-grouted anchor (very fine, loose sand, 40 m below water level, q_c = 15 MN/m²)

① Portland cement, compressive strength $f_{c,k} \geq 35$ N/mm²
② Filter cake of filtered-off cement, supporting ring, lighter and darker rings indicate different w/c ratios
③ Mechanical interlock with the soil to create a shear bond
④ Central position of hollow steel tendon, consistent cement grout cover

7.1.4 How crack widths affect bond behaviour

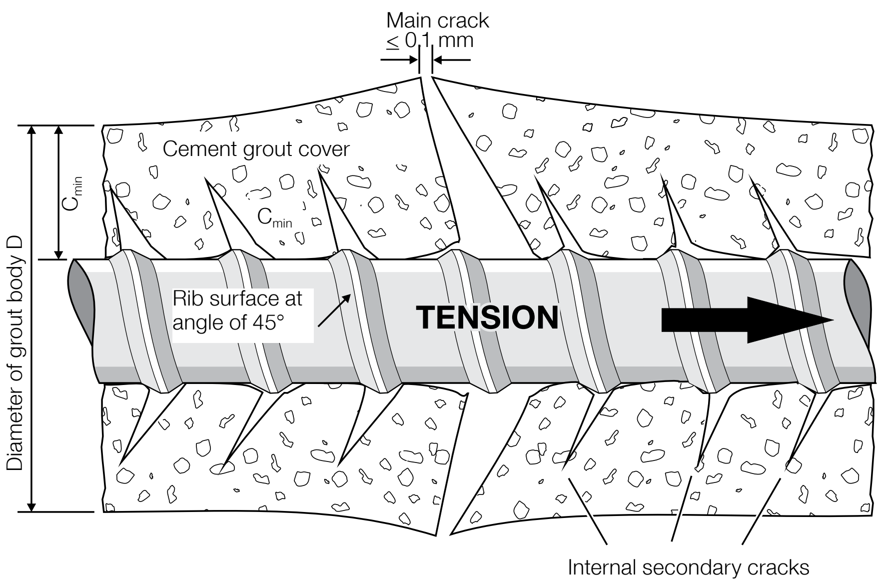
Bond tests with measurement of crack widths on excavated TITAN anchor piles/micropiles, Munich TU, Prof. Dr.-Ing. Zilch, Prof. Dr.-Ing. Schießl



To achieve permanent corrosion protection, it is necessary to limit the crack widths in the grout body to < 0.1 mm (see "Verification of durability", p. 32). Proof of this has been furnished by way of extensive bond tests on TITAN injection piles excavated for inspection purposes, with measurement of crack widths, and by comparative calculations.

The different strains in the steel tendon and the cement are compensated for by microcracks starting at every rib. Radial microcracks < 0.1 mm wide are regarded as insignificant in terms of corrosion and bond. The cracked grout body gives rise to a tension-stiffening effect.

Grout body around TITAN 30/11 injection pile broken away to show completed crack pattern.



7. TENSION

7.1 Proofs and basic tests

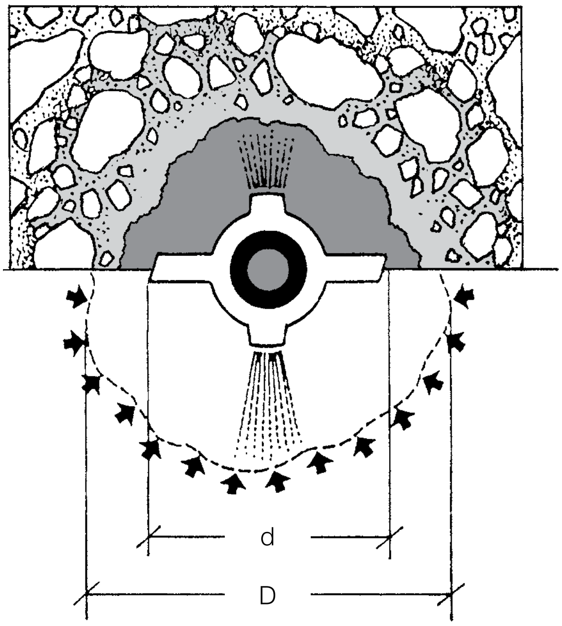
7.1.5 The widening of the drilled hole

The drilling process with radial jets of fluid creates a hole with a larger diameter for the grout body. Based on several test series and the excavation of many TITAN injection piles for inspection purposes, it is possible to assume the following empirical values for the widening of the drilled hole (in cohesive soils):

D = d + a

Widening of drilled hole a:

- to DIN SPEC 18539: a_{min} = 20 mm
  (for installation with external jetting)
- average empirical values supplied by Ischebeck for preliminary design purposes (values measured on excavated grout bodies):
  Sandy soils: a ≈ 50 mm
  Gravelly soils: a ≈ 75 mm



Verification of widening of drilled hole for the grout body in cohesive soils
Site: Casaramona in Barcelona, Spain, approx. 200 TITAN injection piles excavated

	Measured circumference	**Radius of grout body**	**Effective diameter**	**Widening of drilled hole**	**Cement grout cover**
	u	$r = \frac{u}{2 \cdot \pi}$	$d_{eff} = 2 \times r$	**$b = d_{eff} - d_B$ > 25 mm**	$c = \frac{2 \cdot r - d_v}{2}$
	[mm]	[mm]	[mm]	**[-]**	[mm]
TITAN 73/53 injection pile, d_v = 73 mm, 73 mm, cross-cut drill bit, d_B = Ø 130 mm					
Section 1	550.0	87.54	175.07	**45.07**	51.04
Section 2	550.0	87.54	175.07	**45.07**	51.04
Section 3	546.0	86.90	173.80	**43.80**	50.40
Average value	**548.7**	**87.32**	**174.65**	**44.6**	**50.82**
TITAN 40/16 injection pile d_v = 40 mm, clay drill bit, d_B = 110 Ø mm					
Section 4	466.0	74.17	148.33	**38.3**	54.17
Section 5	471.0	74.96	149.92	**39.9**	54.96
Section 6	472.0	75.12	150.24	**40.2**	55.12
Section 7	464.0	73.85	147.70	**37.7**	53.85
Average value	**468.3**	**74.52**	**149.05**	**38.85**	**54.52**

Perimeter beam for Pacific Coast Highway #1, Panamericana, “Devil’s Slide”

Additional anchors for a sheet pile wall, HPA, Port of Hamburg

Drilling underwater

Foundation for a bridge arch using TITAN 40/16 anchor piles
New motorway, Zwardon, Polen

Remainder of embankment stabilised with soil nailing

7.2 Overview of standards

Relevant standards

Verification	Standard
Load-carrying capacity	National Technical Approval Z 34.14-209
Micropiles / injection piles	DIN EN 14199 DIN SPEC 18539
Soil nails	DIN EN 14490 DIN 4084
Geotechnical verification	EC7, comprising: - DIN EN 1997-1:2009-09 - DIN EN 1997-1 / NA:2010-12 - DIN 1054-2010:12 “EA-Pfähle”
Reinforcement (S 460 NH material)	DIN 14199 EN 10210 DIN 488 EC 2
Corrosion protection (cement grout cover)	National Technical Approval Z-34.14-209 DIN EN 14199 DIN EN 14490
Execution of tests	EC7, comprising: - DIN EN 1997-1:2009-09 - DIN EN 1997-1 / NA:2010-12 - DIN 1054:2010:12 DIN EN ISO 22477-1
Testing requirements	DIN EN 14199 DIN EN 14490 DIN EN 1537 / DIN SPEC 18537
Scope of testing (number)	DIN EN 14199 / EC7 DIN EN 14490 DIN EN ISO 22477-1

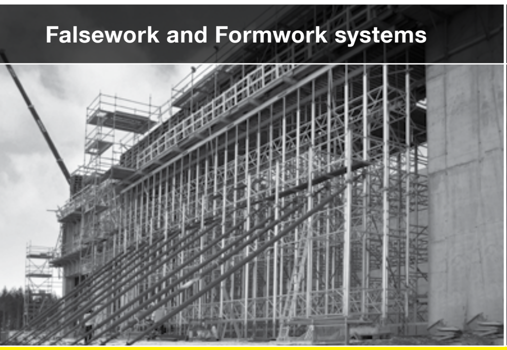
Technical data

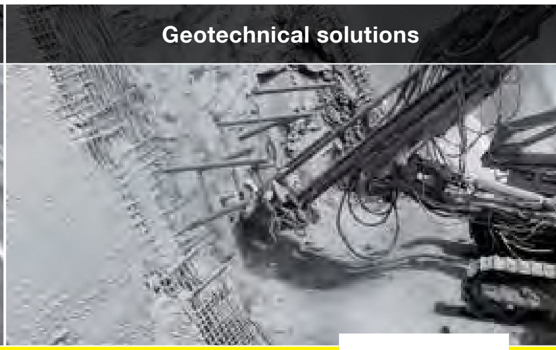
Designation	Unit	TITAN 30/16	TITAN 30/11	TITAN 40/20	TITAN 40/16	TITAN 52/26	TITAN 73/56	TITAN 73/53	TITAN 73/45	TITAN 73/35	TITAN 103/78	TITAN 103/51	TITAN 127/103
Nominal outside diameter D_{steel}	mm	30	30	40	40	52	73	73	73	73	103	103	127
Nominal inside diameter D_{steel}	mm	16	11	20	16	26	56	53	45	35	78	51	103
Effective cross-section A_{eff}	mm²	340	415	730	900	1250	1360	1615	2239	2714	3140	5680	3475
Ultimate load F_u	kN	245	320	540	660	925	1035	1160	1575	1865	2270	3660	2320[4)]
Characteristic load-carrying capacity $R_{M,k}$ according to German approval document[1)]	kN	155[2)]	225	372	465	620	695[2)]	860	1218	1386	1550	2325	1800[2)]
$F_{0.2,k}$ force at 0.2 % proportionality limit (mean value)	kN	190	260	425	525	730	830	970	1270	1430	1800	2670	2030
Strain stiffness E · A[3)]	10^3 kN	63	83	135	167	231	251	299	414	502	580	1022	640
Bending stiffness E · I[3)]	10^6 kNmm²	3.7	4.6	15	17	42	125	143	178	195	564	794	1163
Weight	kg/m	2.7	3.29	5.8	7.17	9.87	10.75	13.3	17.8	21.0	25.3	44.6	28.9
Length	m	3	2/3/4	3/4	2/3/4	3	6.25	3	3	3	3	3	3
Left-/right-hand thread	-	left	left	left	left	left right	right	right	right	right	right	right	right

1) The load-carrying capacities must be reduced according to National Technical Approval Z-34.14-209 in the case of permanent tension loads and cement grout cover c < 40 mm.
2) An approval for these sizes is not yet available. The values were interpolated in a similar way to the approval for TITAN 30/16, 73/56 and 127/103 injection piles.
3) These values were determined in tests. It is not possible to calculate the modulus of elasticity, cross-sectional area or moment of inertia from these figures.
4) Only applies to hollow steel tendon without coupling nut. The ultimate load is 2048 kN for coupled hollow steel tendons.

Slope stabilisation alongside Nuremberg-Regensburg railway line

Some 8000 lin. m of hot-dip galvanised TITAN 30/11 were used on this project.





Certified Management-System to DIN EN ISO 9001 / 2008; Registry-No. DE-96-010

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Vedlegg H

Eksempel mikro stålrørspeler

Boret RD-mikropel

RD® borede peler (RD90–RD320) er spesialpeler installert ved boring i vanskelig jordmonn og miljøforutsetninger. De består av et langsgående eller spiralgående sveiset stålrør og mekaniske skjøter der det behøves.

Pelene kan bores gjennom alle naturlige jordsmonnslag helt inntil grunnfjellet, med små avvikelser i posisjon og helling.

Bruk:

- Kontor- og forretningsbygg
- Industribygninger
- Boliger
- Offentlige bygninger
- Vei- og jernbanestrukturer og broer.

Dimensjoner

Mål og egenskaper for RD- og RDs-peler, skjøtet ved gjenget hylseskjøt eller sveising

Standard stålkvalitet til RD90–RD320 peler er S440J2H. Stålkvaliteten til RDs90–RDs220 er S550J2H. RD270–RD320-peler kan også være av S550J2H stål.

Pel	D(mm)	t (mm)	M (kg/m)	A (mm^2)	A_u(mm^2)	A_b(mm^2)	W_{el}(cm^3)	EI (kNm^2)	$A_{1.2}$(mm^2)	$EI_{1.2}$(kNm^2)	$A_{2.0}$(mm^2)	$EI_{2.0}$(kNm^2)
RD/RDs90	88.9	6.3	12.8	1635	0.28	6207	31.6	295	1304	228	1089	186
RD/RDs115/6.3	114.3	6.3	16.8	2138	0.36	10261	54.7	657	1711	514	1432	423
RD/RDs115/8	114.3	8	21	2672	0.36	10261	66.4	797	2245	654	1966	563
RD/RDs140/8	139.7	8	26	3310	0.44	15328	103.1	1513	2788	1250	2445	1082
RD/RDs140/10	139.7	10	32	4075	0.44	15328	123.4	1810	3553	1547	3210	1379
RD/RDs170/10	168.3	10	39	4973	0.53	22246	185.9	3284	4343	2823	3928	2526
RD/RDs170/12.5	168.3	12.5	48	6118	0.53	22246	222	3924	5488	3462	5073	3165
RD/RDs220/10	219.1	10	51.6	6569	0.69	37703	328.5	7557	5748	6533	5205	5869
RD/RDs220/12.5	219.1	12.5	63.7	8113	0.69	37703	396.6	9124	7292	8100	6749	7436

Dimensjoner og egenskaper for RD- og RDs-peler, skjøtet sveising på stedet

Pel	D(mm)	t (mm)	M (kg/m)	A (mm^2)	A_u(mm^2)	A_b(mm^2)	W_{el}(cm^3)	E_I (kNm^2)	$A_{1.2}$(mm^2)	$EI_{1.2}$(kNm^2)	$A_{2.0}$(mm^2)	$EI_{2.0}$(kNm^2)
RD270/10	273	10	64.9	8262	0.86	58535	524	15024	7238	13037	6560	11741
RD270/12.5	273	12.5	80.3	10230	0.86	58535	637.2	18265	9205	16278	8527	14982
RD320/10	323.9	10	77.4	9861	1.02	82397	751	25533	8645	22207	7839	20031
RD320/12.5	323.9	12.5	96	12229	1.02	82397	916.7	31178	11012	27852	10206	25676

A = Stål tverrsnittsareal

A_u = Utvendig overflateareal

A_b = Totalt tverrsnittsareal

W_{el} = Motstandsmoment

E_I = Bøyestivhet

Tverrsnittverdier redusert med hensyn til korrosjon

$A_{1,2}$ = tverrsnittsområde etter 1.2 mm fradrag for korrosjon

Oppbygging

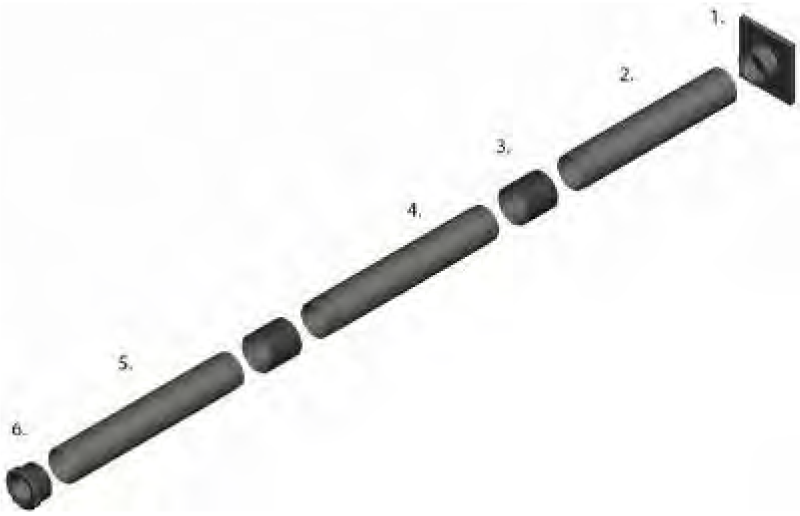
Oppbyggingen til en RD-pel

Oppbyggingen til en RD-pel vises i figuren. En RD-pel består av:

1. En bæreplate installert i den øverste enden av pelen, om nødvendig
2. Enderør (den ene enden er gjenget)
3. En utvendig gjenget hylse
4. Forlengelseserør (begge ender er gjenget)
5. Startrør (den ene enden er gjenget)
6. En ringborkrone og eventuelt en bor-sko i den nederste enden av pelen

RD90–RD320-peler bygger på langssømsveisede rør.

RD-peler leveres enten som pelerør (RD90–RD320) eller RD peleelementer med gjengede ender (RD90–RD220 og RDs90–RDs220).



Tilbehør

RD-peler skjøtes enten med en utvendig gjenget hylse (RD90–RD220 og RDs90–RDs220) eller ved sveising.

Skjøting med en gjenget hylse

Gjengede hylser vises i bildet. Fordelene med en gjenget hylse er:

- Enkel og rask skjøting
- Høy utmattingsstyrke
- Høykvalitets sluttresultat selv under vanskelige installasjonsbetingelser

Ruukkis gjengede hylser imøtekommer styrke- og stivhetskravene i EN 1993-5, finsk nasjonalt vedlegg for mekaniske skjøter. Strekkfastheten til en skjøt garanteres å være 50 % av pelens trykkstyrke.

De utvendige diametrene for gjengede hylser for RD og RDs og anbefalte typer og dimensjoner av ringborkroner

	SKJØTEHYLSE						
RD-pel	**D (mm)**	**RDs-pel**	**D(mm)**	**Atlas Copco Rotex**	**Utvendig diameter på ringborkrone (mm)**	**Robit Rocktools**	**Utvendig diameter på ringborkrone (mm)**
RD90	101.6	RDs90	101.6	Symmetrisk P89/8-RD	107	ROX+ RD90/8	105
RD115/6.3	127.0	RDs115/6,3	127.0	Symmetrisk P114/8-RD	132	DTH-ROX+ RD115/10	134
RD115/8	127.0	RDs115/8	127.0	Symmetrisk P114/8-RD	132	DTH-ROX+ RD115/10	134
RD140/8	152.4	RDs140/8	152.4	Symmetrisk P140/8-RD	158	DTH-ROX+ RD140/10	160

RD-pel	D (mm)	RDs-pel	D(mm)	Atlas Copco Rotex	Utvendig diameter på ringborkrone (mm)	Robit Rocktools	Utvendig diameter på ringborkrone (mm)
	SKJØTEHYLSE						
RD140/10	152.4	RDs140/10	152.4	Symmetrisk P140/10-RD	158	DTH-ROX+ RD140/10	160
RD170/10	181.9	RDs170/10	181.9	Symmetrisk P168/12.5-RD	188	DTH-ROX+ RD170/12.5	188
RD170/12.5	181.9	RDs170/12,5	181.9	Symmetrisk P168/12.5-RD	188	DTH-ROX+ RD170/12.5	188
RD220/10	229.0	RDs220/10	234.9	Symmetrisk P219/10-RD	239	DTH-ROX+ RD220/12.5	240
RD220/12.5	234.9	RDs220/12.5	234.9	Symmetrisk P219/12.5-RD	239	DTH-ROX+ RD220/12.5	240

Styrken til gjengede skjøtehylser og en anbefalt strammedreiningsmoment

Pel	Strekkfasthet (kN)	Pel	Strekkfasthet (kN)	Trykkstyrke	Bøyestyrke	Bøyestivhet EI (0.3–0.8 M)	Anbefalt strammedreiemoment (kNm)
RD90	360	RDs90	450	*)	*)	*)	1.0
RD 115/6.3	470	RDs115/6.3	590				1.0
RD 115/8	590	RDs115/8	750				1.0
RD 140/8	730	RDs140/8	910				1.0
RD 140/10	900	RDs140/10	1120				1.0
RD 170/10	1100	RDs170/10	1370				1.0
RD170/12.5	1350	RDs170/12.5	1680				1.0
RD220/10	1450	RDs220/10	1810				3.0
RD220/12.5	1790	RDs220/12.5	2230				3.0

*) Tilfredsstiller styrke- og stivhetskravene i EN 1993-5, finsk nasjonalt vedlegg for mekaniske skjøter.

Skjøting ved sveising

Når peler skal skjøtes ved sveising leveres de med endene faset for sveising som bestilt, vanligvis i en vinkel på 30 grader. Det kan legges inn et spor i sveisefasen som fungerer som en støtte for mekanisert sveising. Fordetaljer om sveising og inspeksjon, se .

Bæreplater

En bæreplate installeres vanligvis på toppen av en RD-pel for å overføre last fra den øvre strukturen til pelen. Standarddimensjonene til bæreplatene er å finne i tabellen.

Kapasiteter og mål for standard bæreplater

Pel	Bæreplatedimensjon (mm x mm x mm)	Forslått pelelast (kN)
RD90	150 x 150 x 15	350
RD115/6.3	200 x 200 x 20	600
RD115/8	250 x 250 x 25	700

Pel	Bæreplatedimensjon (mm x mm x mm)	Forslått pelelast (kN)
RD140/8 og RD140/10	250 x 250 x 25	950
RD170/10 og RD170/12.5	300 x 300 x 30	1400
RD220/10	300 x 300 x 30	1620
RD220/12.5	300 x 300 x 30	1620
Rd270/10	350 x 350 x 30 *	2100
RD270/12.5	350 x 350 x 30 *	2100
RD320/10	400 x 400 x 30 *	2700
RD320/12.5	400 x 400 x 30 *	2700

*) Ikke på lager

Egenskaper

Kjemisk sammensetning, maks.

Stålkvalitet	C (%)	Mn (%)	P (%)	S (%)	CEV(%)
S355J2H	0.22	1.60	0.030	0.030	0.39
S440J2H	0.16	1.60	0.020	0.018	0.39
S550J2H	0.12	1.90	0.020	0.015	0.43

Stålkvalitet	fy min(MPa)	fu (MPa)	A5 min (%)	T (°C)	KV min (J)
S355J2H	355	470-630		-40	27
S440J2H	440	490-630	17	-40[1)]	27
S550J2H	550	605-760	14	-20[1)]	27

1) Krav til slagseghet må avtales separat ved materialtykkelser over 10 mm.

Vedlegg I

Eksempel grove stålrørspeler

Boret RD-pel med stor diameter

RD® drilled piles (RD400–RD800) er spesialpeler installert ved boring i vanskelig jordsmonn og miljøforutsetninger. De består av et langsgående eller spiralgående sveiset stålrør og mekaniske skjøter der det behøves.

Pelene kan bores gjennom alle naturlige jordsmonnslag helt inntil grunnfjellet, med små avvikelser i posisjon og helling.

Bruk:

- Kontor- og forretningsbygg
- Industribygninger
- Boliger
- Offentlige bygninger
- Vei- og jernbanestrukturer og broer.

Dimensjoner

Dimensjoner og seksjonsegenskaper for RD- og RDS-peler, skjøtet sveising på stedet

Pel	D(mm)	t (mm)	M (kg/m)	A (mm^2)	A_u(mm^2)	A_b(mm^2)	W_{el}(cm^3)	E_I (kNm^2)	$A_{1.2}$(mm^2)	$EI_{1.2}$(kNm^2)	$A_{2.0}$(mm^2)	$EI_{2.0}$(kNm^2)
RD400/10	406.4	10	97.8	12453	1.28	129717	1204.5	51399	10926	44816	9912	40491
RD400/12.5	406.4	12.5	121.4	15468	1.28	129717	1477.9	63064	13941	56481	12928	52156
RD500/12.5	508	12.5	152.7	19458	1.6	202683	2352.6	125486	17548	112605	16279	104118
RD500/14.2	508	14.2	172.9	22029	1.6	202683	2645.6	141117	20118	128236	18849	119749
RD600/12.5	610	12.5	184.2	23464	1.92	292247	3434.6	219985	21169	197655	19644	182915
RD600/14.2	610	14.2	208.6	26579	1.92	292247	3869.0	247808	24284	225478	22759	210738
RD600/14.2	610	14.2	208.6	26579	1.92	292247	3869.0	247808	24284	225478	22759	210738
RD600/16	610	16	234.4	29858	1.92	292247	4320.7	276741	27563	254411	26038	239671
RD700/12.5	711	12.5	215.3	27430	2.23	397035	4707.3	351421	24754	316032	22975	292638
RD700/14.2	711	14.2	244.0	31085	2.23	397035	5309.0	396344	28409	360955	26630	337561
RD700/16	711	16	274.2	34935	2.23	397035	5936.4	443184	32259	407795	30480	384401
RD800/12.5	813	12.5	246.8	31436	2.55	519124	6195.8	528907	28375	475964	26340	440929
RD800/14.2	813	14.2	79.7	35635	2.55	519124	6994.2	597061	32575	544118	30539	509083
RD800/16	813	16	314.5	40062	2.55	519124	7828.3	668266	37001	615323	34966	580288

A = Stål tverrsnittsområde

A_u = Utvendig overflateområde

A_u = Pelbaseområde

W_{el} = Seksjon/modulus

E_I = Bøyestivhet

Tverrsnittverdier redusert med hensyn til korrosjon

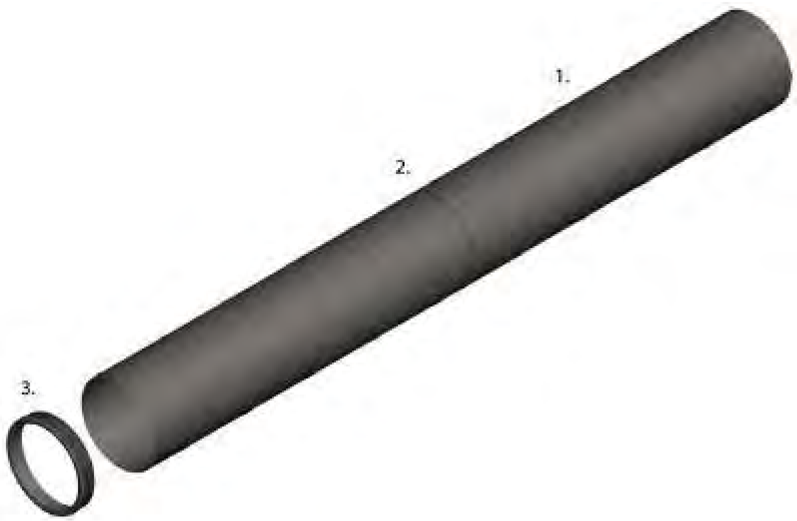
$A_{1,2}$ = tverrsnittsområde etter 1.2 mm fradrag for korrosjon

Struktur

Strukturen til en RD-pel, RD400-RD800

RD400–RD800 peler bygger på spiralsveisede rør.

1. Spiralsveiset pelerør
2. Sveiset skjøt
3. Foringshus /ringborekrone.



Skjøting ved sveising

Når peler skal skjøtes ved sveising leveres de med endene faset for sveising som bestilt, vanligvis i en vinkel på 30 grader.

Det kan legges inn et spor i sveisefasen som fungerer som en støtte for mekanisert sveising. For detaljer angående sveising og inspeksjon, se Skjøting av stålrørspeler ved sveising (PDF).

Egenskaper

Standard stålkvaliteten til RD400–RD800-peler er S355J2H. Kvalitetene X60 og X70, S440J2H og S550J2H er også tilgjengelige.

Kjemisk sammensetning, maks.

Stålkvalitet	C (%)	Mn (%)	P (%)	S (%)	CEV(%)
S355J2H	0.22	1.60	0.030	0.030	0.39
S440J2H	0.16	1.60	0.020	0.018	0.39
S550J2H	0.12	1.90	0.020	0.015	0.43
X60	0.19	1.75 [1)]	0.030	0.030	0.43
X70	0.19	2.00 [1)]	0.030	0.030	0.43

1) Innholdet av Mn kan økes når innholdet av C minskes.

Mekaniske egenskaper

Stålkvalitet	fy min(MPa)	fu (MPa)	A5 min (%)	T (°C)	KV min (J)
S355J2H	355	470-630	20	-40	27
S440J2H	440	490-630	17	-40[2)]	27
S550J2H	550	605-760	14	-20[2)]	27
X60[3)]	415	≥520	18	0	27
X70[3)]	485	≥570	19	0	27

Vedlegg J

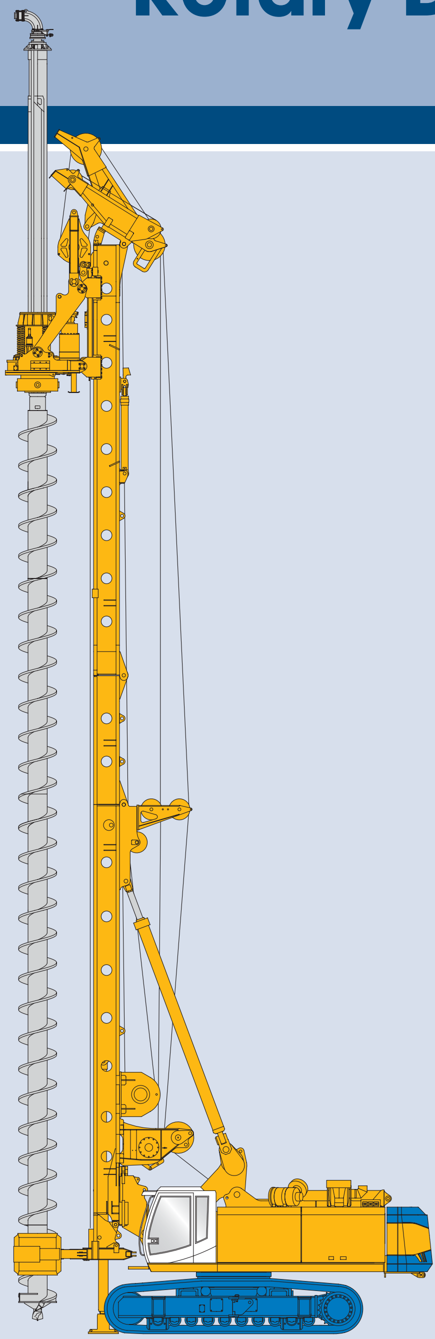
Eksempel borede pillarer

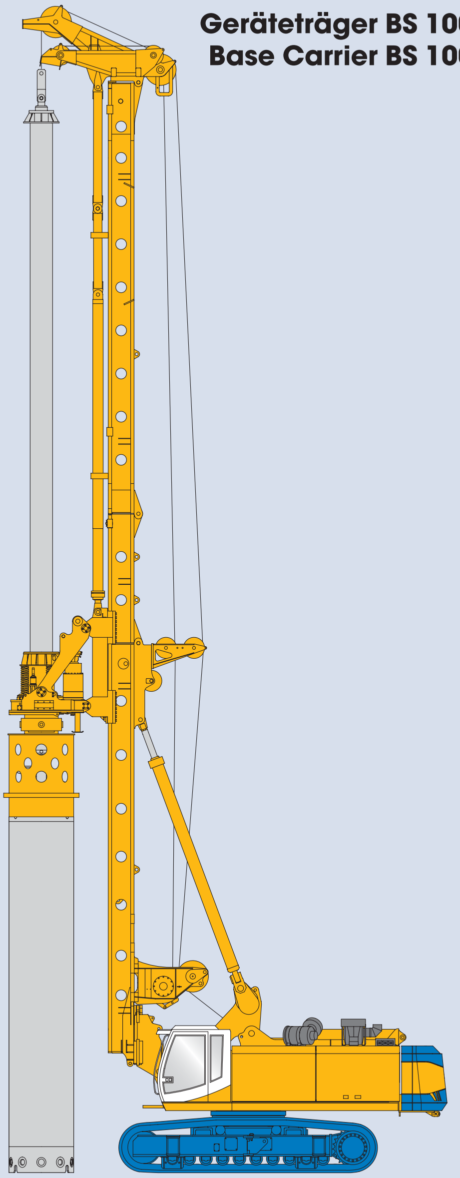
BG 40

Großdrehbohrgerät
Rotary Drilling Rig

6/2009

Geräteträger BS 100
Base Carrier BS 100





BAUER

Abmessungen — Dimensions

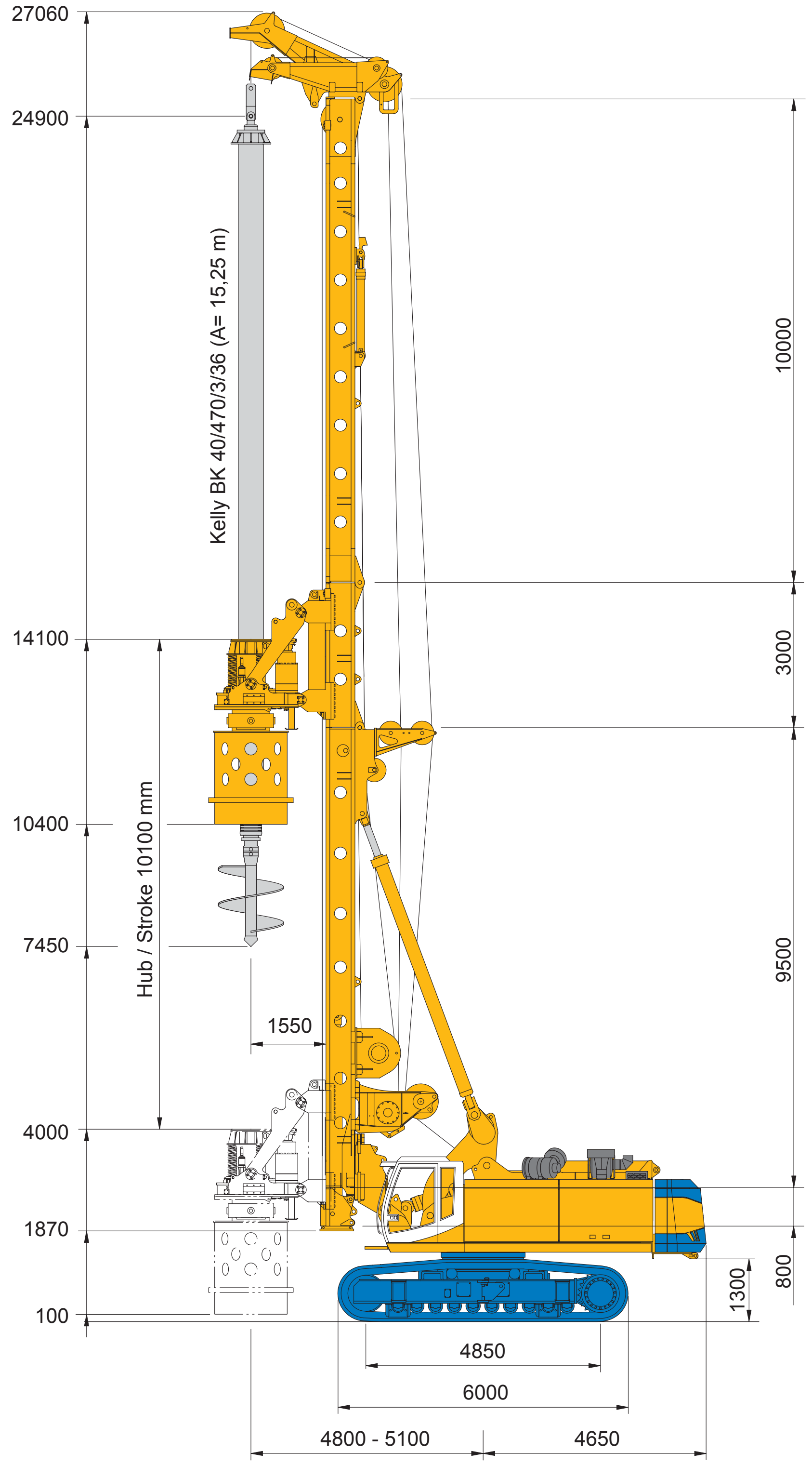
Windenvorschub — Crowd winch type

Die **BG 40,** ein Gerät mit einem Einsatzgewicht von ca. 140 to dient zur Herstellung von

- verrohrten Bohrungen (Eindrehen des Bohrrohres mit dem Drehgetriebe oder mit angebauter Verrohrungsmaschine)
- unverrohrten, flüssigkeitsgestützten Bohrungen
- Bohrungen mit langer Hohlschnecke (SOB) - mit oder ohne Kellyverlängerung
- Sonderverfahren wie VdW-Bohren, Doppelkopfbohren (“verrohrtes SOB-Bohren”), Verdrängerbohrungen, Soil-Mixing Verfahren (CSM und SMW)

The **BG 40** rotary drilling rig has an operating weight of approx. 140 to. It is ideally suited for:

- Drilling cased boreholes (installation of casing by rotary drive or optionally by hydraulic oscillator – both are powered by the drilling rig)
- Drilling uncased deep boreholes that are stabilised by drilling fluid
- Drilling boreholes with long hollow stem augers (CFA system), with or without kelly extensions
- Special drilling systems, such as FOW piles, double rotary head drilling (“cased CFA system”), displacement piles, soil mixing system (CSM and SMW)



Bohrverfahren mit Serienausstattung:

Kellybohren (ohne Verrohrungsmaschine)

SOB-Verfahren (hydraulisch und elektrisch vorgerüstet)

FDP Verdrängerbohren (hydraulisch und elektrisch vorgerüstet)

Drilling processes with standard equipment:

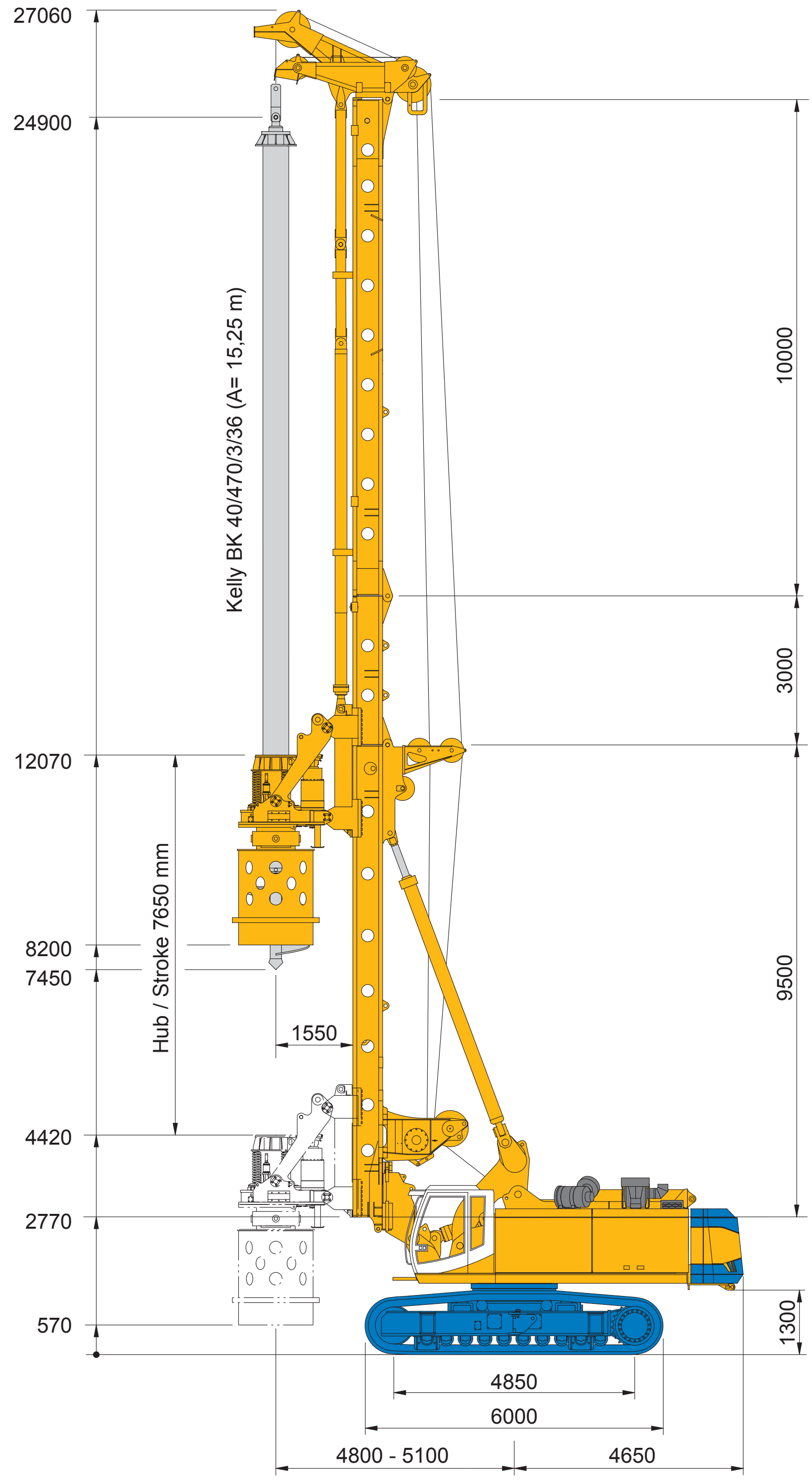
Kelly drilling (without casing oscillator)

CFA drilling (pre-equipped with hydraulic and electric installations)

FDP Full-Displacement-Piling (pre-equipped with hydraulic and electric installations)

Abmessungen Dimensions

Zylindervorschub Crowd cylinder type



Bohrverfahren mit Serienausstattung:

Kellybohren (ohne Verrohrungsmaschine)

SOB-Verfahren (hydraulisch und elektrisch vorgerüstet)

FDP Verdrängerbohren (hydraulisch und elektrisch vorgerüstet)

Drilling processes with standard equipment:

Kelly drilling (without casing oscillator)

CFA drilling (pre-equipped with hydraulic and electric installations)

FDP Full-Displacement-Piling (pre-equipped with hydraulic and electric installations)

Technische Daten — Technical specifications

		Windenvorschub Crowd winch	Zylindervorschub Crowd cylinder
Gesamthöhe	**Overall height**	27.060 mm	27.060 mm
Einsatzgewicht ca. (mit Kelly BK 40/470/3/36)	**Operating weight** (approx.) (with kelly BK 40/470/3/36)	140.000 kg	139.000 kg
Drehantrieb	**Rotary drive**	**KDK 390 S**	**KDK 390 S**
Drehmoment (nominal) bei 300 bar	Torque (nominal) at 300 bar	390 kNm	390 kNm
Drehzahl (max.)	Speed of rotation (max.)	62 U/min (RPM)	62 U/min (RPM)
Vorschubsystem	**Crowd system**		
Druckkraft / Zugkraft (effektiv)	Crowd pressure / pull (effective)	460 / 460 kN	270 / 400 kN
Druckkraft / Zugkraft gemessen am Drehteller KDK	Crowd pressure / pull measured at the casing drive adapter on the rotary drive	440 / 375 kN	355 / 315 kN
Hub (Kellysystem)	Stroke (kelly system)	10.100 mm	7.650 mm
Hub (SOB-System)	Stroke (CFA system)	19.700 mm	19.350 mm
Geschwindigkeit (ab/auf)	Speed (down/up)	6,0 / 6,0 m/min	3,5 / 7,0 m/min
Schnellgang (ab/auf)	Fast speed (down/up)	21 / 21 m/min	18 / 18 m/min
Hauptwinde Windenklasse	**Main winch** winch classification	M6 / L3 / T5	M6 / L3 / T5
Zugkraft (1. Lage) effektiv/nominal	Line pull (1st layer) effective/nominal	300 / 384 kN	300 / 384 kN
Seildurchmesser / Länge	Rope diameter / Length	36 mm / 90 m	36 mm / 90 m
Windengeschwindigkeit (max.)	Line speed max.	60 m/min	60 m/min
Hilfswinde Windenklasse	**Auxiliary winch** winch classification	M6 / L3 / T5	M6 / L3 / T5
Zugkraft (1. Lage) effektiv/nominal	Line pull (1st layer) effective/nominal	130 / 162 kN	130 / 162 kN
Seildurchmesser / Länge	Rope diameter / Length	22 mm / 60 m	22 mm / 60 m
Windengeschwindigkeit (max.)	Line speed (max.)	55 m/min	55 m/min
Mastneigung	**Mast inclination**		
nach hinten / vorne	Backward / forward	15° / 5°	15° / 5°
quer	Lateral	Bohrbetrieb 3° Hilfswindenbetrieb 5°	Drilling mode 3° Aux. winch mode 5°

Serienausstattung

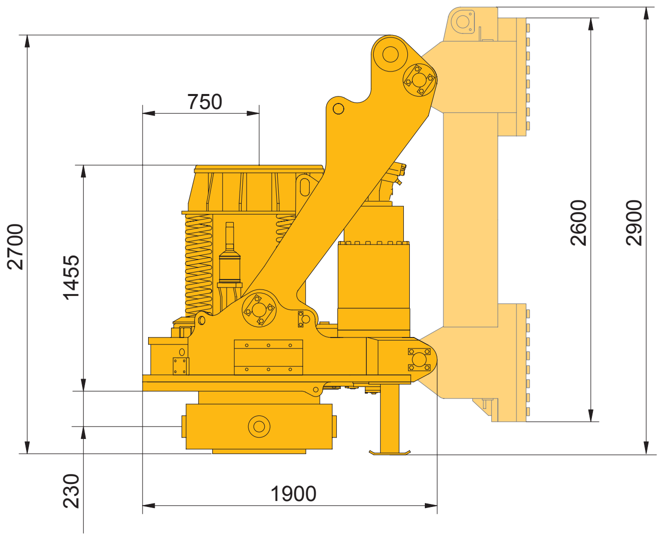
- Drehgetriebe KDK 390 S (Schaltgetriebe)
- Hauptwinde mit hydraulischer Freilaufsteuerung
- Haupt- und Hilfswinde mit Spezialrillung
- Hubendschalter für Haupt- und Hilfswinde
- Wirbel für Hauptseil
- Vorschub schnell / langsam
- Schwenkbarer Anschlagpunkt für Haupt- und Hilfsseil
- Transportstützen für Mastoberteil und Mastunterteil

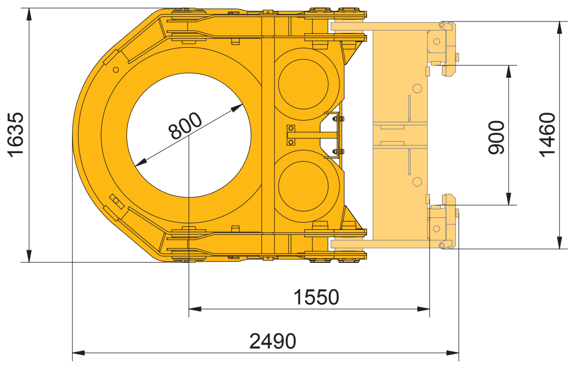
Mess- und Steuerungstechnik
- SPS Rechner für alle elektrisch angesteuerten Funktionen
- B-TRONIC 3.1:
  elektronisches Steuerungs-, Kontroll- und Visualisierungssystem
- Anzeige von Fehlermeldungen in Klartext
- Schockiereinrichtung für KDK
- Notsteuerung Bohrgerät (Kernfunktionen)
- Mastneigungsmessung in x/y Richtung (Anzeige digital/ analog)
- Mastautomatik (automatische Vertikalstellung)
- Hauptwinde mit elektronischer Seilkraftmessung
- Hilfswinde mit hydraulischer Seilkraftmessung
- Tiefenmessung Hauptwinde
- Tiefenmessung Vorschub (bei Windenvorschub)
- Funktion „Wirbel aufstellen“ Hauptwinde
- Drehzahlmessung KDK
- Schlappseilabschaltung Hauptwinde
- Anpresskraft-Einstellung
- Abbohrassistent Kelly
- Ziehsteuerung

Standard equipment

- Rotary drive KDK 390 S (multi gear drive)
- Main winch with hydraulically operated freewheeling
- Main and auxiliary winch with special grooving
- Hoist limit switch on main and auxiliary winches
- Swivel for main rope
- Crowd in fast or slow mode
- Pivoted anchor points for main and auxiliary ropes
- Transport supports for upper and lower mast sections

Measuring and control equipment
- PLC processor for all electrically actuated functions
- B-TRONIC 3.1:
  Electronic monitoring -, control -, and visualization system
- Display of fault messages as plain text
- Uni-directional impact function on KDK (for auger discharge)
- Emergency mode of operation for drilling rig (core functions)
- Mast inclination measurement on x/y axes (digital/analog display)
- Automatic vertical alignment of mast
- Electronic load sensing on main rope
- Hydraulic load sensing on auxiliary rope
- Depth measuring device on main winch
- Depth measuring device (on crowd winch system)
- Swivel alignment function on main winch
- Speed measuring device on KDK
- Rope slack prevention on main winch
- Crowd pressure setting
- Crowd control system Kelly
- Tool extraction control system





Gewicht ohne Schlitten Weight without sledge	8,2 to

Serienausstattung:

- integriertes Kellydämpfungssystem
- Gleitleisten sind ohne Demontage des Drehgetriebes auswechselbar
- auswechselbare Kellymitnehmer
- auswechselbare Mitnehmerleisten
- Kardangelenk
- Hydraulische Verbindungen mit Schnellkupplungen
- 4 einstellbare Betriebsmodi (siehe Diagramme)
- Transportstützen
- Hebegeschirr

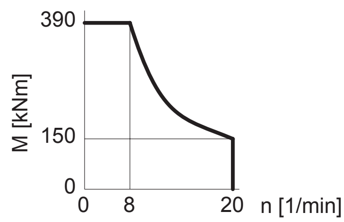
Standard equipment:

- Integrated kelly damping system
- Wear pads exchangeable without removal of rotary drive
- Exchangeable kelly drive adapter
- Exchangeable kelly drive keys
- Cardanic joint
- Quick-release couplers on hydraulic hoses
- 4 selectable modes of operation (refer to diagrams)
- Transport supports
- Slings gear for rotary drive

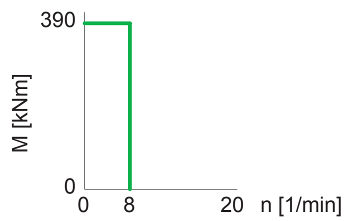
KDK 390 S

Schaltgetriebe
Multi gear rotary drive

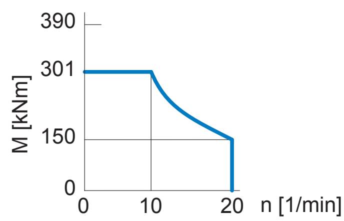
1. Gang Standardbetrieb
1st gear standard mode



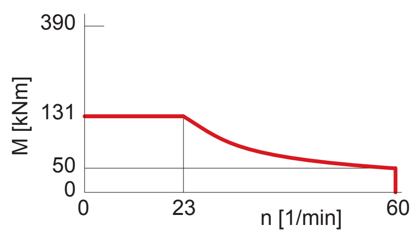
1. Gang Einrichten und Felsbohren
1st gear Set up and rock drilling



1. Gang M_D reduziert
1st gear M_D reduced



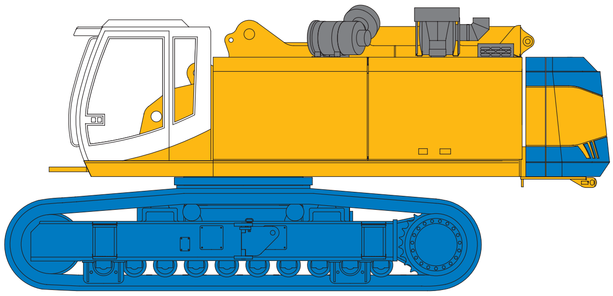
2. Gang Standardbetrieb
2nd gear standard mode



Drehmoment nominal
Darstellung nicht maßstäblich

nominal torque values
not to scale

Geräteträger BS 100 — Base carrier BS 100



Motor	Engine	CAT C15
Nennleistung ISO 3046-1	Rated output ISO 3046-1	433 kW @ 1800 U/min (rpm)
Motor spezifiziert nach Abgasnorm	Engine conforms to Exhaust Emission Standard	EEC 97/68EC Stage 3 und EPA/CARB TIER III
Dieseltank	Diesel tank capacity	800 l
Umgebungstemperatur unter Vollast	Ambient air temperature (at full power)	bis (up to) 42° C
Schalldruckpegel in Kabine (EN 791, Anh. A)	Sound pressure level in cabin (EN 791, Annex A)	L_{PA} 79 dB(A)
Schalleistungspegel (2000/14/EG u. EN 791, Anh.A)	Sound power level (2000/14/EG u. EN 791, Annex A)	L_{WA} 114 dB(A)
Hydrauliksystem	**Hydraulic system**	Dreikreisbohrhydraulik 3-hydraulic circuit system for drilling
Hydraulische Leistung (gemessen am Verteilerblock KDK)	Hydraulic power output (measured at inlet to rotary drive)	**325 kW**
Hydraulikdruck	Hydraulic pressure	300 bar
Fördermengen (Hauptkreise + Hilfskreis)	Flow rates (main circuits + auxiliary circuit)	3 x 300 l/min + 1 x 135 l/min
Tankvolumen	Hydraulic oil tank capacity	900 l
Unterwagen (Teleskopfahrwerk)	**Undercarriage** (Retractable crawler frames)	**UW 130**
Laufwerksklasse	Crawler type	B 8 B
Spurweite (eingefahren/ausgefahren)	Track width (retracted/extended)	2.700 / 4.000 mm
Fahrwerksbreite (eingefahren/ausgefahren)	Overall width of crawlers (retracted/extended)	3.700 / 5.000 mm
3-Steg Bodenplatten	Width of triple grouser track shoes	1.000 mm
Fahrwerkslänge	Overall length of crawlers	6.000 mm
Zugkraft effektiv/nominal	Traction force effective/nominal	790 kN / 930 kN
Fahrgeschwindigkeit	Travel speed	1,1 km/h

Serienausstattung

- Motornotsteuerung
- Leerlaufautomatik (zur Verbrauchsoptimierung)
- Motordiagnostiksystem
- Diagnoseleiste für hydraulische Funktionen
- abnehmbarer Ballast (6,0 to + 6,5 to + 11,5 to)
- abnehmbare Raupenträger
- Verzurraugen an Raupenträgern
- Aufstiegsleiter zum Oberwagen und Begehung am Oberwagen
- Bordbeleuchtungssatz (6 Scheinwerfer)
- Bordwerkzeugsatz
- Elektrische Betankungspumpe
- Komfortfahrerkabine (Breite 950 mm)
- Dachschutzgitter (FOPS Standard)
- Klimaanlage
- Radio und CD
- Trittroste (neben und vor der Kabine)

Standard equipment

- Emergency mode of operation for engine
- Automatic idling mode (to optimise fuel consumption)
- Engine diagnostic system
- Diagnostic panel for hydraulic functions
- Removable counterweight (6,0 to + 6,5 to + 11,5 to)
- Removable crawler side frames
- Transport securing lugs on crawler units
- Access ladder and catwalk on uppercarriage
- On-board lighting set (6 spotlights)
- On-board tool set
- Electric refuelling pump
- High-comfort operator's cab (width 950 mm)
- Protective roof guard (FOPS compliant)
- Air conditioning system
- Radio and CD player
- Catwalk (on side and in front of operator's cab)

Zusatzausstattung / Optional equipment

Ausstattungserweiterung / Additional equipment options

Ausstattungserweiterung	Additional equipment options
Grundgerät	**Base carrier**
Kompressor (1000 l/min Saugleistung)	Compressor (1000 l/min capacity)
Generator (13 kVA)	Generator (13 kVA)
Bioölbefüllung	Bio-degradable oil
Schraubstockanbau	Vise attachment
Panzerverglasung	Tempered safety glass panels
Standheizung mit Zeitschaltuhr	Independent cab heater with time switch
Schutzbelüftung	Pressurized air conditioning system
Bohrgerät	**Drilling equipment**
Freifall Hauptwinde	Freefall main winch
Freifall Hilfswinde	Freefall auxiliary winch
Wirbel für Hilfsseil	Swivel for auxiliary rope
Aufstiegsleiter am Mast	Mast access ladder
Mastabstützung	Mast support unit
obere Kellyführung	Upper kelly guide
Schneckenputzer (Kellysystem)	Auger cleaner (for kelly system)
Zentralschmierung	Central lubrication system
Kameraanbau	Video camera attachment
Drehmomentwandler Kellyverfahren	Torque multiplier kelly technique
Drehmomentwandler für DKS	Torque multiplier for twin rotary head system
Bohrgutabwurfeinrichtung für DKS BTM	Telescopic spoil chute device for DKS BTM
Betonierleitung am Mast	Concrete conductiom
Mechanische Anbauten für Automatikdrehteller	Mechanical attachment for automatic casing drive adapter
Vorrüstung Automatikdrehteller (hydraulisch / elektrisch)	Pre-equipped for automatic casing drive adapter (hydraulic / electrical)
Vorrüstung Sonderbohrverfahren	Pre-equipped for special drilling systems
Traverse für „Single Pass“ Verfahren	Spreader beam for single pass process
Verrohrungsmaschinenanbau (max. BV 2000 HD-07)	Oscillator attachment (max. BV 2000 HD-07)
Mess- und Steuerungstechnik	**Measuring and control equipment**
Fernübertragung der Betriebsdaten	Remote transmission of process and operating data
Überlastschutz für Hauptseil	Overload protection device on main rope
Hilfswinde mit elektronischer Seilkraftmessung	Electronic load sensing on auxiliary rope
Abbohr -, und Ziehassistent für „Single Pass“-Verfahren	Crowd control assistance and tool extraction assistance for “Single Pass” systems

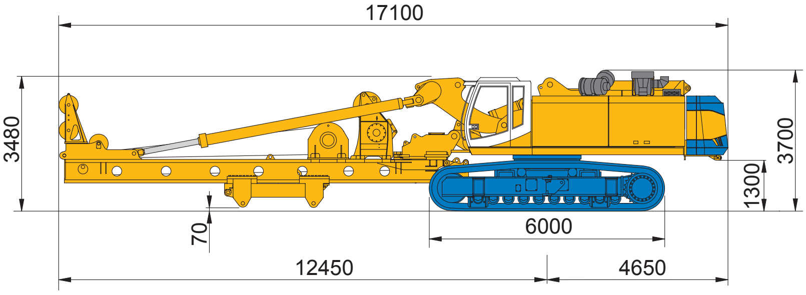
Ausstattungsvarianten / Alternative equipment options

Ausstattungsvarianten	Alternative equipment options
Hauptwinde 400 kN (Huckepack)	Main winch 400 kN (mounted on top of uppercarriage)
Doppelkopfsystem: Sondermastkopf	Double rotary drive system: special mast head
Seilvorschub:Mastverlängerung 4 m (anstatt 3 m)	Crowd winch system: mast extension 4 m (replacing 3 m)

Transportdaten　　　　　　Transport data

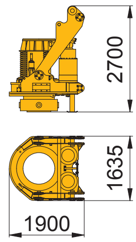
Gewichtsangaben sind ca. Werte, Zusatzausrüstungen (Optionen) können das Gesamtgewicht verändern

Weights shown are approximate values; optional equipment may change the overall weight

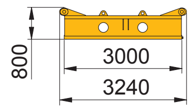


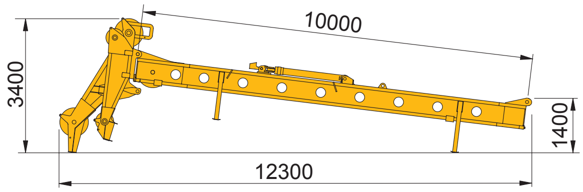
G = 110 to (Windenvorschub / Crowd winch)
G = 106,5 to (Zylindervorschub / Crowd cylinder)

G = 8,2 to

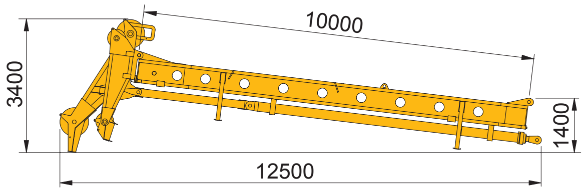


G = 1,9 to
Breite = 900 mm
(Width)

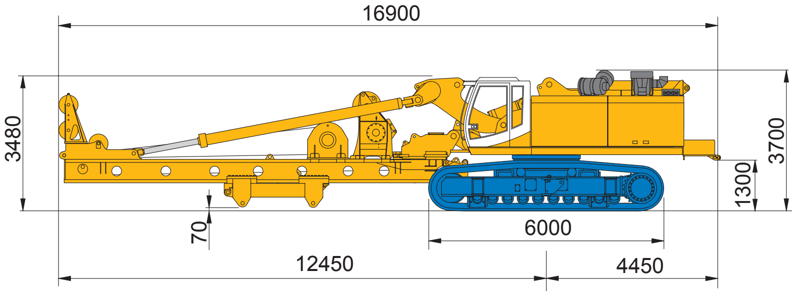




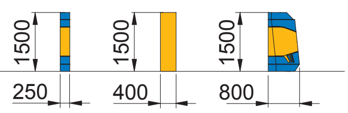
G = 7 to
Breite = 2000 mm
(Width)



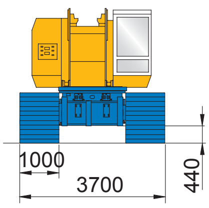
G = 9 to
Breite = 2000 mm
(Width)

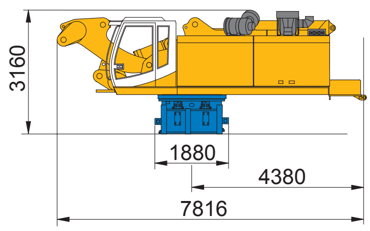


G = 86 to (Windenvorschub / Crowd winch)
G = 82,5 to (Zylindervorschub / Crowd cylinder)

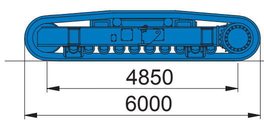


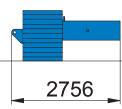
G = 6 to　**G = 6,5 to**　**G = 11,5 to**



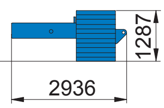


G = 37 to

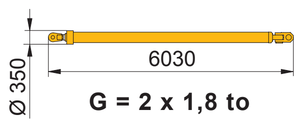




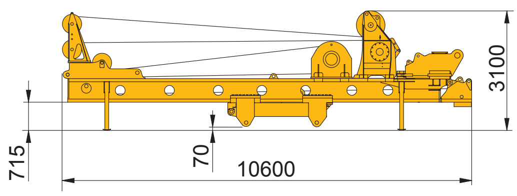
G = 14,5 to



G = 14,5 to



G = 2 x 1,8 to



G = 16,5 to
Breite = 2450 mm
(Width)

Anwendungen — Applications

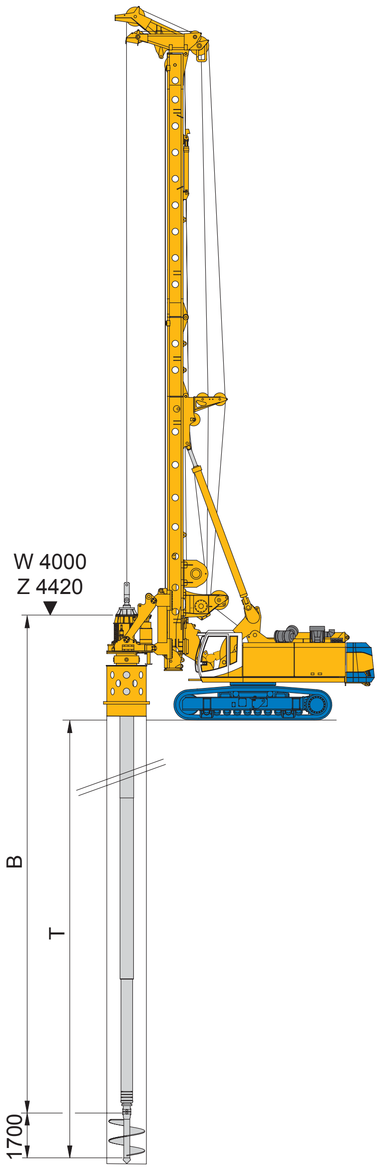
Kellybohrverfahren — Kelly drilling system

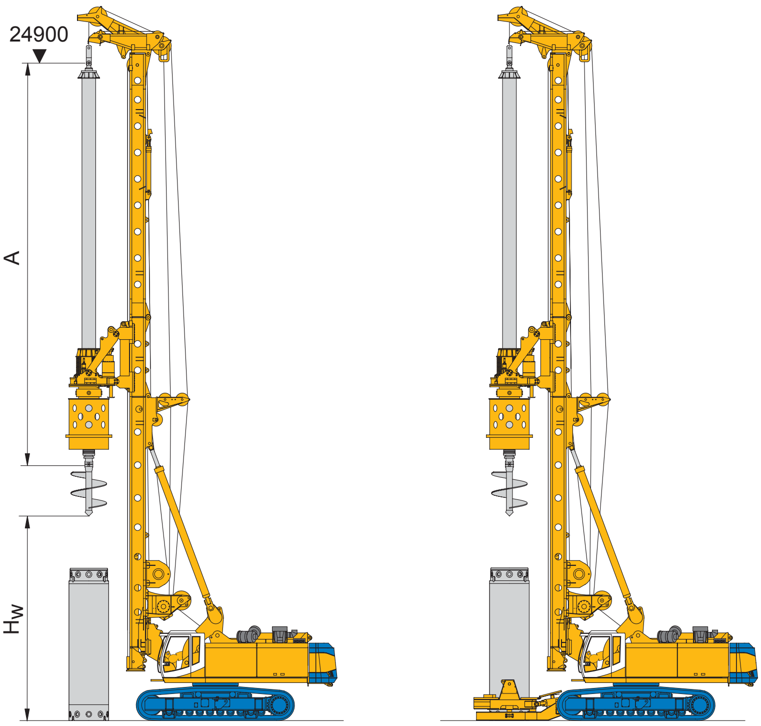
Standardverfahren: unverrohrt, oder Einbau der Bohrrohre mit Drehgetriebe
Option: Einbau der Bohrrohre mit angebauter hydraulischer Verrohrungsmaschine

Standard system: Uncased drilling or installation of casing with rotary drive
Optional: Installation of casing with hydraulic oscillator attached to the drilling rig

Zusatzausstattung / optional equipment:

Anbau Verrohrungsmaschine
Attachment of hydraulic oscillator
BV 2000 HD-07





Bohrtiefen — Drilling depths

Kellytyp / Type of kelly bar	A (m)	B (m)	Gewicht / Weight (kg)	Windenvorschub / Crowd winch: Hw (m)	Windenvorschub / Crowd winch: T (m)	Zylindervorschub / Crowd cylinder: Hw (m)	Zylindervorschub / Crowd cylinder: T (m)
BK 40/470/3/30	13,25	33,16	7.650	9,45	**30,90**	8,20	**30,40**
BK 40/470/3/36	15,25	39,16	8.750	7,45	**36,90**	7,45	**36,40**
BK 40/470/3/48	19,25	51,16	10.950	3,45	**48,90**	3,45	**48,40**
BK 40/470/4/40	13,25	42,79	10.500	9,45	**40,50**	8,20	**40,10**
BK 40/470/4/48	15,25	50,79	12.000	7,45	**48,50**	7,45	**48,10**
BK 40/470/4/56	17,25	58,79	13.500	5,45	**56,50**	5,45	**56,10**
BK 40/470/4/64	19,25	66,79	15.000	3,45	**64,50**	3,45	**64,10**
BK 40/470/4/72	21,25	74,79	16.500	1,45	**72,50**	1,45	**72,10**
BK 40/470/4/80 [1]	23,25	82,79	18.000	0,45	**80,50**	–	**–**

[1] nur mit 4m Mastverlängerung / Only with 4 m mast extension

Bohrdurchmesser — Drilling diameter

		Windenvorschub / Crowd winch	Zylindervorschub / Crowd cylinder
Unverrohrt	Uncased	2.800 mm	3.000 mm
Verrohrt	Cased	2.500 mm	2.700 mm

Bohrrohrlängen — Length of casing sections

		Windenvorschub / Crowd winch	Zylindervorschub / Crowd cylinder
Ohne BV	Without casing oscillator	Hw – 0,5 m	Hw – 0,5 m
Mit BV	With casing oscillator	Hw – 1,5 m	Hw – 1,5 m

Bemerkungen zur Bohrdatenermittlung siehe „Kellystangen 905.518.1“

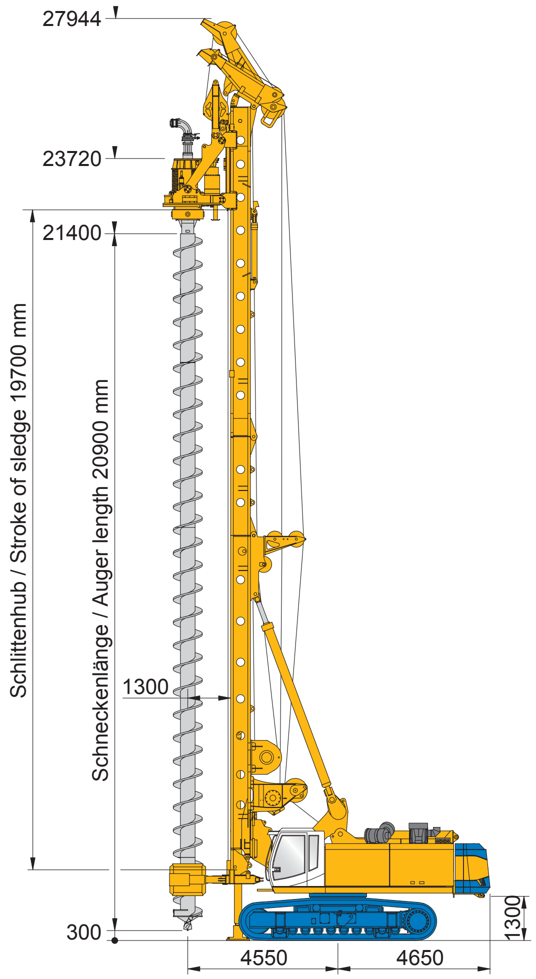
For further details on the acquisition of drilling data please refer to “Kelly Bars 905.518.1”

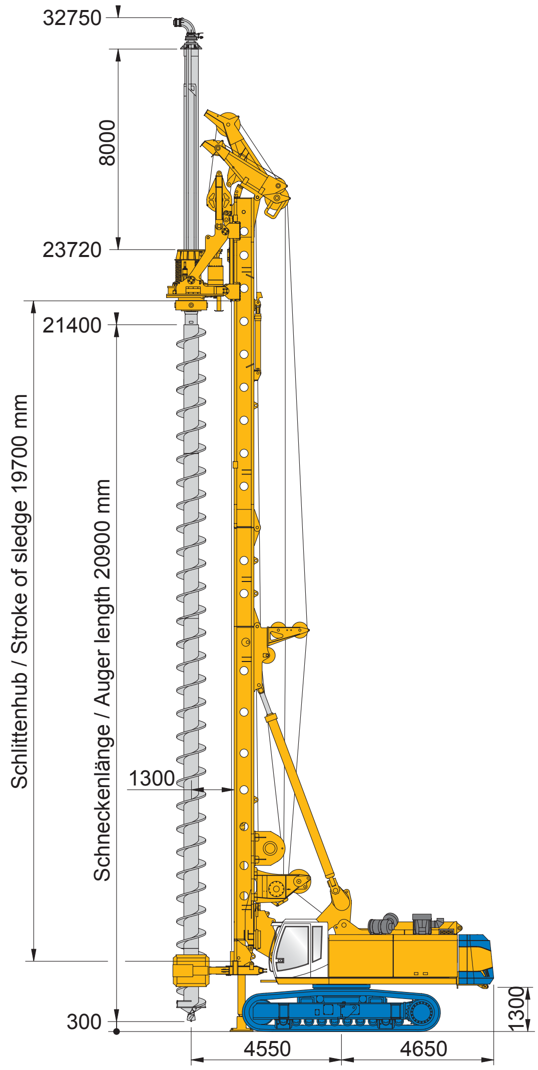
Anwendungen — Applications

SOB – Bohrverfahren — CFA – Drilling system

hydraulische Mastabstützung erforderlich / hydraulic mast support required

Zeichnung mit Windenvorschub / Illustration showing crowd winch module





Vorschubsystem Crowd system	Windenvorschub Crowd winch		Zylindervorschub Crowd cylinder	
Kellyverlängerung Kelly extension	--	8,0 m	--	8,0 m
Bohrtiefe mit Schneckenputzer Drilling depth with auger cleaner	18,00 m	26,00 m	17,40 m	25,40 m
Bohrtiefe ohne Schneckenputzer Drilling depth without auger cleaner	19,20 m	27,20 m	18,60 m	26,60 m
Max. Bohrdurchmesser Max. drilling diameter	1.200 mm	1.200 mm	1.200 mm	1.200 mm
Max. Zugkraft Max. extraction force	460 kN	460 kN	600 kN	600 kN
Max. Zugkraft mit Haupt- und Vorschubwinde (effektiv) Max. extraction force with main- and crowd winch (effective)	1.060 kN (600 + 460 kN)	1.060 kN (600 + 460 kN)		
Max. Anpresskraft Max. crowd force	440 kN + Schneckengewicht 440 kN + auger-weight		Gewicht KDK + Schnecke Weight of rotary drive + auger	
Schneckenlänge (inkl. Anfänger) Continuous flight auger length (incl. starter auger)	20,90 m		20,90 m	

Anwendungen | Applications

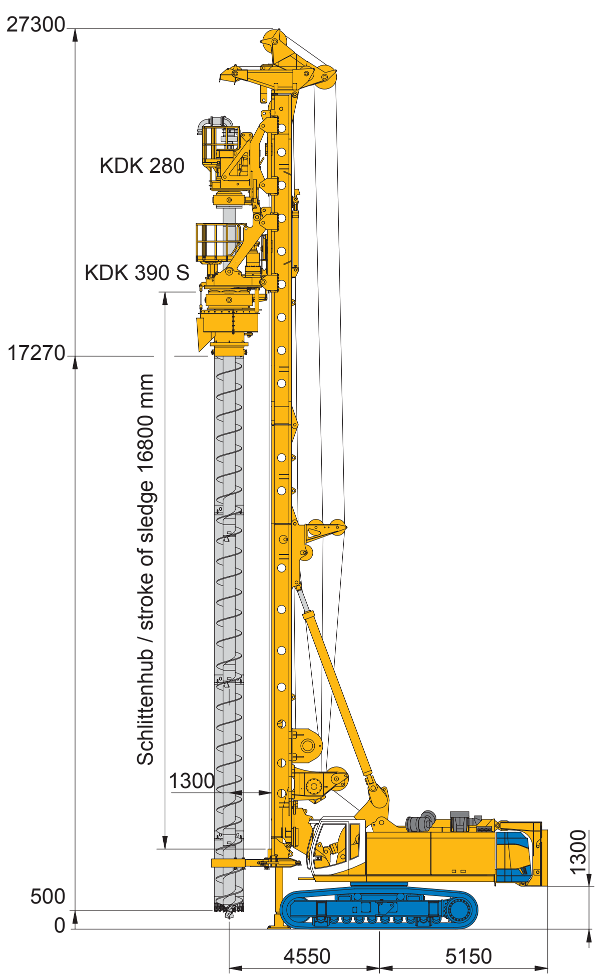
DKS – Doppelkopfverfahren | DKS – Double rotary drive system

Systemvoraussetzungen: zusätzliches Gegengewicht 11,5 to • Windenvorschub • hydraulische Mastabstützung

System requirements: additional counterweight 11,5 to • crowd winch type • hydraulic mast support

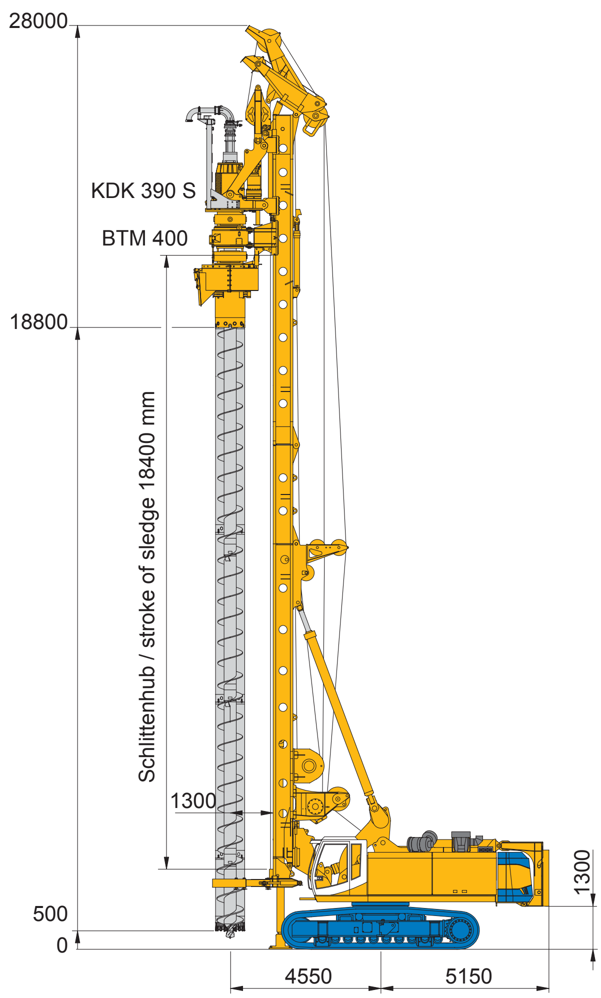
DKS mit 2 unabhängigen Drehantrieben

DKS with 2 independent rotary drives



DKS mit Drehantrieb (Schnecke) und Drehmomentwandler (Bohrrohr)

DKS with rotary drive for auger and torque multiplier BTM for casing



KDK 280 + KDK 390 S

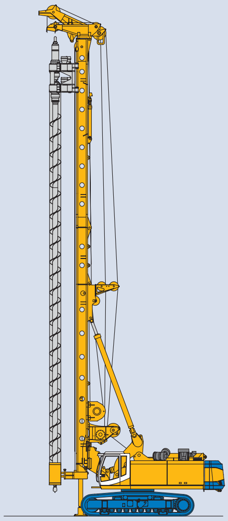
Drehantrieb für Schnecke Rotary drive for auger	**KDK 280**
Drehantrieb für Bohrrohr Rotary drive for casing	**KDK 390 S**
Durchmesser (max.) Diameter (max.)	1.180 mm
Bohrtiefe Drilling depth	16,30 m
Zugkraft (max.) Extraction force (max.)	1.060 kN (600 + 460 kN)
Vertikale Relativverschiebung der Drehantriebe Relative vertical movement between rotary drives	550 mm
Einsatzgewicht (ca.) Operating weight (approx.)	159.000 kg

KDK 390 S + BTM 400

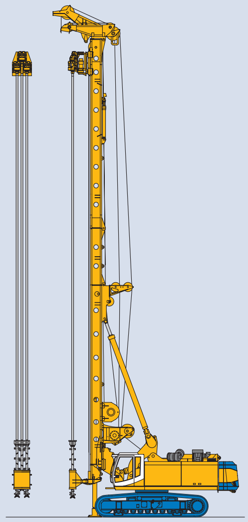
Drehantrieb für Schnecke Rotary drive for auger	**KDK 390 S** (max. 180 kNm)
Drehantrieb für Bohrrohr Rotary drive for casing	**BTM 400 DKS** (max. 360 kNm)
Durchmesser (max.) Diameter (max.)	1.180 mm
Bohrtiefe Drilling depth	17,90 m
Zugkraft (max.) Extraction force (max.)	1.060 kN
Vertikale Relativverschiebung der Drehantriebe Relative vertical movement between rotary drives	550 mm
Einsatzgewicht (ca.) Operating weight (approx.)	155.000 kg

Weitere Verfahren

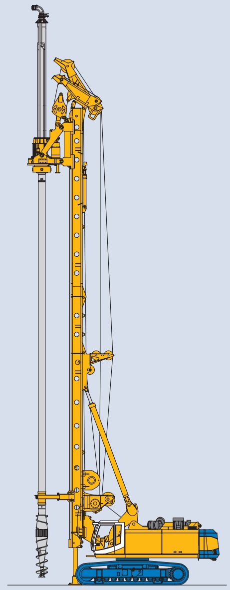
Additional systems



VdW
Vor-der-Wand Bohren
Front-Of-Wall drilling (FOW)



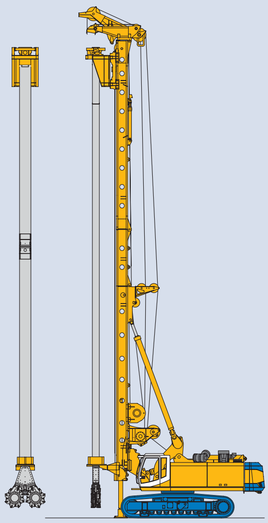
SMW
Soil Mixing Wand Verfahren
Soil Mixing Wall system



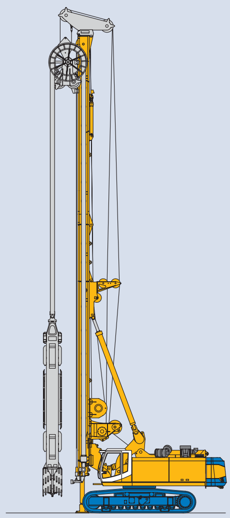
FDP
Verdrängerbohren
Full Displacement Piling

Anbauten Fräsverfahren

Cutter system attachments



CSM
Cutter Soil Mixing



BC / BG
Anbau Schlitzwandfräse BC
BC Diaphragm wall cutter on BG

BAUER Maschinen GmbH
BAUER-Straße 1
D-86529 Schrobenhausen
Tel. +49 (0)82 52/97-0
Fax +49 (0)82 52/97-11 35
e-mail: BMA@bauer.de
www.bauer.de

905.607.1 6/09

Casing Rotator
Casing Oscillators
Casings up to ∅ 3000
Special Hammer Grab
Chisels
Interlocking Tremie Pipes

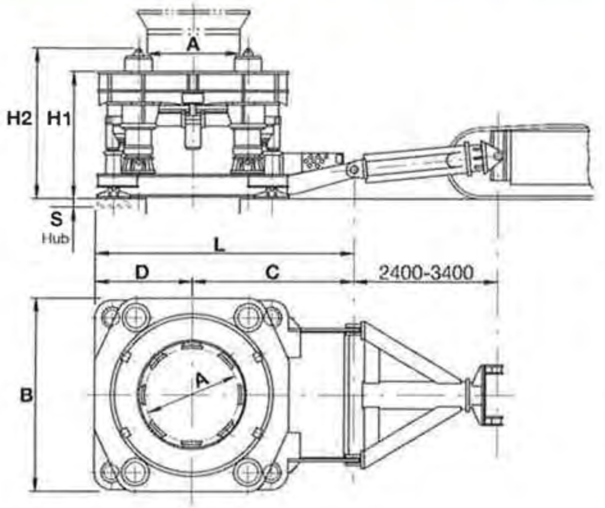
LEFFER

LIEBHERR

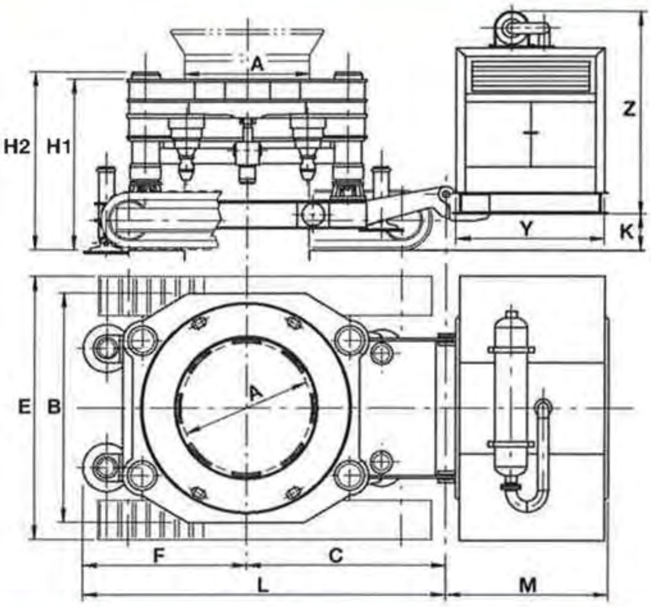
Hydraulic Casing Rotator

RDM/RDM-M

Hydraulic Casing Rotator Type RDM



Type RDM-M



Technical Data Type RDM und Type RDM-M

			RDM 1500	RDM 2000	RDM 2500	RDM 3000
A	Max./min. casing dia	mm	1500-800	2000-1200	2500-1500	3000-2000
LxB	Length x width	mm	4150x3100	6100x3500	6200x4300	6500x4600
C		mm	2600	3550	3000	3200
D	Min. spacing	mm	1550	2530	3000	3200
E	Width	mm	4000	4000	5300	5730
F	Min. spacing	mm	2200	2600	3000	3200
H1/H2	Height min./max.	mm	2050/2320	2600/2695	2600/2695	2600/2695
K		mm	800	900	900	900
M		mm	2000	2100	2600	2600
S		mm	150	350	450	450
	Lifting stroke	mm	600	600	600	600
	Lifting force	KN	1890	2400	3750	4560
	Rotation speed	rpm	0-1,1	0-1,0	0-1,1	0-0,9
	Torque	KNm	2300	2900	4700	7400
	Casing retaining force	KN	800	800	1200	1500
	Working pressure	bar	250 (max. 300)	250 (max. 300)	250 (max. 300)	250 (max. 300)
RDM	Weight	t	32	42	68	80
RDM-M	Weight	t	44	65	97	115

Technical Data Hydraulik Power Pack

		760/370 RDM 1500/RDM 2000	1100/460 RDM 2500	1500/660 RDM 3000
Power	kW	273	338	485
Pump rating	l/min	2x280 – 1x200	3x300 – 1x200	2x600 – 1x300
Dimensions (XYZ)	mm	4000x1900x2200	4000x2200x3000	5500x2400x3000
Weight	t	7	12	20

Hydraulic Casing Rotator

RDM/RDM-M

General Remarks

RDM-M 2000 in operation

The hydraulic full 360 degree turning casing rotators are economically used to construct bored piles with the full casing method under hard soil conditions. The continuous cutting of the hard ground guarantees a boring speed satisfying today's requirements, even for compressive resistance of up to 2500 kg/cm^2.

The full 360 degree continuous turning of the casing minimizes the friction compared to the oscillating method allowing the casing to drill down to 100 m depth with the casing rotator machines.

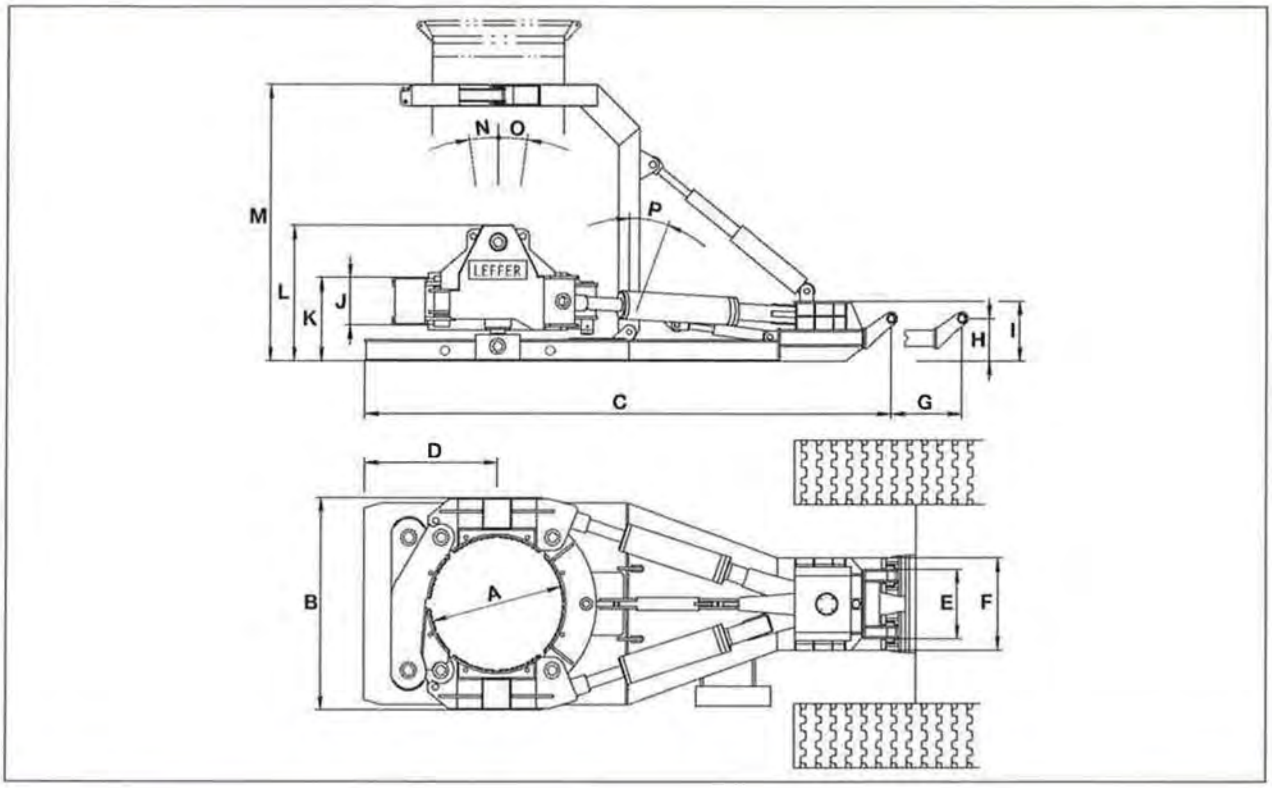
The first casing is fitted with carbide bits which can be adapted to the requirements of the soil conditions offering major advantages when coring through hard rock layers or when constructing secant walls.

The full 360 degree continuous turning of the casing by powerfull hydraulic motors eliminates the possibility of pile misalignment.

Beyond that, the casing rotators are especially suitable for the construction of full casing displacement piles because of the ability to apply very high torque, push down and lifting forces on the casing which is not possible with the known drilling rigs.

Hydraulic Casing Oscillators

VRM



Technical Data

		VRM 1300	VRM 1500	VRM 2000	VRM 2200	VRM 2500	VRM 2800	VRM 3000	VRM 3000T1100	VRM 3300T1260
Stroke	mm	600	600	600	600	650	650	650	650	650
Lifting force	kN	1530	2050	2650	2650	5150	7250	7250	7250	9000
Clamping force	kN	1320	1660	2170	2170	3780	4780	4780	4780	5100
Rotation angle	°	25	25	25	25	25	22	21	21	24
Torque	kNm	1660	2900	4110	4520	7070	8000	8350	11000	12620
Operating pressure	bar	270	270	270	270	300	300	300	300	300
Travel of casing	mm	284	327	436	480	546	538	550	550	690
Weight	t	12	17	25	27	40	48	52	54	63
A Max. casing diameter	mm	1300	1500	2000	2200	2500	2800	3000	3000	3300
B Width of machine	mm	2350	2850	3200	3400	4000	4300	4500	4500	4880
C Length of machine	mm	6500	6500	7500	7500	8800	9100	9140	9900	10470
D Min. spacing	mm	1200	1300	1600	1730	2230	2400	2600	2670	2950
E Width of cradle	mm	1015	1015	1015	1015	1015	1015	1015	1015	1015
F Width of machine excavator side	mm	1200	1400	1400	1400	1500	1500	1500	1600	1600
G Cradle path	mm	1300	1600	1300	1300	-	-	-	-	-
H Axis excavator side	mm	700	700	700	700	700	700	700	700	700
I Height of machine excavator side	mm	870	870	900	940	1130	1130	1165	1225	1265
J Height of cradle guide	mm	600	650	650	650	700	700	800	800	800
K Height from ground to top of cradle guide	mm	1100	1200	1300	1300	1400	1400	1500	1500	1620
L Height of machine	mm	1800	1850	1950	2050	2580	2580	2610	2610	2730
M Height of casing guide	mm	2820	3220	3220	3220	-	-	-	-	-
N Angle of inclination, in front	°	6	6	6	6	-	-	-	-	-
O Angle of inclination, in rear	°	8	8	8	8	-	-	-	-	-
P Angle of inclination, casing guide	°	20	20	20	20	-	-	-	-	-

The casing oscillators can be kept in continuous operation with the specified torque and forces.

LEFFER

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Hydraulic Casing Oscillators

VRM

General Remarks


VRM 3000 in operation

The hydraulic casing oscillators have been designed in accordance with the latest technical know-how. Extremely sturdy construction guarantees cost-effective use on site. By means of exact statical calculations in conjunction with higher quality material, an optimum conformity of loads, weight and material strength is achieved. The internal wielding stresses – difficult to determine for static calculations, which would affect the construction considerably – are eliminated by means of stress relieving prior to machining. A prominent feature of the equipment is the clamping collar consisting of five links operating on the boring implement. The individual links surround the casing like a chain so that a consistent surface pressure is exerted on the casing circumference. In addition, the large height of the collar (600 to 800 mm) prevents any damage to the casings. By means of easily exchangeable reducer pieces the oscillator can be converted, within a few minutes, to a smaller casing diameter. The collar opens uniformly and enables unproblematic insertion of the casing with the cutting shoe. Another advantage of the machine is the low height on the excavator side. The excavator can be swiveled by 360° in coupled condition.

Attachment at the excavator itself is torque rigid and guarantees the transmission of the full rotating movement of 25° to the casing if the excavator is firmly situated.

The design and construction of the casing oscillator is based on the experience of many years of co-operation with companies specializing in pile foundations. In view of the high costs which would result from a breakdown of the equipment on-site, great emphasis has been put on exeptionally sturdy construction.

Accessories

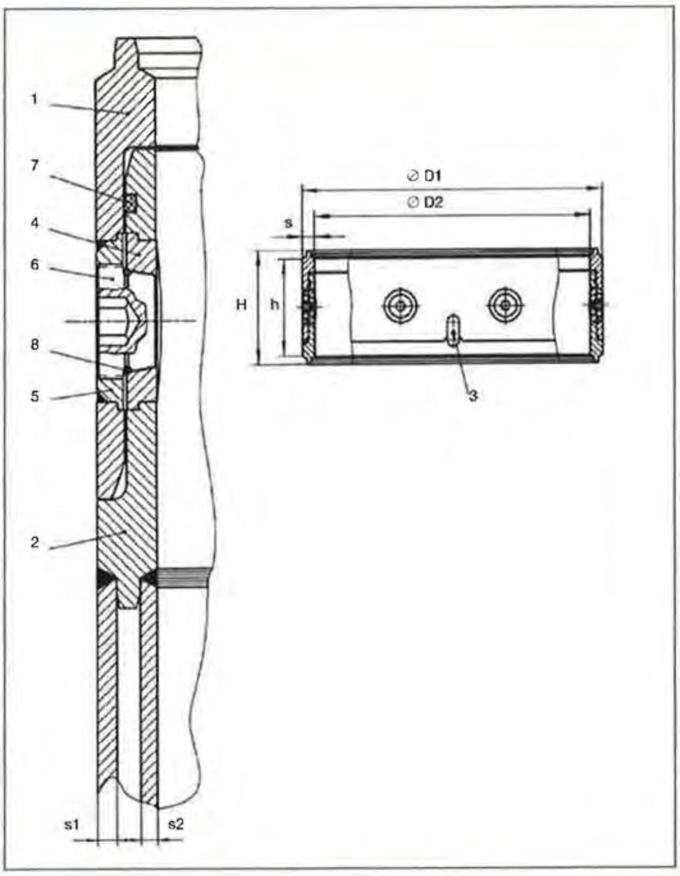
- Upper tube guide
- Inserts
- Lower locking device
- Suspension
- Power pack
- Hose unit

Special types

Short series for the use with rotary boring equipment or light duty types **please refer to the special brochure!**

Casing Joint

Technical Data



1. Female Part
2. Male Part
3. Locating Key
4. Conical Ring
5. Threaded Ring
6. Bolt
7. Sealing
8. O-Ring

D1/D2	H1	H2	S1	S2	B	Conical ring		Threaded ring		Conical bolt		Locating key	Sealing	Weight
		mm				Quantity	Type	Quantity	Type	Quantity	Type	Quantity	mm	kg
540/478	340	380	10	8	31	6	K61	6	G61	6	29S	3	-	130
620/558	340	380	10	8	31	8	K61	8	G61	8	29S	4	-	150
600/520	340	380	15	10	40	8	K64	8	G64	8	38S	4	10x510	197
620/540	340	380	15	10	40	8	K64	8	G64	8	38S	4	10x530	199
640/560	340	380	15	10	40	8	K64	8	G64	8	38S	4	10x550	205
660/580	340	380	15	10	40	8	K64	8	G64	8	38S	4	10x550	212
700/620	340	380	15	10	40	8	K64	8	G64	8	38S	4	10x610	226
710/630	340	380	15	10	40	8	K64	8	G64	8	38S	4	10x630	230
720/640	340	380	15	10	40	8	K64	8	G64	8	38S	4	10x630	232
750/670	340	380	15	10	40	10	K88	10	G88	10	38S	4	10x655	266
800/720	340	380	15	10	40	10	K88	10	G88	10	38S	4	10x700	286
880/800	340	380	15	10	40	10	K88	10	G88	10	38S	4	10x785	315
900/820	340	380	15	10	40	10	K88	10	G88	10	38S	4	10x785	318
1000/920	340	380	15	10	40	10	K88	10	G88	10	38S	4	10x900	327
1080/1000	340	380	18	10	40	12	K118	12	G118	12	38S	4	12x975	336
1180/1100	340	380	18	10	40	12	K118	12	G118	12	38S	4	12x1075	414
1200/1120	340	380	18	10	40	12	K118	12	G118	12	38S	4	12x1075	418
1250/1170	340	380	18	10	40	12	K118	12	G118	12	38S	4	12x1145	421
1300/1220	340	380	18	10	40	12	K118	12	G118	12	38S	4	12x1200	425
1500/1420	340	380	18	10	40	18	K150	18	G150	18	38S	6	12x1370	535
1800/1720	430	470	18	10	40	20	K150	20	G150	20	38S	5	12x1680	724
2000/1910	385	425	18	12	45	20	K200	20	G200	20	43S	5	12x1880	874

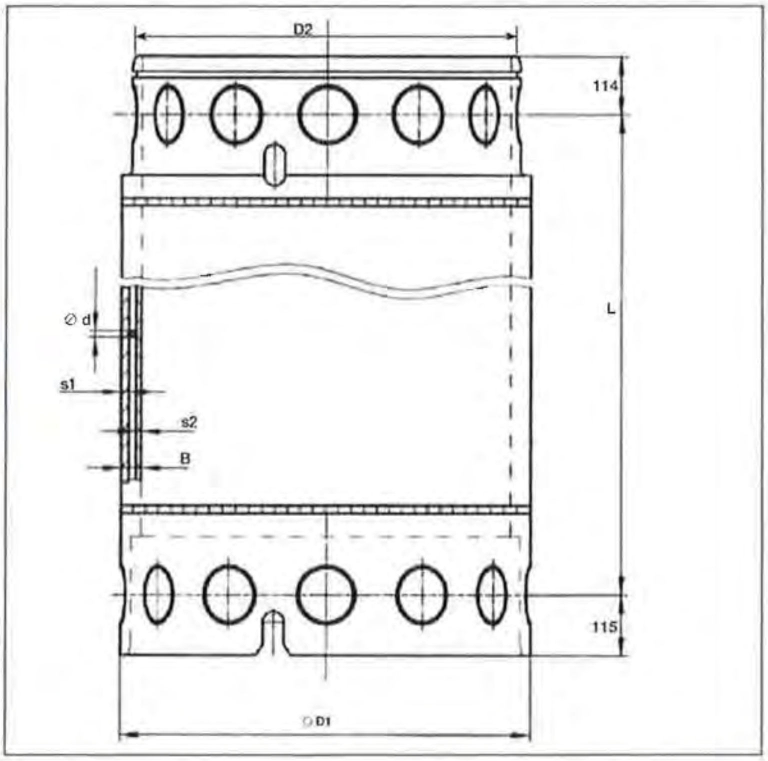
Casings
and Accessories

General Remarks

The casings are designed to create cased holes down to a depth of 35 m. Especially for the construction of bored piles by rotary drilling rigs precisely fitting casing joints guarantee a fast placement and bolting of the casings as well as ideal power transmission.

Technical Data

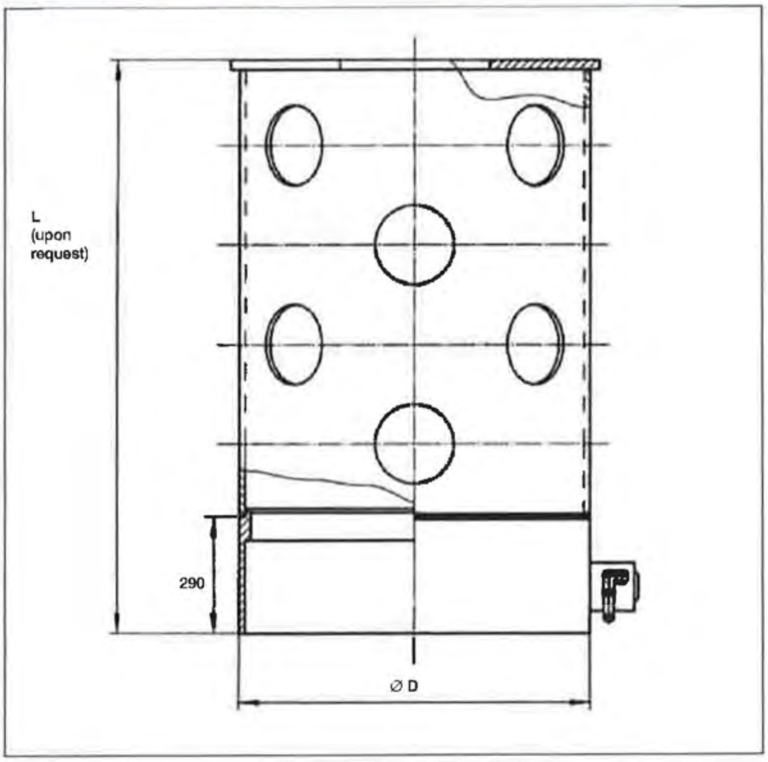
Double-walled



D1/D2	S1	S2	d	B	Z	L - Working length (kg)					
	mm				Quantity of longitudinal bars	1 m	2 m	3 m	4 m	5 m	6 m
540/478	10	8	10	31	16	295	535	770	1015	1255	1495
620/558	10	8	10	31	18	335	610	895	1185	1440	1720
600/520	15	10	13	40	18	440	805	1170	1540	1905	2270
620/540	15	10	13	40	18	450	830	1205	1590	1970	2345
640/560	15	10	13	40	18	465	855	1245	1640	2030	2420
660/580	15	10	13	40	18	480	880	1285	1690	2095	2495
700/620	15	10	13	40	20	510	940	1370	1805	2230	2660
710/630	15	10	13	40	21	520	950	1385	1820	2255	2690
720/640	15	10	13	40	21	530	960	1410	1860	2305	2755
750/670	15	10	13	40	22	575	1035	1495	1965	2425	2890
800/720	15	10	13	40	24	615	1110	1600	2105	2600	3095
880/800	15	10	13	40	26	670	1215	1760	2315	2860	3405
900/820	15	10	13	40	26	685	1245	1805	2370	2930	3485
1000/920	18	10	10	40	30	780	1465	2145	2840	3525	4210
1080/1000	18	10	10	40	32	830	1570	2310	3060	3800	4540
1180/1100	18	10	10	40	36	925	1740	2550	3370	4185	4995
1200/1120	18	10	10	40	36	965	1790	2615	3440	4280	5396
1250/1170	18	10	10	40	38	995	1855	2715	3585	4450	5410
1300/1220	18	10	10	40	40	1025	1920	2810	3725	4620	5520
1500/1420	18	10	10	40	45	1225	2265	3300	4350	5390	6430
1800/1720	18	10	10	40	55	1460	2750	4040	5320	6610	7900
2000/1910	18	12	13	45	62	1590	3080	4570	6060	7550	9050

Adapter

Technical Data



Reinforced female part with quick locking bolts

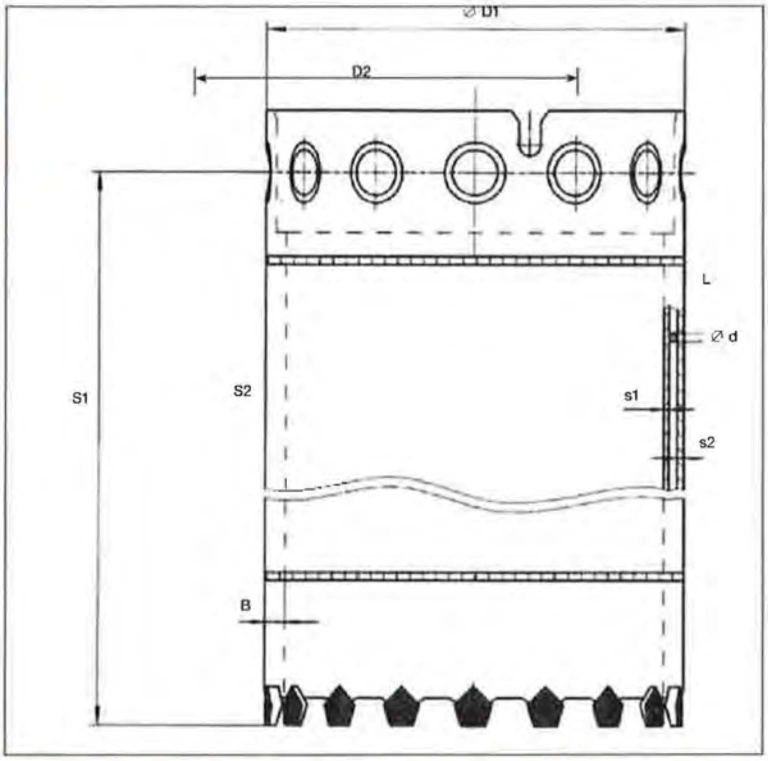
D	Nominal diameter	Quantity of locking bolts
546	540/478	2
626	620/558	2
606	600/520	2
626	620/540	2
646	640/560	2
666	660/580	2
706	700/620	2
716	710/630	2
726	720/640	2
756	750/670	4
806	800/720	4
886	880/800	4
906	900/820	4
1006	1000/920	4
1086	1080/1000	4
1186	1180/1100	4
1206	1200/1120	4
1256	1250/1170	4
1306	1300/1220	4
1506	1500/1420	6
1806	1800/1720	5
2006	2000/1910	5

Bottom Casing

General Remarks

Cutting shoes can be supplied with half-casing connection or as weld-on type.

Technical Data



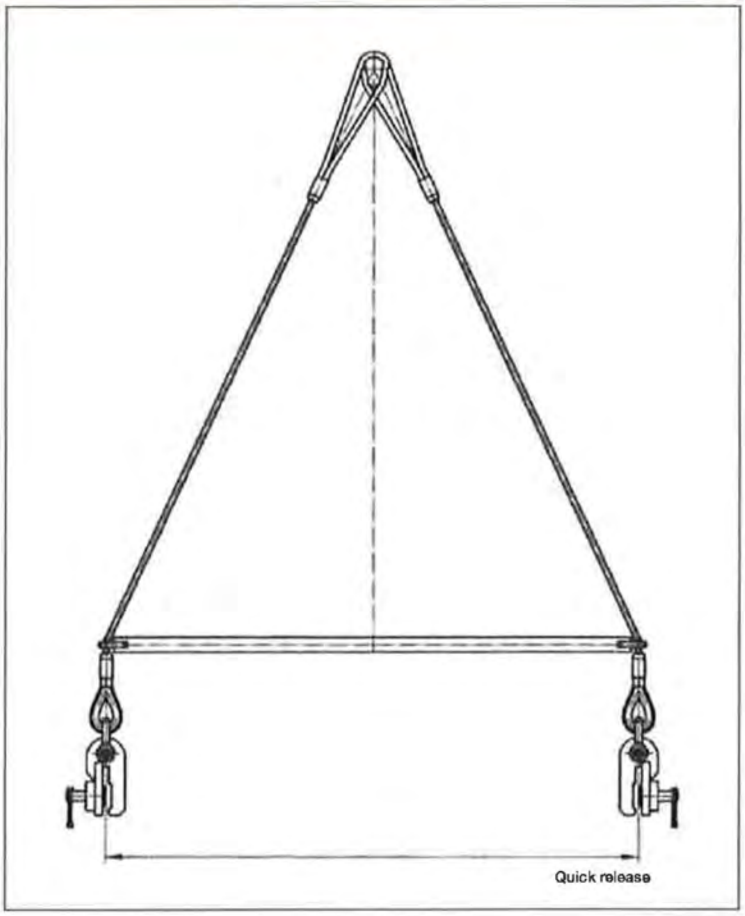
D1/D2	S1	S2	d	B	Z	L - Working length (kg)		
	mm				Quantity of longitudinal bars	4 m	5 m	6 m
540/478	10	8	10	31	16	1030	1270	1510
620/558	10	8	10	31	18	1200	1460	1740
600/520	15	10	13	40	18	1560	1920	2290
620/540	15	10	13	40	18	1610	1990	2370
640/560	15	10	13	40	18	1660	2050	2440
660/580	15	10	13	40	18	1710	2120	2520
700/620	15	10	13	40	20	1830	2250	2680
710/630	15	10	13	40	21	1840	2280	2710
720/640	15	10	13	40	21	1880	2330	2780
750/670	15	10	13	40	22	1980	2440	2900
800/720	15	10	13	40	24	2120	2610	3110
880/800	15	10	13	40	26	2330	2870	3420
900/820	15	10	13	40	26	2390	2950	3500
1000/920	18	10	10	40	30	2870	3560	4240
1080/1000	18	10	10	40	32	3090	3830	4570
1180/1100	18	10	10	40	36	3400	4210	5020
1200/1120	18	10	10	40	36	3470	4310	5330
1250/1170	18	10	10	40	38	3630	4490	5450
1300/1220	18	10	10	40	40	3770	4660	5560
1500/1420	18	10	10	40	45	4380	5420	6460
1800/1720	18	10	10	40	55	5310	6600	7900
2000/1910	18	12	13	45	62	6070	7560	9060

Lifting Device

General Remarks

The lifting device enables a quick assembly and dismantling of the casings without damaging the conical rings.

Technical Data



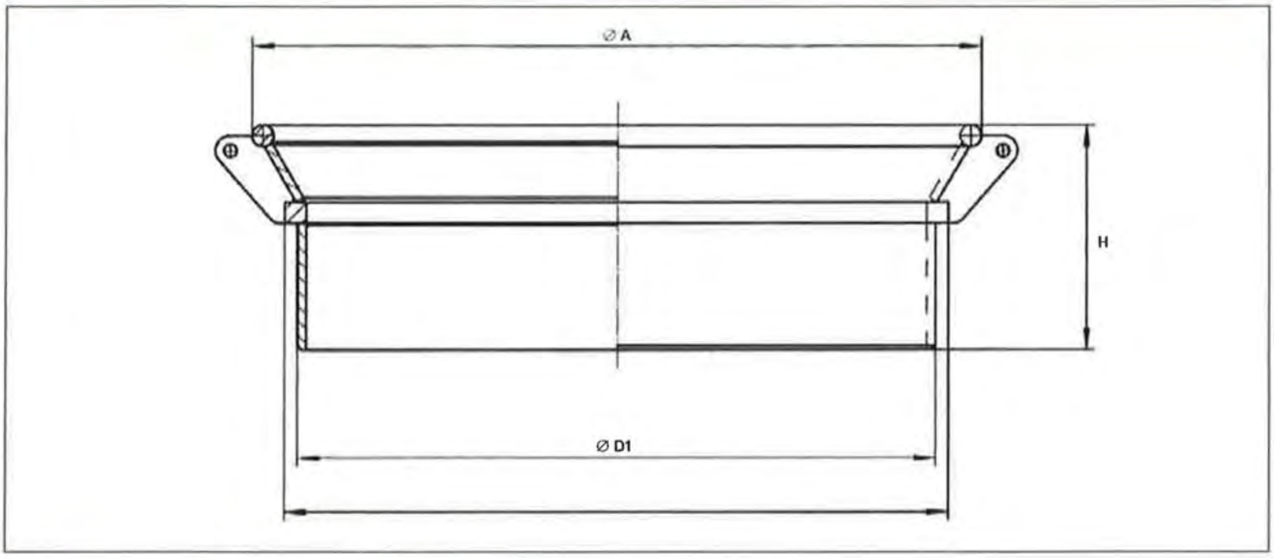
D mm	Weight kg	Capacity KN
540	90	100
600	100	
620	100	
640	100	
660	100	
700	100	
710	100	
720	100	
750	100	
800	102	
880	102	
900	102	
1000	142	
1080	142	
1180	145	
1200	145	
1250	145	
1300	145	
1500	147	
1800	150	
2000	172	200

Casing Funnel

General Remarks

The casing funnel serves as protection for the casing joint and facilitates the insertion of the drilling tools.

Technical Data

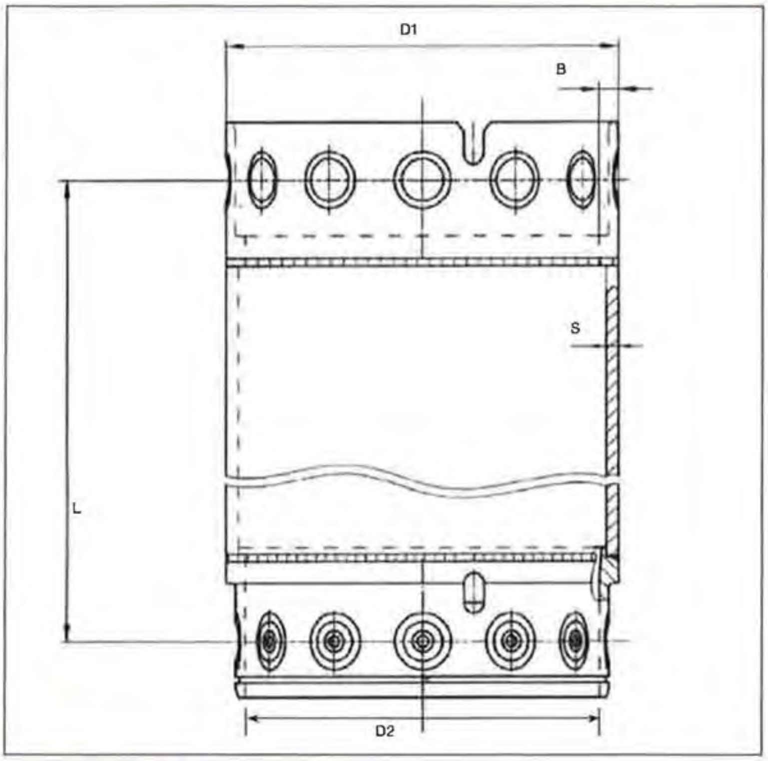


D1	H	A	Weight
	mm		kg
540		750	170
620		830	190
600		810	185
620		830	190
640		850	200
660		870	210
700		910	230
710		920	240
720		930	250
750		960	260
800	500	1010	270
880		1090	280
900		1110	290
1000		1210	310
1080		1290	330
1180		1390	350
1200		1410	365
1250		1460	390
1300		1510	410
1500		1710	450
1800		2010	540
2000		2210	600

Casings

General Remarks

For a diameter of up to 1500 mm we recommend double-walled casings. For weight reasons single walled casings can be used for larger diameters. The bottom casings would always be double-walled.



Technical Data

D1/D2	S	B	L - Working length (kg)						
mm			1 m	2 m	3 m	4 m	5 m	6 m	8 m
600/520	20	40	380	672	993	1255	1546	1838	2421
640/560	20	40	409	720	1032	1345	1657	1969	2593
700/620	20	40	447	789	1131	1473	1815	2157	2841
750/670	20	40	481	848	1215	1582	1949	2316	3050
800/720	20	40	514	906	1298	1690	2082	2474	3258
880/800	20	40	566	998	1430	1862	2294	2726	3590
900/820	20	40	580	1022	1464	1906	2348	2790	3674
1000/920	20	40	640	1133	1626	2119	2612	3105	4091
1080/1000	20	40	690	1190	1720	2260	2820	3350	4420
1180/1100	20	40	760	1350	1925	2510	3100	3680	4840
1200/1120	25	40	860	1600	2340	3080	3820	4560	6030
1300/1220	25	40	945	1745	2545	3375	4150	4950	6550
1500/1400	25	50	1440	2370	3300	4230	5160	6090	7950
1800/1700	25	50	1720	2830	3950	5070	6190	7310	9550
2000/1880	25	60	2190	3430	4670	5910	7150	8390	10870
2200/2080	25	60	2410	3780	5140	6510	7880	9250	11990
2500/2380	25	60	2680	4230	5790	7350	8910	10470	13590
2500/2380	30	60	2810	4670	6530	8400	10270	12140	15880
2800/2680	30	60	3150	5240	7330	9420	11510	13600	17780
2800/2680	32	60	3210	5440	7660	9890	12120	14350	18810
2800/2640	32	80	3890	6120	8340	10570	12800	15030	19490
2800/2640	34	80	3950	6310	8670	11040	13410	15780	20520
2980/2840	32	80	4230	6600	8970	11340	13710	16080	20820
2980/2840	34	80	4290	6810	9330	11850	14370	16890	21930
3000/2840	32	80	4260	6640	9030	11420	13810	16200	20980
3000/2840	34	80	4320	6850	9390	11930	14470	17010	22090
3200/3040	34	80	4610	7315	10020	12725	15430	18140	23550

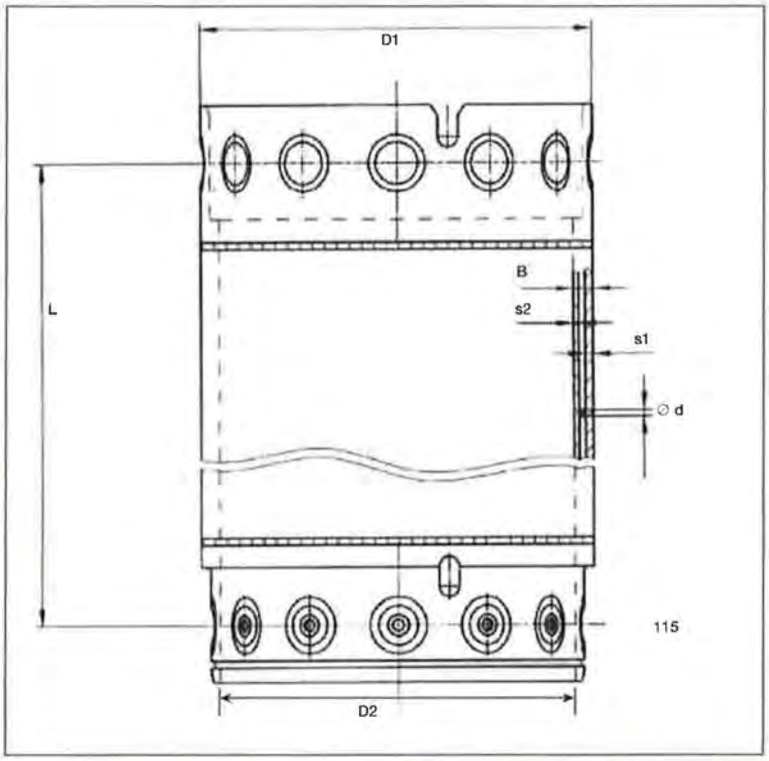
Casings and Accessories

HD

General Remarks

Heavy Duty Design (Patents in many countries)

Because of the further development of hydraulic casing oscillators (type VRM) and the new development of hydraulic full 360 degree turning casing rotators (type RDM) we are now in a position to sink bored piles into depths of 100 m. In order to meet the greater demands facing casing columns operating at such depths, »heavy duty type« casings have been developed.



Technical Data

D1/D2	S1	S2	d	B	Z	L - Working length (kg)						
	mm				Quantity of longitudinal bars	1 m	2 m	3 m	4 m	5 m	6 m	8 m
600/520	15	10	13	40	18	433	805	1177	1549	1921	2293	3037
640/560	15	10	13	40	18	465	862	1259	1656	2053	2450	3244
700/620	15	10	13	40	20	509	945	1381	1817	2253	2689	3561
750/670	15	10	13	40	22	549	1019	1489	1959	2429	2899	3839
800/720	15	10	13	40	24	587	1090	1593	2096	2599	3102	4108
880/800	15	10	13	40	26	637	1179	1720	2260	2801	3342	4424
900/820	15	10	13	40	26	653	1206	1759	2312	2865	3418	4524
1000/920	15	10	13	40	30	724	1343	1962	2581	3200	3819	5057
1080/1000	15	10	13	40	32	790	1440	2155	2845	3530	4210	5570
1180/1100	15	10	13	40	36	860	1590	2340	3070	3810	4540	6020
1200/1120	15	10	13	40	36	870	1620	2365	3120	3870	4610	6110
1300/1220	15	10	13	40	40	950	1770	2480	3400	4210	5020	6650
1500/1400	15	10	22	50	45	1485	2520	3555	4590	5625	6660	8735
1800/1700	20	15	13	50	55	1910	3505	5085	6675	8270	9865	13055
2000/1880	20	20	18	60	60	2530	4600	6670	8730	10800	12870	17010
2200/2080	20	20	18	60	66	2785	5065	7350	9635	11920	14205	18775
2500/2380	20	20	18	60	76	3105	5710	8315	10920	13525	16130	21340
2800/2680	25	25	8	60	86	3730	7210	10685	14165	17645	21125	28085
2800/2640	25	25	27	80	86	4530	8335	12135	15945	19755	23565	31185
2980/2840	25	25	27	80	90	4910	8960	13010	17060	21110	25160	33260
3000/2840	25	25	27	80	90	4940	9015	13090	17170	21250	25330	33490
3200/3040	25	25	27	80	98	5280	9640	14000	18440	22800	27160	35960

Bottom Casing

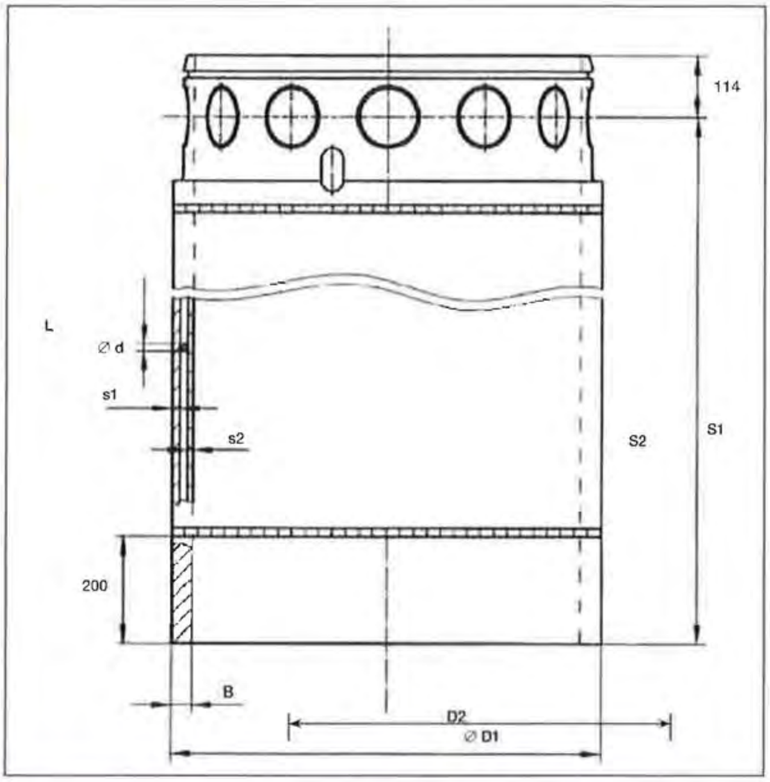
HD

General Remarks

Cutting shoes

can be supplied with half-casing connection or as a weld-on shoe.

Technical Data

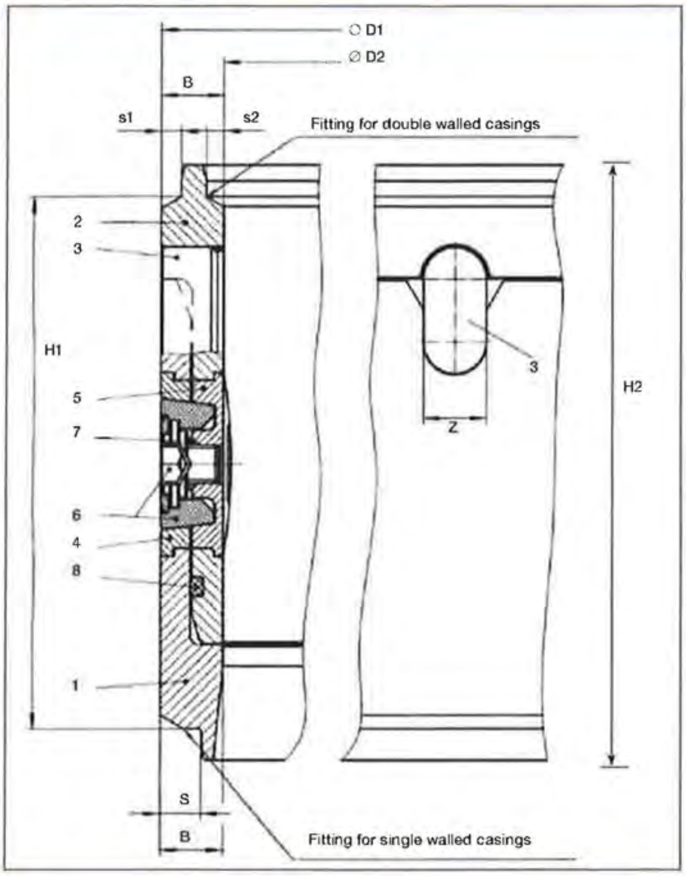


D1/D2	S1	S2	d	B	Z	L - Working length (kg)			
	mm				Quantity of longitudinal bars	4 m	5 m	6 m	8 m
600/520	15	12	10	40	18	1660	2060	2450	3230
640/560	15	12	10	40	18	1780	2200	2620	3450
700/620	15	12	10	40	20	1960	2420	2880	3800
750/670	15	12	10	40	22	2110	2600	3100	4090
800/720	15	15	8	40	24	2430	3010	3600	4760
880/800	15	15	8	40	26	2680	3330	3970	5260
900/820	15	15	8	40	26	2750	3410	4070	5380
1000/920	15	15	8	40	30	3060	3800	4540	6010
1080/1000	15	15	8	40	32	3320	4110	4910	6510
1180/1100	15	15	8	40	36	3640	4510	5390	7130
1200/1120	15	15	8	40	36	3700	4590	5480	7260
1300/1220	15	15	8	40	40	4020	4990	5960	7890
1500/1400	15	15	18	50	45	5140	6325	7510	9880
1800/1700	20	20	8	50	55	7380	9156	10950	14520
2000/1880	20	20	18	60	60	8820	10900	12990	17110
2200/2080	20	20	18	60	66	9730	12010	14300	18860
2500/2380	20	20	18	60	76	11070	13670	16280	21490
2800/2680	20	25	8	60	86	14260	17740	21220	28170
2800/2640	20	25	27	80	86	16170	19970	23770	31380
2980/2840	20	25	27	80	90	17260	21310	25350	33450
3000/2840	20	25	27	80	90	17370	21440	25510	33660
3200/3040	20	25	27	80	98	21290	25650	30010	38810

Casing Joint

HD

Technical Data



1. Female Part
2. Male Part
3. Locating Key
4. Conical Ring
5. Threaded Ring
6. Schraube Bolt
7. Sealing
8. O-Ring

D1/D2	H1	H2	S	S1	S2	B	Conical ring		Threaded ring		Conical bolt		Locating key		Sealing	Weight
		mm					Quantity	Type	Quantity	Type	Quantity	Type	Quantity	Z (mm)	kg	kg
600/520	340	380	22	17	12	40	8	K75	8	G75	8	B32	8	40	10x510	188
640/560	340	380	22	17	12	40	8	K75	8	G75	8	B32	8	40	10x550	203
700/620	340	380	22	17	12	40	8	K75	8	G75	8	B32	8	40	10x610	221
750/670	340	380	22	17	12	40	8	K75	8	G75	8	B32	8	40	10x655	239
800/720	340	380	22	17	12	40	8	K75	8	G75	8	B32	8	40	10x700	255
880/800	340	380	22	17	12	40	8	K75	8	G75	8	B32	8	40	10x785	281
900/820	340	380	22	17	12	40	8	K75	8	G75	8	B32	8	40	10x785	288
1000/920	340	380	22	17	12	40	10	K115	10	G115	10	B32	5	40	10x900	315
1080/1000	340	380	22	17	12	40	12	K115	12	G115	12	B32	4	40	12x975	333
1180/1100	340	380	27	17	12	40	12	K115	12	G115	12	B32	4	40	10x1075	374
1200/1120	340	380	27	17	12	40	12	K115	12	G115	12	B32	4	40	10x1075	375
1300/1220	340	380	27	17	12	40	12	K115	12	G115	12	B32	4	40	10x1200	413
1500/1400	585	625	27	17	17	50	16	K165	16	G165	16	B42	4	50	10x1370	1049
1800/1700	585	625	27	22	17	50	20	k165	20	G165	20	B42	4	50	10x1670	1241
2000/1880	585	625	27	22	22	60	20	K220	20	G220	20	B48	4	50	12x1860	1659
2200/2080	585	625	27	22	22	60	20	K220	20	G220	20	B48	4	50	12x2050	1830
2500/2380	585	625	27	22	22	60	20	K220	20	G220	20	B48	4	50	12x2300	2018
2800/2680	585	625	35	28	28	60	24	K220	24	G220	24	B48	6	50	12x2600	2268
2800/2640	585	625	35	28	28	80	24	K300	24	G300	24	B65	6	50	12x2600	2950
2980/2820	585	625	35	28	28	80	24	K300	24	G300	24	B65	6	50	12x2800	3230
3000/2840	585	625	35	28	28	80	24	K300	24	G300	24	B65	6	50	12x2800	3250
3200/3040	585	625	35	28	28	80	24	K300	24	G300	24	B65	6	50	12x3000	3470

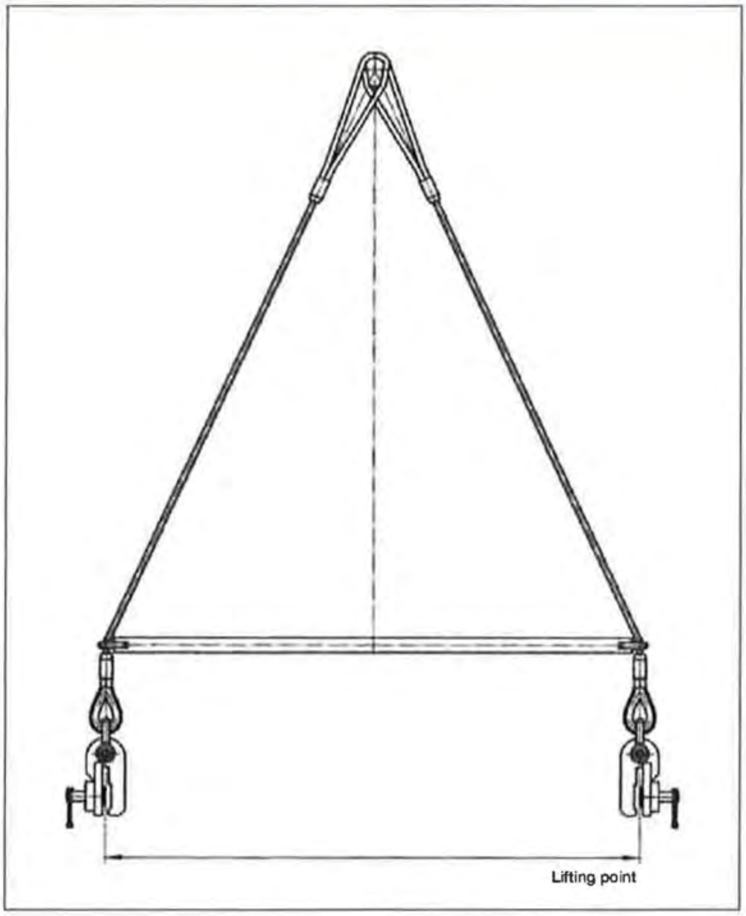
Lifting Device

HD

General Remarks

The lifting device enables a quick assembly and dismantling of the casings without damaging the threaded rings.

Technical Data



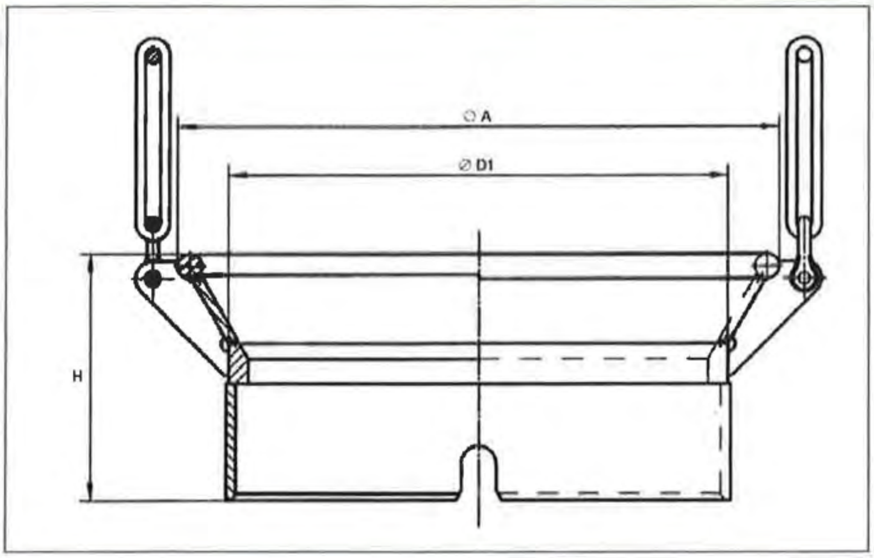
D mm	Weight kg	Capacity t
600	75	10
640	75	
700	76	
750	80	
800	85	
880	90	
900	95	
1000	120	20
1080	120	
1180	120	
1200	121	
1300	150	
1500	167	
1800	170	30
2000	171	
2200	175	
2500	180	
2800	260	40
2980	260	
3000	260	
3200	260	

Casing Funnel

General Remarks

The casing funnel serves as protection for the casing joint and facilitates the insertion of the drilling tools.

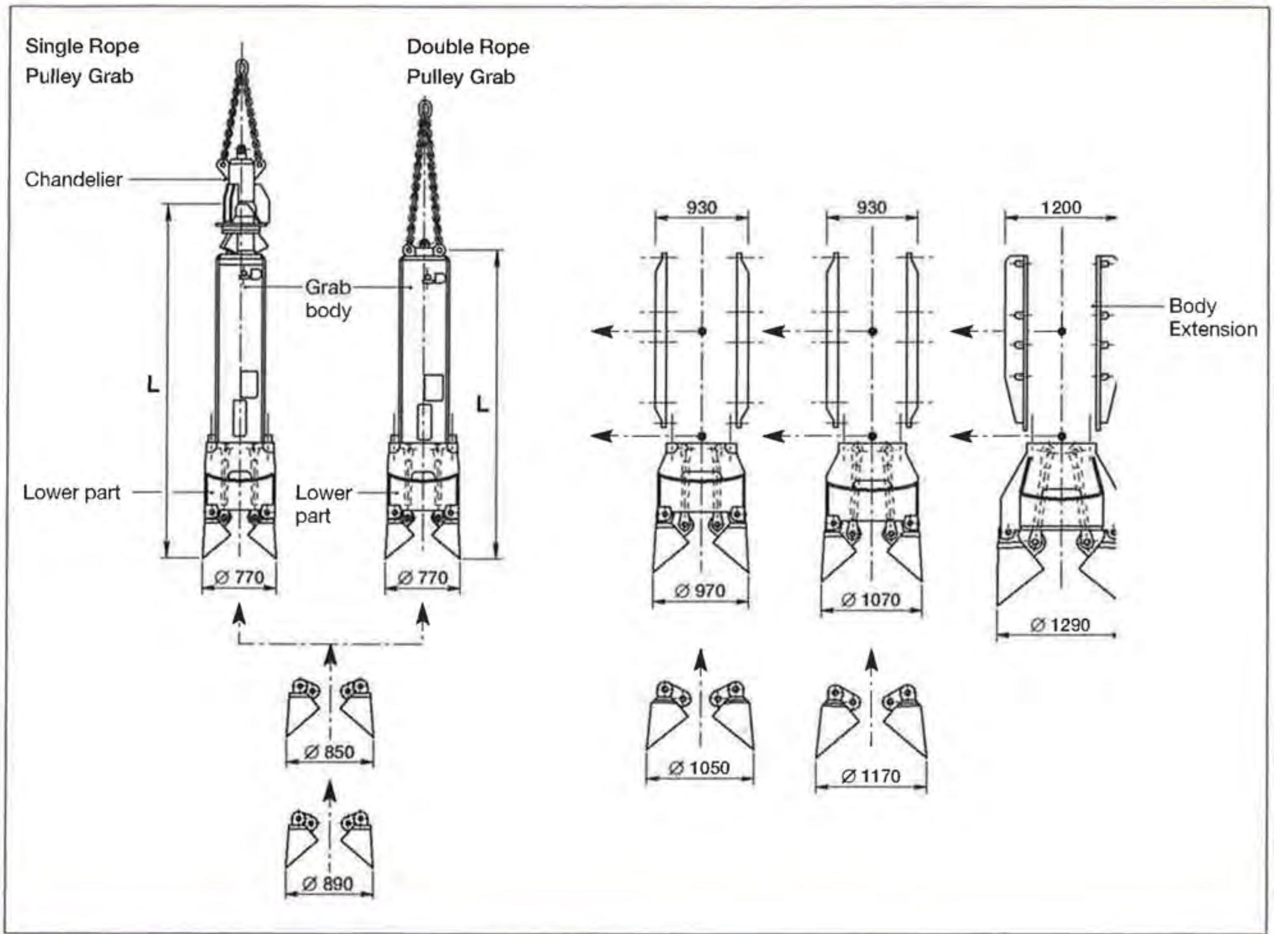
Technical Data



Nominal diameter	D1	H	A	Weight
	mm			kg
600	550	460	775	150
640	590	460	815	160
700	650	460	875	175
750	700	460	925	185
800	750	460	975	200
880	830	460	1055	220
900	850	460	1075	225
1000	950	460	1175	250
1080	1030	460	1255	260
1180	1130	460	1355	285
1200	1150	460	1375	295
1300	1250	460	1475	315
1500	1440	530	1655	500
1800	1740	530	1955	600
2000	1930	545	2150	870
2200	2130	545	2350	950
2500	2430	545	2650	1090
2800	2730	545	2950	1230
2800	2710	565	2910	1640
2980	2890	565	3090	1680
3000	2910	565	3110	1700
3200	3110	565	3310	1800

Single/Double Rope Pulley Grab

L 770-1460 SK/SZ



Technical Data

Type	Casing diameter mm	Length mm	Jaw capacity l	Weight kg
L770 SK	880/800 · 900/820	3725	140	2740
L770 SZ		3325		2410
L850 SK	980/900	3755	180	2760
L850 SZ		3355		2430
L890 SK	1000/920	3765	210	2810
L890 SZ		3365		2480
L970 SK	1080/1000 · 1100/1020	3935	260	3480
L970 SZ		3535		3150
L1050 SK	1180/1100 · 1200/1120	3965	340	3510
L1050 SZ		3565		3180
L1070 SK	1180/1100 · 1200/1120	3985	440	3570
L1070 SZ		3585		3240
L1170 SK	1300/1220	4030	520	3665
L1170 SZ		3630		3335
L1290 SK	1400/1320	4205	710	4880
L1290 SZ		3805		4550
L1360 SK	1500/1420 · 1500/1400	4260	830	4775
L1360 SZ		3860		4445
L1460 SK	1600/1520 · 1600/1500	4295	1060	4900
L1460 SZ		3895		4570

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Special Hammer Grab for Bored Piles

600-3000 mm Ø

General Remarks

Robust free-fall grab with high closing force especially suitable for boring in detritus soils and for water-logged pile foundations. The pulleys are equipped with oil-filled maintenance-free life-time bearings.

Special Hammer Grab

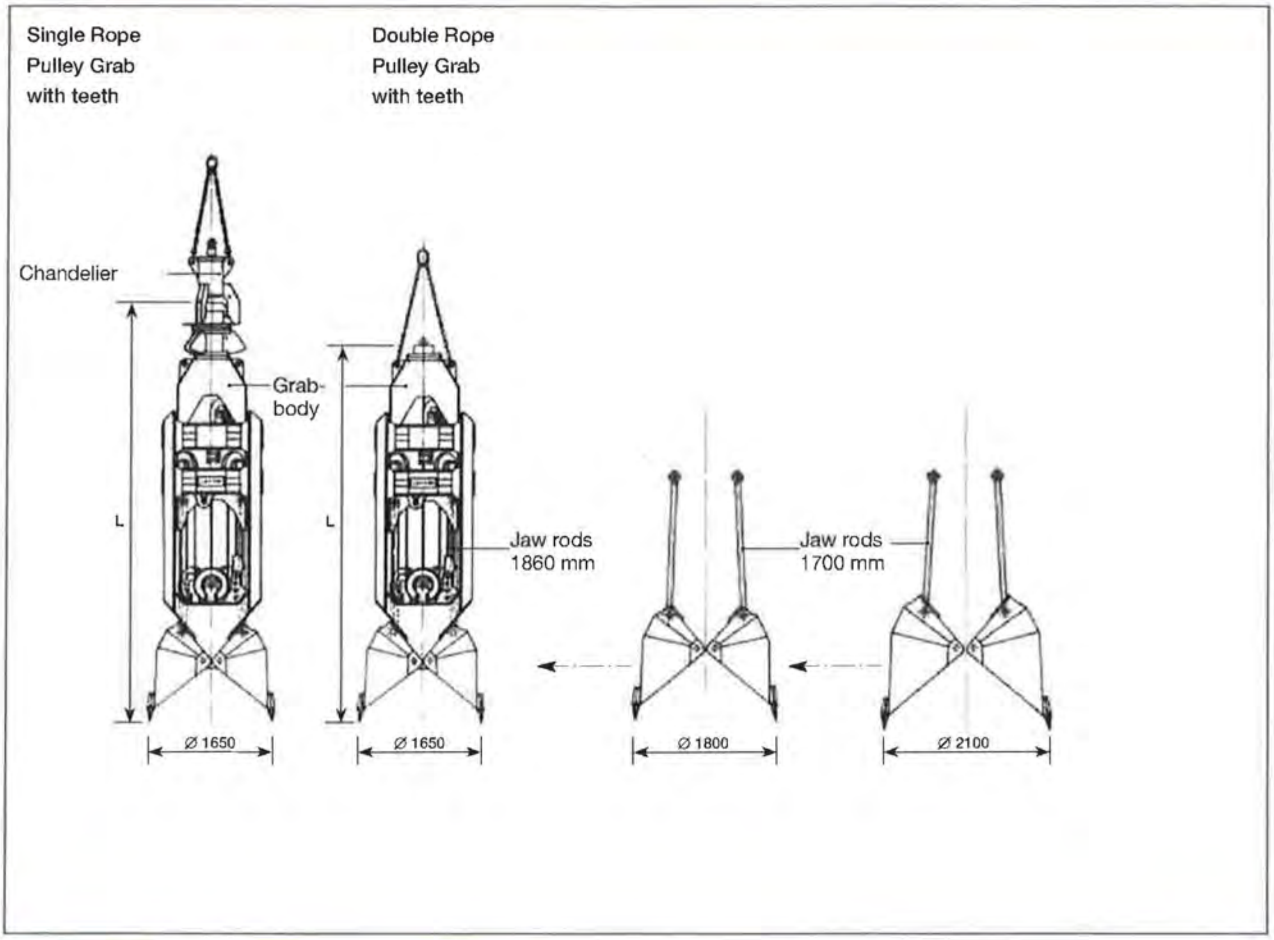
Technical Data

Casing	Types
600-1000	L 490-890 S
900-1600	L 770-1460 S
1500-2500	L 1350-2250 S
2500-3000	L 2170-2570 S

LEFFER

LIEBHERR

Single/Double Rope Pulley Grab L 1350-2100 RK/RZ



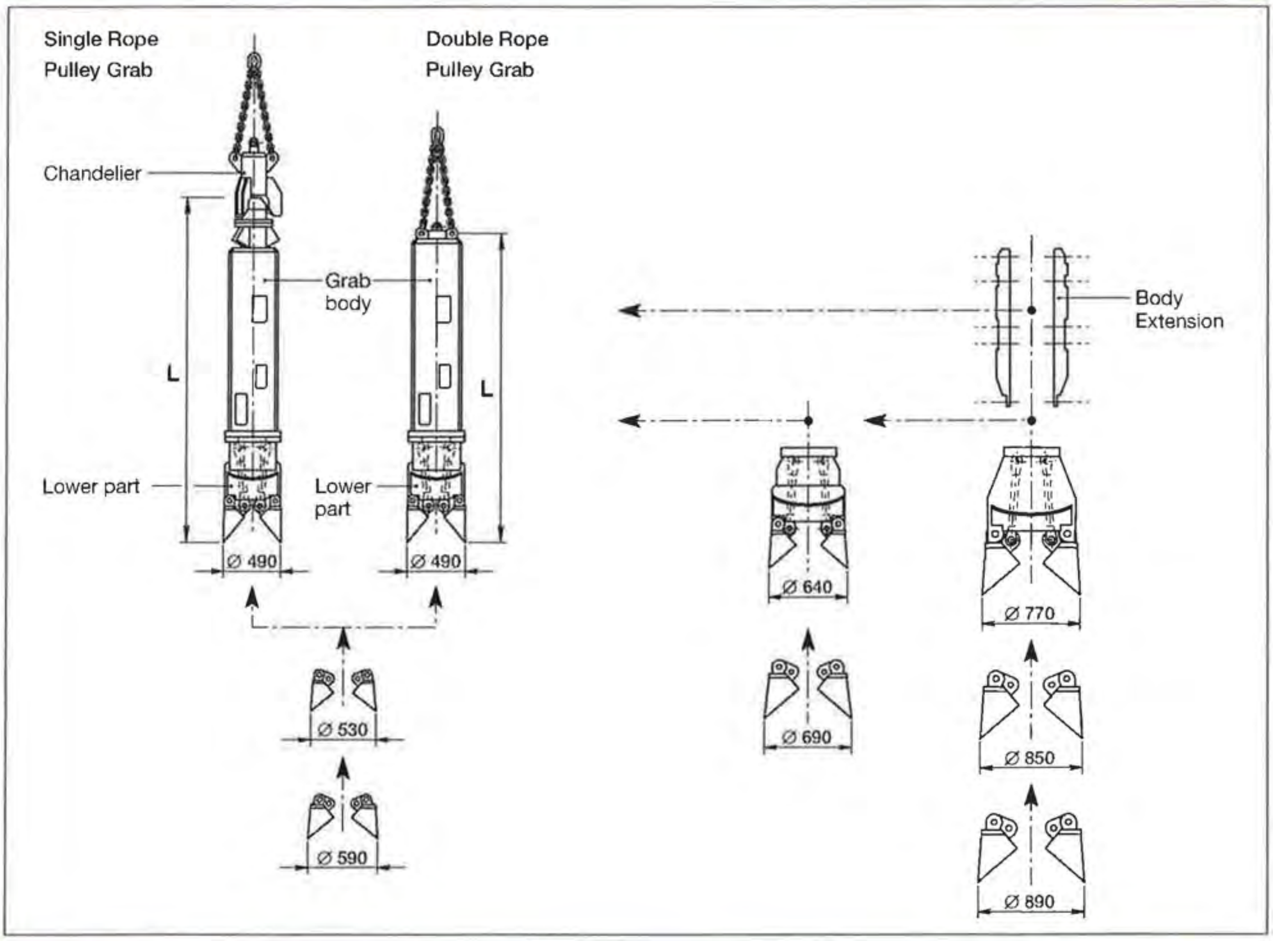
Technical Data

Type	Casing diameter mm	Length mm	Jaw capacity l	Weight kg
L1350 RK	1500/1420 · 1500/1400	5620	800	8480
L1350 RZ		5080		7750
L1650 RK	1800/1720 · 1800/1700	5760	900	8730
L1650 RZ		5220		8000
L1800 RK	200/1910 · 2000/1880	5780	110	9065
L1800 RZ		5240		8310
L2100 RK	2500/2400 · 2500/2380	5960	1300	9595
L2100 RZ		5420		8840

LEFFER LIEBHERR

Single/Double Rope Pulley Grab

L 490-890 SK/SZ



Technical Data

Type	Casing diameter mm	Length mm	Jaw capacity l	Weight kg
L490 SK	600/520 · 620/540	3080	45	1300
L490 SZ		2800		1140
L530 SK	620/558 · 640/560 · 660/580	3100	58	1305
L530 SZ		2820		1145
L590 SK	700/620 · 720/640	3135	70	1335
L590 SZ		2855		1175
L640 SK	750/670	2970	70	1440
L640 SZ		2690		1280
L690 SK	800/720	2990	90	1470
L690 SZ		2710		1305
L770 SK	880/800 · 900/820	3150	140	2105
L770 SZ		2870		1945
L850 SK	980/900	3180	180	2125
L850 SZ		2900		1960
L890 SK	1000/920	3190	210	2175
L890 SZ		2910		2010

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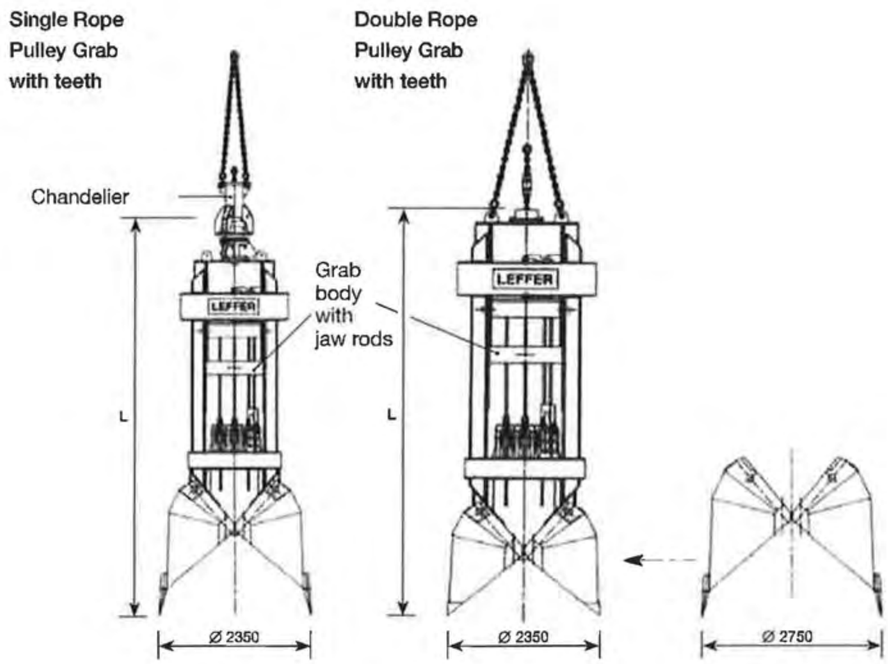
Single/Double Rope Pulley Grab L 2350-2750 RK/RZ

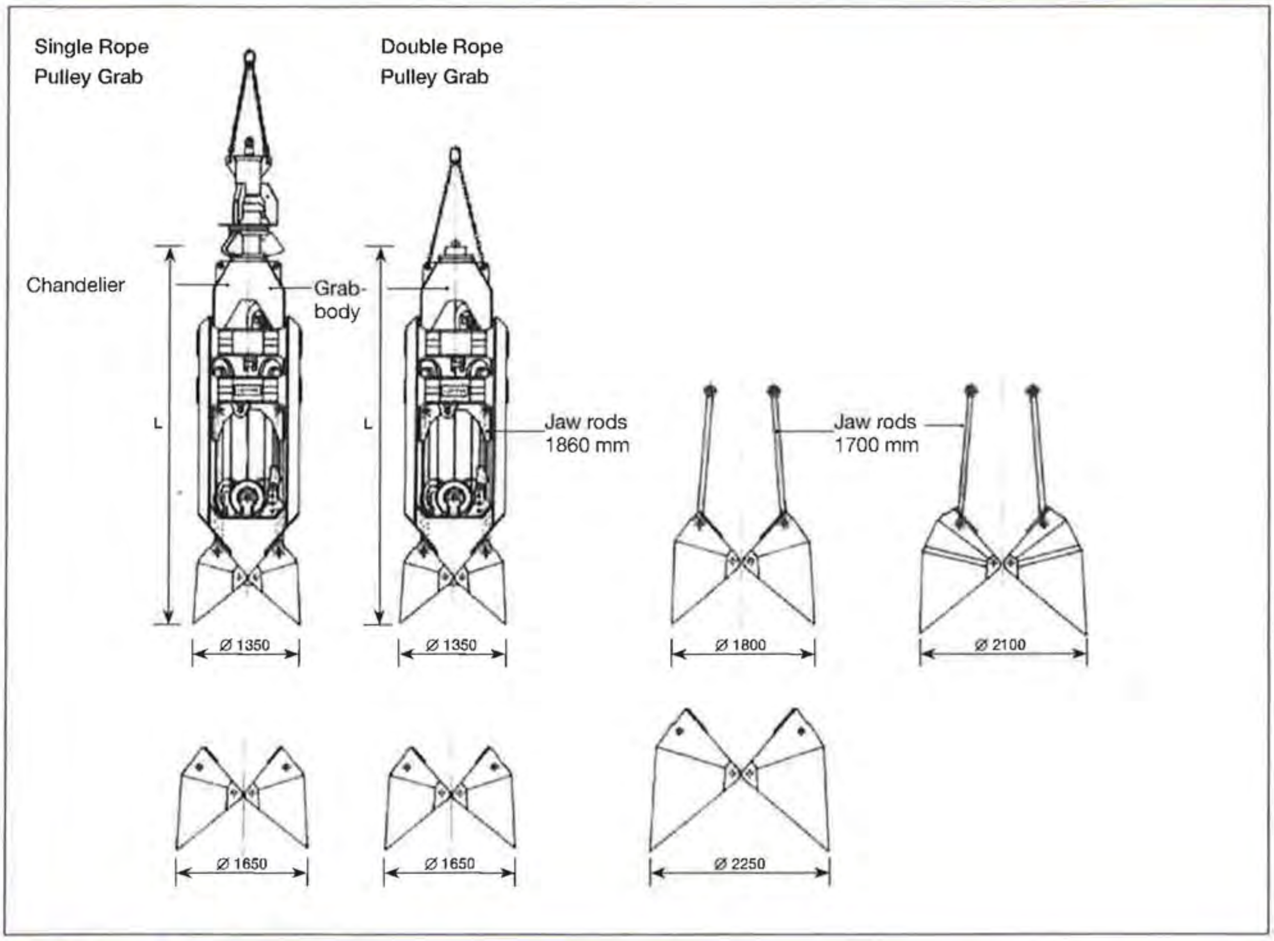


Technical Data

Type	Casing diameter mm	Length mm	Jaw capacity l	Weight kg
L2350 RK	2500/2400 · 2500/2380	6970	2500	17700
L2350 RZ		6435		17375
L2750 RK	3000/2840	7140	4500	18865
L2750 RZ		6605		18540

Single/Double Rope Pulley Grab

L 1350-2250 SK/SZ



Technical Data

Type	Casing diameter mm	Length mm	Jaw capacity l	Weight kg
L1350 SK	1500/1420 · 1500/1400	5480	800	8425
L1350 SZ		4940		7350
L1650 SK	1800/1720 · 1800/1700	5630	1100	8930
L1650 SZ		5090		8205
L1800 SK	2000/1910 · 2000/1880	5690	1200	9555
L1800 SZ		5150		8830
L2100 SK	2500/2400 · 2500/2380	5810	1500	10425
L2100 SZ		5270		9520
L2250 SK	2500/2400 · 2500/2380	5880	1800	10425
L2250 SZ		5340		10085

Hydraulic Spherical Grab

HLKG/HLKG"CD"

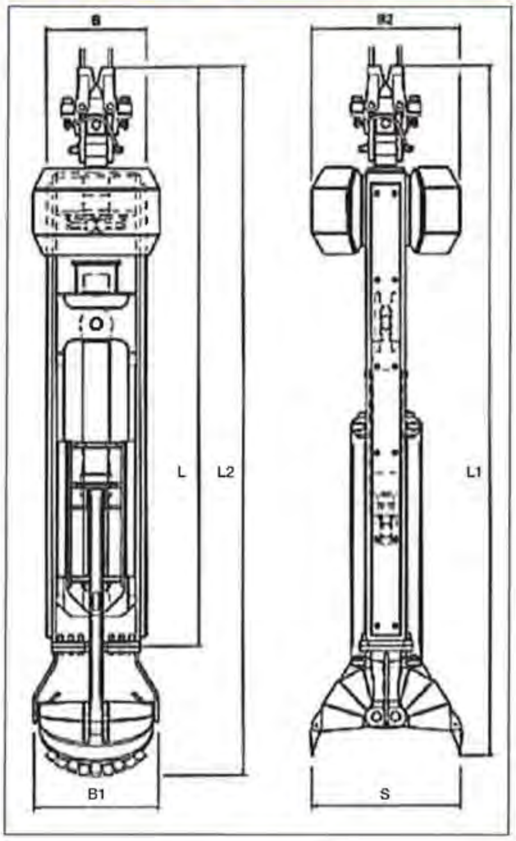
General Remarks

The Hydraulic Spherical Grab type HLKG is used on jobs, where drilling has to be carried out free of vibrations and/or where partially cased or uncased drilled shafts are to be produced.

The high deadweight in conjunction with the high closing force ensures a high efficiency. The hydraulic turning device enables the grab to be turned 100° to ensure a calibration of the borehole.

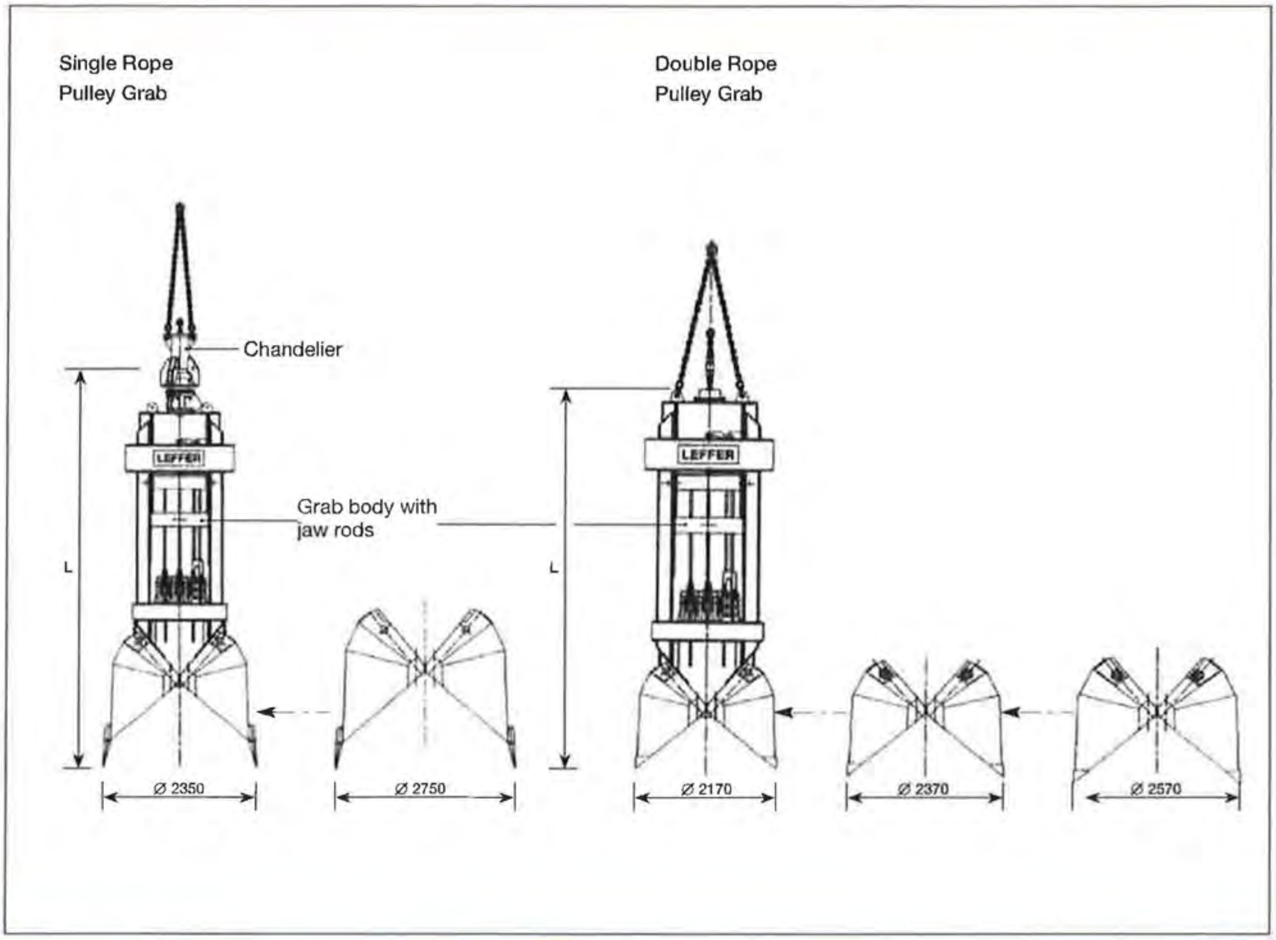
To recognize and correct any deviation of the vertical excavation direction, all hydraulic spherical grabs are equipped with a two-axis inclination sensor. The inclination sensor values are monitored inside the operator's cabin. For uncased drilled shafts the grab type HLKG "CD" is used. The jaw dimensions are adapted to the respective shaft diameter.

Technical Data



Pile diameter	Type	L	L1	L2	B	B1	B2	S	Weight	Capacity
				mm					kg	l
1200 cased	HLKG1-118	5760	6640	6715	870	1020	960	1080	8650	165
1200 uncased	HLKG1-1200 "CD"		6690	6800		1160	1170	1200	10550	230
1300 cased	HLKG1-130	5760	6690	6800	990	1010	1060	1180	8850	23
1300 uncased	HLKG1-1300 "CD"		6740	6900		1260	1270	1300	10850	400
1500 cased	HLKG1-150	5760	6800	7045	990	1350	1260	1380	9420	420
1500 uncased	HLKG1-1500 "CD"		6850	7135		1460	1470	1500	12115	680
1800 cased	HLKG1-180	5760	6975	6975	990	1650	1560	1670	11050	810
1800 uncased	HLKG1-1800 "CD"		7030	7345		1720	1750	1800	13850	1030
2000 cased	HLKG1-200	5760	7030	7470	990	1800	1700	1800	11290	1030
2000 uncased	HLKG1-2000 "CD"		7115	7625		1900	1950	2000	14290	1500

Single/Double Rope Pulley Grab L 2170-2570 SK/SZ



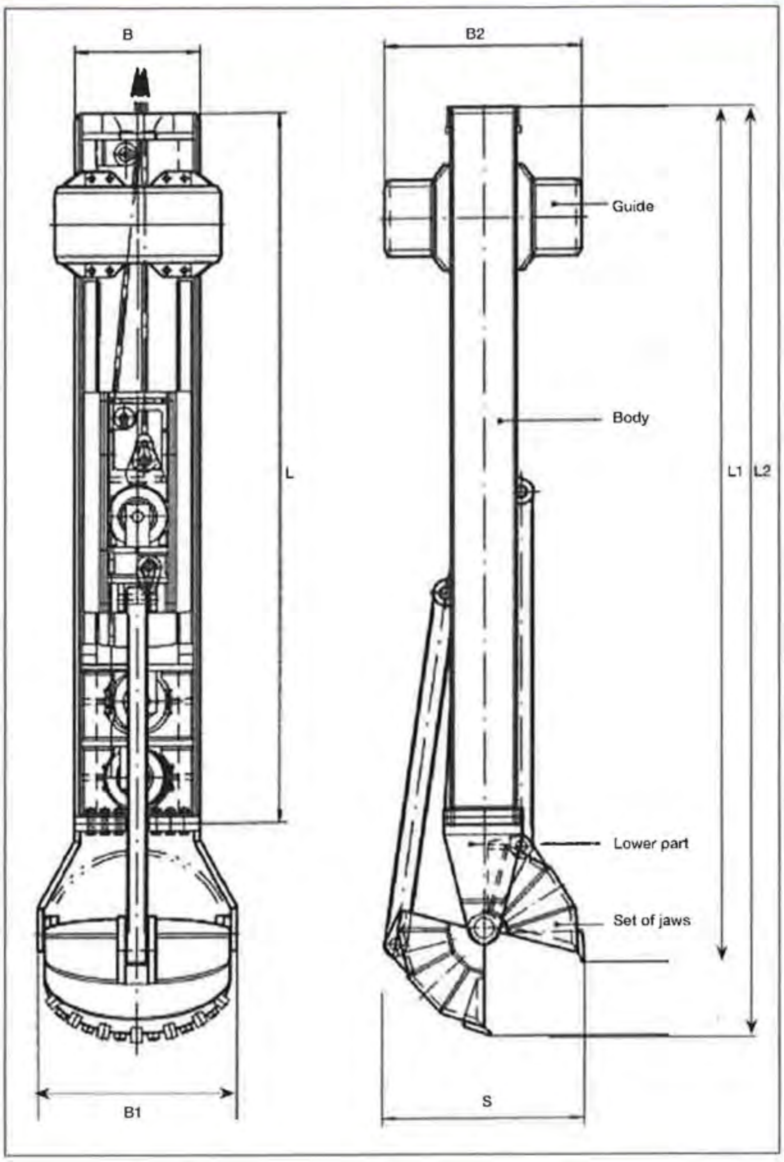
Technical Data

Type	Casing diameter mm	Length mm	Jaw capacity l	Weight kg
L2170 SK	2500/2400 · 2500/2380	6575	2500	17380
L2170 SZ		6040		17055
L2370 SK	2800/2680	6655	3500	18080
L2370 SZ		6125		17755
L2570 SK	2800/2680 · 3000/2840	6745	4500	18830
L2570 SZ		6210		18505

Mechanical Spherical Grab

LKG 0

Technical Data



Casing	Type	L	L1	L2	B	B1	B2	S	Weight	Capacity
				mm					kg	l
880/800 900/820	LKG 0-88	3700	4295	4545	600	670	740	785	5800	175
1000/920	LKG 0-100	3700	4380	4700	600	900	870	890	6000	200
1180/1100/ 1200/1120	LKG 0-118	3700	4460	4815	600	1000	1040	1065	6750	230

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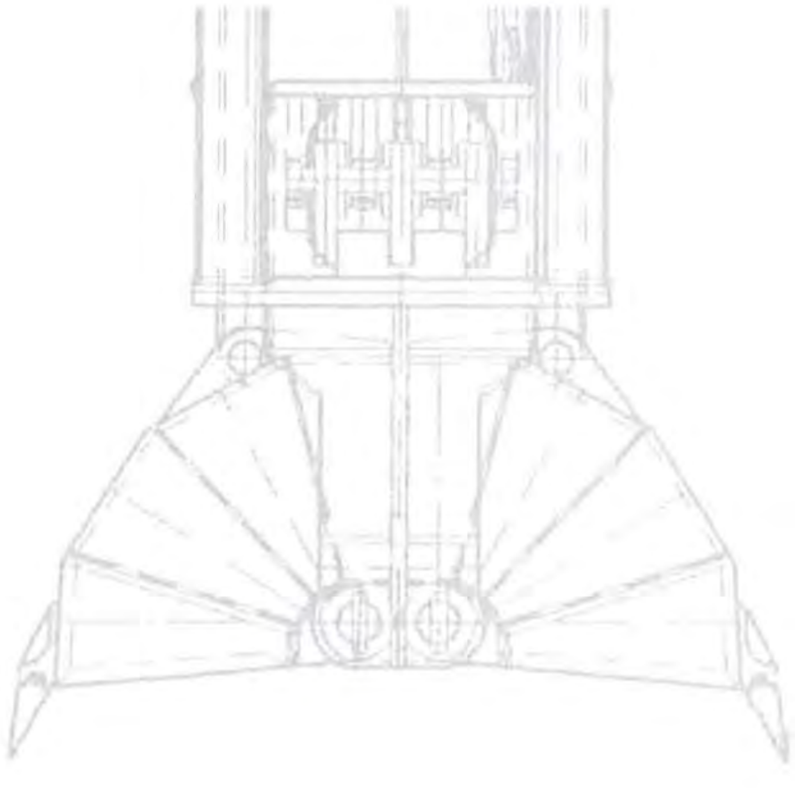
Mechanical Spherical Grab

880-3200 mm

General Remarks

for bored piles 880 – 3200 mm diameter

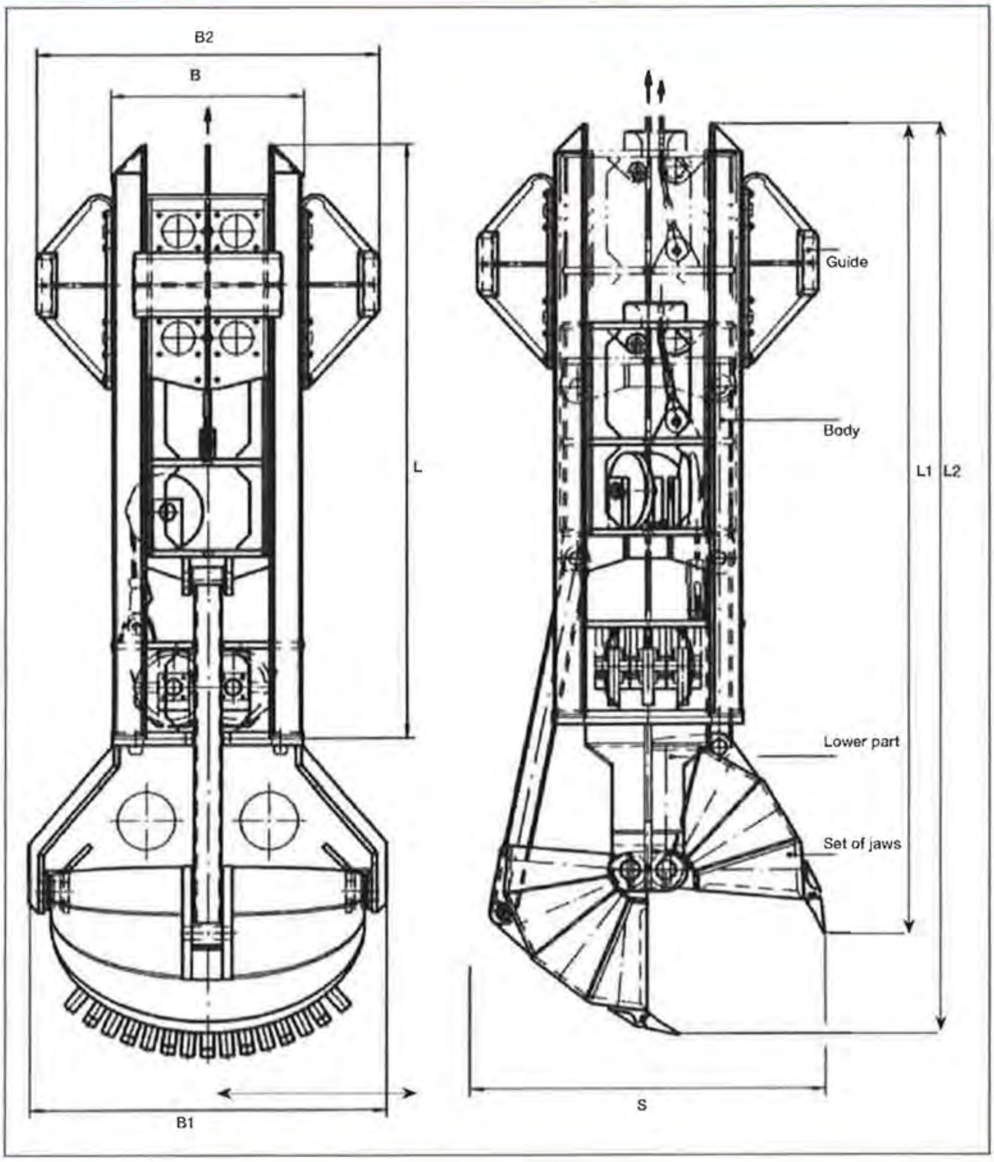
Double rope grab with high closing force especially suitable for vibration-free boring in semi-hard and hard soil conditions.



Mechanical Spherical Grab

LKG 3

Technical Data

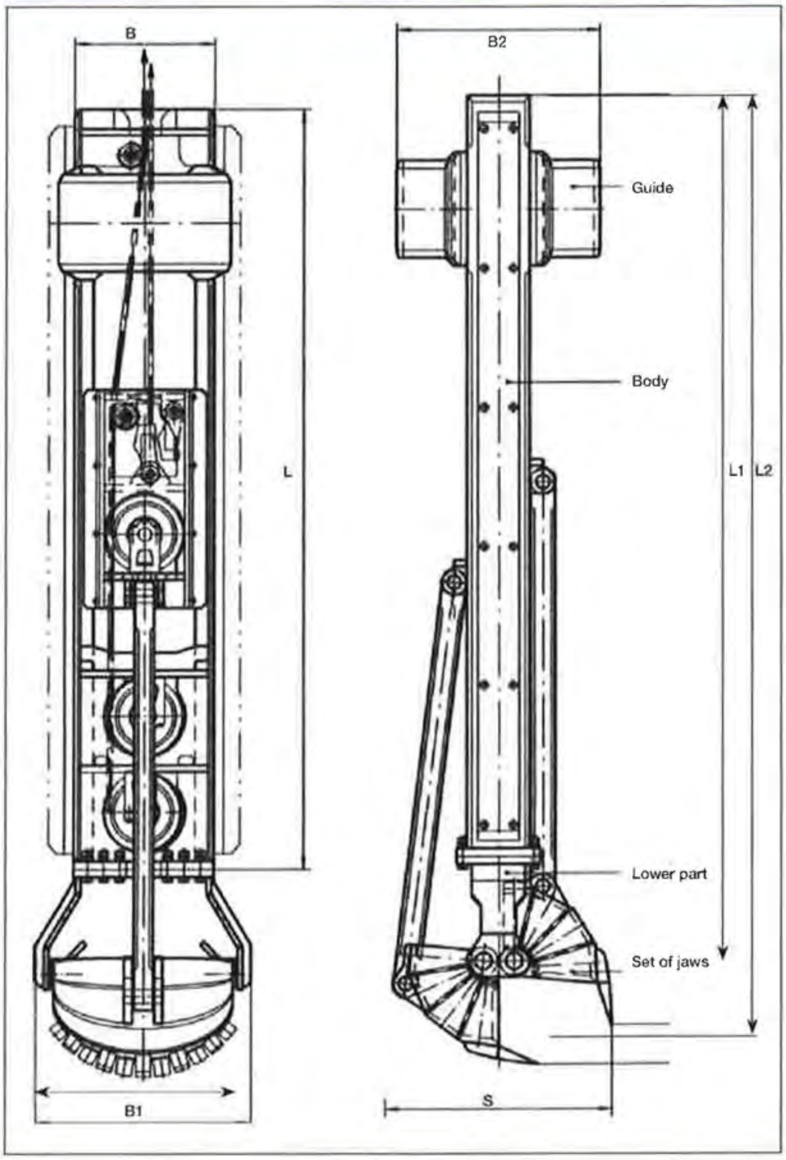


Casing	Type	L	L1	L2	B	B1	B2	S	Weight	Capacity
				mm					kg	l
2000/1880	LKG 3-200	4600	5700	6100	1500	1770	1650	1810	15050	970
2200/2080	LKG 3-220	4600	5800	6280	1500	1980	1900	2010	18200	1450
2500/2380	LKG 3-250	4600	6000	6615	1500	2290	2200	2310	19750	2250
2800/2640 2800/2680	LKG 3-280	4600	6125	6850	1500	2560	2460	2580	20800	3050
2980/2820 3000/2840	LKG 3-300	4600	6215	7000	1500	2760	2660	2710	21500	3900
3200/3040	LKG 3-320	4600	6325	7230	1500	2980	2900	2980	22100	4650

Mechanical Spherical Grab

LKG 1

Technical Data



Casing	Type	L	L1	L2	B	B1	B2	S	Weight	Capacity
				mm					kg	l
1180/1100/ 1200/1120	LKG 1-118	4700	5580	5655	870	1020	960	1080	8300	165
1300/1220	LKG 1-130	4700	5630	5745	870	1130	1060	1180	9700	230
1500/1400/ 1500/1420	LKG 1-150	4700	5745	5955	870	1350	1260	1380	11250	420
1800/1700 1800/1720	LKG 1-180	4700	5915	6285	870	1650	1560	1670	12000	810
2000/1880 2000/1910	LKG 1-200	4700	5980	6460	870	1800	1700	1800	12900	1030

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Interlocking Tremie Pipes

NW 150-NW 250

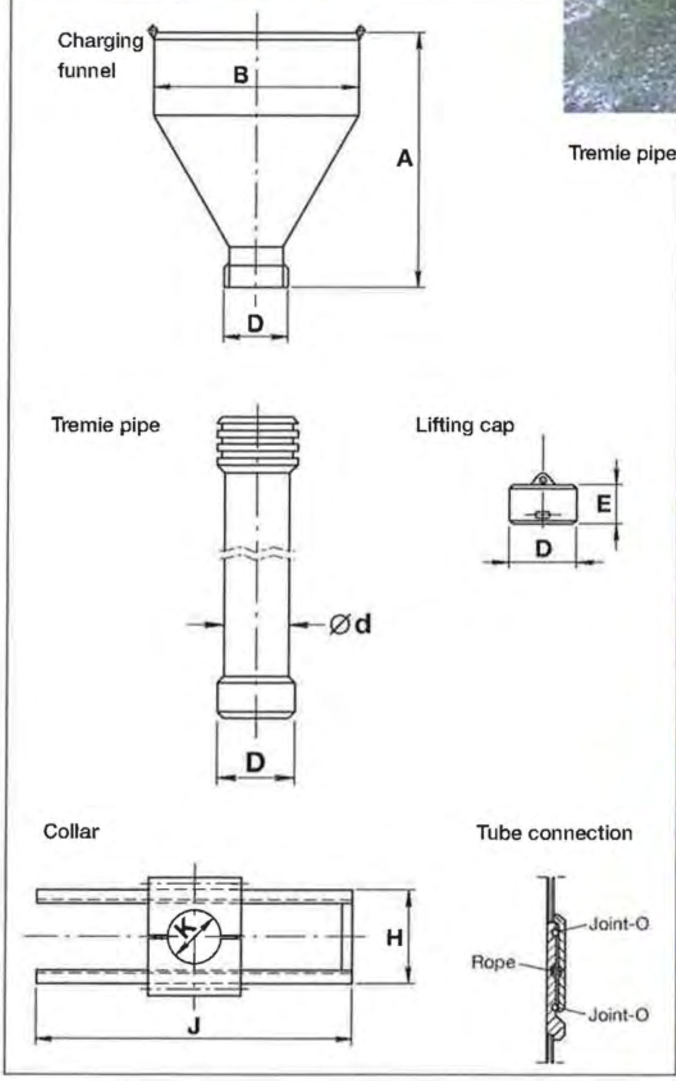
General Remarks

Water-tight interlocking tremie pipes

The tremie pipes can be supplied in all diameters and all lengths, also with charging funnel.

Tremie pipes 250 mm ∅, 2.5 m long, prior to shipment

Technical Data



Nominal diameter		NW 150	NW 200	NW 250
Tubes for concrete work				
∅ D/d	mm	194/159	241/203	300/267
Length 1 m	kg	26	35	45
Length 2 m	kg	42	55	70
Length 3 m	kg	57	74	96
Length 4 m	kg	72	93	121
Length 5 m	kg	87	113	147
Length 6 m	kg	102	132	173
Charging funnel				
∅ B	mm	400	750	1000
Height A	mm	1000	1100	1300
Weight	kg	45	85	160
Lifting cap				
Height E	mm	125	125	125
Weight	kg	9	11	12
Tremie pipe				
∅ K	mm	164	208	272
Width H	mm	400	400	450
Length J	mm	1200	1200	1500
Weight	kg	65	65	75

Chisel

Type A - Type B

General Remarks

To drive casings through rock

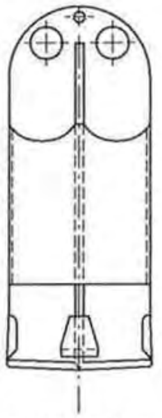
For the different rock conditions we offer two types of chisel:

Type A: Cross chisel with additional tangential cutting edges for rock with a compression strength of less than 1500 kg/cm^2.

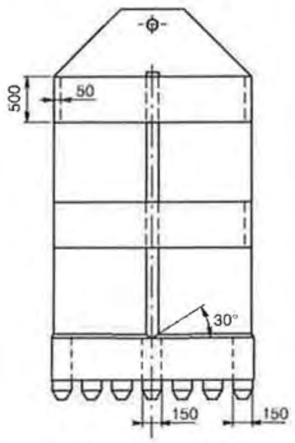
Type B: Round chisel with a cross inside for rock with a compression strength of more than 1500 kg/cm^2. The teeth are made of high manganeze steel.

Chisel Type B for hard rock

Technical Data



Cross chisel type A



Round chisel type B

Diameter of casings mm	Width of chisel mm	Length of chisel mm	Weight kg
640	530	3500	1930
700	590	3500	2200
750	640	3500	2400
800	690	3150	2550
880	770	3150	2700
900	770	3150	2700
1000	890	3000	3300
1080	970	3000	3600
1100	970	3000	3700
1180	1070	3500	5000
1200	1070	3500	5000
1300	1190	3500	5200
1500	1370	3500	7000
1800	1640	3500	8000
2000	1840	3850	10000
2200	2040	4000	12000
2500	2220	4000	14000
2800	2520	4000	16000
3000	2700	4000	18000

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Drehbohrwerkzeuge
Rotary Drilling Tools

3/2008




BAUER

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Zusatzbezeichnungen (für Schneckenbohrer und Bohreimer)
Additional classifications (for augers and buckets)

2 zweischneidig
double cut starter

F Felsausführung
for rock drilling

K Kaliberschneide
collar plate cutting ring

P Progressivausführung
tapered shape

Z ohne Zentrumspilot
without pilot bit

Schneckenbohrer
Augers

Die **Schneckenbohrer SB** sind sowohl für den Einsatz in trockenen Böden als auch für das Bohren im Fels geeignet.
Je nach Einsatzzweck wird ein verschiedener Zahnbesatz angeboten.
Die Geometrie des Zahnbesatzes ist für eine optimale Schneid- oder Reißwirkung abgestimmt.

Bei großen Bohrdurchmessern und bei unverrohrten Bohrungen wird eine zweischneidige Ausführung empfohlen.

Die Durchmesserreihe der Bauer Schneckenbohrer ist auf die Bauer Bohrrohre abgestimmt.

Sonderlängen und -durchmesser können auf Anfrage geliefert werden.
Die angegebenen Gewichte sind Cirka-Werte.

The **SB augers** have been designed for drilling in dry soil and in rock.
Various teeth configurations are available for different soil conditions. The geometry of the teeth arrangement is optimized for reaching excellent cutting performance.

For large drilling diameters or for the use in uncased bores, augers with double start head are recommended.

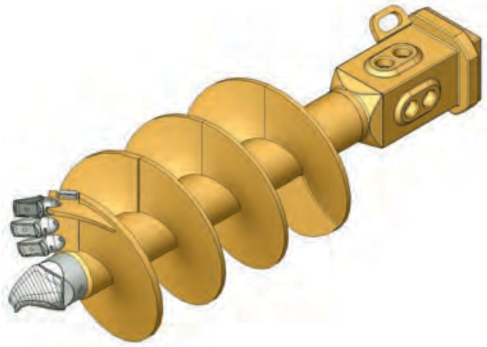
The diameter series of Bauer augers match with the Bauer casing tubes.

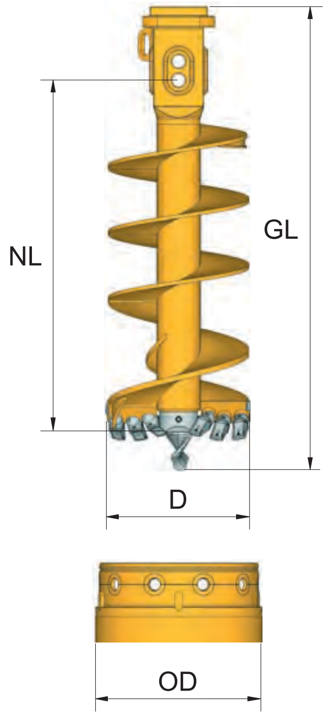
Other lengths and diameters can be supplied on request.
The weights are approximate values.

SB

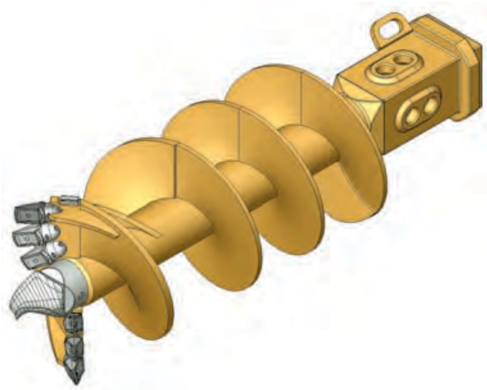
Schneckenbohrer
Auger

SB
einschneidig
single cut





SB-2
zweischneidig
double cut



Anwendungsbereich
weiche bis steife bindige Böden, locker bis mitteldicht gelagerte nichtbindige Böden
SB-2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser

Ausstattung
Kellybox 200 mm
Wendelpilot und Flachzähne FZ
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

Main application
soft to stiff silt and clay, loose to medium dense sand ,gravel
SB-2 is recommended for uncased bores or for bigger diameters

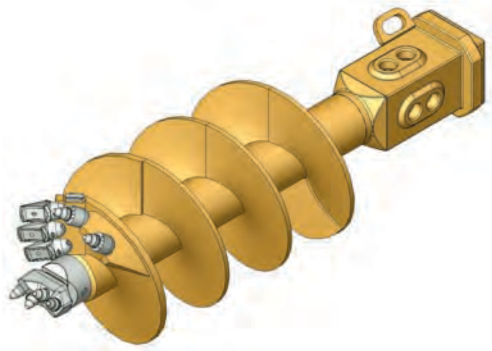
Features
Kellybox 200 mm
fishtail pilot and teeth FZ
wear protection: hard facing (standard) or wear strips (optional)

		SB		SB-2	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.315	2.865	2.315	2.865
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	630	770		
600		670	835		
650	750	690	850		
700		730	900		
780	880	780	970	740	930
800		790	980	750	940
900	1.000	810	1.010	780	980
1.000		880	1.100	830	1.055
1.060	1.180	940	1.190	885	1.130
1.180	1.300	1.020	1.270	930	1.190
1.200		1.100	1.355	970	1.240
1.350	1.500	1.185	1.470	1.050	1.330
1.500	1.650	1.260	1.630	1.175	1.470
1.650	1.800			1.415	1.920
1.800				1.660	2.203
1.830	2.000			1.705	2.260
2.000				1.945	2.510
2.320					2.950
2.500					3.250

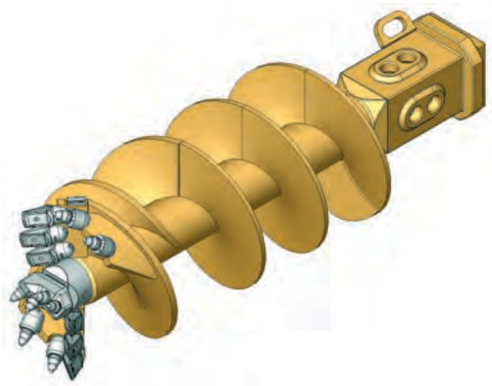
Schneckenbohrer (mit Kaliberschneide)
Auger (with collar plate)

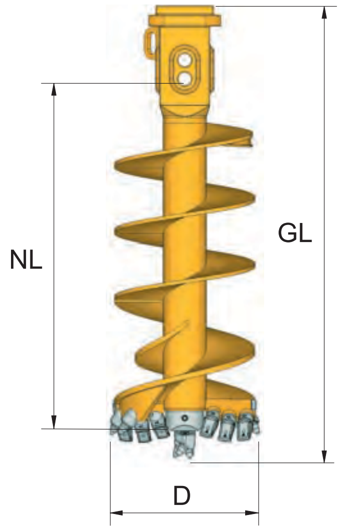
SB-K

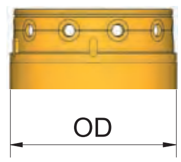
SB-K
einschneidig
single cut



SB-K2
zweischneidig
double cut







Anwendungsbereich
steife bis harte bindige Böden, mitteldicht bis dicht gelagerte nichtbindige Böden
SB-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Flachzähne FZ und Kaliberring mit Rundschaftmeißel
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

Main application
stiff to hard silt and clay, medium dense to dense sand, gravel
SB-K2 is recommended in uncased bores or for bigger diameters and for secant pile walls

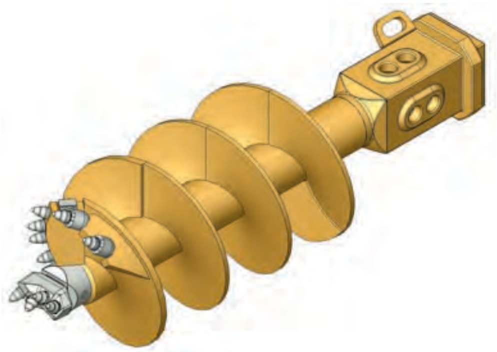
Features
Kellybox 200 mm
Round shank chisel pilot bit RP4, teeth FZ and collar plate with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

		SB-K		**SB-K2**	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.240	2.790	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	660	800		
600		695	840		
650	750	730	890		
700		770	940		
780	880	825	1.015	810	1.000
800		835	1.025	820	1.010
900	1.000	865	1.065	850	1.050
1.000		940	1.160	900	1.125
1.060	1.180	1.005	1.255	975	1.220
1.180	1.300	1.095	1.345	1.020	1.280
1.200		1.175	1.430	1.060	1.330
1.350	1.500	1.265	1.550	1.140	1.420
1.500	1.650	1.350	1.720	1.260	1.560
1.650	1.800			1.505	2.000
1.800				1.750	2.220
1.830	2.000			1.800	2.280
2.000				2.100	2.610
2.320					3.050
2.500					3.350

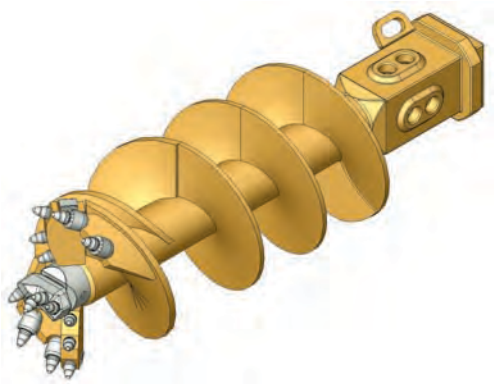
SBF-K

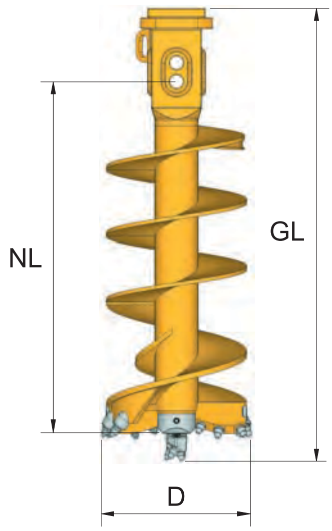
Felsschneckenbohrer (mit Kaliberschneide)
Rock auger (with collar plate)

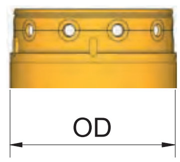
SBF-K
einschneidig
single cut



SBF-K2
zweischneidig
double cut







Anwendungsbereich
sehr dichter Sand und Kies, Bodenkasse 6-7, leichter Fels
SBF-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Schneidleiste und Kaliberring mit Rundschaftmeißeln
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

Main application
very dense sand and gravel, weak rock (< 5 Mpa)
SBF-K2 is recommended in uncased bores or for bigger diameters and secant pile walls

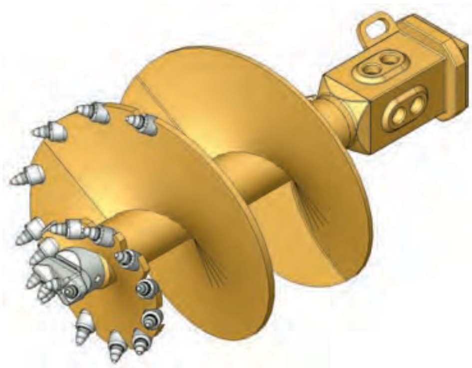
Features
Kellybox 200 mm
Round shank chisel pilot bit RP4, cutting edge and collar plate with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

		SBF-K		SBF-K2	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.240	2.790	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	660	805		
600		730	876		
650	750	760	917		
700		800	970		
780	880	835	1.026	880	1.030
800		840	1.035	890	1.050
900	1.000	870	1.070	930	1.130
1.000		940	1.160	1.000	1.230
1.060	1.180	1.030	1.267	1.070	1.320
1.180	1.300	1.090	1.340	1.150	1.370
1.200		1.150	1.405	1.220	1.480
1.350	1.500	1.230	1.515	1.320	1.560
1.500	1.650	1.300	1.655	1.450	1.840
1.650	1.800			1.690	2.290
1.800				1.930	2.575
1.830	2.000			1.980	2.630
2.000				2.220	2.880
2.320					3.350
2.500					3.520

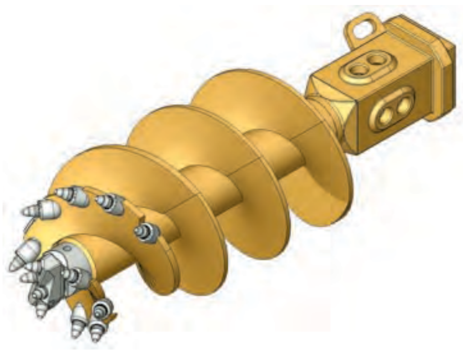
Progressivschneckenbohrer
Tapered rock auger

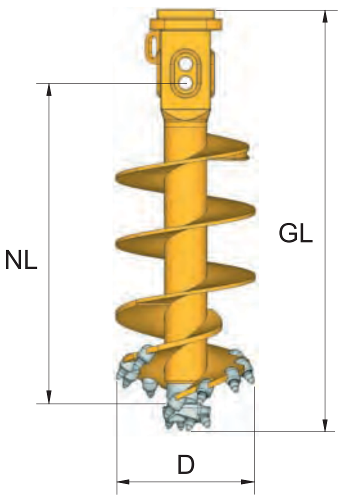
SBF-P

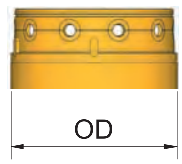
SBF-P
einschneidig
single cut



SBF-P2
zweischneidig
double cut







Anwendungsbereich
mittelharter bis harter Fels (12 – 100 MPa)
SBF-P2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4
progressive Schneidleiste mit Rundschaftmeißeln
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

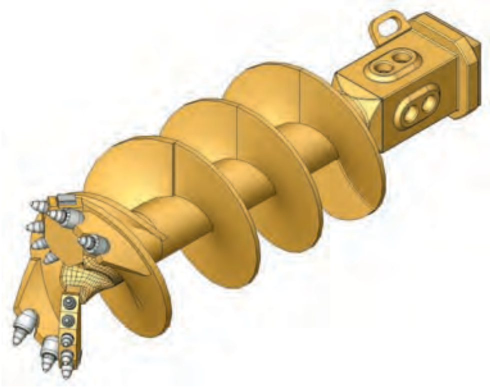
Main application
moderately strong to strong rock (12 – 100 MPa)
SBF-P2 is recommended in uncased bores or for bigger diameters

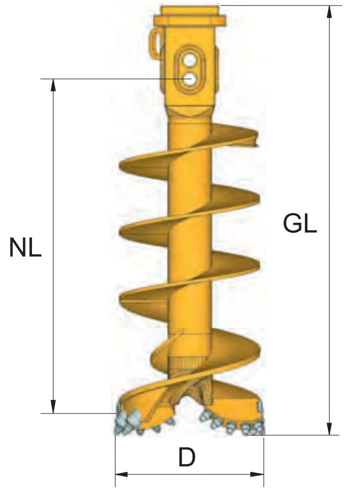
Features
Kellybox 200 mm
pilot bit RP4 with round shank chisels
progressive cutting edge with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

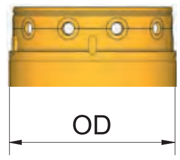
		SBF-P		**SBF-P2**	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.240	2.790	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	600	750		
600		625	770		
650	750	660	830		
700		695	870		
780	880	755	950	768	968
800		761	955	775	976
900	1.000	790	980	813	1.013
1.000		890	1.070	866	1.082
1.060	1.180	940	1.185	930	1.175
1.180	1.300	995	1.252	985	1.242
1.200		1.010	1.280	1.000	1.263
1.350	1.500	1.090	1.400	1.118	1.409
1.500	1.650	1.215	1.620	1.276	1.630
1.650	1.800			1.570	1.572
1.800				1.845	1.680
1.830	2.000			1.900	1.700
2.000				2.050	1.950
2.320					2.356
2.500					2.570

SBF-Z2 Felsschneckenbohrer (ohne Zentrumspilot)
Rock auger (without pilot bit)

SBF-Z2
zweischneidig
double cut







Anwendungsbereich
leichter bis mittelharter Fels (5 – 50 Mpa)
gut geeignet für klüftigen Fels

Ausstattung
Kellybox 200 mm
ohne Zentrumspilot
Schneidleiste mit Rundschaftmeißeln
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

Main application
moderately weak to moderately strong rock (5 – 50 Mpa)
very suitable in fractured rock

Features
Kellybox 200 mm
without pilot bit
cutting edge with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

		SBF-Z2	
	NL (mm)	1.700	2.250
	GL (mm)	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	675	800
600		700	845
650	750	760	915
700		820	995
780	880	900	1.050
800		910	1.065
900	1.000	950	1.150
1.000		1.030	1.270
1.060	1.180	1.100	1.350
1.180	1.300	1.180	1.400
1.200		1.250	1.510
1.350	1.500	1.360	1.600
1.500	1.650	1.500	1.890
1.650	1.800	1.750	2.350
1.800		2.000	2.642
1.830	2.000	2.050	2.700
2.000		2.300	2.950
2.320			3.420
2.500			3.700

Kernrohre
Core barrels

Mit **Kernrohren KR** wird ein Ringraum in Fels oder in (bewehrtem) Beton geschnitten.
Der Kern wird üblicherweise mit einem Fallmeißel, mit einer Felsschnecke oder mit einem „Cross-cutter“ zerstört.
Die Wirksamkeit des Kernrohres beruht auf der Konzentration des Drehmoments und der Anpresskraft auf einen schmalen Ring.

Die Durchmesserreihe der Bauer Kernrohre ist auf die Bauer Bohrrohre abgestimmt.

Sonderlängen und -durchmesser können auf Anfrage geliefert werden.
Die angegebenen Gewichte sind Cirka-Werte.

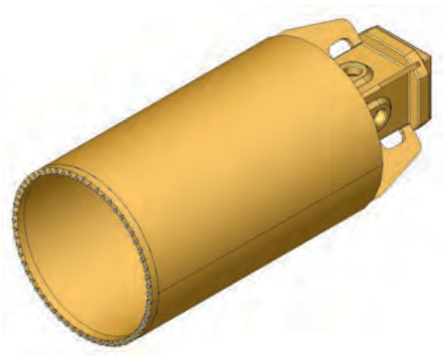
Core barrels KR are used for cutting an annular ring in rock or concrete (also reinforced concrete).
The centre core is usually broken with chisel, rock auger or cross-cutter.
The advantage of a core barrel is the concentration of the crowd force and torque on a small ring of cutting teeth.

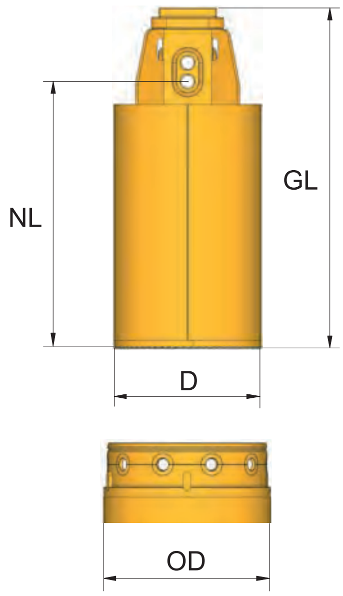
The diameter series of Bauer core barrels match with the Bauer casing tubes.

Other lengths and diameters can be supplied on request.
The weights are approximate values.

KR-S Kernrohr mit Stiftzähnen
Core barrel with pin teeth

KR-S





Anwendungsbereich
bevorzugt zum Durchkernen von (bewehrtem) Beton

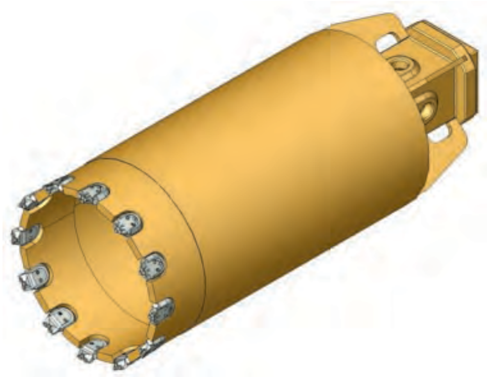
Main application
mainly recommended for cutting through (reinforced) concrete (e.g. slabs)

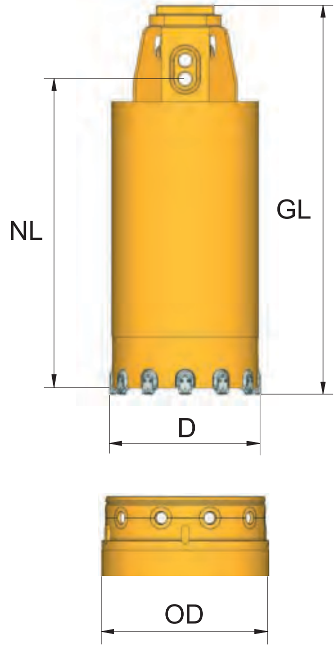
		KR-S	
	NL (mm)	1.475	1.575
	GL (mm)	1.865	1.965
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	420	
600		465	
650	750	500	
700		540	
780	880		680
800			695
900	1.000		780
1.000			870
1.060	1.180		920
1.180	1.300		1.040
1.200			1.055
1.350	1.500		1.220
1.500	1.650		1.370
1.650	1.800		1.530
1.800			1.690
1.830	2.000		1.725
2.000			1.920

Kernrohr mit Wechselstollen
Core barrel with replaceable blocks

KR-WS

KR-WS





Anwendungsbereich
harter Fels (bis 100 Mpa), leicht bewehrter Beton

Ausstattung
Kellybox 200 mm
Schneidring mit hartmetallbesetzten Stollen. Die Stollenhalter sind im Kernrohr versenkt angeschweißt.
Die Stollen sind mit einem Stift gesichert und können leicht gewechselt werden.

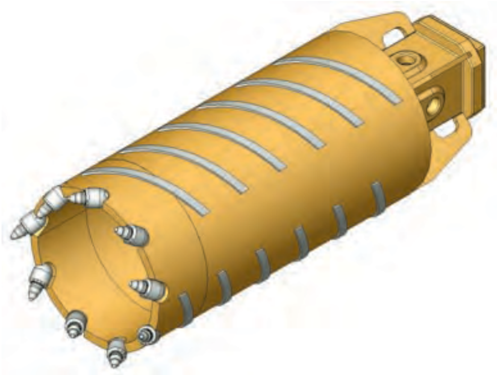
Main application
up to strong rock (100 Mpa), lightly reinforced concrete

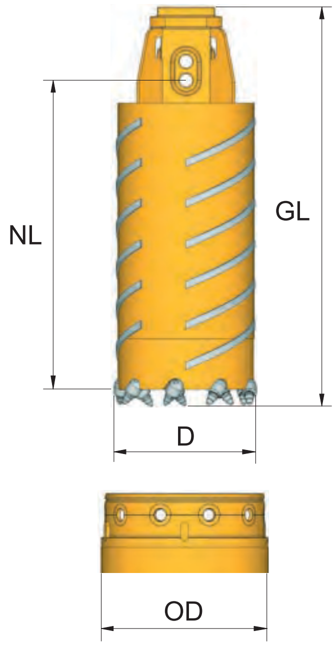
Features
Kellybox 200 mm
Cutting ring with tungsten carbide armoured blocks. The block holders are welded into the base ring of the core barrel.
The blocks are secured with a pin and can be easily replaced.

		KR-WS	
	NL (mm)	1.300	1.600
	GL (mm)	1.700	2.000
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	525	
600		570	
650	750	595	
700		645	
780	880		835
800			860
900	1.000		965
1.000			1.070
1.060	1.180		1.135
1.180	1.300		1.290
1.200			1.315
1.350	1.500		1.500
1.500	1.650		1.690
1.650	1.800		1.880
1.800			2.155
1.830	2.000		2.210
2.000			2.520

KR-R Kernrohr mit Rundschaftmeißel
Core barrel with round shank chisel

KR-R





Anwendungsbereich
harter Fels (bis 100 Mpa)
gut geeignet in klüftigem Fels

Ausstattung
Kellybox 200 mm
Schneidring mit versetzt angeordneten Rundschaftmeißeln mit einer Gesamtschnittbreite von 120 mm
Angeschweißte Meißelhalter
Die Rundschaftmeißel können mit geeignetem Werkzeug leicht ausgewechselt werden.

Main application
up to strong rock (100 MPa)
suitable for cutting through fissured rock

Features
Kellybox 200 mm
Cutting ring with staggered arrangement of round shank chisels with a total cutting width of 120 mm
Chisel holders are welded to the base body. The round shank chisels can be easily replaced when using suitable tools.

		KR-R	
	NL (mm)	1.475	1.825
	GL (mm)	1.815	2.215
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	575	
600		650	
650	750	705	
700		780	
780	880		930
800			955
900	1.000		1.080
1.000			1.200
1.060	1.180		1.270
1.180	1.300		1.440
1.200			1.470
1.350	1.500		1.680
1.500	1.650		1.880
1.650	1.800		2.090
1.800			2.200
1.830	2.000		2.220
2.000			2.600
2.320			2995
2.500			3265

Bohreimer
Drilling buckets

Die **Bohreimer KB** sind vor allem zum Bohren aller Bodenarten in wasserführenden Böden geeignet.
Für die Anwendung in verschiedenen Bodenarten stehen Drehböden mit verschiedenem Zahnbesatz zur Verfügung.

Die Öffnung des Drehbodens erfolgt durch ein Verriegelungssytem, das durch den Drehteller oder manuell ausgelöst werden kann. Ein Entlüftungskanal verhindert den Aufbau eines Vakuums beim Ziehen des Bohreimers.

Bei großen Bohrdurchmessern und bei unverrohrten Bohrungen wird eine zweischneidige Ausführung empfohlen.

Die Durchmesserreihe der Bauer Bohreimer ist auf die Bauer Bohrrohre abgestimmt.

Sonderlängen und -durchmesser können auf Anfrage geliefert werden.
Die angegebenen Gewichte sind Cirka-Werte.

The **drilling buckets KB** are designed specifically for drilling all types of soils below groundwater.
For drilling in a variety of soil conditions swivelled bottom gates can be supplied with different types of teeth.

The opening of the swivelled bottom gate is facilitated by an automatic or manual tip mechanism. A ventilation pipe prevents the occurrence of a vacuum when lifting the tool.

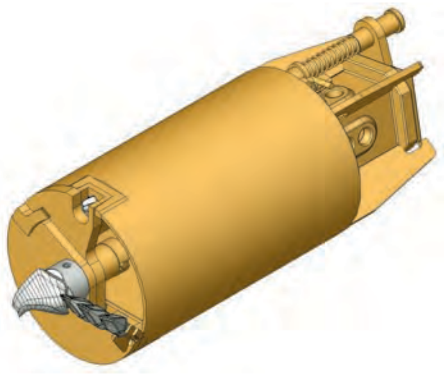
For large drilling diameters or for the use in uncased bores, buckets with double start head are recommended.

The diameter series of Bauer buckets match with the Bauer casing tubes.

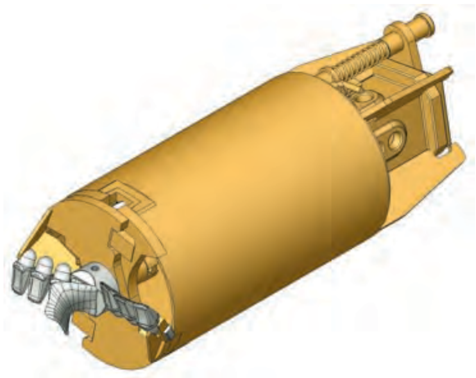
Other lengths and diameters can be supplied on request.
The weights are approximate values.

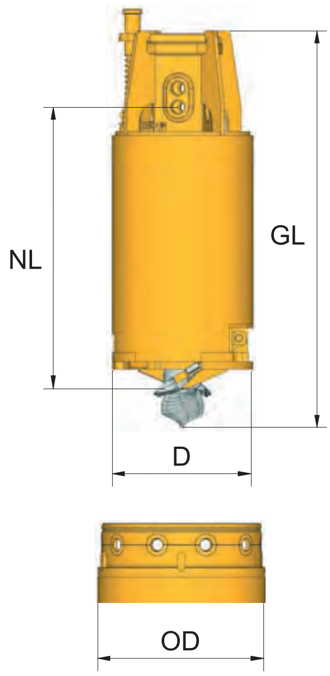
KB Bohreimer
Drilling bucket

KB
einschneidig
single cut



KB-2
zweischneidig
double cut





Anwendungsbereich
weiche bis steife bindige Böden, locker bis mitteldicht gelagerte nichtbindige Böden
KB bis Grobkies
KB-2 bevorzugt für unverrohrte Bohrungen und für große Durchmesser.

Ausstattung
Kellybox 200 mm
Wendelpilot und Flachzähne FZ
Belüftungsschacht
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißstreifen (optional)

Main application
soft to stiff silt and clay, loose to medium dense sand and gravel
KB up to coarse gravel
KB-2 is recommended in uncased bores and for bigger diameters.

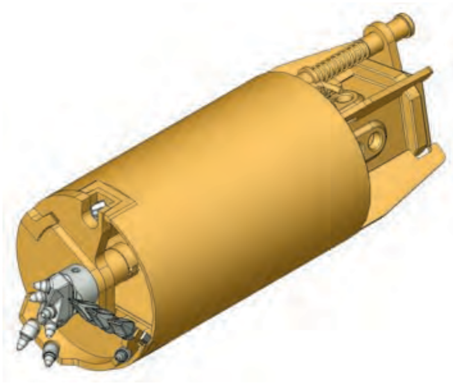
Features
Kellybox 200 mm
fishtail pilot and flat teeth FZ
ventilation pipe pipe
wear protection: hard facing (standard) or wear strips (optional)

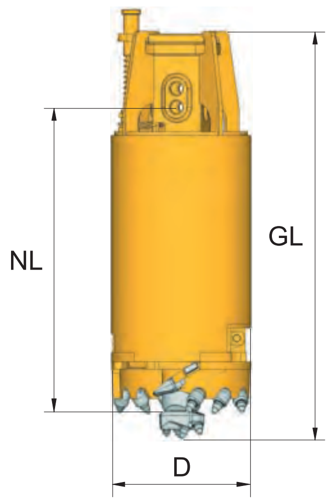
		KB		KB-2	
	NL (mm)	1.550	1.850	1.750	1.850
	GL (mm)	2.300	2.600	2.500	2.600
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	656	733		
600		750	893		
650	750	824	908		
700		894	894		
780	880	1.006	1.107		
800		1.040	1.140		
900	1.000	1.195	1.310		
1.000		1.380	1.500		
1.060	1.180	1.515	1.593	1.620	1.750
1.180	1.300	1.702	1.830	1.794	1.934
1.200		1.770	1.930	1.855	1.995
1.350	1.500	2.033	2.196	2.057	2.207
1.500	1.650	2.290	2.460	2.217	2.387
1.650	1.800			2.565	2.750
1.800				3.705	3.915
1.830	2.000			3.795	4.005
2.000				4.120	4.350
2.320				4.935	5.495
2.500				5.510	5.795

Bohreimer (mit Kaliberschneide)
Drilling bucket (with collar plate)

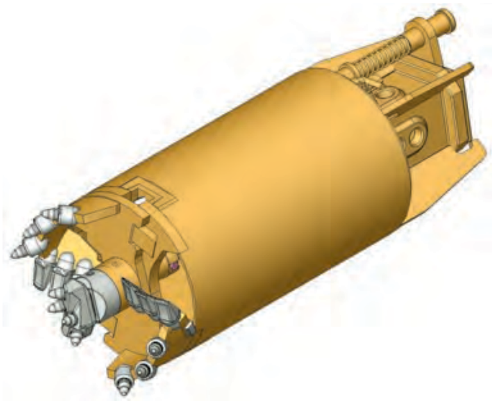
KB-K

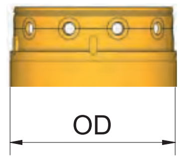
KB-K
einschneidig
single cut





KB-K2
zweischneidig
double cut





Anwendungsbereich
weiche bis harte bindige Böden, locker bis dicht gelagerte nichtbindige Böden
KB-K bis zu Grobkies
KB-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und für überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Flachzähne FZ und Kaliberring mit Rundschaftmeißel
Entlüftungsschacht
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißstreifen (optional)

Main application
soft to hard silt and clay, loose to dense sand and gravel
KB-K up to coarse gravel
KB-K2 is recommended in uncased bores or for bigger diameters and for secant pile walls.

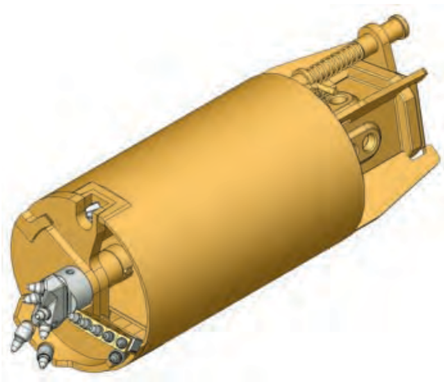
Features
Kellybox 200 mm
round shank chisel pilot bit RP4, teeth FZ and collar plate with round shank chisels
ventilation pipe
wear protection: hard facing (standard) or wear strips (optional)

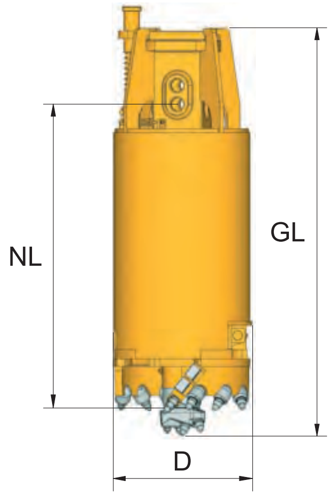
		KB-K		KB-K2	
	NL (mm)	1.550	1.850	1.750	1.850
	GL (mm)	2.350	2.550	2.450	2.550
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	689	766		
600		790	933		
650	750	869	953		
700		929	1.019		
780	880	1.041	1.142		
800		1.075	1.180		
900	1.000	1.250	1.365		
1.000		1.432	1.552		
1.060	1.180	1.580	1.658	1.680	1.810
1.180	1.300	1.747	1.875	1.865	2.005
1.200		1.867	2.027	1.900	2.040
1.350	1.500	2.164	2.327	2.077	2.227
1.500	1.650	2.465	2.635	2.265	2.435
1.650	1.800			2.705	2.890
1.800				3.720	3.930
1.830	2.000			3.750	3.960
2.000				4.260	4.490
2.320				4.955	5.215
2.500				5.510	5.795

KBF-K

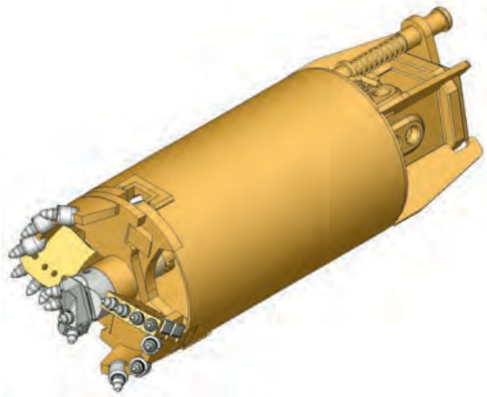
Felsbohreimer (mit Kaliberschneide)
Rock drilling bucket (with collar plate)

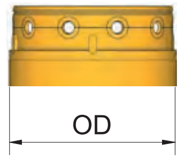
KBF-K
einschneidig
single cut





KBF-K2
zweischneidig
double cut





Anwendungsbereich
sehr dichter Sand und Kies, Bodenkasse 6, leichter Fels
KBF-K bis zu Grobkies
KBF-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Schneidleiste und Kaliberring mit Rundschaftmeißel
Entlüftungsschacht
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißstreifen (optional)

Main application
very dense sand and gravel, weak rock
KBF-K up to coarse gravel
KBF-K2 is recommended in uncased bores or for bigger diameters and for secant pile walls

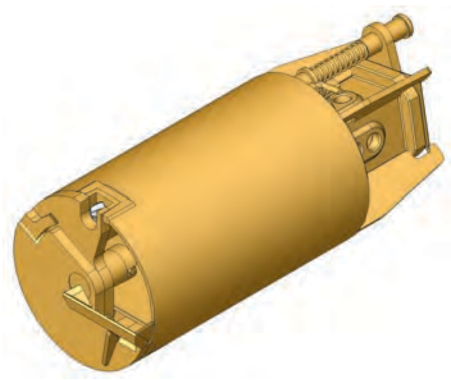
Features
Kellybox 200 mm
round shank chisel pilot bit RP4, cutting edge and collar plate with round shank chisels
ventilation pipe
wear protection: hard facing (standard) or wear strips (optional)

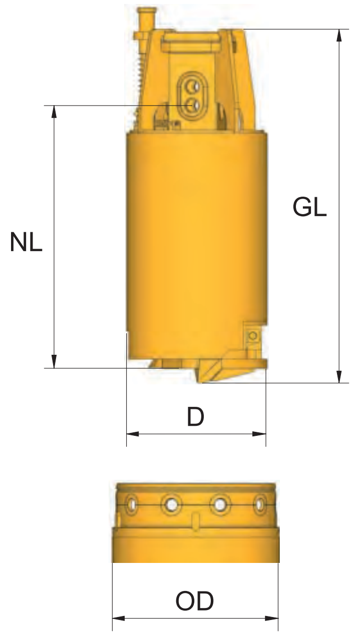
		KBF-K		KBF-K2	
	NL (mm)	1.550	1.850	1.750	1.900
	GL (mm)	2.250	2.550	2.450	2.600
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	681	758		
600		780	923		
650	750	853	937		
700		932	1.022		
780	880	1.040	1.141		
800		1.076	1.180		
900	1.000	1.258	1.373		
1.000		1.437	1.557		
1.060	1.180	1.600	1.678	1.680	1.810
1.180	1.300	1.802	1.930	1.840	1.980
1.200		1.885	2.045	1.885	2.025
1.350	1.500	2.152	2.315	2.130	2.280
1.500	1.650	2.450	2.620	2.330	2.500
1.650	1.800			2.750	2.935
1.800				3.680	3.890
1.830	2.000			3.705	3.915
2.000				4.240	4.470
2.320				5.125	5.385
2.500				5.620	5.905

Bohreimer mit Räumerleiste
Drilling bucket with cleaning edge

KB-L

KB-L





Anwendungsbereich
Säubern der Bohrlochsohle

Main application
cleaning the bottom of the borehole

		KB-L	
	NL (mm)	1.550	1.850
	GL (mm)	2.100	2.400

D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	614	691
600		709	852
650	750	782	866
700		850	940
780	880	959	1.060
800		990	1.095
900	1.000	1.141	1.256
1.000		1.327	1.447
1.060	1.180	1.474	1.552
1.180	1.300	1.652	1.780
1.200		1.714	1.874
1.350	1.500	1.984	2.147
1.500	1.650	2.227	2.397

Sonderbohrwerkzeuge

KR-RM Rollenmeißelkernrohr
Core barrel with round shank chisel

Rollenmeißelkernrohre werden bei sehr hartem Fels mit einer Festigkeit > 100 MPa verwendet.
Die Schneidbreite des Ringspalts beträgt je nach Rollenmeißelbesatz 220 oder 320 mm.

Das Bohrklein wird normalerweise in einen Auffangbehälter gefördert der über dem Kernrohr sitzt. (Lufthebeverfahren oder Druckspülung mit Ventilklappe). Nach etwa 1 m Kernfortschritt wird das Kernrohr aus der Bohrung gehoben und der Auffangbehälter entleert. Bei kürzeren Kerntiefen kann auch ohne Spülung gearbeitet werden.

Roller bit core barrels KR-RM are used in very strong rock formations (compressive strength > 100 MPa). KR-RM core barrels use rock roller bits for cutting the annular groove with a width of 220 or 320 mm and remove the rock chippings by air-lift technique or flushing (activated by a vent flap) into a dust collector box mounted on top of the core barrel. The core barrel is extracted from the bore after coring a length of about 1 m and the dust collector box is emptied. For shorter coring lengths it is possible to work without a flushing system.

Pfahlfußaufschneider
Belling bucket

Pfahlfußaufschneider werden in standfesten Böden zur Erweiterung der Pfahlsohle eingesetzt. Die Schneidarme werden beim Aufschneiden durch vertikales Andrücken auf die Schubstange nach außen geklappt. Der Boden, der durch die Drehbewegung der Schneidarme gelöst wird, fällt in den Aufschneiderkörper. Vor dem Ziehen des Pfahlfußaufschneiders werden die Schneidarme durch Zug an der Schubstange geschlossen.
Der Öffnungswinkel des aufgeweiteten Fußes beträgt normalerweise 60°. Der Durchmesser des aufgeschnittenen Pfahlfußes ist ungefähr 2 – 3 mal so groß wie der Schaftdurchmesser.

A belling bucket is used for enlarging the pile base in stable (mainly cohesive) soil conditions. The cutting arms are gradually opened by applying vertical crowd force on a push rod and a leverage system. The spoil falls into the open shell of the bucket. When extracting the tool from the borehole, the upward movement of the kelly bar transmits the pull onto the push rod and the cutting arms are closed. The maximum opening angle of the bell is about 60° and the standard increase of diameter is about 2 – 3 times the shaft diameter.

Special drilling tools

Cross cutter KR-X

„Cross Cutter“ KR-X werden zum Zerstören von Kernstöcken, die beim Bohren mit Kernrohren stehen bleiben, eingesetzt. Der entspannte Felskern wird mit dem "Cross Cutter" zerkleinert und das Bohrgut wird anschließend mit einem Bohreimer gefördert.

A Cross-Cutter (KR-X) is used to break rock cores which remain in the borehole after using a core barrel.
The core is broken with round shank chisels. The cuttings are then removed with buckets.

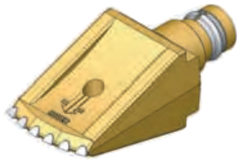
Bohreimer für Ton Clay bucket KB-C

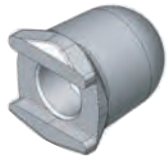
Zum Bohren von Tonböden wird normalerweise der Standarbohreimer KB verwendet. Für Bohrungen die ausschließlich aus Ton bestehen oder beim Antreffen von hochplastischem klebrigen Ton wird der Spezialbohreimer KB-C vorgeschlagen.
Er besitzt keinen Drehboden aber vergrößerte Eintrittsöffnungen und lange Schneidzähne.
Zusätzlich kann er als Variante mit einem konischen Grundkörper versehen werden. Diese Grundkörperform erleichtert das Entleeren von stark plastischem Ton.

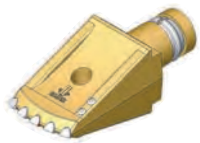
The bucket KB is the standard tool when drilling in clay. When encountering sticky clay with high plasticity or when drilling in clay, a special clay bucket KB-C can be offered.
The bucket has no swivelled bottom gate. It is equipped with enlarged bottom openings and long cutting teeth.
Optionally it can be provided with a conical base body.
The conical shape eases discharging of sticky clay.

Verschleißteile Bohrwerkzeuge — Wear parts for drilling tools

Flachzähne FZ
Flat teeth FZ


FZ 87


FZH 87


FZ 72

Rundschaftmeißel RSM
Round shank chisel RSM


C 402


C 403


H 85-1

Anschweißzähne
Weld-on blocks


AS 29/4


AS 34/7


AS 40/7

Wechselstollen
Replaceable blocks

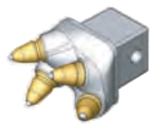

WS 38

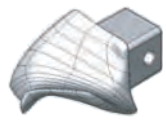

WS 39


Halter SH 35
Holder SH 35

Piloten
Pilot bits

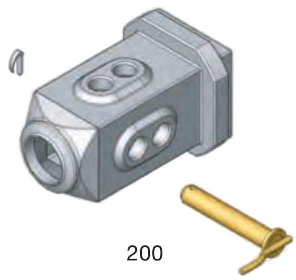

ZP 190


RP 4-200


Wendelpilot
Fishtail bit

Kellybox
Kelly box


150


200

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Technische Änderungen ohne Vorankündigung und Verpflichtung gegenüber früher gelieferten Geräten. Die abgebildeten Geräte können Sonderausstattungen haben. Für weitere Verschleißteile siehe 905.618.1. Irrtum und Druckfehler vorbehalten.

Technical Specifications are subject to change without prior notice and incurring responsibility for machines previously sold. The shown machines may have special equipment. For more wear parts please refer to 905.618.1. Error and misprints reserved.

Drehbohrwerkzeuge
Rotary Drilling Tools

3/2008

BAUER

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Zusatzbezeichnungen (für Schneckenbohrer und Bohreimer)
Additional classifications (for augers and buckets)

2 zweischneidig
double cut starter

F Felsausführung
for rock drilling

K Kaliberschneide
collar plate cutting ring

P Progressivausführung
tapered shape

Z ohne Zentrumspilot
without pilot bit

Schneckenbohrer
Augers

Die **Schneckenbohrer SB** sind sowohl für den Einsatz in trockenen Böden als auch für das Bohren im Fels geeignet.
Je nach Einsatzzweck wird ein verschiedener Zahnbesatz angeboten. Die Geometrie des Zahnbesatzes ist für eine optimale Schneid- oder Reißwirkung abgestimmt.

Bei großen Bohrdurchmessern und bei unverrohrten Bohrungen wird eine zweischneidige Ausführung empfohlen.

Die Durchmesserreihe der Bauer Schneckenbohrer ist auf die Bauer Bohrrohre abgestimmt.

Sonderlängen und -durchmesser können auf Anfrage geliefert werden.
Die angegebenen Gewichte sind Cirka-Werte.

The **SB augers** have been designed for drilling in dry soil and in rock.
Various teeth configurations are available for different soil conditions. The geometry of the teeth arrangement is optimized for reaching excellent cutting performance.

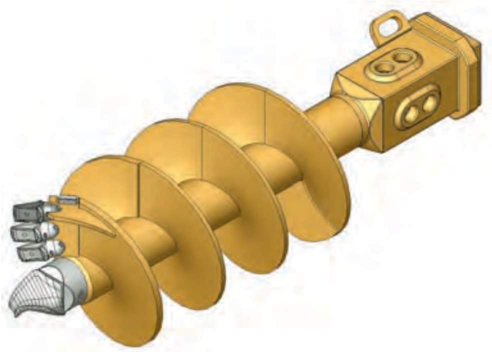
For large drilling diameters or for the use in uncased bores, augers with double start head are recommended.

The diameter series of Bauer augers match with the Bauer casing tubes.

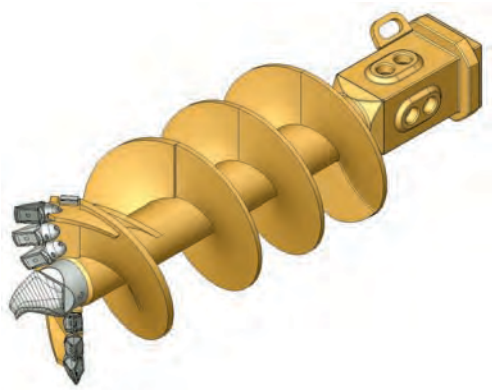
Other lengths and diameters can be supplied on request.
The weights are approximate values.

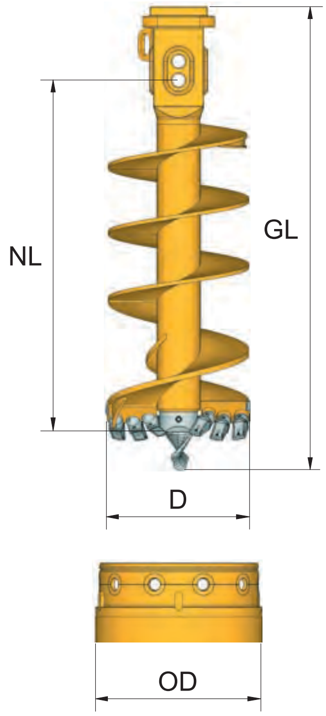
SB Schneckenbohrer
Auger

SB
einschneidig
single cut



SB-2
zweischneidig
double cut





Anwendungsbereich
weiche bis steife bindige Böden, locker bis mitteldicht gelagerte nichtbindige Böden
SB-2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser

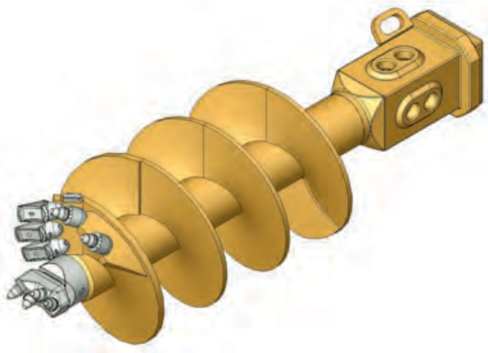
Ausstattung
Kellybox 200 mm
Wendelpilot und Flachzähne FZ
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

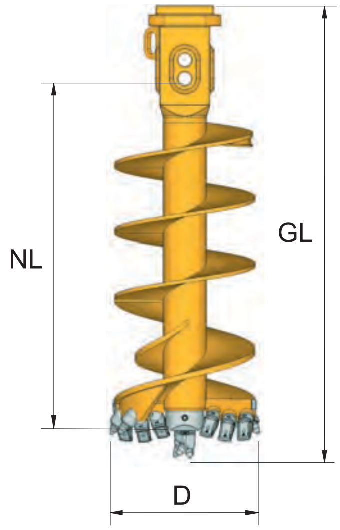
Main application
soft to stiff silt and clay, loose to medium dense sand ,gravel
SB-2 is recommended for uncased bores or for bigger diameters

Features
Kellybox 200 mm
fishtail pilot and teeth FZ
wear protection: hard facing (standard) or wear strips (optional)

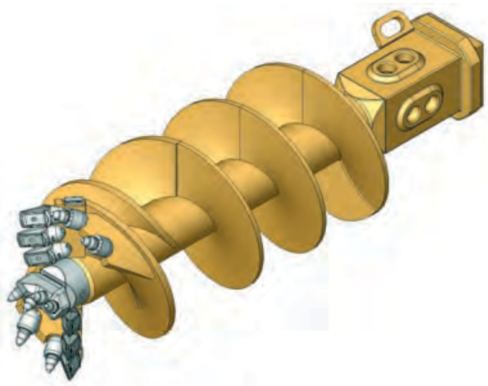
		SB		SB-2	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.315	2.865	2.315	2.865
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	630	770		
600		670	835		
650	750	690	850		
700		730	900		
780	880	780	970	740	930
800		790	980	750	940
900	1.000	810	1.010	780	980
1.000		880	1.100	830	1.055
1.060	1.180	940	1.190	885	1.130
1.180	1.300	1.020	1.270	930	1.190
1.200		1.100	1.355	970	1.240
1.350	1.500	1.185	1.470	1.050	1.330
1.500	1.650	1.260	1.630	1.175	1.470
1.650	1.800			1.415	1.920
1.800				1.660	2.203
1.830	2.000			1.705	2.260
2.000				1.945	2.510
2.320					2.950
2.500					3.250

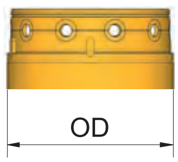
SB-K
einschneidig
single cut





SB-K2
zweischneidig
double cut





Anwendungsbereich
steife bis harte bindige Böden, mitteldicht bis dicht gelagerte nichtbindige Böden
SB-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Flachzähne FZ und Kaliberring mit Rundschaftmeißel
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

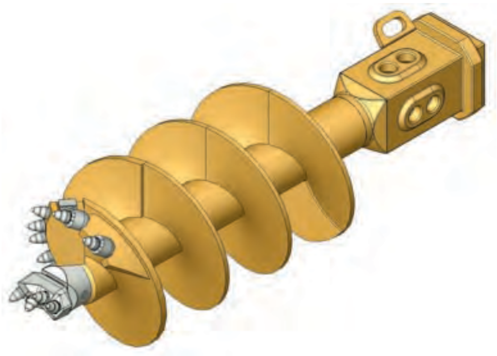
Main application
stiff to hard silt and clay, medium dense to dense sand, gravel
SB-K2 is recommended in uncased bores or for bigger diameters and for secant pile walls

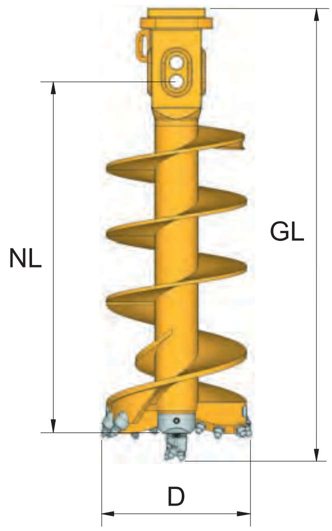
Features
Kellybox 200 mm
Round shank chisel pilot bit RP4, teeth FZ and collar plate with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

		SB-K		SB-K2	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.240	2.790	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	660	800		
600		695	840		
650	750	730	890		
700		770	940		
780	880	825	1.015	810	1.000
800		835	1.025	820	1.010
900	1.000	865	1.065	850	1.050
1.000		940	1.160	900	1.125
1.060	1.180	1.005	1.255	975	1.220
1.180	1.300	1.095	1.345	1.020	1.280
1.200		1.175	1.430	1.060	1.330
1.350	1.500	1.265	1.550	1.140	1.420
1.500	1.650	1.350	1.720	1.260	1.560
1.650	1.800			1.505	2.000
1.800				1.750	2.220
1.830	2.000			1.800	2.280
2.000				2.100	2.610
2.320					3.050
2.500					3.350

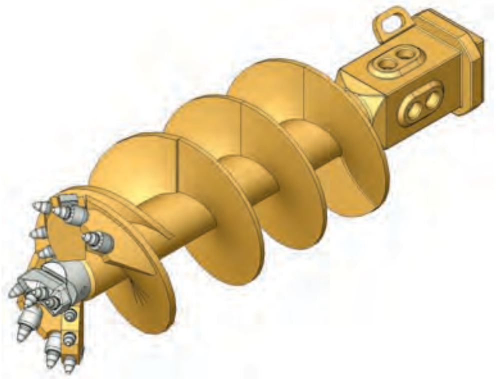
SBF-K Felsschneckenbohrer (mit Kaliberschneide)
Rock auger (with collar plate)

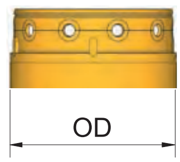
SBF-K
einschneidig
single cut





SBF-K2
zweischneidig
double cut





Anwendungsbereich
sehr dichter Sand und Kies, Bodenkasse 6-7, leichter Fels
SBF-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Schneidleiste und Kaliberring mit Rundschaftmeißeln
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

Main application
very dense sand and gravel, weak rock (< 5 Mpa)
SBF-K2 is recommended in uncased bores or for bigger diameters and secant pile walls

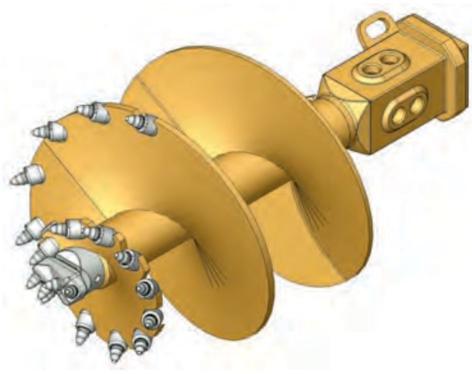
Features
Kellybox 200 mm
Round shank chisel pilot bit RP4, cutting edge and collar plate with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

		SBF-K		SBF-K2	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.240	2.790	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	660	805		
600		730	876		
650	750	760	917		
700		800	970		
780	880	835	1.026	880	1.030
800		840	1.035	890	1.050
900	1.000	870	1.070	930	1.130
1.000		940	1.160	1.000	1.230
1.060	1.180	1.030	1.267	1.070	1.320
1.180	1.300	1.090	1.340	1.150	1.370
1.200		1.150	1.405	1.220	1.480
1.350	1.500	1.230	1.515	1.320	1.560
1.500	1.650	1.300	1.655	1.450	1.840
1.650	1.800			1.690	2.290
1.800				1.930	2.575
1.830	2.000			1.980	2.630
2.000				2.220	2.880
2.320					3.350
2.500					3.520

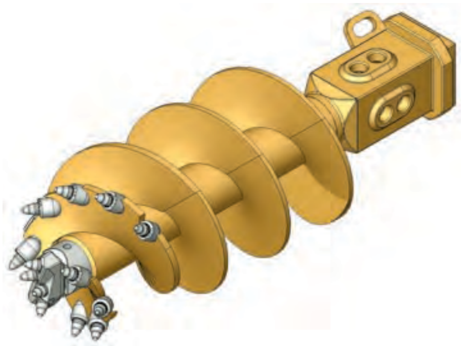
Progressivschneckenbohrer
Tapered rock auger

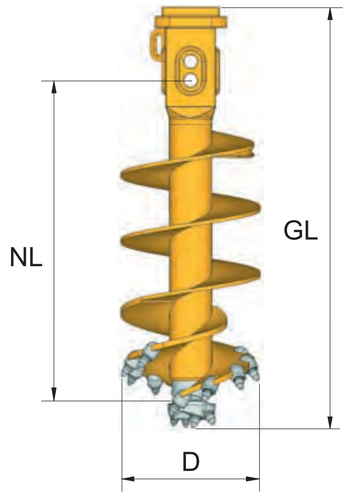
SBF-P

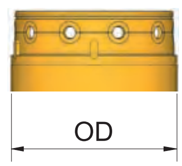
SBF-P
einschneidig
single cut



SBF-P2
zweischneidig
double cut







Anwendungsbereich
mittelharter bis harter Fels (12 – 100 MPa)
SBF-P2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4
progressive Schneidleiste mit Rundschaftmeißeln
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

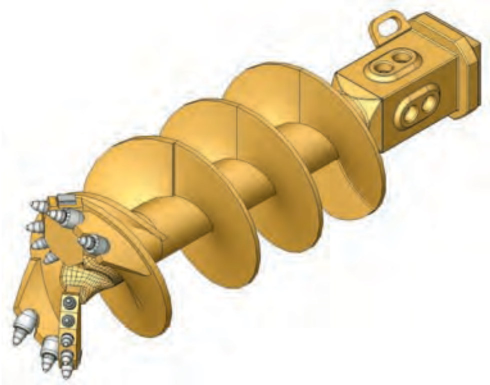
Main application
moderately strong to strong rock (12 – 100 MPa)
SBF-P2 is recommended in uncased bores or for bigger diameters

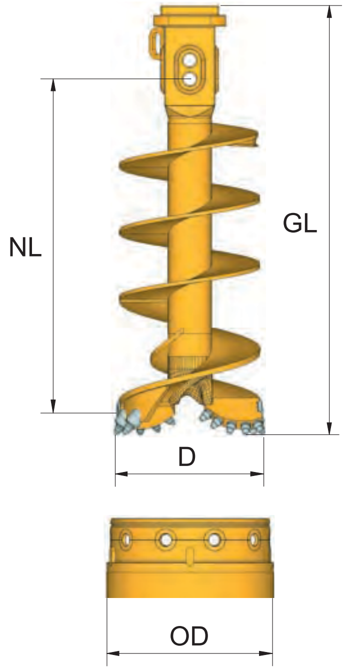
Features
Kellybox 200 mm
pilot bit RP4 with round shank chisels
progressive cutting edge with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

		SBF-P		SBF-P2	
	NL (mm)	1.700	2.250	1.700	2.250
	GL (mm)	2.240	2.790	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	600	750		
600		625	770		
650	750	660	830		
700		695	870		
780	880	755	950	768	968
800		761	955	775	976
900	1.000	790	980	813	1.013
1.000		890	1.070	866	1.082
1.060	1.180	940	1.185	930	1.175
1.180	1.300	995	1.252	985	1.242
1.200		1.010	1.280	1.000	1.263
1.350	1.500	1.090	1.400	1.118	1.409
1.500	1.650	1.215	1.620	1.276	1.630
1.650	1.800			1.570	1.572
1.800				1.845	1.680
1.830	2.000			1.900	1.700
2.000				2.050	1.950
2.320					2.356
2.500					2.570

SBF-Z2 Felsschneckenbohrer (ohne Zentrumspilot)
Rock auger (without pilot bit)

SBF-Z2
zweischneidig
double cut





Anwendungsbereich
leichter bis mittelharter Fels (5 – 50 Mpa)
gut geeignet für klüftigen Fels

Ausstattung
Kellybox 200 mm
ohne Zentrumspilot
Schneidleiste mit Rundschaftmeißeln
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißwinkel (optional)

Main application
moderately weak to moderately strong rock (5 – 50 Mpa)
very suitable in fractured rock

Features
Kellybox 200 mm
without pilot bit
cutting edge with round shank chisels
wear protection: hard facing (standard) or wear strips (optional)

		SBF-Z2	
	NL (mm)	1.700	2.250
	GL (mm)	2.240	2.790
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	675	800
600		700	845
650	750	760	915
700		820	995
780	880	900	1.050
800		910	1.065
900	1.000	950	1.150
1.000		1.030	1.270
1.060	1.180	1.100	1.350
1.180	1.300	1.180	1.400
1.200		1.250	1.510
1.350	1.500	1.360	1.600
1.500	1.650	1.500	1.890
1.650	1.800	1.750	2.350
1.800		2.000	2.642
1.830	2.000	2.050	2.700
2.000		2.300	2.950
2.320			3.420
2.500			3.700

Kernrohre
Core barrels

Mit **Kernrohren KR** wird ein Ringraum in Fels oder in (bewehrtem) Beton geschnitten.
Der Kern wird üblicherweise mit einem Fallmeißel, mit einer Felsschnecke oder mit einem „Cross-cutter“ zerstört.
Die Wirksamkeit des Kernrohres beruht auf der Konzentration des Drehmoments und der Anpresskraft auf einen schmalen Ring.

Die Durchmesserreihe der Bauer Kernrohre ist auf die Bauer Bohrrohre abgestimmt.

Sonderlängen und -durchmesser können auf Anfrage geliefert werden.
Die angegebenen Gewichte sind Cirka-Werte.

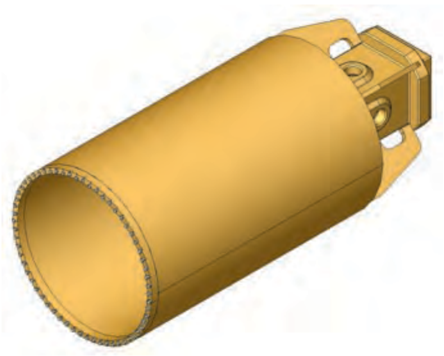
Core barrels KR are used for cutting an annular ring in rock or concrete (also reinforced concrete).
The centre core is usually broken with chisel, rock auger or cross-cutter.
The advantage of a core barrel is the concentration of the crowd force and torque on a small ring of cutting teeth.

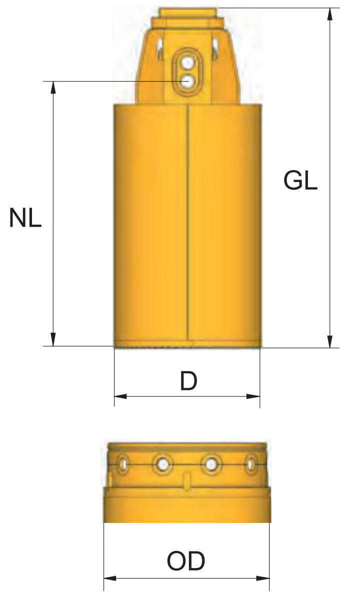
The diameter series of Bauer core barrels match with the Bauer casing tubes.

Other lengths and diameters can be supplied on request.
The weights are approximate values.

KR-S Kernrohr mit Stiftzähnen
Core barrel with pin teeth

KR-S





Anwendungsbereich
bevorzugt zum Durchkernen von (bewehrtem) Beton

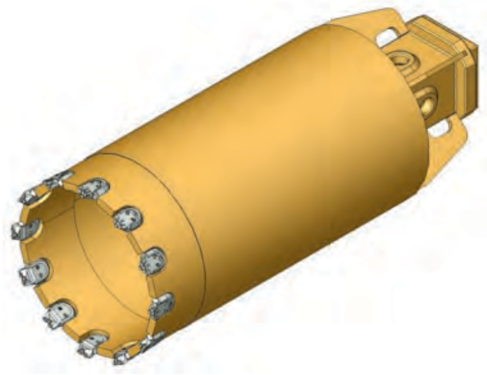
Main application
mainly recommended for cutting through (reinforced) concrete (e.g. slabs)

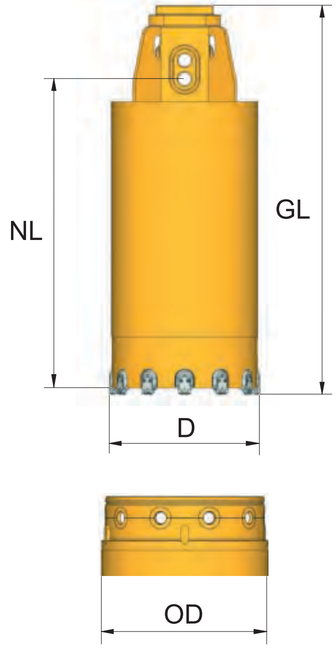
		KR-S	
	NL (mm)	1.475	1.575
	GL (mm)	1.865	1.965
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	420	
600		465	
650	750	500	
700		540	
780	880		680
800			695
900	1.000		780
1.000			870
1.060	1.180		920
1.180	1.300		1.040
1.200			1.055
1.350	1.500		1.220
1.500	1.650		1.370
1.650	1.800		1.530
1.800			1.690
1.830	2.000		1.725
2.000			1.920

Kernrohr mit Wechselstollen
Core barrel with replaceable blocks

KR-WS

KR-WS





Anwendungsbereich
harter Fels (bis 100 Mpa), leicht bewehrter Beton

Ausstattung
Kellybox 200 mm
Schneidring mit hartmetallbesetzten Stollen. Die Stollenhalter sind im Kernrohr versenkt angeschweißt.
Die Stollen sind mit einem Stift gesichert und können leicht gewechselt werden.

Main application
up to strong rock (100 Mpa), lightly reinforced concrete

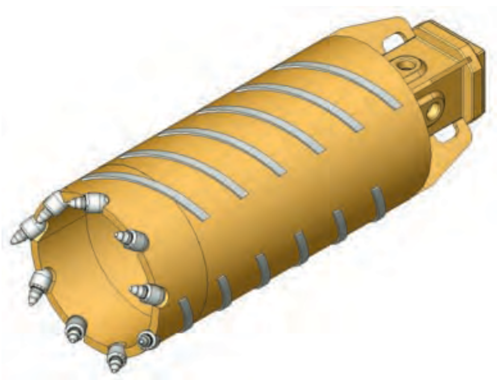
Features
Kellybox 200 mm
Cutting ring with tungsten carbide armoured blocks. The block holders are welded into the base ring of the core barrel.
The blocks are secured with a pin and can be easily replaced.

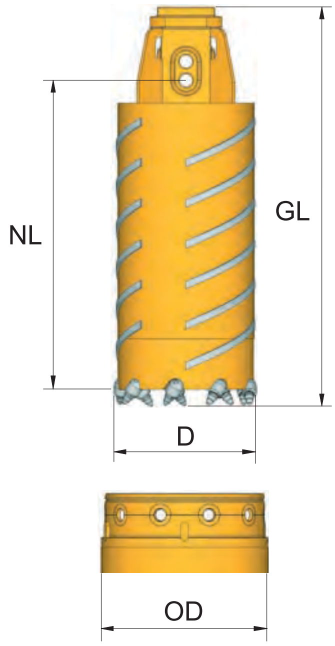
		KR-WS	
	NL (mm)	1.300	1.600
	GL (mm)	1.700	2.000
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	525	
600		570	
650	750	595	
700		645	
780	880		835
800			860
900	1.000		965
1.000			1.070
1.060	1.180		1.135
1.180	1.300		1.290
1.200			1.315
1.350	1.500		1.500
1.500	1.650		1.690
1.650	1.800		1.880
1.800			2.155
1.830	2.000		2.210
2.000			2.520

KR-R

Kernrohr mit Rundschaftmeißel
Core barrel with round shank chisel

KR-R





Anwendungsbereich
harter Fels (bis 100 Mpa)
gut geeignet in klüftigem Fels

Ausstattung
Kellybox 200 mm
Schneidring mit versetzt angeordneten Rundschaftmeißeln mit einer Gesamtschnittbreite von 120 mm
Angeschweißte Meißelhalter
Die Rundschaftmeißel können mit geeignetem Werkzeug leicht ausgewechselt werden.

Main application
up to strong rock (100 MPa)
suitable for cutting through fissured rock

Features
Kellybox 200 mm
Cutting ring with staggered arrangement of round shank chisels with a total cutting width of 120 mm
Chisel holders are welded to the base body. The round shank chisels can be easily replaced when using suitable tools.

		KR-R	
	NL (mm)	1.475	1.825
	GL (mm)	1.815	2.215
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	575	
600		650	
650	750	705	
700		780	
780	880		930
800			955
900	1.000		1.080
1.000			1.200
1.060	1.180		1.270
1.180	1.300		1.440
1.200			1.470
1.350	1.500		1.680
1.500	1.650		1.880
1.650	1.800		2.090
1.800			2.200
1.830	2.000		2.220
2.000			2.600
2.320			2995
2.500			3265

Bohreimer
Drilling buckets

Die **Bohreimer KB** sind vor allem zum Bohren aller Bodenarten in wasserführenden Böden geeignet.
Für die Anwendung in verschiedenen Bodenarten stehen Drehböden mit verschiedenem Zahnbesatz zur Verfügung.

Die Öffnung des Drehbodens erfolgt durch ein Verriegelungssytem, das durch den Drehteller oder manuell ausgelöst werden kann. Ein Entlüftungskanal verhindert den Aufbau eines Vakuums beim Ziehen des Bohreimers.

Bei großen Bohrdurchmessern und bei unverrohrten Bohrungen wird eine zweischneidige Ausführung empfohlen.

Die Durchmesserreihe der Bauer Bohreimer ist auf die Bauer Bohrrohre abgestimmt.

Sonderlängen und -durchmesser können auf Anfrage geliefert werden.
Die angegebenen Gewichte sind Cirka-Werte.

The **drilling buckets KB** are designed specifically for drilling all types of soils below groundwater.
For drilling in a variety of soil conditions swivelled bottom gates can be supplied with different types of teeth.

The opening of the swivelled bottom gate is facilitated by an automatic or manual tip mechanism. A ventilation pipe prevents the occurrence of a vacuum when lifting the tool.

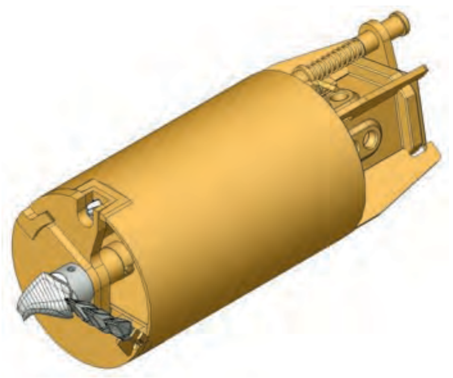
For large drilling diameters or for the use in uncased bores, buckets with double start head are recommended.

The diameter series of Bauer buckets match with the Bauer casing tubes.

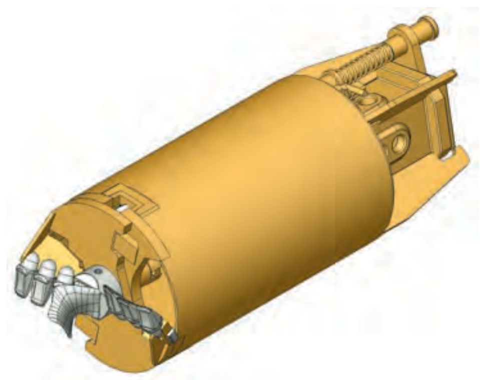
Other lengths and diameters can be supplied on request.
The weights are approximate values.

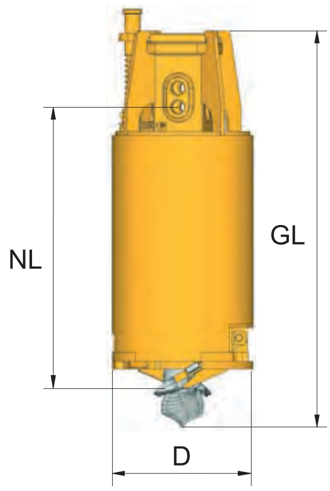
KB Bohreimer
Drilling bucket

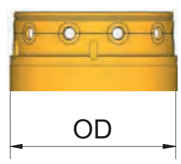
KB
einschneidig
single cut



KB-2
zweischneidig
double cut







Anwendungsbereich
weiche bis steife bindige Böden, locker bis mitteldicht gelagerte nichtbindige Böden
KB bis Grobkies
KB-2 bevorzugt für unverrohrte Bohrungen und für große Durchmesser.

Ausstattung
Kellybox 200 mm
Wendelpilot und Flachzähne FZ
Belüftungsschacht
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißstreifen (optional)

Main application
soft to stiff silt and clay, loose to medium dense sand and gravel
KB up to coarse gravel
KB-2 is recommended in uncased bores and for bigger diameters.

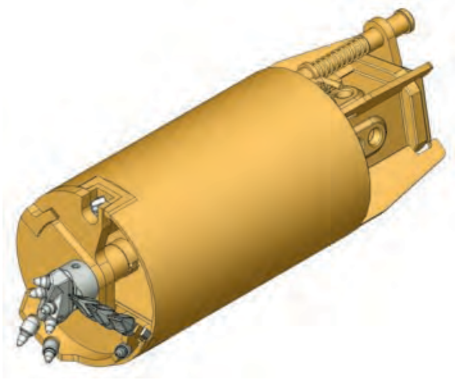
Features
Kellybox 200 mm
fishtail pilot and flat teeth FZ
ventilation pipe pipe
wear protection: hard facing (standard) or wear strips (optional)

		KB		**KB-2**	
	NL (mm)	1.550	1.850	1.750	1.850
	GL (mm)	2.300	2.600	2.500	2.600
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	656	733		
600		750	893		
650	750	824	908		
700		894	894		
780	880	1.006	1.107		
800		1.040	1.140		
900	1.000	1.195	1.310		
1.000		1.380	1.500		
1.060	1.180	1.515	1.593	1.620	1.750
1.180	1.300	1.702	1.830	1.794	1.934
1.200		1.770	1.930	1.855	1.995
1.350	1.500	2.033	2.196	2.057	2.207
1.500	1.650	2.290	2.460	2.217	2.387
1.650	1.800			2.565	2.750
1.800				3.705	3.915
1.830	2.000			3.795	4.005
2.000				4.120	4.350
2.320				4.935	5.495
2.500				5.510	5.795

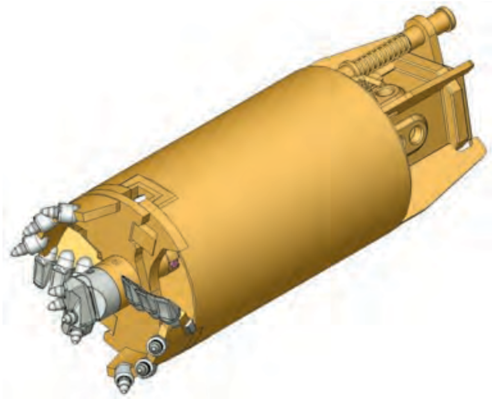
Bohreimer (mit Kaliberschneide)
Drilling bucket (with collar plate)

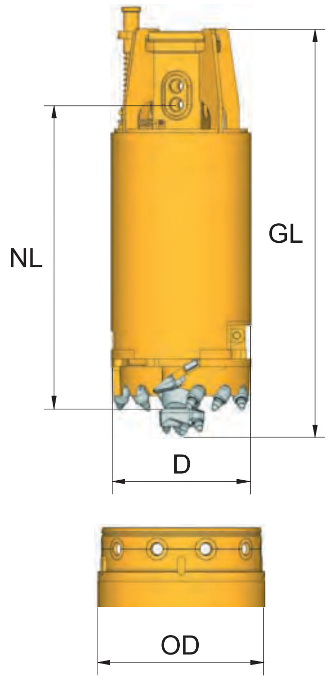
KB-K

KB-K
einschneidig
single cut



KB-K2
zweischneidig
double cut





Anwendungsbereich
weiche bis harte bindige Böden, locker bis dicht gelagerte nichtbindige Böden
KB-K bis zu Grobkies
KB-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und für überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Flachzähne FZ und Kaliberring mit Rundschaftmeißel
Entlüftungsschacht
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißstreifen (optional)

Main application
soft to hard silt and clay, loose to dense sand and gravel
KB-K up to coarse gravel
KB-K2 is recommended in uncased bores or for bigger diameters and for secant pile walls.

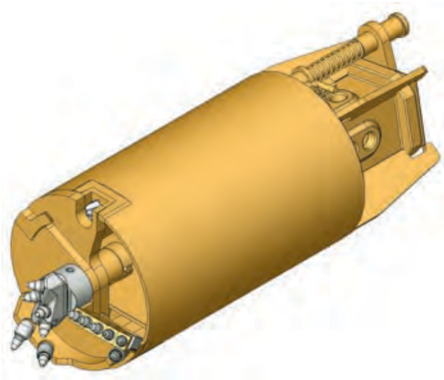
Features
Kellybox 200 mm
round shank chisel pilot bit RP4, teeth FZ and collar plate with round shank chisels
ventilation pipe
wear protection: hard facing (standard) or wear strips (optional)

		KB-K		KB-K2	
	NL (mm)	1.550	1.850	1.750	1.850
	GL (mm)	2.350	2.550	2.450	2.550
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	689	766		
600		790	933		
650	750	869	953		
700		929	1.019		
780	880	1.041	1.142		
800		1.075	1.180		
900	1.000	1.250	1.365		
1.000		1.432	1.552		
1.060	1.180	1.580	1.658	1.680	1.810
1.180	1.300	1.747	1.875	1.865	2.005
1.200		1.867	2.027	1.900	2.040
1.350	1.500	2.164	2.327	2.077	2.227
1.500	1.650	2.465	2.635	2.265	2.435
1.650	1.800			2.705	2.890
1.800				3.720	3.930
1.830	2.000			3.750	3.960
2.000				4.260	4.490
2.320				4.955	5.215
2.500				5.510	5.795

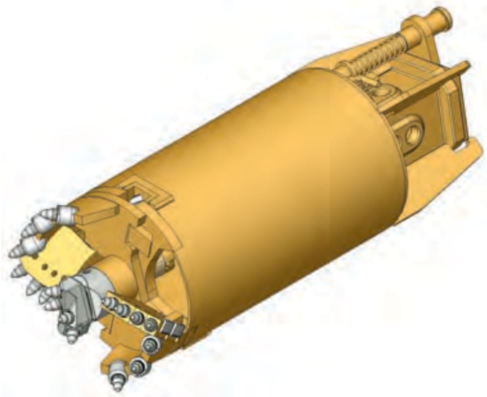
KBF-K

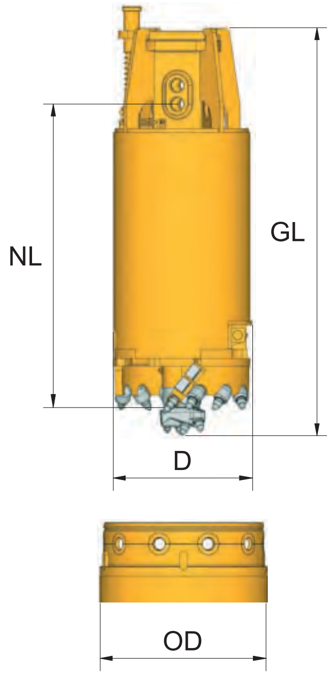
Felsbohreimer (mit Kaliberschneide)
Rock drilling bucket (with collar plate)

KBF-K
einschneidig
single cut



KBF-K2
zweischneidig
double cut





Anwendungsbereich
sehr dichter Sand und Kies, Bodenkasse 6, leichter Fels
KBF-K bis zu Grobkies
KBF-K2 bevorzugt für unverrohrte Bohrungen oder für große Durchmesser und überschnittene Pfahlwände

Ausstattung
Kellybox 200 mm
Rundschaftmeißelpilot RP4, Schneidleiste und Kaliberring mit Rundschaftmeißel
Entlüftungsschacht
Verschleißschutz: Auftragsschweißung (Standard) oder Verschleißstreifen (optional)

Main application
very dense sand and gravel, weak rock
KBF-K up to coarse gravel
KBF-K2 is recommended in uncased bores or for bigger diameters and for secant pile walls

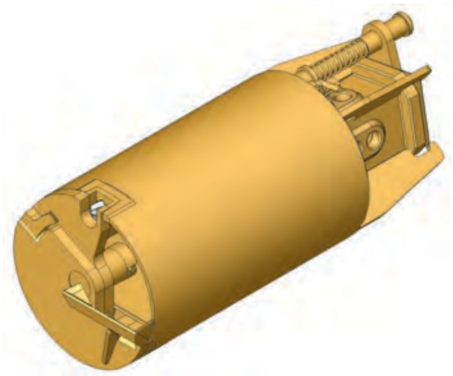
Features
Kellybox 200 mm
round shank chisel pilot bit RP4, cutting edge and collar plate with round shank chisels
ventilation pipe
wear protection: hard facing (standard) or wear strips (optional)

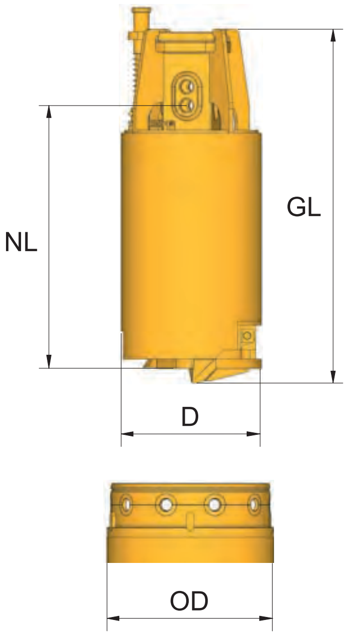
		KBF-K		**KBF-K2**	
	NL (mm)	1.550	1.850	1.750	1.900
	GL (mm)	2.250	2.550	2.450	2.600
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	681	758		
600		780	923		
650	750	853	937		
700		932	1.022		
780	880	1.040	1.141		
800		1.076	1.180		
900	1.000	1.258	1.373		
1.000		1.437	1.557		
1.060	1.180	1.600	1.678	1.680	1.810
1.180	1.300	1.802	1.930	1.840	1.980
1.200		1.885	2.045	1.885	2.025
1.350	1.500	2.152	2.315	2.130	2.280
1.500	1.650	2.450	2.620	2.330	2.500
1.650	1.800			2.750	2.935
1.800				3.680	3.890
1.830	2.000			3.705	3.915
2.000				4.240	4.470
2.320				5.125	5.385
2.500				5.620	5.905

Bohreimer mit Räumerleiste
Drilling bucket with cleaning edge

KB-L

KB-L





Anwendungsbereich
Säubern der Bohrlochsohle

Main application
cleaning the bottom of the borehole

		KB-L	
	NL (mm)	1.550	1.850
	GL (mm)	2.100	2.400
D (mm)	OD (mm)	Gewicht (kg) Weight	Gewicht (kg) Weight
520	620	614	691
600		709	852
650	750	782	866
700		850	940
780	880	959	1.060
800		990	1.095
900	1.000	1.141	1.256
1.000		1.327	1.447
1.060	1.180	1.474	1.552
1.180	1.300	1.652	1.780
1.200		1.714	1.874
1.350	1.500	1.984	2.147
1.500	1.650	2.227	2.397

Sonderbohrwerkzeuge

KR-RM Rollenmeißelkernrohr
Core barrel with round shank chisel

Rollenmeißelkernrohre werden bei sehr hartem Fels mit einer Festigkeit > 100 MPa verwendet.
Die Schneidbreite des Ringspalts beträgt je nach Rollenmeißelbesatz 220 oder 320 mm.

Das Bohrklein wird normalerweise in einen Auffangbehälter gefördert der über dem Kernrohr sitzt. (Lufthebeverfahren oder Druckspülung mit Ventilklappe). Nach etwa 1 m Kernfortschritt wird das Kernrohr aus der Bohrung gehoben und der Auffangbehälter entleert. Bei kürzeren Kerntiefen kann auch ohne Spülung gearbeitet werden.

Roller bit core barrels KR-RM are used in very strong rock formations (compressive strength > 100 MPa). KR-RM core barrels use rock roller bits for cutting the annular groove with a width of 220 or 320 mm and remove the rock chippings by air-lift technique or flushing (activated by a vent flap) into a dust collector box mounted on top of the core barrel. The core barrel is extracted from the bore after coring a length of about 1 m and the dust collector box is emptied. For shorter coring lengths it is possible to work without a flushing system.

Pfahlfußaufschneider
Belling bucket

Pfahlfußaufschneider werden in standfesten Böden zur Erweiterung der Pfahlsohle eingesetzt. Die Schneidarme werden beim Aufschneiden durch vertikales Andrücken auf die Schubstange nach außen geklappt. Der Boden, der durch die Drehbewegung der Schneidarme gelöst wird, fällt in den Aufschneiderkörper. Vor dem Ziehen des Pfahlfußaufschneiders werden die Schneidarme durch Zug an der Schubstange geschlossen.
Der Öffnungswinkel des aufgeweiteten Fußes beträgt normalerweise 60°. Der Durchmesser des aufgeschnittenen Pfahlfußes ist ungefähr 2 – 3 mal so groß wie der Schaftdurchmesser.

A belling bucket is used for enlarging the pile base in stable (mainly cohesive) soil conditions. The cutting arms are gradually opened by applying vertical crowd force on a push rod and a leverage system. The spoil falls into the open shell of the bucket. When extracting the tool from the borehole, the upward movement of the kelly bar transmits the pull onto the push rod and the cutting arms are closed. The maximum opening angle of the bell is about 60° and the standard increase of diameter is about 2 – 3 times the shaft diameter.

Special drilling tools

Cross cutter KR-X

„Cross Cutter“ KR-X werden zum Zerstören von Kernstöcken, die beim Bohren mit Kernrohren stehen bleiben, eingesetzt. Der entspannte Felskern wird mit dem "Cross Cutter" zerkleinert und das Bohrgut wird anschließend mit einem Bohreimer gefördert.

A Cross-Cutter (KR-X) is used to break rock cores which remain in the borehole after using a core barrel.
The core is broken with round shank chisels. The cuttings are then removed with buckets.

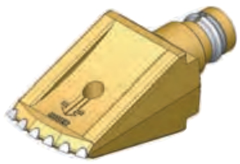
Bohreimer für Ton Clay bucket KB-C

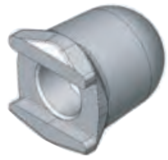
Zum Bohren von Tonböden wird normalerweise der Standarbohreimer KB verwendet. Für Bohrungen die ausschließlich aus Ton bestehen oder beim Antreffen von hochplastischem klebrigen Ton wird der Spezialbohreimer KB-C vorgeschlagen.
Er besitzt keinen Drehboden aber vergrößerte Eintrittsöffnungen und lange Schneidzähne.
Zusätzlich kann er als Variante mit einem konischen Grundkörper versehen werden. Diese Grundkörperform erleichtert das Entleeren von stark plastischem Ton.

The bucket KB is the standard tool when drilling in clay. When encountering sticky clay with high plasticity or when drilling in clay, a special clay bucket KB-C can be offered.
The bucket has no swivelled bottom gate. It is equipped with enlarged bottom openings and long cutting teeth.
Optionally it can be provided with a conical base body.
The conical shape eases discharging of sticky clay.

Verschleißteile Bohrwerkzeuge — Wear parts for drilling tools

Flachzähne FZ
Flat teeth FZ


FZ 87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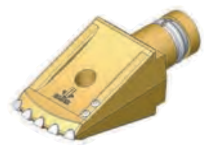
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Rundschaftmeißel RSM
Round shank chisel RSM


C 402


C 403


H 85-1

Anschweißzähne
Weld-on blocks


AS 29/4


AS 34/7


AS 40/7

Wechselstollen
Replaceable blocks

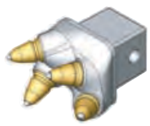

WS 38

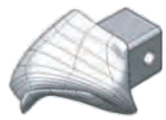

WS 39


Halter SH 35
Holder SH 35

Piloten
Pilot bits

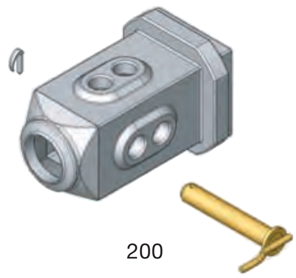

ZP 190


RP 4-200


Wendelpilot
Fishtail bit

Kellybox
Kelly box


150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Vedlegg K

Erfaringer forankringer og stag

Erfaringer

FORANKRINGER OG STAG

JBV Dobbeltspor Sandvika-Asker (2002)

FJELLSPRENGNINGSTEKNIKK
BERGMEKANIKK/GEOTEKNIKK 2002

BORING AV STAG OG STÅLKJERNEPELER I TETTBYGD STRØK- ERFARINGER FRA NYTT DOBBELTSPOR SANDVIKA - ASKER

Installation of steel core piles and rock anchors in urban areas – experiences from new double track Sandvika - Asker

Siv.ing. Gunvor Baardvik, Jernbaneverket Utbygging
Cand. scient. Anne Braaten, Jernbaneverket Utbygging

SAMMENDRAG

Jernbaneverket Utbygging har på prosjektet Sandvika - Asker prosjektert og etablert et stort antall foringsrør for stag og stålkjernepeler i flere ulike typer løsmasse. Pr. i dag har vi etablert over 2/3 av et samlet antall på ca. 3000 stk. Vi har gjennom dette arbeidet samlet oss en del erfaringer knyttet til utførelse og funksjon som vi ønsker å formidle videre. Dette er kunnskap som finnes i bransjen, men som vi på prosjektet ikke synes har vært så lett tilgjengelig til enhver tid. Vi har sett på boring for stag og peler med kompleks geometri, boring i; fyllmasser, morene, lite sensitiv leire og kvikk leire.

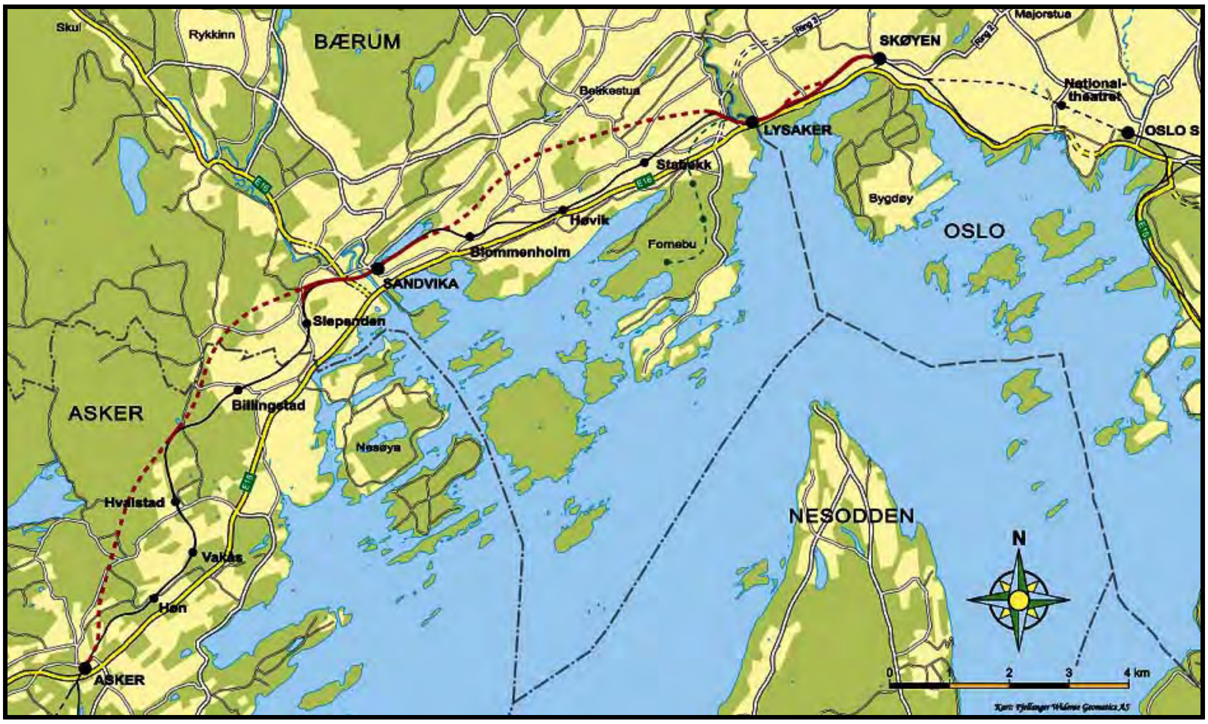
SUMMARY

On the new double track project; Skøyen – Asker, the building division of the Norwegian railroad authority have had designed and established a large amount of steel tube casings for installation of steel core piles and grout bounded rock anchors. The steel tube casings are drilled down through different kind of soils into bedrock. During these operations we have collected experiences related to execution and function. This is no new knowledge but has not always been commonly awailable. We have looked at installaions with high degree of complexity, installations in fills, moraine, non sensitive clay and very sensitive clay.

1. KORT ORIENTERING OM PROSJEKTET

Jernbaneverket Utbygging har under bygging nytt dobbeltspor på strekningen Sandvika - Asker i Bærum og Asker kommune. Utbyggingen er en del av prosjektet Skøyen - Asker, som i hht. NTP skal skal stå ferdig i løpet av 2011. Sandvika - Asker skal etter planen stå ferdig i 2005. Den første entreprisen ble påbegynt våren 2001 og den siste grunnarbeidsentreprisen, Asker stasjon er under oppstart. Prosjektet Skøyen - Asker skal gi økt kapasitet på jernbanenettet for trafikk vestfra og inn til Oslo. Strekningen Sandvika - Asker bygges først fordi dette gir størst umiddelbar kapasitetsgevinst og lønnsomhet. Prosjektet er totalt kostnadsberegnet til 6.5 milliarder kroner, og Sandvika - Asker har en kostnadsramme på 3.285 milliarder kroner.

Prosjektet innebærer en utvidelse fra to til fire spor. Gjennom Sandvika sentrum skal det eksisterende dobbeltsporet som ble bygget i 1958, utvides med et nytt spor på hver side på en strekning på ca 1 km. Deretter splittes nytt og gammelt dobbeltspor. Det nye dobbeltsporet vil videre gå i tunneler fram til Asker stasjon, med unntak av en kort dagsone på 600 m ved Solstad i Asker. De første 700 m av østre tunnel er en løsmassetunnel i til dels meget bløt leire. Fjelltunnelene Jong-Solstad og Solstad-Hønsveien er hhv. 2.7 km og 3.5 km lange. Fra påhugget for fjelltunnelen i Asker og fram til Asker stasjon skal det bygges en 130 m lang betongkulvert for dobbeltsporet. Videre blir Asker stasjon helt ombygd som følge av ny sporplan. Det vil bli bygd et nytt spor mot øst samt en ny undergang under sporene som sikrer god tilgjengelighet til alle plattformer.

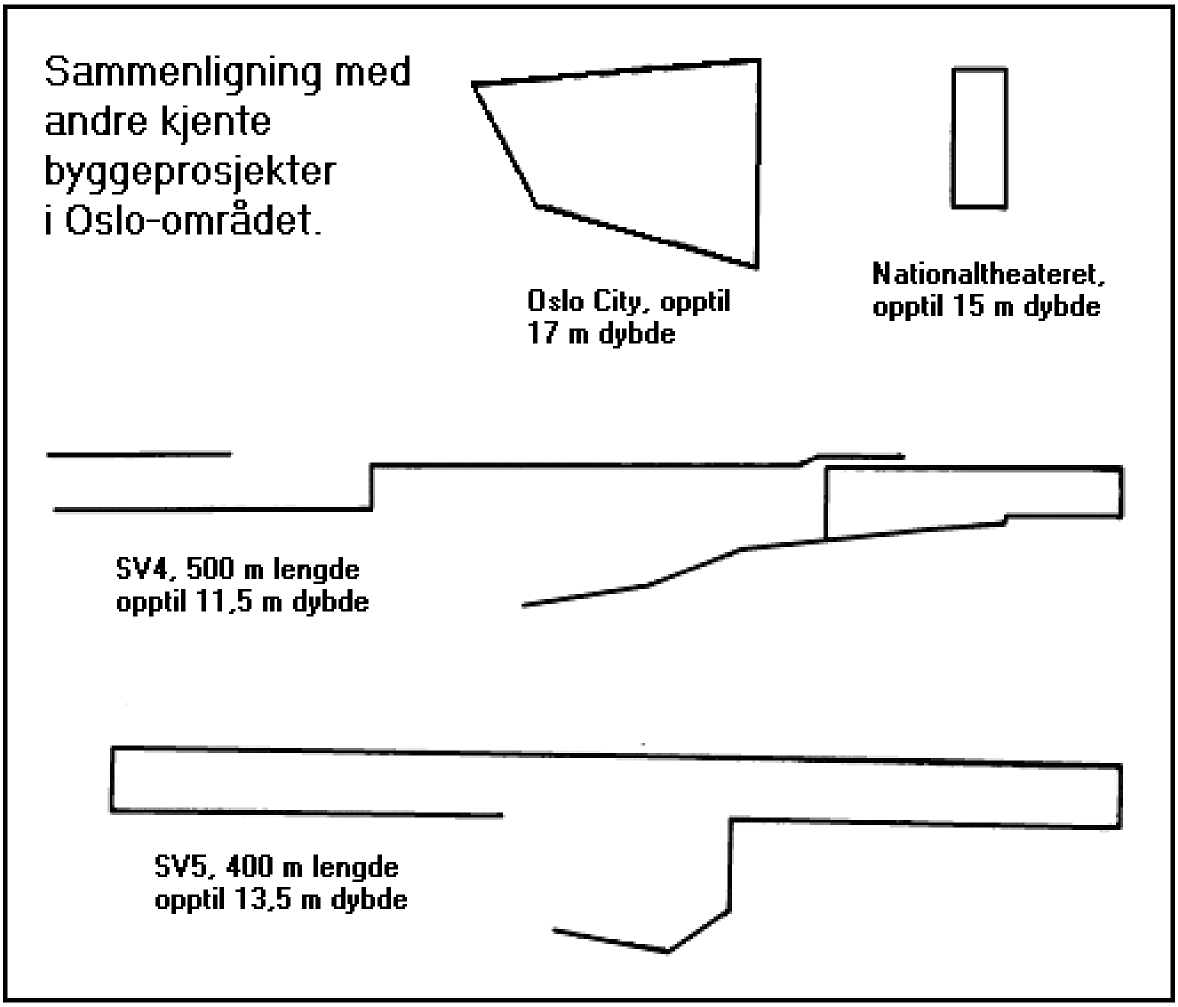


Figur 1. *Oversikt Sandvika - Asker*

På prosjektets dagsoner berøres flere ulike typer grunnforhold og prosjektet innebærer en svært stram utvidelse langs eksisterende spor. Det begrensende arealet gjennom Sandvika og Asker sentrum sammen med løsmassetunnelen på 700 m har gitt grunnlag for et meget komplekst og vanskelig byggeprosjekt, hvor det er benyttet store mengder spunt og stag, både i midlertidige og permanente løsninger. Det er også prosjektert og satt et stort antall stålkjernepeler i forbindelse med konstruksjonene på strekningen.

I tillegg til det begrensede bygge- og anleggsarealet, ligger også kompleksiteten i:

- bygging nær spor og mellom spor med full togtrafikk
- bygging nær bebyggelse
- bygging nær hovedvegtrafikk (E16) og bytrafikk med stort antall myke trafikanter
- bruer og andre konstruksjoner bygges i etapper
- en og tosidig fyllingsutvidelse fram til betongtunnelene i Sandvika
- spuntgropa for løsmassetunnelens størrelse



Figur 2. Størrelsen på byggegropa for løsmassetunnelen i Sandvika sammenlignet med andre byggegroper i Oslo.

Prosjektets mengder: (ihht. kontrakt):

Midlertidig spunt	25710 m^2	
Permanent spunt	1820 m^2	
Midlertidige stag	33000 lm	totalt ca. 1550 stag
Permanente stag	5100 lm	
Stålkjernepeler Ø = 180 og Ø = 150 mm	13000 lm	ca. 950 stk
HP-peler	1200 lm	ca. 70 stk
Betongpeler 270 x 270	480 lm	22 stk
Kalk/sementpeler	110090 lm	ca. 7000 stk.
EPS	8000 m^3	
Lettklinker	6000 m^3	

Grunnarbeidene knyttet til prosjektets dagsoner er kostnadsberegnet til 574 mill. (uten MVA) og utgjør 30% av totale underbygningskostnader (dvs. alle arbeider unntatt jernbanetekniske som skinner, kjøreledningsanlegg og signalanlegg). Stagsetting og stålkjernepeler er en betydelig del av disse kostnadene. Kostnader for Asker stasjon er ikke medtatt da det ennå ikke er tegnet kontrakt. Mengdene er med i oppsettet over.

Planlegging og prosjektering av både detaljplan/reguleringsplan og byggeplan med anbudsutarbeidelse, er for strekningen gjennom Sandvika og fram til fjelltunnelen ved Jong, utført av Aas-Jakobsen i samarbeid med GeoVita AS. Asker stasjon og fjelltunnelene er planlagt og prosjektert av Norconsult AS. Det vises for øvrig til foredrag nr. 16 av Magne Paulsen, hvor en mer inngående presentasjon av prosjektet finnes. Foredrag nr. 32, "Dyp utgraving ved bruk av redusert sikkerhetsfaktor og økt kontroll av arbeidene" omhandler også data fra grunnarbeidene på parsellene i Sandvika.

2. GRUNNFORHOLD

Grunnforholdene på strekningen mellom Sandvika og tunnelpåhugget ved Lars Jongsveg kan kort beskrives som følgende:

2.1 Sandvika – E16

I Sandvika sentrum bærer stedet sitt navn med rette. Toppmassene består av grus, sand og sandig silt. På hver side av Sandvikselva går jernbanen på fyllinger, bygd opp under anleggsarbeider før 1916 og ved utvidelsen til dobbeltspor i 1958. Fyllmassene varierer fra sand og grus til grov stein og blokk, og vi har også funnet rester av gamle konstruksjoner inne i fyllingene. Grunnforholdene i brutraseen over Sandvikselva består av siltig sand som med dybden går over i en middels fast siltig leire ned til fjell, stedvis med et morenelag over. Leira er lite sensitiv. Morenen har svært varierende mektighet og fasthet. Fjellet antas å bestå av leir og kalkskifer, som i området rundt. Prosjekterte fjelldybder er fra 5 til 35 m fra fundamentnivå for bruene.

2.2 Fra E16 til Hestehaugen

Det er på denne strekningen store variasjoner i fjellnivåene. Omtrent midt under bruene over E16 er det en lokal dyprenne der dybde til fjell er inntil 35 m. Fra E16 og til dit ny jernbanetrase skjærer inn i en morenerygg, Hestehaugen, er det stedvis fjell i dagen og stedvis lokale dyprenner. Løsmassene over fjell består av leire, silt og sand. I tillegg til naturlige avsetninger er det fyllingsmasser fra eksisterende jernbaneanlegg.
I Hestehaugen består løsmassene over fjell stort sett av ca. 1 m tørrskorpe over fast lagrede morenemasser i store mektigheter. På grunn av fastheten i massene og forekomster av stein var det ikke mulig å ta opp vanlige sylinderprøver av morenematerialet.

2.3 Hestehaugen – Slependveien - Jongsjordet

På denne strekningen avtar tykkelsen av morenemassene gradvis og leire blir etter hvert det dominerende materialet. Tykkelsen på morenelaget over fjell varierer lokalt. Grunnundersøkelsene viser at leira til dels er bløt og meget sensitiv (kvikk). Udrenert skjærstyrke s_u er i størrelsesorden 5 – 15 kPa. Fjellnivåene varierer langs traseen slik at traubunn stedvis ligger på utsprengt fjell og stedvis på løsmasser ved lokale dyprenner. Dybder til fjell er inntil ca. 40 m fra eksisterende terreng. Løsmassene over fjell består under tørrskorpa av leire / siltig leire over et morenelag. Tykkelsen på morenelaget varierer lokalt. Leira beskrives som normalkonsolidert.

2.4 Asker stasjon

Nord for Asker stasjon er det registrert dybder til fjell på opptil 5 - 6m. Løsmassene består under fyllmasser med variabel mektighet av fast leire og sand/grus.

På Asker stasjon er dybder til fjell inntil 20 m. Under fyllmassene består naturlig grunn stort sett av middels fast leire, bortsett fra et stykke vest for den planlagte gangkulverten under sporene der det er bløt leire. Hovedsakelig er denne middels sensitiv, men det er også påvist noe kvikkleire. Videre viser prøveseriene at det er torv av varierende mektighet og i varierende dybde. På selve stasjonsområdet antas torven i stor grad å være skiftet ut med stein, men det må påregnes at det også er gjenværende torv under steinfylling.

På den østre delen av stasjonsområdet er det relativt faste masser av fylling, sand, grus, silt og leire ned til 4 - 5 m, som også stort sett er største dybde til fjell.

3. ERFARINGER FRA UTFØRTE ARBEIDER.

Den viktigste erfaringen vi har fra boring av stag og stålkjernepeler er at slike arbeider betinger oppfølging og kontroll, både hos entreprenør og byggherre. Det er viktig at entreprenøren setter seg inn i grunnforholdene på stedet og utarbeider prosedyrer og framdriftsplaner som reflekterer grunnforholdene og andre føringer i kontrakten.

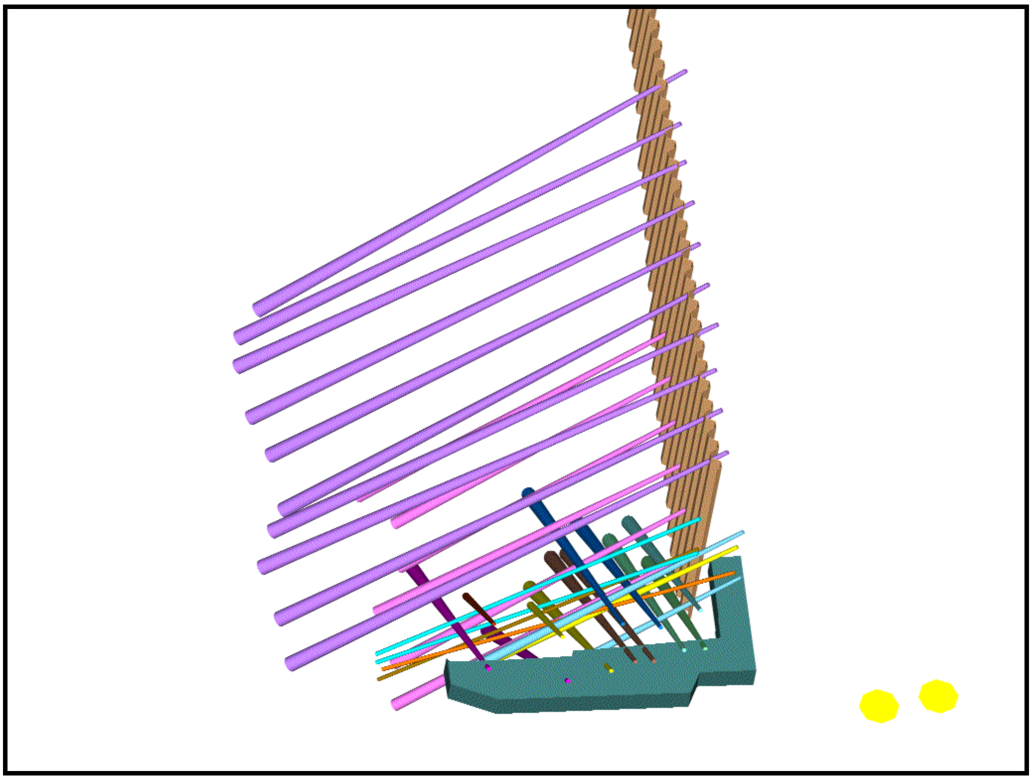
Den andre generelle erfaringen vi har gjort oss er viktigheten av at entreprenøren har en dyktig stikker som benyttes ved utsetting og for kontroll av ansett, helning og retning. For en del av konstrukjsonene på anlegget har dette vist seg å være tidkrevende og vanskelig, og det har ikke vært prioritert godt nok av entreprenørene til en hver tid. Toleransene for ansett av stålkjernepeler og stag er så små at de krever kontroll av stikker, og det må også sjekkes på helning og retning etter 2 – 3 m, for å sikre mot avdrift.

3.1 Tidsforbruk ved boring av foringsrør

Mye av borearbeidet er blitt utført med stor fart på selve boringen, og det har vært vanskelig å få gehør for det overordnede kravet i kontrakten om at arbeidene skal utføres på en betryggende måte. Vi har foretatt enkle tidsstudier ved boring av foringsrør for stålkjernepeler og disse viser at det ikke er nevneverdig forskjell på det totale tidsforbruket pr. lm pel ved å bore raskt, for det er tiden som går med til rengjøring, entring og skjøting av foringsrørene som er utslagsgivende her. Det er også på alle disse mellomoperasjonene at entreprenøren kan og bør spare tid, om de har behov for det.

3.2 Boring av stag og peler med kompleks geometri.

Spesielt for konstruksjonene i Sandvika sentrum har vi hatt høye krav til presisjon ved boring av foringsrør, både for stag og for stålkjernepeler. Bruene og konstruksjonene bygges etappevis fra sør mot nord, og hver enkelt etappe får flere midlertidige lastsituasjoner som skal ivaretas. Det er svært trangt, og det skal plasseres stag og peler med stor presisjon for å unngå kollisjoner.



Figur 3. Stag i landkar og tilløpsfylling til bru over Sandvikselva

Figur 3 viser alle stag som er prosjektert i landkaret og i tilløpsfyllingen for bru over Sandvikselva. Stagene skal flettes både i løsmasse og i fjell, og bak landkarene er det grove tilbakefyllingsmasser. Det har vært vanskelig å oppnå god retningsstabilitet på stagene ved boring i så grov stein, selv om entreprenøren etter vår oppfatning her har truffet de tiltak som har vært mulige. Steinblokkene har kilt seg rundt foringsrøret og det har blitt vinklendringer ved hvert ”ansett” mot stein inne i fyllingen. Vi har hatt 3 kollisjoner mellom stag her, og det har ikke vært lett å finne plass til erstatningsstag, men entreprenør og konsulent har til nå klart å løse de problemer som har oppstått.

Mellom Sandvikselva og E16 går jernbanen på fylling. Utvidelsen til fire spor er utført ved at det er bygget en støttemur på hver side av eksisterende fylling. Støttemurene er forankret i hverandre med stag horisontalt gjennom fyllingen. Ved etablering av disse stagene er det boret med stor presisjon i fast lagret sand og grus. Der det er påtruffet fyllmasser, trepeler, EPS, bygningsrester osv. Selv om det har vært små mengder av dette har det vært retningsavvik opp til 1 m over en lengde på ca. 30 m.

3.3 Boring i faste/grove masser.

For bruene over Sandvikselva skal boring for stålkjernepeler utføres i 3 etapper. Mellom etappe 1 og 2 har det gått 1 år. Ved boring av foringsrør i etappe 1 ble det påtruffet morene som var meget fast mellom siltig leire og fjell. Borekrona kilte seg fast i massen og vi kunne observere at det boblet opp i et gammelt borhull ca 50 m nedstrøms i elva, når det ble arbeidet med å løsne denne. Ved boring for etappe 2 i samme fundament kunne boremannskapene fortsatt registrere morenen og tykkelsen på denne som i etappe 1. Boringen gikk derimot lett og greit, og massene kunne ikke tolkes som faste, slik de hadde vært et år tidligere. Vi har tolket dette dithen at morenelaget kan ha ”mørnet” under boringen av etappe 1.

Ved inngangen til betongtunnelene er det etablert et teknisk bygg. Ved boring av stålkjernepeler for fundamentering av dette ble det observert at det boblet i foten av jernbanefyllingen 20 m unna boområdet. Massene består her av siltig leire over fast morene. Det ble også observert setninger av magerbetongplata rundt pelepunktene på inntil 10 cm. Dette tyder på utvasking og erosjon av massene der pelene ble satt.

For bruene over Sandvikselva har boring av foringsrørene blitt fulgt nøye opp av byggherren. Det er en prosjekteringsforutsetning at det ikke må vaskes ut rundt pelene da disse er avhengig av full sidestøtte. Omrøring og erosjon er etter vår oppfatning i stor grad operatøravhengig. På bakgrunn av alle observasjonene vi har gjort av bobling rundt peler er det etter vår oppfatning klart at boring med luft omrører massene langs røret. Det at leira her er lite sensitiv har vært utslagsgivende for at vi føler oss komfortable med resultatet så langt. Det er ikke registrert massetransport opp langs pelene i disse massene.

3.4 Boring i bløte masser

3.4.1 Hulltaking – tetting mot leireinnpressing og vann.

Som nevnt også under pkt. 3; Erfaringer fra utførte arbeider er det meget viktig at entreprenørene lager og skreddersyr sine prosedyrer for arbeidene. Fra overgangen morene/leire og til fjellpåhugget, dvs. for størstedelen av byggegropen for betongtunnelen, er det bløt og meget sensitiv leire. Hulltaking i spunten vil i slike masser kunne føre til erosjonsbrudd bak spunten og innsig av leire, spesielt dersom hullene er store og blir stående åpne ved boring av nabostag.

I forbindelse med stagsetting på Jongsjordet hadde vi flere slike erosjonsbrudd med påfølgende innlekkasje og innsynking bak spunten. Konsekvenser her var at det måtte avlastes bak spunten. På Jongsjordet var ikke dette noe stort problem da det var tilstrekkelig med ubenyttet areal på sidene. Hadde dette skjedd på strekninger der det er bebyggelse/konstruksjoner nær inntil spunten ville konsekvensene imidlertid vært store.

Erfaringer fra stagarbeidene på prosjektet har vist at det enkleste tiltaket for å forhindre erosjonsbrudd bak spunten vil være å skjære hullet i spunten så lite som mulig. Det bør lages en mal tilpasset aktuell stagvinkel og størrelsen på foringsrøret. På grunn av problemer med innpressing av leire er det også bestemt at alle staggjennomføringer skal være på spuntrygg, da dette gir mindre hull og også gjør det enklere å sveise på stålplater for tetting der dette er nødvendig. Videre bør hullet skjæres ut rett før foringsrøret settes og boringen begynner. Det er klart at en slik framgangsmåte vil påvirke framdriften og dette må planlegges av entreprenøren. Det betinger også en godt gjennomarbeidet og tilpasset prosedyre og tett oppfølging og kontroll under arbeidene.

Prosesskodens 83.7 som omhandler blant annet midlertidige forankringer i fjell slår etter vår mening fast at stagarbeider skal planlegges og gjennomføres på en slik måte at f.eks erosjonsbrudd bak spunten ikke skjer. Sitat; "Nødvendig tetting av jord og fjell for å gjennomføre arbeidet på en betryggende måte inngår også i prosessene." Vår erfaring er at skånsom boring / stagsetting ikke har særlig høy prioritet og at det har vært en tung prosess å få utarbeidet gode prosedyrer som skal gi en betryggende og sikker gjennomføring av arbeidene med tanke på å minimalisere deformasjoner og uheldige konsekvenser.

3.4.2 Boring med bruk av luft – vann.

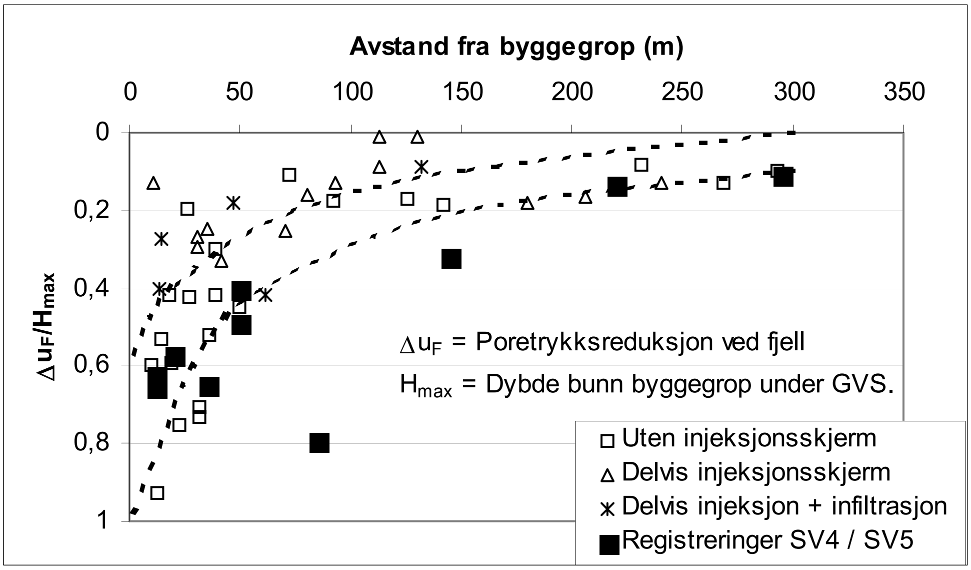
Bløt sensitiv leire over meget fast morene byr på store utfordringer for å unngå deformasjoner av tilliggende grunn. Prosesskoden angir at boring gjennom leire skal utføres uten bruk av luft og erfaringer fra andre prosjekter (Helland bruer) har også vist at bruk av luft ved boring i bløt leire kan føre til omrøring og utvasking av de bløte massene rundt foringsrøret. Imidlertid er det nødvendig med bruk av luft for å komme gjennom det faste morenelaget over fjell. Konsekvensene ved erosjon/utvasking i bløte sensitive masser kan være store og det er viktig at det utvises stor forsiktighet med hensyn på matekraft, bruk av luft osv. ved overgangen til morene og ved eventuell fastkiling.

3.4 Innlekkasjer og poretrykk.

Grunnundersøkelser/poretrykksmålinger utført i forbindelse med detaljplan viste at grunnvannstand i området står like under terreng. Tunnelen bygges derfor med vanntett tverrsnitt for å unngå dreneringseffekter i området på grunn av den ferdige konstruksjonen.

Imidlertid er det klart at byggegropene for etablering av betongkonstruksjonene vil påvirke poretrykksforholdene i anleggsperioden. Lekkasjer inn i tilsvarende byggegroper inntreffer vanligvis; via fjellet, mellom spuntfot og fjell, gjennom utette spuntlåser eller opp gjennom staghull med topp under grunnvannstanden. Som oftest vil det være en kombinasjon av disse effektene. I tillegg til dette vil lokale geologiske forhold ha betydning for effektene.

Etablering av byggegropene for betongtunnelene fra Hestehaugen og til påhugget for fjelltunnelen har medført boring og etablering av i størrelsesorden 1400 stag og dermed 1400 potensielle lekkasjepunkter. Stagsetting av et slikt omfang betinger god oppfølging og kontroll, blant annet for å sikre at lekkasjer fanges opp og tettes fortløpende.



Figur 4. *Sammenstilling av erfaringsdata vedrørende poretrykksreduksjon ved fjell sammenlignet med målinger i Sandvika (SV4/SV5). Basert på Kjell Karlsrud, 1990.*

Figur 4 er basert på Kjell Karlsruds innlegg på NIF-kurset: "Tetting av tunneler, bergrom og byggegroper" i 1990, og er supplert med målinger fra Sandvika. Som det framgår av figuren er det for byggegropene registrert større poretrykksreduksjoner ved fjell enn en kunne forventet ut i fra tidligere erfaringer. Etter vår oppfatning skyldes dette hovedsakelig følgende forhold: Det tok for lang tid før tetting av vannlekkasjer både opp gjennom foringsrør og gjennom spunten rundt foringsrørene ble tilstrekkelig intensivert. Det er også viktig å være klar over at byggegropene i Sandvika har en langt større utstrekning (størrelse) enn det materialet erfaringsdataene bygger på. De geologiske forholdene i området, med et permeabelt morenelag over fjell, bidrar også til at poretrykksreduksjonene ved fjell blir større og sprer seg lenger ut fra byggegropa enn tilfelle ville vært dersom det var leire direkte på fjell.

3.5 Andre erfaringer

3.5.1 Stag med / uten foringsrør

I forbindelse med stagarbeidene på Jongsjordet kom det forslag fra entreprenøren om å benytte stag med gjenga foringsrør som trekkes etter installasjon av staget i stedet for prosjektert løsning med sveising av rør og tradisjonell Odex-boring med etterfølgende montering av liner og gysing.

Metoden med topphammerboring og gjenga foringsrør som trekkes var forventet å gi større produksjon enn tradisjonell metode med sveisede rør og Odex. Imidlertid vil en slik metode kunne føre til deformasjoner bak spunten, når foringsrørene trekkes. Av denne grunn ble derfor metoden bare godkjent for bruk på Jongsjordet der deformasjoner på grunn av avstanden til boliger og installasjoner ikke ville ha store uheldige konsekvenser.

Stagsetting der deformasjoner bak spunten kunne gi uheldige konsekvenser for boliger, veger, rør/kabler osv. ble utført med sveisede foringsrør som blir stående i grunnen.

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Vedlegg L

Erfaringer stålkjernepeler

Erfaringer

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E6 Julsrud bru - Erfaringsrapport nr.2 (1992)

E6 Arteid bru - Erfaringsrapport (1993)

Rv1 Matre bru (1994)

E18 Helland bruer (1999)

JBV Sandvikselva jernbanebruer (2002)

E6 Sandesund bru (RC-boring) (2006)

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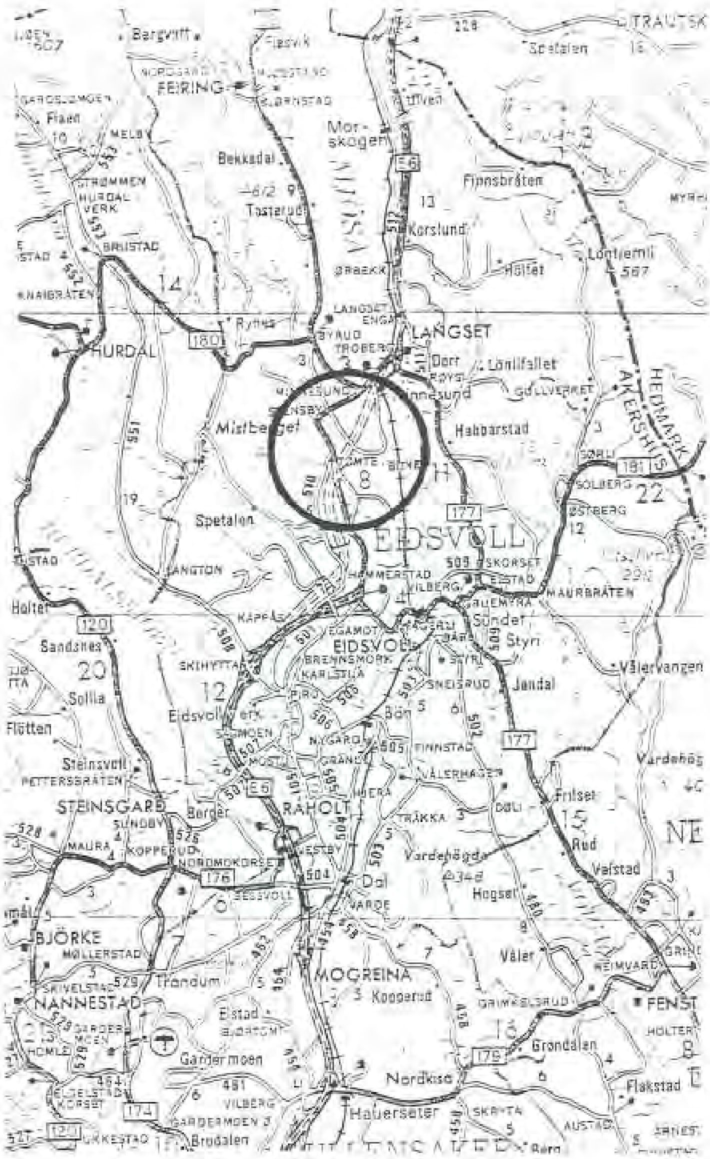


17. november 1993

Veglaboratoriet

Laboratorieserien

Rapport nr. 62

E6 Julsrud bru, Akershus

Stålkjernepeler

Erfaringsrapport

Juni 1994

Statens vegvesen
Vegdirektoratet

Veglaboratoriet

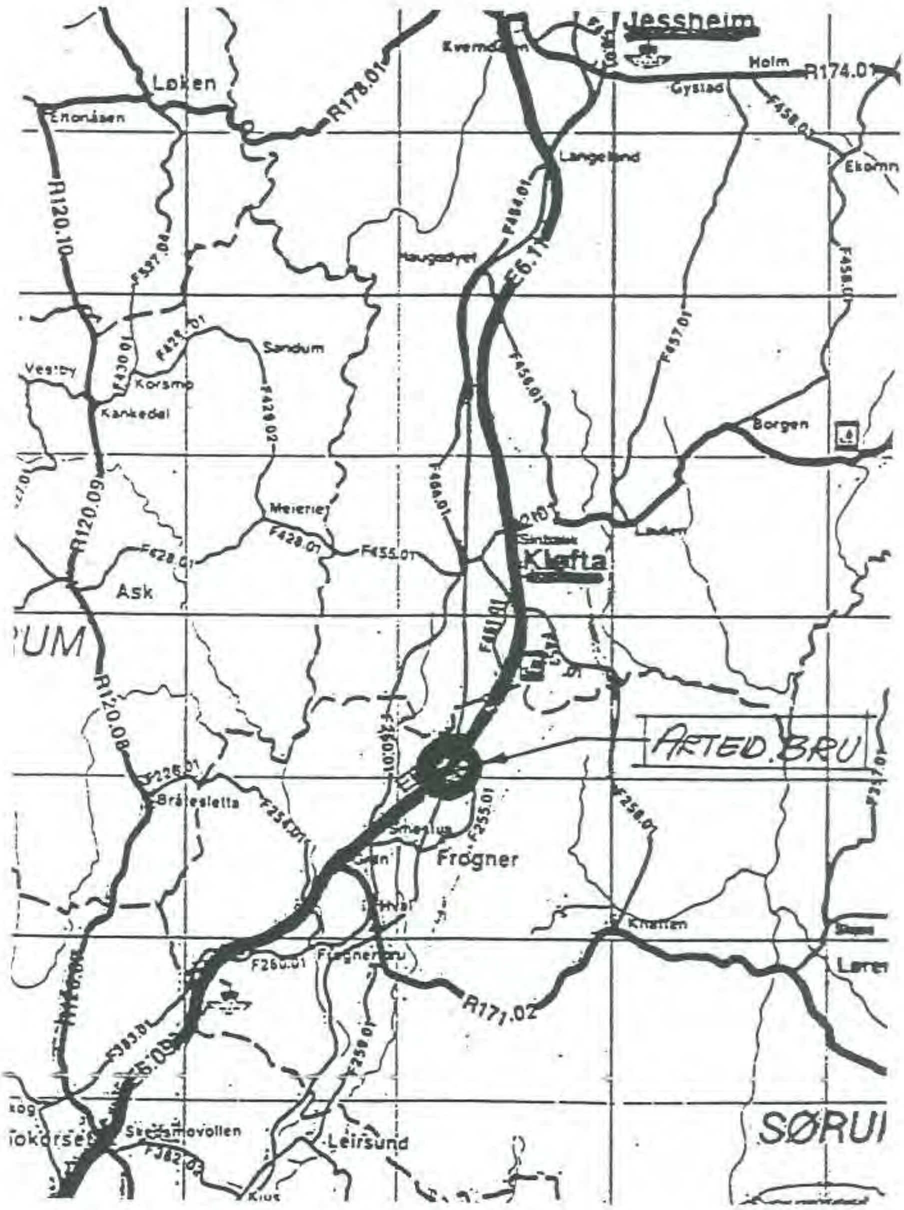
Boks 660

Oppdrag C-195 L, rapport nr. 4

E 6 ARTEID BRU

2. byggetrinn.

Erfaringsrapport fundamentering.



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20.04.2001

Statens vegvesen
Vegdirektoratet

Vestfold

Statens vegvesen

UTDRAG AV:

TEKNISK SLUTTRAPPORT GRUNNARBEIDER OG FUNDAMENTERING

ÅRUM – ALVIM

Ny Sandesund Bru

E6 i Region ØST

Stålkjernepeler RC-boring

Laboratorieserien

Rapport nr. 82

Hølendalen jernbanebru.

Borede peler.

Oktober 1996

Akershus

Statens vegvesen
Vegdirektoratet

Statens vegvesen

Utdrag av:

TEKNISK SLUTTRAPPORT GRUNNARBEIDER OG FUNDAMENTERING

ÅRUM – ALVIM

Ny Sandesund Bru

E6 i Region ØST

Borede peler Ø1800

Rapporten er skrevet av : Yngvar A. Hanson

Godkjent dato :

Godkjent av :

Signatur :

Vedlegg M

Erfaringer borede peler

Erfaringer

BOREDE PELER

NSB-bru Hamang (1992)

Hølendalen jernbanebru (1994)

E6 Sandesund bru (2006)

Rapport nr. 81

Borede peler.

NSB-bru ved Hamang

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Statens vegvesen
Vegdirektoratet

Akershus

Laboratorieserien

Rapport nr. 82

Hølendalen jernbanebru.

Borede peler.

Oktober 1996

Statens vegvesen
Vegdirektoratet

Akershus

Statens vegvesen

Utdrag av:

TEKNISK SLUTTRAPPORT GRUNNARBEIDER OG FUNDAMENTERING

ÅRUM – ALVIM

Ny Sandesund Bru

E6 i Region ØST

Borede peler Ø1800

Rapporten er skrevet av : Yngvar A. Hanson

Godkjent dato :

Godkjent av :

Signatur :

Vedlegg N

Erfaringer borede stålrør

Erfaringer

BOREDE STÅLRØR

E6 Møllenberg (Trondheim) (2010)

E6 TRONDHEIM-STJØRDAL, PARSELL TRONDHEIM – DAGSONE VEST. GEOTEKNISKE ASPEKTER KNYTTET TIL RØRSPUNTVEGGEN. PRØVESPUNT, ISTRUMENTERING, GEOTEKNISKE BORINGER VED PRØVESPUNT, NOEN ERFARINGER VED UTFØRELSEN.

E6 Trondheim – Stjørdal, parcel Trondheim – cut and cover tunnel Geotechnical aspects around the drilled steel pipe wall. Results from instrumentation and of the test steel pipes, and some experiences from the installation of the drilled steel pipe wall.

Siv. ing. Sigbjørn Rønning Multiconsult AS, for tiden Statens vegvesen

SAMMENDRAG

Som grunnlag for valg av spuntmetode ble det utført prøvespunting med boret rørspunt vinteren 2010. Det var på forhånd stort fokus på å begrense omrøring av kvikkleire og poretrykksreduksjon, noe som medførte en omfattende instrumentering av forsøket. Resultatene av målingene og erfaringene fra utførelsen av forsøket og innledende spunting medførte justeringer av utstyr og metode for installering. Målinger og observasjoner under utgraving viser at installasjon av rørspunt ikke har medført omrøring av kvikkleire i vesentlig grad utenfor den mekanisk omrørte sonen. Framgraving av spuntfot mot berg viser at en tett overgang uten lekkasjer, bortsett fra punkter der spunten ikke er boret ned i berg. Installeringen av spunten var sårbar for stålrester i grunnen (fyllmasser). Låsefriksjonen medførte behov for å fravike planlagt installasjonsmetode, med boring fra terreng, noe som sannsynligvis resulterte i mindre omrøring av kvikkleire.

SUMMARY

Test installation of RD-wall was executed during winter of 2010 as a tool for choosing method of installation of supporting walls in sensitive clay. The major concerns was remoulding of sensitive clay and reduction of pore pressure during installation of the wall. The test installation was monitored using piezometers, total pressure cells, inclinometer and CPTU-soundings. Results from the tests and experience form the installation of the test pipes made it necessary to make adjustments of equipment and installation method. The monitoring results and observations during excavation close to the RD-wall show that remoulding of the sensitive clay is limited. The wall footing is dry, except for the steel pipes not drilled into rock.

Interlock friction made it necessary to find a new installation method. Installation of RD-wall by this method is vulnerable to steel parts in the ground (for instance fill material). As a side effect less remoulding of sensitive clay was obtained.

INNLEDNING

Statens vegvesen bygger ny hovedinnfartsåre til Trondheim fra øst. Det bygges fire felt tunnel fra Lademoen til Leangen. Byggingen omfatter ca. 20m utgraving i kvikkleire mellom husene på Møllenberg for bygging av en cut-and-cover-tunnel i vestre ende av tunnelen. For generell beskrivelse av prosjektet vises til kapittel 22 v/Anders Beitnes /Ref. 1/. For hovedprinsippene i løsningen av byggegropa vises til kapittel 33 v/Torgeir Haugen /Ref. 2/.

Figur 1: Prinsipp rørspuntvegg (kilde Ruukki)

Figur 2: Rørspunt med pilotkrone, ringborkrone og spuntlås.

NCC har kontrakt på bygging av tunnelen, og hadde ved kontraktsinngåelsen 2 alternative oppstøttingsløsninger for etablering av byggegropa, der det ene alternativet var en tidligere utprøvd løsning med bruk av spunt med jet-injisering for tetting mellom spuntfot og berg og det andre alternativet var bruk av rørspunt (RD-vegg) som ble boret gjennom løsmasser med fullt tverrsnitt inn i berg. Utførelse av rørspunt var ikke tidligere prøvd under slike grunnforhold. Det var derfor forutsatt gjennomføring av instrumentert prøvespunting som grunnlag for beslutning om valg av metode. Denne artikkelen tar for seg instrumenteringen og resultatene fra målingene under prøvespuntingen, samt oppsummerer noen av erfaringene fra utførelsen av rørspunten.

GRUNNLAG

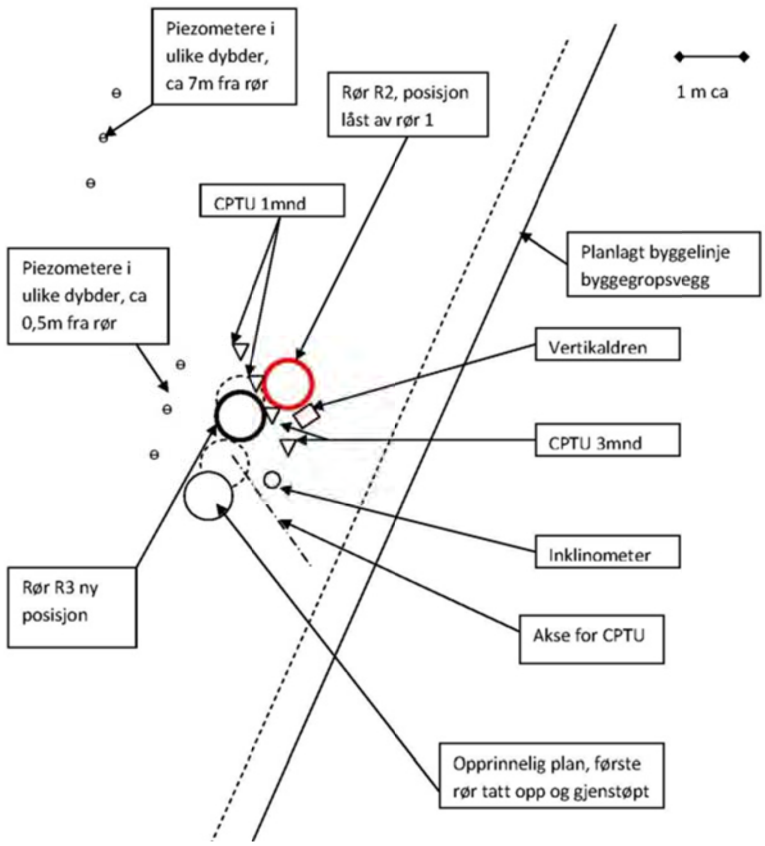
Prøvespuntingen var planlagt å omfatte 3 spuntrør med spuntlåser. Løsningen med boret rørspunt (RD-vegg) er utviklet av Ruukki i samarbeid med Atlas Copco. Spuntrør med låser var levert av Ruukki som underleverandør til Kynningsrud Fundamentering AS. Hallingdal bergboring AS utførte rørboringen. Rørene har dimensjon Ø = 610mm, t = 10mm. Spuntlåsene bygger på prøvespunten 5 cm.

Som resultat av samråd mellom de ulike aktørene ble det besluttet å instrumentere rørspuntforsøket med følgende:

- Elektriske piezometere på to steder i 3 nivåer, henholdsvis 0,5m og 7m fra spunten.
- Totaltrykkceller ved spissen av rørspunten.
- Inklinometerkanal ca. 1,0m fra rørspunten.
- CPTU-sonderinger inntil rørspunten som grunnlag for vurdering av omrørt sone.

Som forsøk ble det på det ene røret montert vertikaldren, ut fra en ide om mulig utdrenering av poreovertrykk ved installering av rørspunt. Et år etter installering av prøvespunt ble det utført prøvetaking i tilknytning til masteroppgave ved NTNU v/Shaima Ali Hassan Alnajim.

Relativ plassering av instrumentering i forholdt til rørspuntforsøket er angitt i plan på figur 2.



Figur 3: Instrumentering, planskisse

Grunnundersøkelsene utført på forhånd var omfattende, og inkluderte blant annet blokkprøvetaking. Den mest relevante blokkprøvetakingen var ca. 15m fra prøvespunten. Grunnen i prøvepunktet består av fyllmasser og sand til ca. 2m dybde over finsandig silt og siltig leire til ca. 4,5m dybde. Videre er det kvikkleire ned til et tynt morenelag over berg i 18-20m dybde. Kvikkleira har varierende vanninnhold i området 26-47 %. Sensitiviteten varierer fra ca. 30 til ca. 250. Leirinnholdet ligger i området 20-40 %, noe som oppfattes som høyt for trønderske leirer.

RØRSPUNTFORSØKET

I forkant av forsøket ble det diskutert hvor stor sone kvikkleira ville bli omrørt, og hvor stor risiko det var for at luft ville lekke ut og komme opp på utsiden av spuntrøret. Etter å ha sett hvordan boring av rørspunt ble utført i Helsingfors på en kort prøvevegg som ble installert der, ble det diskutert hvordan ringborkrona kunne reduseres i diameter og hvordan spuntlåsen kunne modifiseres til å passe til et mindre borkroneutstikk. For selve forsøket fikk dette ingen betydning, men for spuntingen av byggegropa ble utstikket redusert til 30mm og en annen spuntlås ble benyttet (se figur 1).

Grenseverdier for akseptabelt totaltrykk ble satt på forhånd i samråd mellom byggherre og entreprenør. Nedre grense ble satt til hydrostatisk vanntrykk fra terreng. Lavere trykk ville indikere at masse fra utsiden av røret ble spylt ut. Øvre grense ble satt til hydrostatisk vanntrykk med tung væske (omrørt kvikkleire) med egenvekt 20 kN/m^3. Høyere trykk ville indikere at røret ble ført ned raskere enn masse ble spylt ut, og dermed gi massefortrenging og større omrørt sone enn forutsatt. For å redusere et eventuelt overtrykk ble det besluttet å montere vertikaldren på et av spuntrørene.

Rør R3, første posisjon 4/2-2010
Rørspuntforsøket ble startet opp den 4/2-2010. Pilotkrona ble montert inn i spuntrøret og boringen ble gjennomført til ca. 12 m dybde. Under hele nedboringen ble det benyttet vannspyling kontinuerlig. Det hadde da blitt sent på dagen, slik at videre boring måtte utsettes til neste dag. Dagen etter var borkrona tett, og hele røret måtte trekkes opp igjen. Selv om det ble fylt tilbake i hullet, medførte dette sannsynligvis noe omrøring av massene rundt pelen.

Rør 3, andre posisjon 8/2-2010
Etter det mislykkede første forsøket ble rør R3 flyttet ca. 1,0m, for å unngå å bore gjennom tilbakefylte masser. Rør R3 i andre posisjon ble boret ned den 8/2-2010. Dette forsøket ble startet så tidlig på dagen at problemene som oppstod ved første forsøk skulle unngås.

Figur 4: Tømming av rør med luft.

Figur 5: Luft kommer opp langs utsiden av røret.

Penetrasjon under boring gjennom leire var 0,5 – 1,0 m/min. Det ble ikke registrert massestrøm langs utsiden av røret. Fra ca. 4 m dybde strømmet masse/vann over kanten på røret. Totaltrykksmåler like bak fronten viste opp mot 2 ganger hydrostatisk trykk, falt noe ved stillstand og økte litt under bevegelse. Poretrykksmålerne viste opp mot 0,5 m trykkstigning like etter at borefronten passerte. Svært mye av utspylt masse kom ut mellom rørtopp og pakkboks, noe som medførte utrivelig arbeidsplass og manglende kontroll med returstrømmen. Prosessen gir ikke anleggsstøy av betydning så lenge nedsetting foregår i leire. Når boret møtte masser med grus og stein like over antatt berg, oppsto flere situasjoner med forkiling, men det lot seg fortsatt bore med spyling og uten slag i ca. 0,5 m. Total dybde var da ca. 18 m med 6 m gjenstående høyde over bakken. Maskinen ble så omstilt for boring/spyling med luft, pakkboksen ble løftet fra for å gi god visuell kontroll med returstrømmen og man satte på fullt lufttrykk for å tømme slam ut av røret. Boring med og uten slag fortsatte, med gjentatte forkilinger som ble løst ved å trekke boret noen cm tilbake tilsvarende slakk/frihetsgrad i inngrepet med ringkrona. Dette medførte kraftige rykk i boreriggen og synlige bevegelser i spuntrøret.

Bergoverflaten ble nådd etter ytterligere ca. 20 cm boring. Under denne prosessen begynte det å komme opp luft utenfor rørveggen og terrenget fikk kraftige bevegelser ”som kokende grøt” i ca. 3 m diameter, se figur 4. Totaltrykkmåleren viste et kraftig fall i trykket, tolket som ”mammutpumpe”-effekt av luftspylingen. Masse kom også over rørkanten, men helst i støt, med grus og småstein innblandet. Søle sprutet ut og griset til alt som befant seg innen radius på 10 – 15 m, se figur 3. Samtidig må spuntrøret ha beveget seg under ansett mot berg, slik at det roterte ca. 15 grader mot høyre og dro seg ”utfor bakke” til en skjevstilling som anslås til 0,5m i foten.

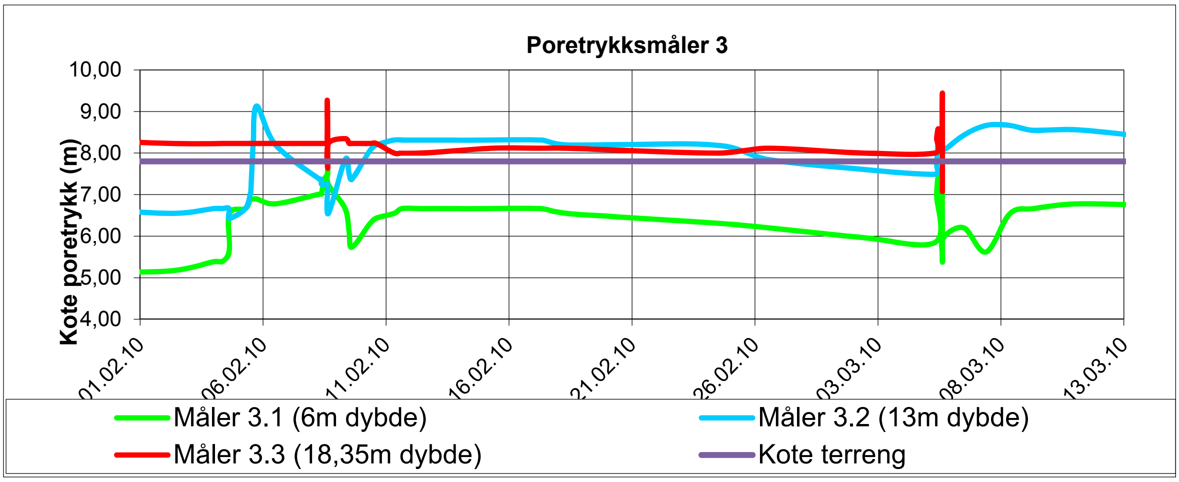
Når boret, etter alt å dømme hadde entret berget, ble forholdene omkring returmasse roligere og bevegelsene i riggen mindre, men det oppsto nå merkbare rystelser i grunnen og metallisk slaglyd fra toppen av røret. Det fortsatte å komme luft opp på utsiden av røret, men nå i form av mindre luftbobler i en mer kontrollert strøm. Boringen fortsatte ca. 0,6 m i berg, og forsøket ble avbrutt. Forsøket ble vurdert som så lite vellykket, at det ikke kunne fortsette uten at det ble gjennomført modifikasjoner av borkrona.

Rør 2, 5/3-2010
Det andre røret ble satt den 5/3-2010. I forhold til første rør var følgende endringer av boreprosedyren utført: Atlas Copco har levert endret borkrone med enklere forbedret system for returluft, og Hallingdal bergboring gjennomførte oppstart av luftboring ved topp av steinrikt morenelag.

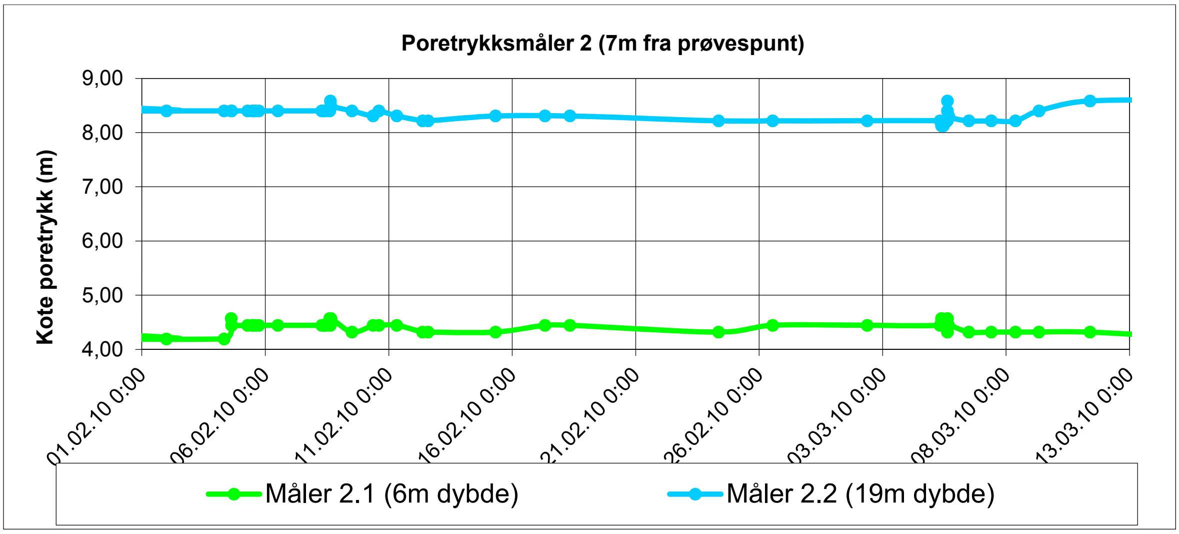
Forsøk med rør R2 ble instrumentert med: Poretrykksmålere 0,5m fra rør (dybder 6m, 13m og 18,3m) og ca. 7m fra rør (dybder 6m og 19m), inklinometerkanal ca. 1,2m fra rør R2 (og 0,7m fra rør R3), totaltrykkceller 0,5m, 7m og 13m over bunn rør, og CPTU er utført i avstand ca. 0,1m og 1,0m ca. en måned etter installering av rør, og etter ca. tre måneder etter installering av rør. Det ble montert vertikaldren langs en side av røret for å se om dette ga utslag i poreovertrykk under installasjon.

Følgende ble observert under nedsetting av rør R2:
Noe innledende rotasjon med spyling, før rør begynte å bores ned. Sakte nedboring til 6 m dybde før montering av trykkcelle 2. Vann kommer over rørtopp fra ca. 7m dybde.
Stor friksjon i låser medfører sakte framdrift og forkiling, og skyldes sannsynligvis unøyaktigheter i spuntlåsene og for lite nedpressingskraft i boreriggen. Etter at røret ble hevet for deretter å senkes ned igjen gled røret forbi forkilingspunktet. Leirvann kommer over rørtopp ved rørspiss i ca. 9m dybde. Avsluttet i ca. 11m dybde for skjøting og montering av trykkcelle 3. Luftboring startet når morenelag over berg ble nådd – ingen lekkasje av luft på utsiden av røret.

MÅLERESULTATER
Poretrykksmålinger
Resultater er vist i figurer nr. 5 og 6.
Poretrykket ble overvåket manuelt under og like etter nedboring. Hovedfokuset var på piezometere som stod 0,5m fra spuntrørene (poretrykksmåler 3). Under installering av spuntrørene viste målerne i dybde 6 og 13 m dybde en økning i poretrykket tilsvarende 2 og 2,5m stigehøyde. Etter at spissen av spuntrøret hadde passert falt trykket raskt med ca. 1,0m stigehøyde. Poretrykksmåleren ved berg viste en svært rask respons når luftboring startet, for deretter å gå tilbake til opprinnelig nivå i løpet av minutter etter at luftboring sluttet.



Figur 6: Poretrykksavlesninger 0,5m fra installasjon av rørspunt.



Figur 7: Poretrykksavlesninger ca. 7m fra installasjon av rørspunt.

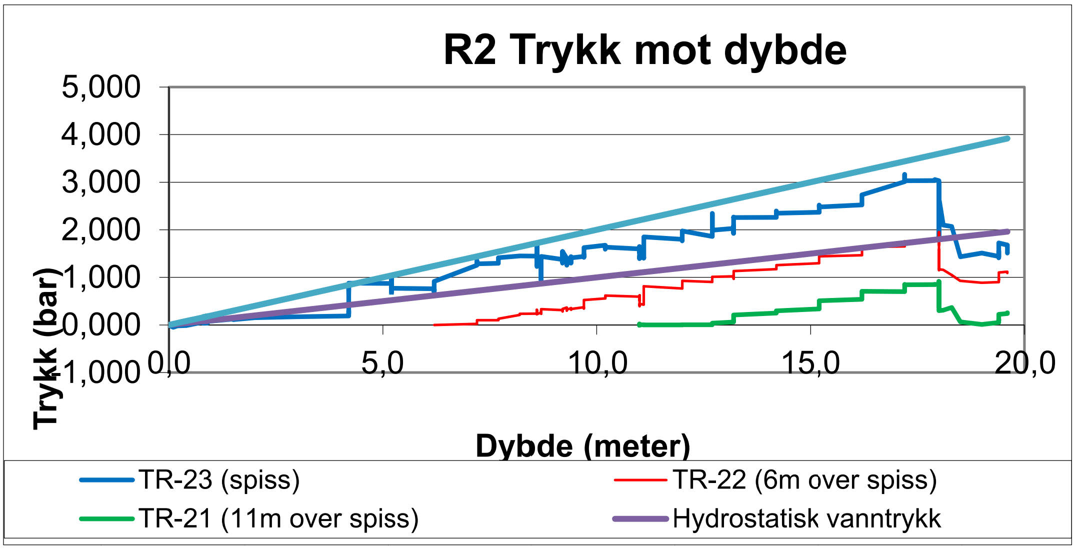
Tilsvarende poretrykksmålinger i avstand 7m fra rørspuntforsøket (poretrykksmåler 2) viste en vesentlig mindre respons enn for poretrykksmålere i punkt 3. Poretrykksresponsen her var kortvarig (minutter).

Totaltrykkceller

Det ble montert totaltrykkceller på de to prøvespuntrørene. På rør R3 ble det montert på en celle ca. 0,1m bak spissen på røret. På rør R2 ble det montert 3 celler i nivå 0,1m fra spissen, 6m fra spissen og 13m fra spissen. Målerne ble levert, montert og avlest av Sintef v/Torgeir Jensen. Resultatet av målingene plottet mot dybde av spissen er vist på figur 7-9.

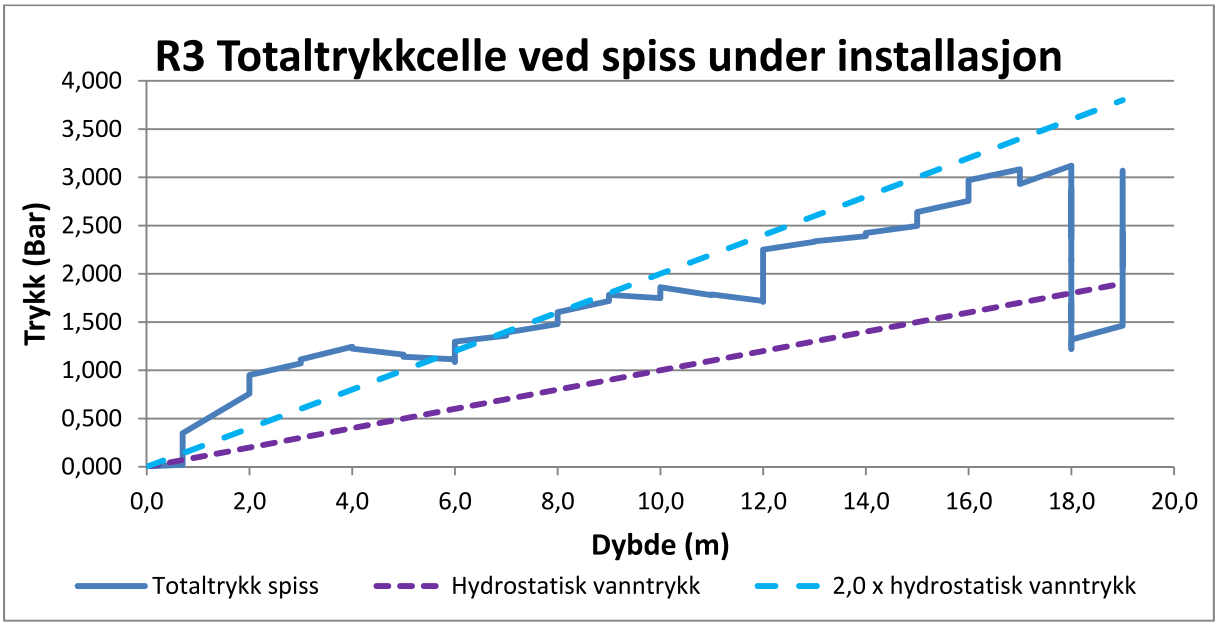
For rør R3 steg trykket til mer enn dobbelt hydrostatisk vanntrykk under boring ned til 5-6m dybde. På stedet ble det antatt at det høye trykket skyldtes massefortrenging. Videre ned sank trykket til under dobbelt hydrostatisk vanntrykk, noe som ble vurdert å skyldes mindre grad av massefortrenging. Ved oppstart av lufthammer falt trykket til noe under hydrostatisk vanntrykk fra terreng. Det kom luft på utsiden av røret ved denne boringen. Etter at lufthammeren ble stanset økte trykket til ca. 1,7 ganger hydrostatisk vanntrykk.

Figur 8: Totaltrykkcelle montert på spuntrør. Rør for injeksjon mellom rør og berg er påmontert. Til høyre modifisert montering med beskyttelse.



Figur 9: Resultat totaltrykkceller plottet mot dybde rør R2.

Ved boring av rør R2 ble det boret med lavere penetrasjonshastighet for å redusere den antatte massefortrengingen under boring av rør R3. Dette lyktes, slik at trykket ved spissen hele tiden ble holdt under dobbelt hydrostatisk vanntrykk. Trykkcellene høyere opp langs røret viste et trykk tilsvarende ca. 1,5 ganger hydrostatisk vanntrykk fra terreng. Ved boring i med luft i berg sank trykket til under hydrostatisk vanntrykk fra terreng.



Figur 10: Resultat totaltrykkceller plottet mot dybde rør R3 (andre posisjon).

CPTU-sonderinger
Tre dager etter boring av rørspunt R3 ble det utført CPTU-sonderinger i avstand 0,5m, 2,0m og 4,0m fra rørspuntforsøket. Etter at luft kom opp på utsiden av spuntrøret under boring med lufthammer var det usikkerhet knyttet til hvor stor sone av kvikkleira som var omrørt. Resultatene ble sammenholdt med tidligere CPTU-er i nærheten. Sonderingen ble utført av Tyrens AB og tolket av Multiconsult v/Rolf Sandven. Tolkingen antydet at spuntboringen hadde stor påvirkning i 0,5m avstand, mulig påvirkning i 2m avstand, og upåvirket tilstand i 4m avstand.

Det ble utført en CPTU-sonderinger ca. en og tre måneder etter installasjon av rør R2 ved spuntlåsen mellom de to prøvespuntrørene. Plasseringen ble valgt for å treffe en så stor omrørt sone som mulig. Formålet var å få noe kunnskap om rekonsolideringen av den omrørte kvikkleira. Sonderingene ble utført og tolket av Multiconsult. Resultatet av tolkingen antydet en mulig gjenvinning av opprinnelig skjærstyrke med 50-70 %, men med store usikkerheter.

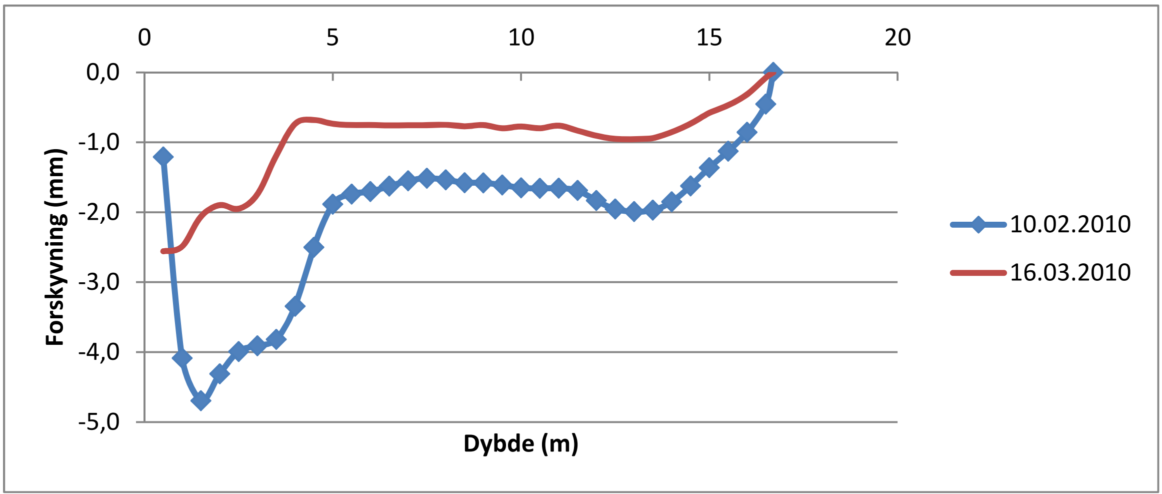
I forbindelse med masteroppgaven ved NTNU tok Shaima Ali Hassan Alnajim opp prøver av omrørt sone inntil spuntlåsen mellom rørene. Prøvene ble tatt opp ca. et år etter boringen av spuntrørene. Prøvene viste at massen ikke besto av rekonsolidert leire, men av sedimenterte masser i lag. Der noe var silt, noe var leire, og noe fortsatt var vann med en suspensjon av leire.

Inklinometer
Inklinometermålingene i 1,0m avstand fra prøvespunten. Måling etter installasjon av rør viser at kanalen har beveget seg bort fra spuntrøret fra terreng til ca. 5m dybde, mens det ned mot berg kan se ut til at kanalen har nærmet seg røret.
Det beskrevne bevegelsesmønsteret for toppen av kanalen kan forklares ut fra følgende alternativer:

1. Det har skjedd en massefortrenging under nedsetting av rørspunten til ca. 5 m dybde. Deretter har massestrømmen gått inne i røret. Dette underbygges av registreringen av trykk på trykkcella.

2. På grunn av ”liljeform” på luftstrømmen under boring med luft har det skjedd en massefortrenging av toppen. Det er så vidt vi kan se ingen andre forhold en risting av inklinometerkanalen under luft boringen som underbygger dette hendelsesforløpet.

Bevegelsen av den nedre delen av kanalen kan skyldes luftstrømmen, og den reduksjonen av trykk som har vært inntil røret under oppstrømming av luft. Det er mulig at dette har ført til en viss bevegelse i massen, og dermed kanalen.
Etter nedsetting av rør R2 er det en tendens til at kanalen har beveget seg noe inn mot det første røret, mest i toppen. Dette ble først vurdert å kunne skyldes rekonsolidering inntil rør R3, men en mer sannsynlig forklaring i etterkant er nok at leire har fylt opp hulrom inntil rør R3.
Den mest nærliggende forklaringen er at omrørt sone rundt det første røret er under rekonsolidering. Dette vil medføre en viss volumreduksjon. Bevegelsen av toppen av kanalen skyldes sannsynligvis at massetapet i toppen var størst ved luftlekkasjen på rør R3. Det bemerkes at bevegelsen er liten, og kan være et utslag av målenøyaktighet.



Figur 11: Rørspuntforsøk, Inklinometerresultater (positiv retning mot rørspunt)

VURDERING AV RESULTATER
Poretrykket under installering av rørspunten reagerte kraftig inntil spunten, men reaksjonen var liten noen meter fra spuntrøret. CPTU-sonderingene utført like etter installasjon indikerer også et begrenset område inntil spunten som har vært påvirket av spuntinstallasjonen. Dette til tross for de uheldige hendelsene under forsøket med luft som kom opp langs utsiden av røret.

Totaltrykkcellene ga vesentlig informasjon om hvor stor grad av massefortrenging som oppstod under nedboringen gjennom løsmasse. Massefortrenging oppstod sannsynligvis pga vanntrykket som stod inne i røret under nedboring. Inne i røret var det for den første rørlengden hele tiden vannfylt til toppen. Etter at røret var boret ned noen meter ble potensialforskjellen gradvis redusert til et nivå der massefortrengingen ble elliminert.

Med så stort omfang av instrumentering inntil et rørspuntforsøk er det alltid fare for å mistolke måleresultatene. Under og like etter prøvespuntforsøket ble totaltrykket tolket til å være en funksjon av vanntrykk pluss et aktivt trykk, noe som gav godt samsvar med de målte resultatene. Ved prøvetaking inntil spuntrørene er det grunn til å tolke de målte totaltrykkene som et væsketrykk av tung væske, dvs. vann og omrørt kvikkleire i suspensjon.

Vertikaldren langs spuntrøret viste seg ikke å ha målbar effekt.

Inklinometermålingene indikerer at massen rundt prøvespunten har blitt påvirket av spuntetableringen. Det er ovenfor antydet en mulig årsak til de målte bevegelsen, men det er knyttet stor usikkerhet til dette.

Etter utført forsøk var det stor usikkerhet knyttet til om metoden var gjennomførbar for dette prosjektet. Leverandør av borsystemet, Atlas Copco, mente det var mulig å modifisere borkrona slik at risikoen for luft på utsiden av røret ble redusert. Basert på de presenterte dataene, og vurderingen av fordelen for tetteproblematikken en full innboring i berg ville gi, ble metoden med rørspunt valgt å gjennomføre.

SLUTTKOMMENTAR

Ved oppstart av spunting for byggegropa viste det seg at låsefriksjonen var for stor til at det var mulig å bore ned rør gjennom løsmasse med kun vannspyling og rotasjon gjennom løsmassene. Etter forslag fra Kynningsrud ble videre installering av rørspunt utført ved først å vibrere ned rørene til berg/morene. Deretter ble rørene tomt for masse ved hjelp av spyletrykk gjennom pilotkrona. Pilotkrona ble koblet sammen med ringborkrona, med etterfølgende innboring i berg. Etter en del oppstartsproblemer ble det i gjennomsnitt etablert ca. 2 spuntrør pr borerigg pr arbeidsdag. Rørene varierte i lengde fra ca. 10 m til ca. 30 m. Angitt tid inkluderer sveiseskjøting av rør som ble utført på alle rør med lengde over ca. 18m.

Ca. 15 av de 350 spuntrørene, som utgjør oppstøttingen rundt gropa, er ikke boret inn i berg. Årsaken til at enkelte rør ikke ble boret inn i berg er fortsatt usikker. Gjenliggende stålrester i grunnen etter forgraving i fyllmassen kan være en mulig forklaring der pilotkrona ikke fikk entret ringborkrona. Skrått berg, kombinert med for stor kraft under forsøk på entring av ringborkrona er en annen. Forhåpentligvis vil dette bli noe klarere etter at spuntfoten ved disse punktene er frigravd, og de aktuelle spuntrørene er åpnet.

Under installasjon av spunten oppstod det et økende loddavvik langs spuntveggen, noe som ble rettet opp ved hjelp av opprettingsnåler som ikke ble boret inn i berg.

Ved all spunt som ikke er boret inn i berg er det utført jet-injeksjon for tetting mellom spunt og berg. Etter spuntetablering var poreovertrykket ved berg tilbake på normalt nivå før spuntarbeidene. Spuntrørene ble deretter armert og støpt ut. Foringsrør for injeksjon var montert på armeringen i rørene. Det ble injisert under spuntfoten i berg til 10m under planlagt grave-/ sprengningsnivå. Utstøpingen ga mottrykk for denne injeksjonen.

Det er til nå frigravd deler av spuntfoten. Spuntfoten framstår generelt som tett, bortsett fra i noen av punktene der rørspunten ikke er boret inn i berg. Det kan se ut til at jet-injeksjonen ikke har fungert godt nok som tettetiltak i morenemassene. Noe av årsaken kan være valget av jet-injeksjonsmetode i forhold til steininnholdet i morena.

Rørspunten oppfører seg stivt, og har så langt gitt målte deformasjoner som ligger innenfor kravet til 0,25 % av utgravingsdybden.

Inntrykket fra byggegropa er at spunten er tettere enn det vi sannsynligvis ville oppnådd med tradisjonell fordyblet spunt med jet-injisert fot. Valget av spuntmetode var dermed riktig, sett i etterkant. Rørspuntløsningen har fungert godt i dette prosjektet, men metoden framstår fortsatt som lite utviklet. Dette gjelder blant annet for boring gjennom bløte masser og for luftboring i berg.

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